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Seasonal abundance shifts by the Australian White Ibis *Threskiornis molucca* across parts of eastern Australia in 2007: a survey using questionnaires

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The Australian White Ibis *Threskiornis molucca* has recently expanded its breeding range from inland wetlands into coastal areas of eastern Australia. Here it inhabits many urban environments and its high abundances require management. However, the lack of knowledge on large-scale abundances and movements of ibises prevents the development of appropriate management. This study investigates the abundances and distribution of ibises in New South Wales (NSW) and southern Queensland (Qld.) in two large-scale surveys – one during the non-breeding season (March–April) and the other during the early breeding season (June–July). Abundances increased significantly in coastal areas of NSW and southern Qld. during the breeding period, while they decreased in central and inland areas. The significantly higher abundances in bioregions with large coastal cities (e.g. Sydney, Brisbane) in comparison to those with towns (e.g. Eden, Ballina) suggest that ibises favour large cities for breeding. Some urban areas (e.g. Gold Coast, Sunshine Coast) had high abundances of ibises during both surveys with no significant increases during the breeding season, which suggests ibises are predominantly sedentary there. The findings support the view that ibis populations on the east coast consist of sedentary and mobile subpopulations that enter city areas for breeding. This needs to be considered in their management.

INTRODUCTION

The Australian White Ibis *Threskiornis molucca* (ibis hereafter), a native waterbird once common to Australia's inland wetland systems (Carrick 1962), has dramatically increased in abundance in coastal, mainly urban environments of eastern Australia since the 1970s (Smith and Munro 2010). The reasons for its coastward expansion and high abundances are unknown, but may be linked to the degradation and disappearance of inland wetlands due to drought and increased irrigation for agriculture (see Kingsford and Johnson 1998). The escape of captive birds from zoos (Ross 2004) and the high availability of anthropogenic food sources (Smith 2009; Smith and Munro 2011) may have also contributed to the increase in numbers in urban environments.

The high abundance of ibises in coastal urban areas has many economical, social and environmental consequences (see Martin *et al.* 2007). Here they may compete with native wildlife (Ross 2004), destroy vegetation and foul water bodies (Kentish 1999). They may also carry and transmit diseases (e.g. avian influenza, Newcastle disease, salmonella (Ross 2004)) and other pathogens (Epstein *et al.* 2006), and threaten aircraft safety (Shaw 1999; ATSB 2002; Corben and Munro 2008; Smith 2009). They are generally regarded as smelly, noisy and dirty birds (Ross 2004; Martin *et al.* 2007), which scavenge from landfills and garbage bins (Smith 2009). Currently, the general public and many government and non-government agencies with increasing ibis populations demand an immediate, rigorous reduction of ibis abundance (Smith 2009). However, effective management of ibises is difficult, since little is known about this species (e.g. where do the ibises in our cities originate?).

Recent studies have shown that ibis abundances in the urban environment (Sydney) increase dramatically during the breeding season (Corben and Munro 2008; Martin *et al.* 2010; Smith and Munro 2010), which suggests that birds enter these areas for breeding, and that coastal urban environments host both resident and mobile subpopulations (Corben and Munro 2008). If such mobile subpopulations exist, then management actions that focus on the rigorous reduction of ibis abundance (i.e. destruction of adults, nests, eggs and nestlings (see Marin *et al.* 2007)) may not only affect resident, but also mobile subpopulations (Corben and Munro 2008). Currently, it is not known from where the ibises that enter coastal cities originate. It has been speculated that they may stem from the former, now dry or heavily degraded inland wetlands (Haig *et al.* 1998; Smith 2009), which are now unsuitable for breeding. While studies on abundance changes in urban environments (Martin *et al.* 2010; Smith and Munro 2010) and population fluctuations of inland waterbirds in response to water availability (Maher and Braithwaite 1992; Kingsford and Norman 2002; Roshier *et al.* 2002) support this view, this remains speculative until large-scale surveys on ibis abundances are available.

In this study, data are presented which were obtained via public surveys on the abundances and distribution of ibises from coastal, central and inland New South Wales and southern Queensland during the non-breeding (April–May) and early breeding season (June–July). The distribution and abundances of ibises are influenced by geographic location, habitat type and bioregion, and, water availability and rainfall (Marchant and Higgins 1990; Halse *et al.* 1998) while breeding depends on habitat type and bioregion (Perrins 1970; Hancock *et al.* 1992; DEC 2003; Porter *et al.* 2006). All these aspects were incorporated into this analysis.

METHODS

Study species

The Australian White Ibis's natural habitat includes wetlands, sheltered marine areas, and grass, farm and pasture lands. Over the past few decades the ibises have extended their range into urban parks, recreation areas, landfills and other places with sufficient food and water, where they can breed (Smith 2009; Snape 2011; Smith *et al*. 2013). At the same time, ibis numbers have dramatically decreased in their traditional inland wetlands in eastern Australia (Porter *et al*. 2006). Their natural diet consists mainly of aquatic invertebrates and crustaceans (Carrick 1959), but can also contain small fish, frogs, crickets, beetles, locusts and earthworms (Marchant and Higgins 1990). In urban areas they generally survive on anthropogenic waste from garbage bins and landfills (Smith 2009). Ibises are colonial breeders and usually nest close to water.

High water levels initiate breeding and in their natural environment breeding events usually correlate with sufficient waterflows into wetlands (Kingsford and Johnson 1998). Receding water levels can result in the abandonment of nests, eggs and/or young (Thomas 2007). In the urban environment breeding is most pronounced between June and February, but can occur during the whole year. Breeding is least common in April (Smith 2009).

Study area and data collection

The distribution and abundances of ibises were studied in New South Wales (NSW) and southern Queensland (Qld.) (up to a latitude of 23°22'S, just below Rockhampton) (total area: 1 769 925 km²) by producing and distributing a survey form to bird interest groups, people with knowledge of ibises or experience in bird surveys, national parks branches and councils from this area. Nine hundred and eighty-five survey forms were sent out and 560 forms were returned. The participants had been asked to use their local knowledge and select an area, where ibises are usually present. The areas selected included: 192 landfills/waste transfer stations, 104 playing fields/golf courses/paddocks, 82 wetlands/swamp/reserves with water, 15 large urban parks with large bodies of water, 4 zoo/wildlife sanctuaries, 103 urban sites, 5 bushland areas with no water and 14 beaches. Participants were requested to complete two surveys for their area. During these surveys the volunteer counters were asked to count all Australian White Ibises in their area. They did not have to distinguish between juveniles and adults and males and females. Since the counts were generally conducted in open areas, which allowed unrestricted views, the ibises were easily detected by the observers and could be quickly counted with the naked eye or binoculars. The first survey was conducted between 20 March and 20 April 2007 (non-breeding season), while the second survey took place between 20 June and 20 July 2007 (early breeding season) (Marchant and Higgins 1990; Smith 2009). Participants were allowed to complete the surveys at any time during the two count seasons, but had to perform both counts at exactly the same place. If participants were counting at multiple sites in an area, they had to conduct all counts concurrently and on the same day, so that double counting did not occur. Once the survey forms were completed, they were returned for further processing and analysis. Only survey forms from counters, who had conducted surveys during both periods and had followed the above guidelines (n = 519 forms for each count), were included in the final analysis.

In the analysis of the surveys the fact that ibis distribution and abundances are influenced by environmental factors (Smith 2009) was taken into account, instead of administrative or government boundaries. This was accounted for by sorting, and later analysing, the survey results according to geographic location, bioregions and areas of equivalent rainfall. Since the distribution and abundances of ibises change with distance from the coastline (see Smith 2009), the total survey area was divided into coastal, central and inland regions. The coastal region encompassed the area from the coastline to the Great Dividing Range (144 647 km²). All land west of the Great Dividing Range up to the border of the inland region, which runs from the southern border of NSW (35°49'S, 144°54'E) through the towns of Griffith, Cobar and Bourke across the northern state border (29°00'S, 145°41'E) to Cunnamulla and Yaraka into Qld. (up to 23°23'S, 143°17'E), makes up the central region (841 617 km²). The inland area (783 661 km²) includes all areas west of the central area to the western edges of the NSW and Qld. state borders.

Survey results were also assigned to the 20 bioregions (broad habitat types) that occur in the sample area in NSW (DEC 2003) and southern Qld. (Queensland Government Environment and Resource Management 2011), and to the seven regions with equivalent mean annual rainfall (201–300, 301–400, 401–600, 601–900, 901–1200, 1201–1800 and 1801–2400 mm) (ABM 2007).

Data analysis

Prior to any detailed analysis on the data a t-test was performed to determine whether total ibis abundance differed between the first (non-breeding season) and second count (breeding season). The t-tests were performed using raw data. In council areas where there was more than one counter an average was taken. Following the t-test two paired gradient maps (Figs. 1 and 2) were created to show the distribution and general abundances of ibises during the two counts.

For each geographical location (coastal, central and inland region), all 18 bioregions, and the seven areas with similar mean annual rainfall (from 201–300 to 1801–2400 mm) mean abundance ± standard error (s.e.) were calculated from the abundances at all single sites per area and the results are shown in Figs. 4, 5 and 6.

Since the participants counted ibises at the same location during both counts, problems regarding increased counting efforts were eliminated. However, in the coastal area, for example, more counts were performed, and therefore the counting effort was higher than in the central and inland areas. To account for this problem and any bias due to differences in area sizes and increased participation due to higher human population in areas, mean abundance of ibises for each site was compared with one-way repeated measures ANOVAs followed by Tukey's post-hoc tests (Zar 1996).

Three one-way repeated measures ANOVAs were performed to test for differences in ibis abundance between the sample areas and the two counts. The sample areas for the first comparison were based on their geographic location and subdivided into coastal, central and inland areas. The second comparison was based on the 18 bioregions that exist in NSW and southern Qld., and the third comparison was based on the seven different regions in the overall area with similar mean

annual rainfall (ABM 2007). The results from the Newcastle region were excluded from statistical tests since a severe storm caused a dramatic decrease in ibis abundance, which produced extreme outliers.

RESULTS

Over 1100 completed forms were returned. Only surveys where the participant had returned information for both counts for the same site were used. This resulted in a total of 1038 completed forms (519 forms for each count) being used in the analysis. These completed forms included one from each council area in NSW ($n = 152$ forms) and southern Qld. ($n = 81$ forms). In some council areas multiple areas were counted (due to some council areas containing multiple ibis sites), which resulted in 346 completed count forms from NSW and 173 from southern Qld. Double counting of sites did not occur. In total there were 255 completed count forms from the coastal area, 182 from the central area and 82 from the inland area.

Figures 1 to 3 present the distribution range and abundances of ibises reported via the questionnaire in NSW and southern Qld. and its two major cities (Sydney and Brisbane) during the non-breeding and breeding season. Total abundance of ibises counted in this area did not differ significantly between these two seasons ($P = 0.97$, t-test). Overall ibis abundances were also similar between the non-breeding and breeding count with regards to geographic location, bioregions and areas of similar mean annual rainfall. However, while total abundances were not affected by survey time, repeated measures ANOVAs in conjunction with Tukey's Pairwise Comparisons revealed significant differences between ibis abundance between specific geographic regions, bioregions and areas of similar mean annual rainfall regions (see below).

Abundances in coastal, central and inland regions

The coastal area had a significantly higher total abundance of ibises than the central ($P < 0.01$) and inland area ($P < 0.01$), while total abundances were similar in the central and inland area ($P = 0.97$) (Fig. 4). In the coastal area ibis abundance increased significantly from the non-breeding to the breeding season ($P < 0.01$), which coincided with a significant decline in abundance in the combined central and inland area ($P < 0.01$).

Abundances in bioregions

Highest ibis abundances were recorded in four coastal bioregions, and included in order of highest abundances the South-eastern Qld., NSW North Coast, and Sydney Basin and NSW South-western Slopes bioregion (Fig. 5). Significant increases in ibis abundance from the non-breeding to the breeding season occurred in the Sydney Basin ($P = 0.02$) and the NSW North Coast ($P = 0.03$) bioregions. Significant decreases in ibis abundance from the non-breeding to the breeding season occurred in the Nadewar ($P = 0.02$), Darling Riverine Plains ($P = 0.02$), Mulga Lands ($P = 0.03$), Desert Uplands ($P = 0.04$) and Mitchell Grass bioregions ($P = 0.04$). Mean ibis numbers were higher in the non-breeding season than the breeding season in the Cobar Peneplain ($P = 0.14$), Murray Darling Depression ($P = 0.29$), NSW South-western Slopes ($P = 0.21$) and Riverina bioregions ($P = 0.06$). However, these differences were not significant. Mean ibis numbers were higher in the breeding season than in the non-breeding season on the Brigalow Belt ($P = 0.34$), New England Tablelands ($P = 0.10$), South-eastern Corner ($P = 0.08$), South-eastern Highlands ($P = 0.35$) and South-eastern Qld. ($P = 0.12$) bioregions. Again, these differences were not significant. No ibises were recorded in the Australian Alps, Broken Hill Complex and Simpson Strzelecki Dunefields bioregions during both the non-breeding and breeding season.
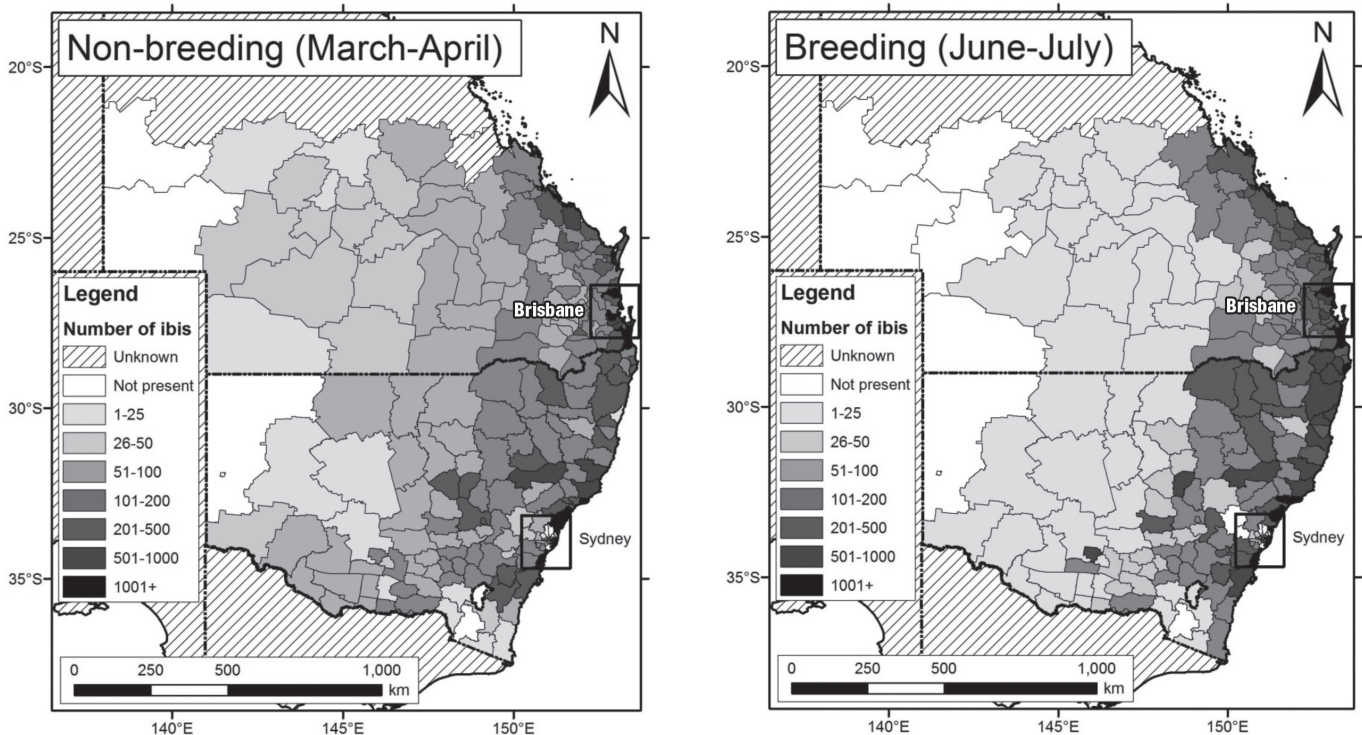
Figure 1. *Ibis abundances and distribution in all shire councils of NSW and southern Qld. during the non-breeding (left) and breeding season (right). Black squares inside the maps indicate the Sydney (bottom) and Brisbane region (top).*
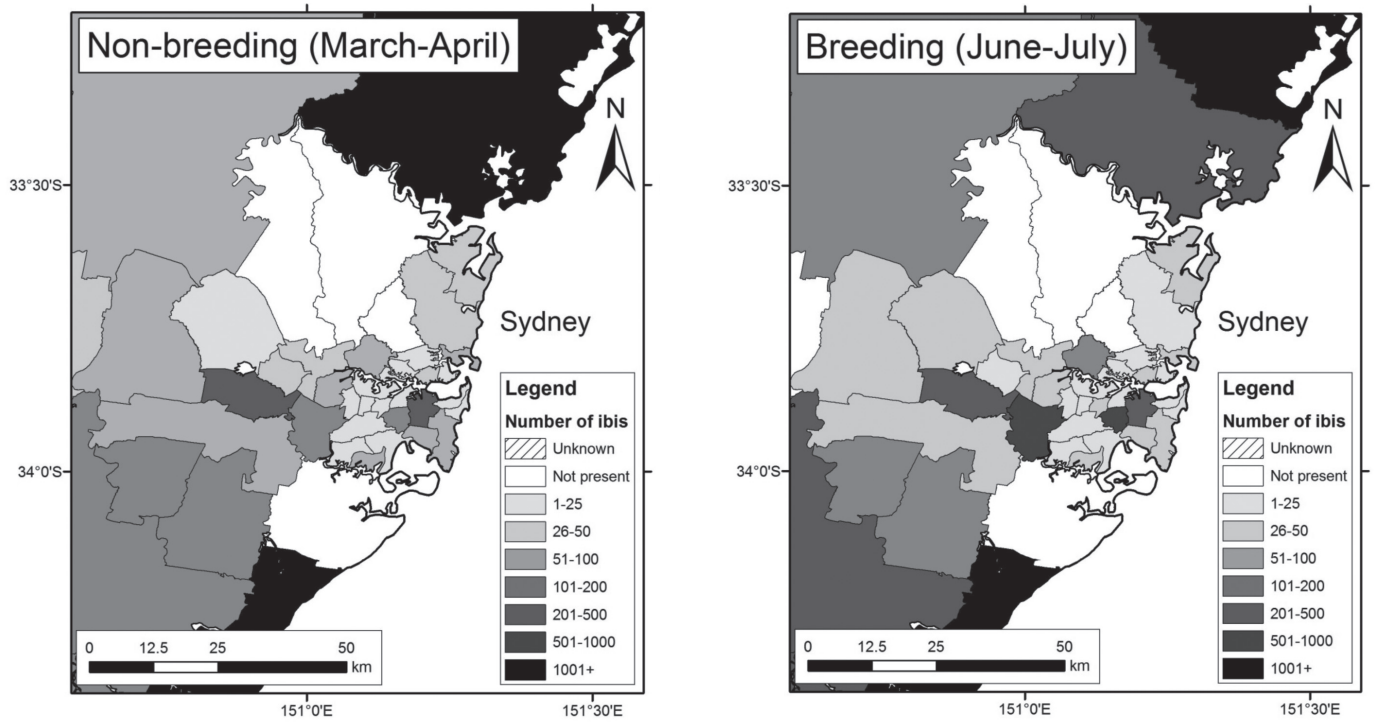
Figure 2. *Ibis abundances and distribution in council areas of Sydney during the non-breeding season (left) and breeding season (right).*
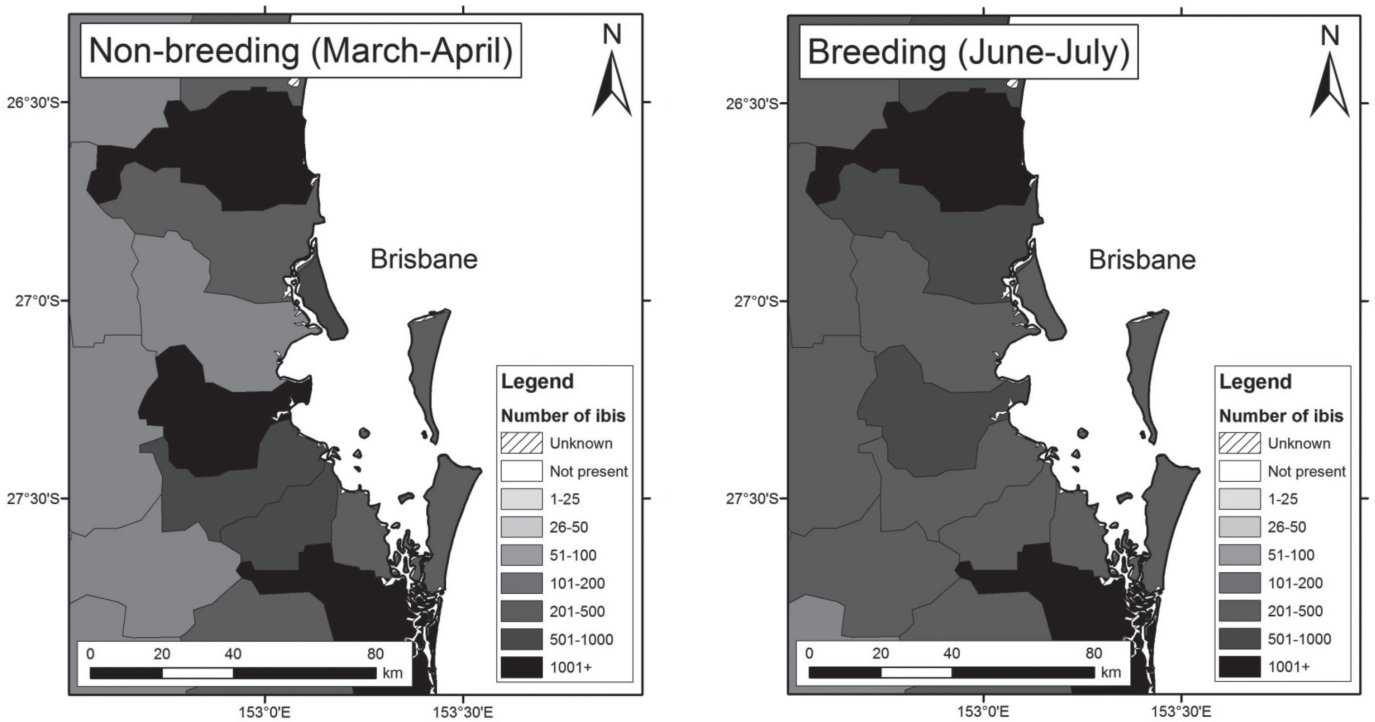
Figure 3. *Ibis abundances and distribution in council areas of Brisbane during the non-breeding season (left) and breeding season (right).*
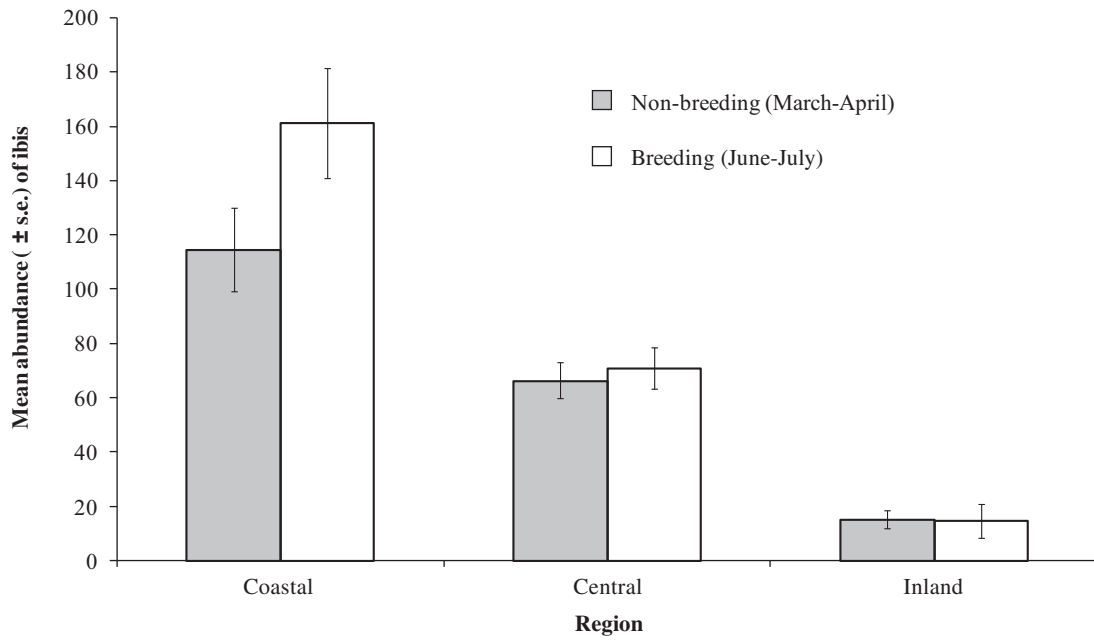
Figure 4. *Mean abundances (± s.e.) of ibises in the coastal, central and inland region at the counts during the non-breeding (March–April) and breeding season (June–July).*
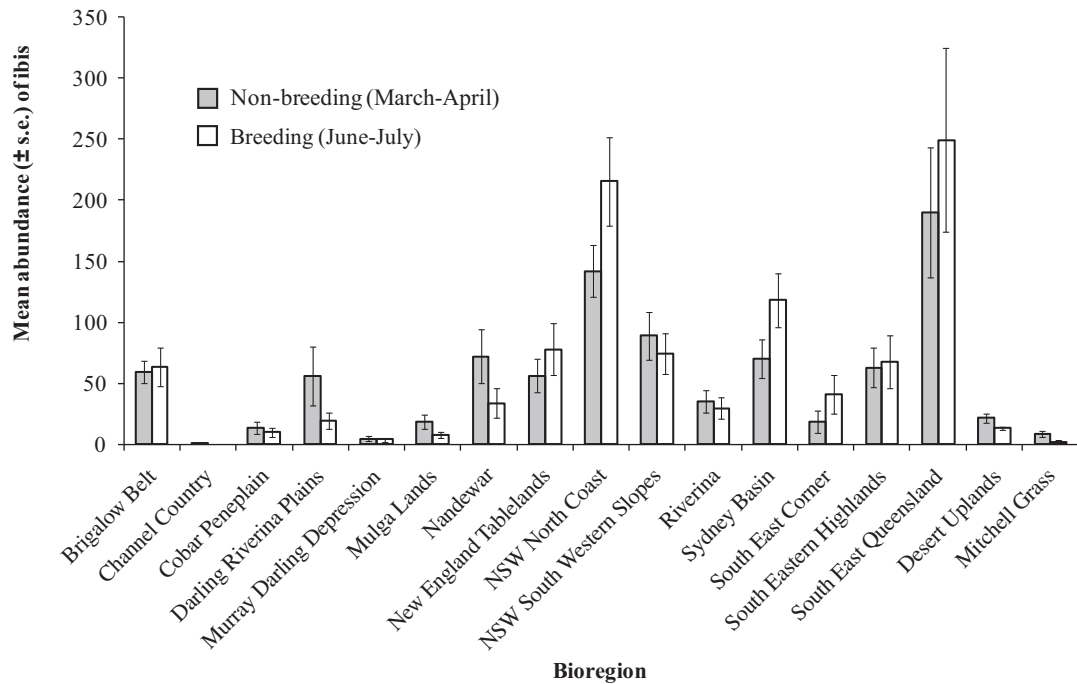
Figure 5. *Mean abundances (± s.e.) of ibises recorded in 17 out of the 20 bioregions of the survey area (NSW and southern Qld.) during the non-breeding (March–April) (grey bars) and breeding season (June–July) (white bars). No ibises were recorded for three bioregions (i.e. the Australian Alps, Broken Hill Complex and Simpson Strzelecki Dunefields).*
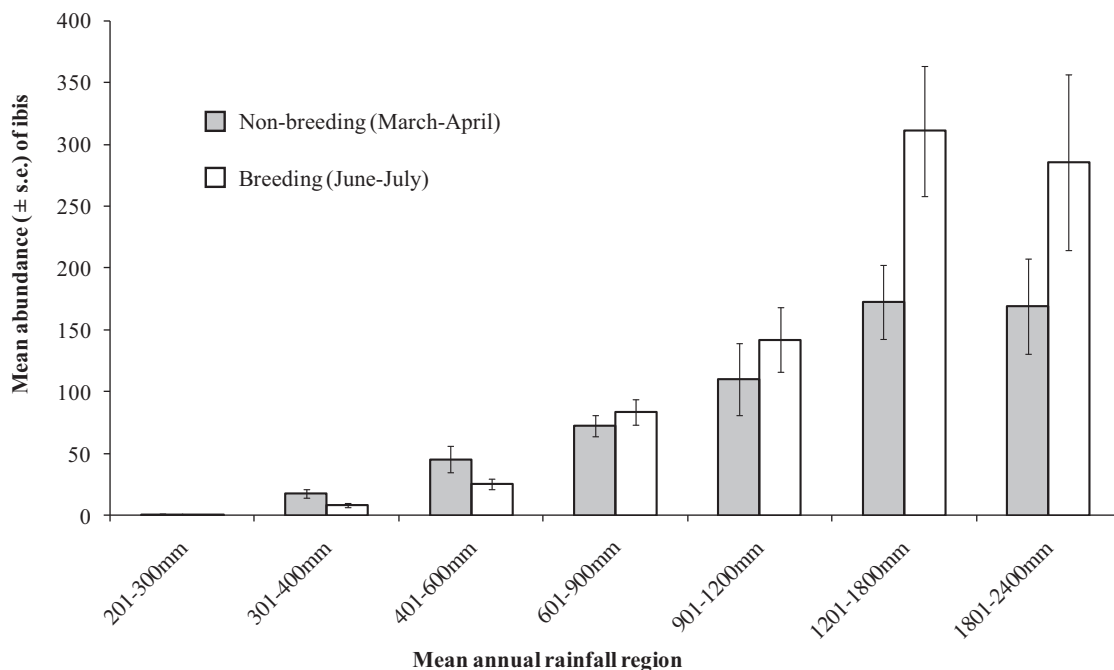
Figure 6. *Mean abundances (± s.e.) of ibises recorded in relation to mean annual rainfall (201–2400 mm) during the non-breeding (March–April) and breeding season (June–July).*

Abundances in areas of different mean annual rainfall

Ibis abundance differed between areas of very high and low rainfall ($P = 0.04$). Overall ibis abundance increased with the amount of rainfall and was significantly higher in areas with 1201–1800 and 1801–2400 mm of rainfall than those with lower rainfall (201–1200 mm) (Fig. 6). While ibis abundance did not differ in the 201–300 mm rainfall area between both counts ($P = 0.72$), abundance decreased significantly in the 301–400 ($P < 0.01$) and 401–600 mm rainfall area ($P = 0.03$). Significant increases in ibis abundances were recorded for the 1201–1800 ($P < 0.01$) and 1801–2400 mm ($P = 0.02$) mean annual rainfall areas from the non-breeding to the breeding season.

Abundances in significant wetland areas

While this study did not examine ibis abundances in specific wetland areas, ibis abundances in council areas with major wetland systems were reviewed as part of the data analysis. Decreases in ibis abundances from the first to the second count were recorded in nearly all council areas of major wetland systems, such as the Paroo wetlands and overflow, Lowbidgee and Bodigal wetlands, Narran Lake, Macquarie Marshes, Little Llangothllin Lagoon, Fiveborough Tuckbill and Albury wetlands systems. All of these wetlands were affected by drought during this study. The only increase in ibis abundance from the first to the second count in a major wetland area was in the council area containing the Gywdir wetlands system.

DISCUSSION

Distribution and overall abundances

This study examines the abundances and distribution of the Australian White Ibis during the non-breeding (March–April) and early breeding season (June–July) on a large-scale (NSW and southern Qld.). Overall, the results were able to show that ibises occur in significantly higher abundances in eastern Australian coastal regions than in central and inland areas, which confirms that ibises do not live predominantly in inland wetlands anymore and have invaded coastal areas (Corben and Munro 2008; Smith 2009). This has also been documented by Cowling and Lowe (1981), Loyn (1987) and Marchant and Higgins (1990). The reasons for this phenomenon and the birds' high abundances especially in coastal urban environments are not entirely clear, but have been attributed to the loss and degradation of wetlands ibises and other aquatic birds need for survival and successful reproduction (Corben and Munro 2008). Abundances of ibises in coastal urban environments are particularly high towards and during the breeding season, which has already led to the assumption that ibises enter coastal environments from inland areas for breeding (Corben and Munro 2008). While annual surveys of ibises have already identified steady declines of these birds in inland wetland systems in eastern Australia over the past decade (Porter *et al.* 2006), they do not show that ibises move coastward for breeding.

The data indicate that there are abundance changes of ibises between the coast and more inland areas with distinct increases at the coast and declines farther inland during the breeding season. While in any large-scale survey of highly mobile species (such as ibises) it needs to be considered that population changes can be caused by animals leaving or entering the study area – no net change of ibises was observed in this study. Total abundance of ibises during the non-breeding (March–April 2007) and breeding season (June–July 2007) did not differ, which suggests a stable total population of ibises in NSW and southern parts of Qld. during this time. In addition no large-scale latitudinal movements (along a north-south axis), which could affect the total population, was discerned. Therefore, an effect of net emigration of birds out of the study area can be largely

excluded, and the previously expressed views that (a) ibises enter coastal environments for breeding from inland areas (Corben and Munro 2008), and (b) urban ibises populations consist of mobile (only present during breeding) and sedentary sub-populations (always present) (Corben and Munro 2008; Smith and Munro 2010) is supported. This has important implications for management. Currently urban ibises are rigorously managed by culling adults and destroying nests, eggs and young with the overall aim to reduce abundance (Smith 2009). Based on the results this will not only affect ibises that remain permanently in urban environments, but also birds from inland areas, where populations have declined massively (Porter *et al.* 2006). This needs to be considered in further management of this native species, so that their overall survival is ensured.

While the results suggest that ibises are moving coastward for breeding, there exist some non-coastal areas with high ibis abundances during both the non-breeding and breeding seasons (Figs. 1 and 2) and some areas where an influx of birds occurred during the breeding season. They include the shire councils of Griffith (34°10'S, 146°1'E), Dubbo (32°7'S, 148°20'E) and Albury (36°1'S, 146°33'E). Here abundance increased from approximately 201–500 birds during the non-breeding season to 501–1000 birds during the breeding season. All of these council areas include medium sized towns (16 200 to 83 000 inhabitants) with appropriate breeding habitat and food sources for ibis (e.g. Griffith landfill, Tharabong; Lake Wyanagan near Griffith; Western Plains Zoo and Dubbo landfill, both in Dubbo; and Wonga Wetlands in Albury). It appears that these non-coastal areas still provide ibises with sufficient resources for their existence.

Bioregions

The highest abundances of ibises were recorded in the South-eastern Qld. (includes Brisbane), NSW North Coast and Sydney Basin bioregions (includes Sydney, Newcastle and Wollongong). All of these bioregions are located on the coast and contain major coastal cities, which may suggest that ibises prefer these types of habitats. The reasons for this preference are unknown, however, food (from landfills) and water resources in such habitats are likely to be major contributing factors (Smith 2009). Of these three bioregions, only two (i.e. NSW North Coast and Sydney Basin bioregions) showed a significant increase in ibis abundances from the non-breeding to the breeding season. In the South-eastern Qld. bioregion abundances were high at both counts, but did not differ significantly from each other. This suggests that sedentary or permanently present birds may reside in this area. Since these local birds probably occupy most available roosting and nesting spaces, it appears likely that fewer birds can immigrate into these areas for breeding. However, since variation in counts is high in the South-eastern Qld. bioregion, further surveys focusing on these areas are needed, before this can be stated with certainty.

Regions with different mean annual rainfall

High ibis abundances generally occurred in areas along the coast, which experience high mean annual rainfall (e.g. northern NSW, mean annual rainfall of 1200–1600 mm; and southern Qld., mean annual rainfall of 1200–2000 mm), and areas with a mean annual precipitation of above 1200 mm per year were favoured, while significantly fewer ibises occurred in areas with lower rainfall (201–1200 mm) (Fig. 5). Since ibises depend on high water levels for breeding and predominantly roost and nest close to water bodies (Kingsford and Johnson 1998), it is of little surprise that they chose high rainfall areas. The degradation of Australia's inland wetlands and lack of flooding events has most likely increased ibis populations in coastal area, where more reliable water sources can still support breeding. Ibis abundance decreased significantly in low rainfall areas (301–400 and 401–600 mm) from the non-breeding to the breeding season, while they increased significantly in coastal areas of higher rainfall (1201–1800 and 1801–2400 mm), which further supports the view that in the year of this study and other drought years, coastal breeding habitats are important for these birds.

CONCLUSIONS AND IMPLICATIONS

These findings suggest that abundances in the ibises' traditionally occupied inland wetland areas (Marchant and Higgins 1990) have decreased, and the already large populations of ibises along the eastern coast experience an influx of birds from central and inland areas during the breeding season (Corben and Munro 2008). This is probably directly linked to the destruction and degradation of inland wetland systems from inappropriate irrigation and other flow limiting practises that have been exacerbated by recent droughts (Kingsford and Johnson 1998; Smith 2009). The main breeding areas for ibises and possibly other waterbirds appear to have shifted towards the coast, in particular to areas with large cities, and may today constitute the major sites for reproduction. This needs to be considered, when developing management strategies for these birds. Australian White Ibises are native to Australia (Marchant and Higgins 1990) and management needs to consider the continuous survival of the species by ensuring that their overall breeding output does not decline to unsustainable levels. Several authors have already expressed concern about current management practices of urban ibises (Corben and Munro 2008; Smith 2009), which aim to rigorously reduce their abundance (Martin *et al.* 2007). The findings support this view and show that coastal and inland populations are interlinked. Thus, any reduction in abundance in large coastal cities will affect not only the local population but also the populations that enter coastal environments from areas where breeding is restricted or has ceased (Smith and Munro 2010).

Since this research is of limited temporal scale and does not present a fully closed system, more studies over multiple seasons are desirable, so that the movements of ibises become better understood and can be accounted for in future management plans. In these further abundance and distribution surveys it is particularly important to assess the effect of drought and non-drought conditions and habitat availability in traditional breeding areas on the coastward movements of ibis. During this study in 2007 the traditional breeding areas of ibises were affected by a heavy and widespread drought and provided no or very little breeding opportunities for these birds (Smith 2009). Therefore it may not have been surprising that the ibises had moved coastwards, where breeding was still possible. In order to determine whether coastal areas act as a refuge during droughts only or are now regularly visited by inland birds for breeding further long-term abundance and distribution surveys especially during non-droughts are needed. Data from such studies could then be used in conjunction with bird Atlas data and aerial surveys for developing and implementing management strategies for this species.

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Evaluation of four bird survey methods for species inventory in subtropical rainforest

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A species inventory aims to list all of the species present in an area over some period of time. Exhaustive sampling is rarely practical and estimator models can be applied to predict total species richness. Four bird survey methods have been evaluated for species inventory in a northern New South Wales subtropical rainforest. Total sampling time (360 minutes) was equal for all methods. True species richness was approximately 36. The standardised search recorded 32 species, transects 30, point counts 30 and the two-hectare search 26 species. Both standardised search and unlimited width transects delivered more accurate estimates of total species richness. This work extends a previous study (Totterman 2012) to a different habitat, with a different assemblage of birds and in a different season. It is confirmed that large area, active search methods are most suitable for bird species inventories.

INTRODUCTION

Species richness (the number of species) is a simple and practical measure of biodiversity (Gaston and Spicer 2004). This paper concerns the evaluation of species richness within sites or habitats (alpha diversity *sensu* Whittaker 1972).

Two major challenges for species inventories are to present meaningful and complete results. Species inventories should be defined in terms of the species, habitats, area, and time periods covered (Remsen 1994). 'Core species' are persistent, often abundant and are biologically associated with habitats in the site (Magurran and Henderson 2003). In diurnal forest surveys, open-country birds, waterbirds, aerial foragers, nocturnal birds and raptors are usually separated from the core list (Watson 2004, 2010).

Bird lists of unknown completeness and precision should not be compared between inventories and between sites (Walther and Martin 2001; Watson 2004). The effort required to record complete inventories has commonly been underestimated and estimator models can be applied to predict total species richness (Colwell and Coddington 1994). For bird species inventories, these undiscovered species (i.e. the difference between estimated and observed species richness) might then be identified from incidental observations (Watson 2004) and supplementary surveys: sound-recordings (Parker 1991), mist-net sampling (e.g. Gram and Faaborg 1997) and call playback. Estimators are not a substitute for poor field work, however. They do not correct for measurement error (e.g. observer error, ineffective methods) and non-representative sampling (Walther and Moore 2005).

Watson (2003b, 2004, 2010) has promoted a 'standardised search' bird survey method that combines active, timed searches with a results-based 'stopping rule' to indicate when a species inventory is satisfactorily complete (i.e. to standardise completeness). Previous Australian evaluations of the standardised search have been from grassy box woodland in southern New South Wales (NSW) (Watson 2004) and dry sclerophyll forest (DSF) in northern NSW (Totterman 2012). In both studies, the standardised search accumulated species more rapidly than other bird survey methods. Confirmatory studies in other forest types were recommended (Totterman 2012). This paper compares survey methods and species richness estimators in subtropical rainforest.

Herzog *et al.* (2002) and Watson (2010) have previously investigated bird survey methods and species richness estimation in rainforests of South America and Central America. Surveying birds in such highly diverse forests is challenging because of high species richness (hundreds of species), many low abundance species, unknown seasonality, varying lifestyles and behaviour of the species, mixed species flocks, low calling rates, secretive species, dense vegetation and difficult access, micro-habitats, localised resources and altitudinal ranges (Bibby *et al.* 2000). Australian rainforests have lower bird species richness (tens of species, e.g. Williams *et al.* 2010) and this study is from a relatively uncomplicated patch, small in area and at 1000 metres altitude. The discussion notes agreement with the earlier evaluation from DSF (Totterman 2012), recommends methods for bird species inventories and points out weaknesses in other methods evaluated.

METHODS

This paper follows previous authors (e.g. Colwell and Coddington 1994) and uses the general term 'sample' to refer to a sampling occasion (e.g. a fixed period of time, quadrat, transect or point) or to a subset of observations from a population (the statistical definition, e.g. Zar 1999).

Study Site

Surveys were performed during summer 2011–2012 at Acacia Plateau in Koreelah National Park (NP), NSW (28°19'S,
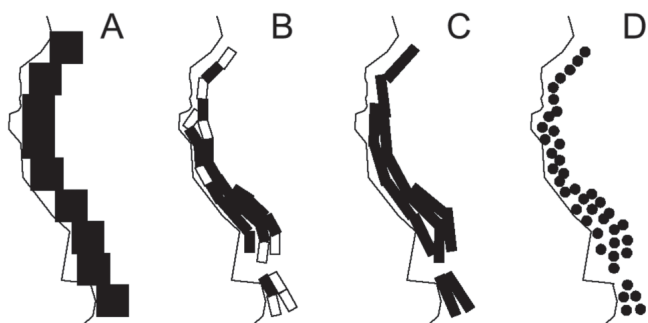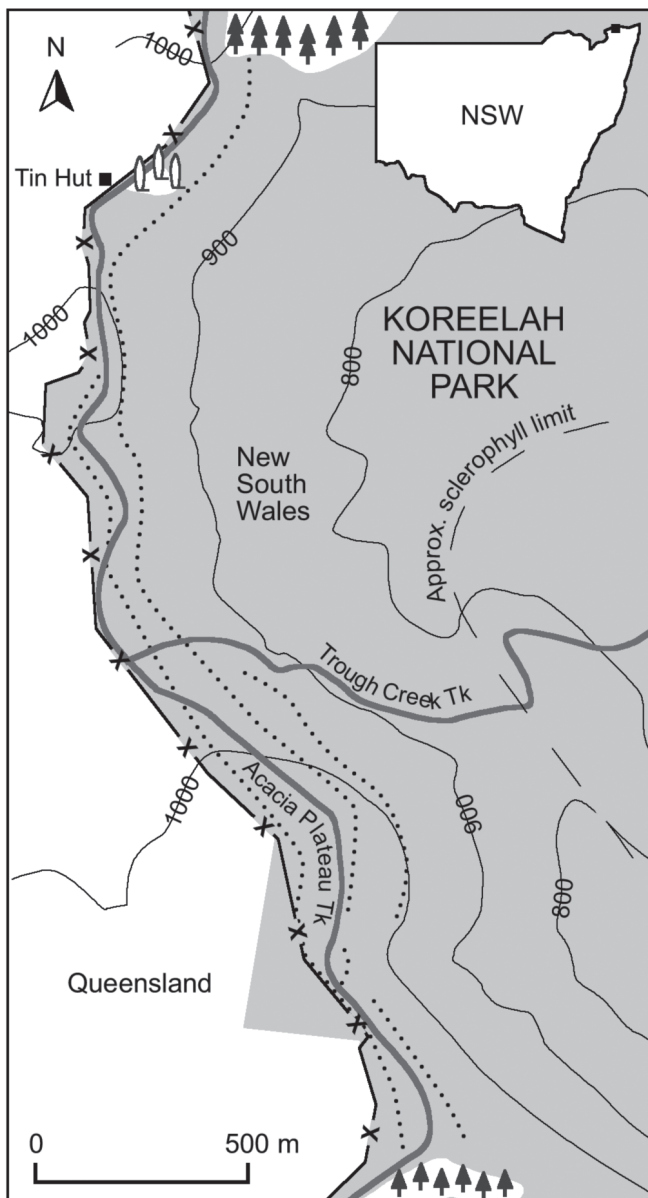
Figure 1. *Study area in Acacia Plateau, Koreelah NP (redrawn from SUNMAP 1982). Survey routes dotted. Natural vegetation light-grey. Cleared land white. Pine plantations indicated to the north and south and a eucalypt plot at Tin Hut. Lower figures (1/4 scale) illustrate sampling grids for standardised search (A), two-hectare search (B), transects (C) and point counts (D). Black grid cells were sampled. Most point count locations were sampled twice.*

152°25'E; Fig. 1), 12 kilometres east of Killarney, Queensland. A strip of cool subtropical rainforest follows the Queensland–NSW border at the top of the Great Dividing Range. The study patch is bounded by grazing land across the border, a Radiata Pine *Pinus radiata* plantation to the south and a Bunya Pine *Araucaria bidwillii* plantation to the north. Rainforest grades into sclerophyll forest types downslope. Surveys were conducted between the 900-metre and 1000-metre (asl) contours and the patch size was approximately 80 hectares. Springs can be found along the escarpment, flowing into Trough Creek. Timber harvesting from the Acacia Plateau rainforest ended decades before Koreelah NP was gazetted in 1999.

Acacia Plateau has a warm-temperate climate (Bureau of Meteorology 2012a). Mean annual rainfall is 1333 millimetres (Top Plains, Queensland; elevation 995m asl; 28°19'S, 152°25' E), wet in late summer and dry in winter-spring (Bureau of Meteorology 2012b). Minimum-maximum temperature averages are 2°C to 17°C in July and 16°C to 29°C in January (Killarney, Queensland; elevation 507 m asl; 28°20'S, 152°18'E) (Bureau of Meteorology 2012c).

The study patch vegetation was mostly Yellow Carabeen *Sloanea woolsii* subtropical rainforest. Associated species include Rosewood *Dysoxylum fraseranum*, Crabapple *Schizomeria ovata*, Giant Stinging Tree *Dendrocnide excelsa*, Black Booyong *Heritiera actinophylla*, Socketwood *Daphnandra* sp. and Sour Cherry *Syzygium corynanthum*. The understorey was more open on the slopes and Walking Stick Palm *Linospadix monostachya* was common. Ground ferns were more abundant on the plateau. Viney scrub rainforest occurred on rocky slopes and heavily disturbed areas. Common viney scrub species are Brush Bloodwood *Baloghia inophylla*, Whalebone Tree *Streblus brunonianus*, Scrub Wilga *Geijera latifolia* and Native Holly *Coelobogyne ilicifolia*. There was a small stand of unidentified tall eucalypts opposite 'Tin Hut', apparently planted for forestry (Fig. 1). Bird surveys bypassed impenetrable vine thickets and the eucalypt stand.

Koreelah NP was selected for this study because the Acacia Plateau rainforest boundaries are clearly defined and the patch size was appropriate for a short study. Bird species richness peaks in summer for higher altitude forests in north-eastern NSW and within-summer movements are minimal (Gosper 1992). The summer assemblage of birds at Acacia Plateau was expected to be reasonably stable. Observer experience and bird identification skills were developed during earlier visits to the site in 2009, twice in 2011 and from other experiences in northern NSW rainforests.

Survey methods

The same four survey methods from Totterman (2012) were compared. Standardised search sample units were 40 minutes in duration. Two-hectare searches followed the recommended procedure in the *New Atlas of Australian Birds* (Barrett *et al.* 2003): 20 minutes and 200 by 100 metres quadrats.

Distance boundaries for transects and point counts were designed following a trial transect in December 2012 and grouped in three bands: from zero to 15 metres, from 15 to 50 metres and beyond 50 metres (='unlimited distance').
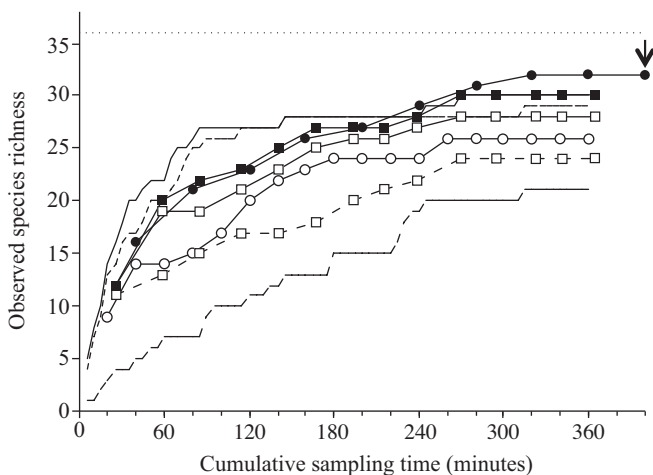
Figure 2. *Species accumulation curves (field data, not resampled) for standardised search (solid circles), two-hectare search (open circles), transect 0-15 m (open squares, long-dashed line), transect 0-50 m (open squares, solid line), unlimited distance transect (solid squares), point count 0-15 m (long-dashed line), point count 0-50 m (short-dashed line) and unlimited distance point count (solid line). True species richness was c. 36 (dotted line). The arrow indicates where the standardised search strict satisfied the strict stopping rule, with no additional species in three consecutive samples.*

Transects were 400 metres long. The narrow strip area was 1.2 hectares (400 × 30 m) and the wide strip was four hectares (400 × 100 m). Transect duration was nominally 25 minutes (speed 16 m per min.).

Waiting time for point counts was three minutes, followed by a five minute count. The small circular plot (radius 15 m) area was 0.07 hectares and the large circular plot (radius 50 m) was 0.79 hectares.

Transect and point count methods were not modified for species inventory except that birds flying overhead were recorded, which can usefully add to the species list. Species richness was estimated from presence/absence data and counts are not presented in this paper.

Sampling

The species inventory was conducted over 15 days: from 2 to 16 February 2012. Sampling was between 0545 and 1152 hours (Eastern Standard Time). Sampling was stopped earlier on hot days and no sampling occurred in rain or windy conditions. The survey ended when the standardised search recorded no additional species in three consecutive samples ('strict stopping rule', Watson 2004).

Three survey routes were flagged through the rainforest with two-hectare search, transect and point count waypoints marked at regular intervals (Fig. 1). Waypoints were located by Global Positioning System (Garmin GPS 76). Distance flags were placed 15 metres parallel on both sides of the survey routes. There was rarely a clear line of sight for 50 metres and this distance was estimated.

Samples were selected randomly and without replacement. Consecutive samples were separated spatially and/or temporally and with rotation between methods. If the sampling grid

became exhausted, a repeat cycle of random sampling without replacement was continued. A separate list was maintained for incidental records (i.e. additional species observed when not sampling).

Total sampling time was equal for all methods, with two 20-minute searches and eight five-minute point counts to every 40-minute standardised search sample. Transect duration varied slightly according to the walking conditions and abundance of birds. Total sampling time was monitored for transects.

Species richness and incidence rates

The same three non-parametric species richness estimators from Totterman (2012) were compared: Chao2 (Chao 1987) and first- and second- order jackknives (Burnham and Overton 1978). Richness and variance estimates were computed with the software EstimateS (Version 8.2, Colwell 2009). Log-transformed (asymmetric) 95 per cent confidence intervals (Chao 1987) are reported for species richness estimates.

Core species interpreted from results of the four survey methods and the incidental list were merged to estimate true species richness. Accuracy was quantified with Mean Absolute Error (MAE) (Walther and Moore 2005).

Incidence rates (frequency or reporting rates) provide a crude index of abundance and were used to compare species sensitivity between methods. Incidence is the number of samples (lists) in which a species was recorded divided by the total number of samples (Verner 1985).

RESULTS

Distance-sampling trial

A 2.5 hour trial transect through the study site on 29 December 2011 recorded 177 detections of 30 core species and two non-core species. Forty-eight per cent of birds counted were seen or heard within 10 metres, 77 per cent within 20 metres, 89 per cent within 40 metres and 97 per cent within 60 metres. Based on these results, distance-sampling cut-points were set at 15 and 50 metres (c. 60 and 90 per cent of total detections respectively).

Species inventory

The standardised search inventory was most complete in the final results, although point counts accumulated species more rapidly in early-time (Fig. 2). At 360 minutes all species accumulation curves indicated a plateau and one additional standardised search sample confirmed the strict stopping rule. This tenth sample was not used in the analyses.

True species richness was approximately 36; including three expected core species recorded only incidentally (Table 1). With 15 survey days and 24.7 combined sampling hours, this inventory should be reasonably complete. The Red-browed Finch *Neochmia temporalis* was considered a core species because it was regularly observed along the Acacia Plateau track and has previously been reported to frequent internal edge habitat in rainforests (e.g. Gosper 1992; Harden *et al.* 1986). Lorikeets were excluded from the inventory because they were only heard flying over twice. It was unclear whether the Pale-yellow Robin *Tregellasia capito* was a core species or a visitor from rainforest lower down the escarpment as it was only recorded once.

Table 1

Composite species list from Acacia Plateau, Koreelah NP, Summer 2011–2012. Most of the species listed were recorded on multiple occasions and are considered core species of this patch. True diurnal core species richness was c. 36, including three incidental (I) core species. Non-core species (NC) are two nocturnal birds, one diurnal raptor and five birds of adjacent habitats observed passing over the patch. Blank cells are zero incidence.

Species	Incidence rates							
	Stan. search	Two-hectare search	Transect 0-15 m	Transect 0-50 m	Transect 0-inf.	Point Count 0-15 m	Point Count 0-50 m	Point Count 0-inf.
Australian Brush-turkey *Alectura lathami* (I)								
White-headed Pigeon *Columba leucomela*	0.33	0.11	0.21	0.21	0.21	0.01	0.03	0.03
Brown Cuckoo-Dove *Macropygia amboinensis*	0.78	0.33	0.07	0.43	0.64		0.14	0.47
Wonga Pigeon *Leucosarcia picata*	0.22				0.07	0.01	0.01	0.03
Wompoo Fruit-Dove *Ptilinopus magnificus*	0.11		0.07	0.07	0.14		0.04	0.08
White-throated Nightjar *Eurostopodus mystacalis* (NC)						0.01	0.01	0.01
Pacific Baza *Aviceda subcristata* (I, NC)								
Yellow-tailed Black-Cockatoo *Calyptorhynchus funereus* (NC)							0.01	0.01
Sulphur-crested Cockatoo *Cacatua galerita* (I, NC)								
Lorikeet sp. (NC)		0.06						0.01
Crimson Rosella *Platycercus elegans*	0.44	0.22	0.07	0.07	0.29		0.04	0.17
Shining Bronze-Cuckoo *Chalcites lucidus*	0.11					0.01	0.03	0.06
Fan-tailed Cuckoo *Cacomantis flabelliformis* (I)								
Southern Boobook *Ninox novaeseelandiae* (NC)	0.11							
Laughing Kookaburra *Dacelo novaeguineae*	0.22	0.06		0.14	0.14			
Noisy Pitta *Pitta versicolor*	0.56	0.06	0.07	0.07	0.07		0.03	0.06
Albert's Lyrebird *Menura alberti*	0.56	0.11	0.21	0.21	0.36	0.01	0.10	0.19
White-throated Treecreeper *Cormobates leucophaea*	0.89	0.39	0.43	0.57	0.64	0.04	0.26	0.57
Green Catbird *Ailuroedus crassirostris*	0.44	0.17	0.07	0.29	0.29		0.07	0.07
Regent Bowerbird *Sericulus chrysocephalus* (I)								
Satin Bowerbird *Ptilonorhynchus violaceus*	0.44	0.06		0.21	0.36	0.01	0.11	0.19
Yellow-throated Scrubwren *Sericornis citreogularis*	1.00	0.89	0.86	0.93	0.93	0.33	0.42	0.42
White-browed Scrubwren *Sericornis frontalis*	0.89	0.72	0.79	0.79	0.79	0.21	0.33	0.33
Large-billed Scrubwren *Sericornis magnirostra*	1.00	0.72	0.86	0.93	0.93	0.15	0.33	0.33
Brown Gerygone *Gerygone mouki*	1.00	1.00	0.93	0.93	0.93	0.36	0.90	0.92
Brown Thornbill *Acanthiza pusilla*	0.67	0.72	0.57	0.71	0.71	0.13	0.26	0.26
Eastern Spinebill *Acanthorhynchus tenuirostris*	0.33	0.11		0.21	0.21		0.06	0.08
Lewin's Honeyeater *Meliphaga lewinii*	1.00	0.67	0.43	0.93	0.93	0.06	0.51	0.61
Noisy Friarbird *Philemon corniculatas* (NC)							0.01	0.01
Australian Logrunner *Orthonyx temminckii*	0.89	0.83	0.86	0.93	1.00	0.10	0.26	0.46
Eastern Whipbird *Psophodes olivaceus*	0.89	0.39	0.29	0.50	0.57	0.03	0.19	0.57
Golden Whistler *Pachycephala pectoralis*	0.67	0.39	0.36	0.71	0.71	0.01	0.24	0.35
Grey Shrike-thrush *Colluricincla harmonica*	0.67	0.17	0.07	0.29	0.36	0.03	0.14	0.19
Pied Currawong *Strepera graculina*	0.22				0.14			0.03
Rufous Fantail *Rhipidura rufifrons*	0.33	0.17	0.43	0.64	0.64	0.06	0.10	0.10
Grey Fantail *Rhipidura albiscapa*	0.56	0.22	0.07	0.07	0.07		0.06	0.06
Crow/Raven species Corvus sp. (NC)							0.01	0.01
Black-faced Monarch *Monarcha melanopsis*	0.78	0.56	0.14	0.57	0.71	0.03	0.22	0.49
Rose Robin *Petroica rosea*	0.11						0.01	0.01
Pale-yellow Robin *Tregellasia capito*			0.07	0.07	0.07			
Eastern Yellow Robin *Eopsaltria australis*	0.89	0.50	0.43	0.64	0.71	0.04	0.24	0.35
Silvereye *Zosterops lateralis*	0.56	0.28		0.29	0.29	0.01	0.17	0.22
Bassian Thrush *Zoothera lunulata*	0.22	0.22	0.07	0.07	0.07	0.03	0.03	0.04
Red-browed Finch *Neochmia temporalis*	0.11							
Number of species recorded by survey method	33	27	24	28	30	22	33	35
Core species richness by survey method	32	26	24	28	30	21	29	30

Table 2

Final species richness results and estimates at 360 minutes total sampling time for each survey method. True core species richness was c. 36. Estimated species richness ± s.d. with 95 per cent confidence intervals in brackets. Symmetric confidence interval reported for unlimited distance point count Jackknife2 result where estimated richness was less than observed.

	Observed species richness					Estimated species richness			All estimators Mean Abs. Error
	Observed richness	Completeness	Uniques	Duplicates					
	Sobs	Sobs/36	Q1	Q2	Q1/Q2	Q1/Sobs	Chao2	Jackknife1	Jackknife2	MAE
Stan. Search	32	0.89	4	4	1.0	0.13	34 ± 3 [32 - 46]	36 ± 1 [34 - 40]	36 ± 4 [33 - 50]	0.8
Two-hectare search	26	0.72	3	3	1.0	0.12	28 ± 2 [26 - 39]	29 ± 2 [27 - 34]	29 ± 3 [26 - 44]	7.6
Transect 0-15 m	24	0.67	9	1	9.0	0.38	65 ± 49 [30 - 285]	32 ± 3 [29 - 39]	39 ± 5 [32 - 52]	11.8
Transect 0-50 m	28	0.78	6	1	6.0	0.21	46 ± 24 [31 - 156]	34 ± 2 [31 - 38]	38 ± 4 [33 - 48]	4.8
Transect 0-inf.	30	0.83	5	3	1.7	0.17	34 ± 5 [31 - 56]	35 ± 2 [32 - 41]	37 ± 4 [32 - 51]	1.2
Point 0-15 m	21	0.58	7	4	1.8	0.33	27 ± 6 [22 - 52]	28 ± 3 [24 - 35]	31 ± 5 [25 - 45]	7.4
Point 0-50 m	29	0.81	2	4	0.5	0.07	30 ± 1 [29 - 35]	31 ± 1 [30 - 36]	29 ± 3 [29 - 46]	6.2
Point 0-inf.	30	0.83	1	3	0.3	0.03	30 ± 1 [30 - 34]	31 ± 1 [30 - 35]	29 ± 3 [23 - 35]	5.9
All search methods MAE							9.0	4.1	4.0	

Table 3

Early-time species richness results and estimates at 160 minutes total sampling time for each survey method (resampled results from EstimateS software). True species richness was c. 36. Estimated species richness ± s.d. with 95 per cent confidence intervals in brackets.

	Observed species richness					Estimated species richness			All estimators Mean Abs. Error
	Observed richness	Completeness	Uniques	Duplicates					
	Sobs	Sobs/36	Q1	Q2	Q1/Q2	Q1/Sobs	Chao2	Jackknife1	Jackknife2	MAE
Stan. Search	28	0.78	7	6	1.1	0.26	34 ± 5 [29 - 54]	34 ± 2 [32 - 37]	35 ± 5 [31 - 44]	1.8
Two-hectare search	23	0.63	6	4	1.3	0.25	28 ± 6 [24 - 55]	28 ± 2 [26 - 31]	29 ± 5 [26 - 38]	7.5
Transect 0-15 m	18	0.50	6	3	1.9	0.34	26 ± 8 [19 - 62]	23 ± 2 [21 - 26]	26 ± 5 [22 - 34]	11.1
Transect 0-50 m	23	0.65	6	4	1.6	0.26	29 ± 6 [24 - 53]	28 ± 2 [27 - 31]	30 ± 5 [27 - 38]	6.7
Transect 0-inf.	26	0.71	6	4	1.5	0.24	32 ± 8 [27 - 65]	31 ± 2 [29 - 34]	33 ± 5 [29 - 41]	4.1
Point 0-15 m	15	0.43	6	3	2.3	0.42	28 ± 14 [17 - 89]	22 ± 3 [19 - 26]	25 ± 6 [20 - 35]	11.2
Point 0-50 m	26	0.72	5	3	1.5	0.18	32 ± 7 [27 - 63]	30 ± 2 [29 - 34]	32 ± 5 [28 - 41]	4.6
Point 0-inf.	28	0.78	4	3	1.2	0.15	32 ± 5 [29 - 53]	32 ± 2 [30 - 35]	33 ± 4 [30 - 41]	3.8
All search methods MAE							5.9	7.5	5.6	

Standardised search incidence rates were relatively high for species with far-carrying calls, e.g. Wonga Pigeon *Leucosarcia picata* (Table 1). The standardised search was also more sensitive to some inconspicuous species, e.g. Rose Robin *Petroica rosea* which called much less frequently late in summer than in December. Point count incidence rates were low for patchily distributed species, e.g. White-headed Pigeon *Columba leucomela*, and for less vocal warblers, e.g. Yellow-throated Scrubwren *Sericornis citreogularis* which nearly always gave an alarm call when flushed but could otherwise be silent. Two-hectare searches missed four low-abundance core species with far-carrying calls: Wonga Pigeon, Wompoo Fruit-Dove *Ptilinopus magnificus*, Shining Bronze-Cuckoo *Chalcites lucidus* and Pied Currawong *Strepera graculina*.

The standardised search (MAE = 0.8) and unlimited width transect (MAE = 1.2) delivered the most accurate species richness estimates in the final results (Table 2). Unlimited distance point count estimates were negatively biased, with a low number of unique species. Two-hectare search final observed species richness and estimates were low. At half the total sampling time (160 minutes, rounded down to the nearest 40 minute increment), standardised search estimates were again most accurate (MAE = 1.8, Table 3). The standardised search was 78 per cent complete with just four samples although Chao (1987) recommended at least five samples before applying the Chao2 estimator.

A 'fraction uniques stopping rule' was recently suggested in Totterman (2012): stop sampling when the ratio of unique species to observed species richness is less than 0.25. Applied to the present results, this stopping rule was only moderately successful at predicting completeness ≥0.75: 6/8 in early time results (Table 3) and 6/8 in late-time results (Table 2). The 'lenient stopping rule' (Watson 2004), which uses the ratio of uniques to duplicates (ratio less than one) achieved similar success rates: 6/8 in in early time results (Table 3) and 5/8 in late-time results (Table 2). The strict stopping rule was reliable for the standardised search but cannot be applied to other methods with slower rates of species accumulation (Totterman 2012).

DISCUSSION

In previous studies from open forests, the standardised search has clearly outperformed other bird survey methods in species accumulation (Totterman 2012; Watson 2004). In the rainforest of Acacia Plateau, advantages of the standardised search were more subtle. Birds were more abundant in the rainforest compared to DSF (Totterman 2012) and species evenness was higher. Visibility and detection distances were shorter in rainforest and most detections were by calls. Therefore, rainforest species accumulation curves for standardised search, large-area transects and large-area point counts were not widely separated. Differences between methods were more apparent in the relative numbers of unique records and accuracy of estimates.

Large-area transects have produced satisfactory species inventories in DSF (Totterman 2012) and in rainforest. Unlimited width transects in rainforest added two additional core species to 100-metre wide transects and delivered more accurate species richness estimates. Unlimited width transects can be recommended for species inventory. An extra cost for transects is the additional time spent marking random transects lines.

In the rainforest of Acacia Plateau, the numerous short duration point counts were more widely distributed temporally and spatially than other methods and early-time species accumulation was rapid. It might have been tempting to halt point count sampling very early at c. 100 minutes and the inventory might then be completed with incidental records and supplementary methods. Early-time point count estimates were inaccurate however.

Point counts have been problematic in two comparative evaluations of bird survey methods for species inventory (herein; Totterman 2012). In DSF (Totterman 2012), persistent unique records increased variance in the estimates. In rainforest, a shortage of unique records negatively biased species richness estimates. Point counts were not effective at finding rare species in both studies and five-minute point counts cannot be recommended for species inventory. Longer duration point counts would increase the number of species per list as birds move into the search area and/or secretive species are revealed. Movements towards the point generate positive bias in population density estimates however and long duration point counts are also not recommended (Buckland 2006). An extra cost for point counts is the non-surveying time spent moving between stations, which is often large compared to counting time (Bibby *et al.* 2000).

The 20 minute, two-hectare search method of the continuing Atlas of Australian Birds (http://www.birdata.com.au/) has been unsatisfactory for patch scale species inventories in DSF (Totterman 2012) and rainforest. Species accumulation was slow because search areas are small and far detections are ignored. Resulting species richness estimates were inaccurate despite moderate sampling effort (sample sizes were 28 in DSF and 18 in rainforest). The two-hectare search can be improved by following Loyn's (1986) recommendations: 1) observations inside the search area, including counts, are used for relative abundance estimates; 2) observations outside the search area (presence/absence) but still inside the patch can be used for species inventory. An alternative to two-hectare searches, the 500 metre radius search option in the Atlas of Australian Birds is compatible with standardised search methods.

Rather than sampling, most of the species present in a patch might be found with a single, long-duration area search. The 2.5 hour trial transect at Acacia Plateau in December 2011 recorded 30 core species. However, without sampling there are no incident rate results and species richness estimates to interpret and validate the species inventory.

Results-based stopping rules are useful to optimise sampling effort per site (Peterson and Slade 1998; Watson 2003b, 2010). In evaluations from DSF (Totterman 2012) and rainforest, a robust general stopping rule has not been found. Stopping rules are best evaluated and adjusted for individual survey methods and different habitats and bird assemblages.

CONCLUSIONS

Efficient bird species inventories require patch scale sampling and active, large area search methods. In this and preceding studies (Totterman 2012; Watson 2004), the standardised search has been shown to be a simple, efficient and robust method for bird species inventories in Australian woodlands, sclerophyll forest and rainforest. Watson (2003a; 2010) has also demonstrated the utility of the standardised search method in pine-oak forests in Mexico and rainforest in Panama. Large-area transects can also produce accurate species inventories in sclerophyll forest (Totterman 2012) and rainforest.

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Diet of the Sooty Owl *Tyto tenebricosa* at Blaxland, New South Wales

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The diet of the Sooty Owl *Tyto tenebricosa* was studied at Blaxland in the lower Blue Mountains, New South Wales, by analysis of regurgitated pellet material. Small and medium-sized mammals were the most common prey, as also documented by previous studies. However, birds and reptiles contributed an unusually high proportion of the diet, especially the Pink-tongued Skink *Cyclodomorphus gerrardii,* which was the second most important prey species, by both number and biomass.

INTRODUCTION

The diet of the Sooty Owl *Tyto tenebricosa* has been the subject of a number of studies, including Smith (1984), Loyn *et al.* (1986), Lundie-Jenkins (1993), Holmes (1994), Higgins (1999), Kavanagh (2002) and Bilney *et al.* (2006, 2007, 2011). These studies indicate that the Sooty Owl preys mainly on mammals, taking a wide range of arboreal and terrestrial mammals at each study site. Birds, reptiles and insects are also taken, but have been only a minor component of the diet in previous studies. Bilney *et al.* (2006) compared the current diet of the Sooty Owl in eastern Victoria with the diet before and shortly after European settlement, by analysing cave deposits at long-term roosts. They found that Sooty Owls took a wider range of terrestrial mammals in the past, but have since increased their consumption of arboreal mammals to compensate for the decline of their terrestrial prey species, a number of which are now locally extinct.

We report here on the diet of the Sooty Owl at Blaxland in the lower Blue Mountains, west of Sydney, based on analysis of regurgitated pellet material at one roost site. The results of the analysis are noteworthy because they indicate a greater dietary importance of reptiles and birds at this site than has been recorded at other locations.

STUDY AREA AND METHODS

Regurgitated pellets and broken-down pellet material were collected from beneath an occupied Sooty Owl roost-site in a sandstone overhang cave in a pocket of *Backhousia myrtifolia-Ceratopetalum apetalum* closed-forest (rainforest) surrounded by *Eucalyptus piperita-Angophora costata* open-forest in Saint Helena Gully, a tributary of Glenbrook Creek, in Blue Mountains National Park on the western side of the township of Blaxland. The study area ($33^o 45'$ S, $150^o 36'$ E) is located about 65 kilometres west of the Sydney coastline, at an elevation of about 100 metres. Pellet material was collected on two visits in November 2002 and May 2003. A Sooty Owl was present on both occasions. Additional visits were made in March 2007 and November 2012, but the site was unoccupied and no further pellet material was found.

Prey items were identified from skulls and mandibles in the pellet material. For each collection date, all pellet material was combined and the minimum number of individuals was determined from a count of the number of left or right mandibles, depending on which were the more numerous. Mammal species were identified using Triggs (2004) and Watts and Aslin (1981), and by comparison with our reference collection of skulls and mandibles. Assistance with identification of reptile and bird material was obtained from Martyn Robinson and Walter Boles, respectively, of the Australian Museum.

Average weights for each mammal and bird species were determined from measurements made in previous mammal trapping and bird banding studies that we have carried out in the Blue Mountains, and from Menkhorst and Knight (2004). The Common Ringtail Possum weight was calculated from mandible length, using the formula provided by Bilney *et al.* (2011). Reptile and insect weights were estimated.

RESULTS AND DISCUSSION

A variety of animal species were represented in the Sooty Owl pellets from Blaxland, including four mammal, four bird, two reptile and one insect species (Table 1). By number, the diet consisted of 66 per cent mammals, 11 per cent birds, 21 per cent reptiles and 2 per cent insects. By biomass, the diet consisted of 67 per cent mammals, 2 per cent birds, 31 per cent reptiles and less than 1 per cent insects. The most frequent prey species, in decreasing order, were the Sugar Glider, Pink-tongued Skink, Common Ringtail Possum and Brown Antechinus (scientific names in Table 1). In terms of biomass, the main prey species, in decreasing order, were the Common Ringtail Possum, Pink-tongued Skink and Sugar Glider. The largest prey species, the Common Ringtail Possum, was represented mainly by sub-adults (five of six individuals).

The prey species are a mixture of arboreal and terrestrial species, but even the terrestrial species, the Brown Antechinus, Bush Rat and Pink-tongued Skink, spend part of their time in trees and shrubs (Cogger 2000; Menkhorst and Knight 2004; pers. obs.). Thus, it is unclear how many prey items were actually taken on the ground (if any) and how many were taken in trees and shrubs.

Table 1

Minimum number of prey items in two samples of Sooty Owl pellet material from Blaxland.

Prey species	Weight (g)	Nov 2002 sample	May 2003 sample	Total	% number	% biomass
Mammals						
Sugar Glider *Petaurus breviceps*	125	10	7	17	36	24.5
Common Ringtail Possum *Pseudocheirus peregrinus*	550	4	2	6	13	38.0
Brown Antechinus *Antechinus stuartii*	25	6		6	13	1.7
Bush Rat *Rattus fuscipes*	125		2	2	4	2.9
Total mammals		*20*	*11*	*31*	*66*	*67.1*
Birds						
Eastern Spinebill *Acanthorhynchus tenuirostris*	10	1		1	2	0.1
?Common Myna *Sturnus tristis*	110	1		1	2	1.3
Medium-sized honeyeater (Meliphagidae)	15	1		1	2	0.2
Small passerine (Passeriformes)	7	2		2	4	0.2
Total birds		*5*		*5*	*11*	*1.7*
Reptiles						
Pink-tongued Skink *Cyclodomorphus gerrardii*	300	3	6	9	19	31.1
Gecko (Geckonidae)	10		1	1	2	0.1
Total reptiles		*3*	*7*	*10*	*21*	*31.2*
Insects						
Cicada (Cicadidae)	1	1		1	2	0.01
Total insects		*1*		*1*	*2*	*0.01*
TOTAL		**29**	**18**	**47**	**100**	**100**

The dominance of small and medium-sized mammals in the diet at Blaxland, and the particular mammal species taken, are consistent with previous dietary studies. In particular, a comprehensive study by Kavanagh (2002) at a range of sites in south-eastern and central coastal New South Wales found that, although a wide variety of mammal species were taken, the same four species as at Blaxland - the Common Ringtail Possum, Sugar Glider, Bush Rat and Brown Antechinus (in a broad sense, including the Agile Antechinus *Antechinus agilis*) - were the most frequent prey species, and were taken at almost every site. The introduced Black Rat *Rattus rattus* was another important prey species near Sydney. Lundie-Jenkins (1993), in a study at Bowen Mountain, only about 20 kilometres north of Blaxland, found that the most frequent prey species there were the Black Rat, Sugar Glider, introduced House Mouse *Mus musculus* and Brown Antechinus. At Bowen Mountain, the two introduced species made up 68 per cent of the diet by number, whereas neither species was represented in the pellets from Blaxland.

The numbers of both birds and reptiles found in the Blaxland pellets were unusually high. Birds and reptiles have been reported previously as each comprising only 0–4 per cent of the diet by number (Smith 1984; Loyn *et al*. 1986; Lundie-Jenkins 1993; Holmes 1994; Higgins 1999; Kavanagh 2002; Bilney *et al*. 2006, 2007, 2011). At Blaxland, birds comprised 11 per cent of the diet by number, with four different species represented. In terms of biomass, however, their contribution to the diet was much less – only 1.7 per cent (Table 1).

Reptiles were an important component of the Sooty Owl diet at Blaxland, comprising 21 per cent of the diet by number and 31 per cent by biomass, with the Pink-tongued Skink being the main reptile prey species (Table 1). Like the Sooty Owl, it is a species associated with rainforest and tall, moist eucalypt forest (Smith and Smith 1990). The Pink-tongued Skink was second only to the Sugar Glider in terms of its overall contribution to the diet by number, and second only to the Common Ringtail Possum in terms of its contribution by biomass. This contrasts with the findings of Lundie-Jenkins (1993) only 20 kilometres away at Bowen Mountain, where no reptiles were found in the Sooty Owl pellets analysed. As discussed above, Lundie-Jenkins (1993) also found a different mix of mammal species in the diet. These differences suggest that the Sooty Owl is an adaptable species whose diet can vary markedly from site to site, even over a short distance, presumably reflecting differences in the prey species available at the local level.

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Erratum

Sexual size dimorphism and geographic variation in body size in a group-living, insectivorous passerine: Hall's Babbler *Pomatostomus halli*

Dean J. Portelli

Corella **38:** 1-9.

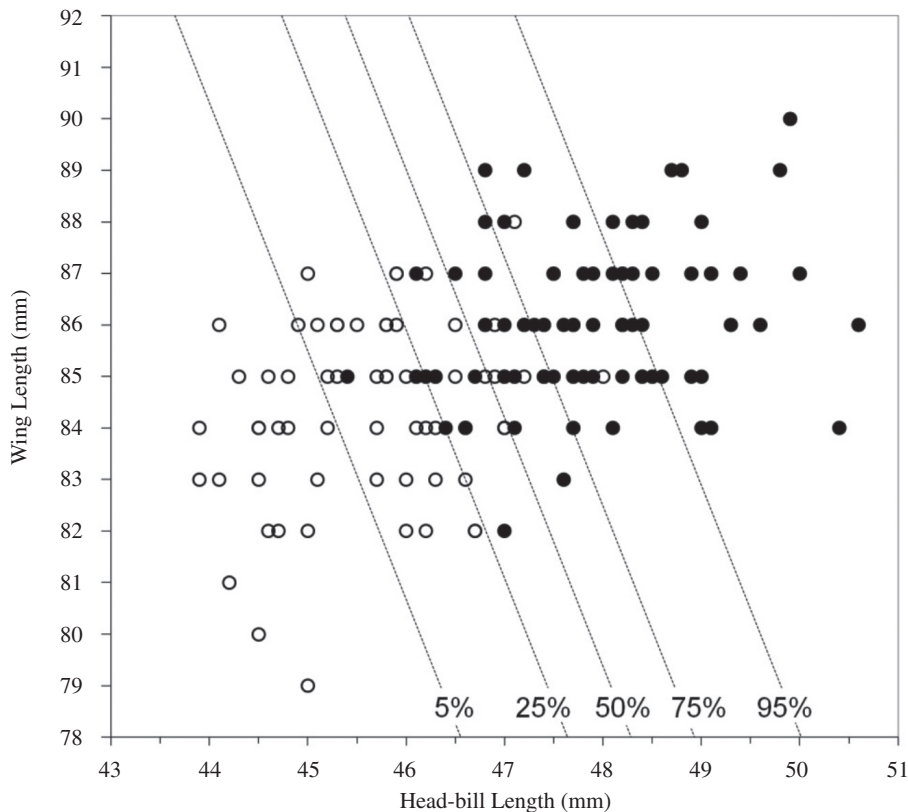Page 5, Figure 3 is incorrect and should be replaced with the Figure 3 hereunder.

Figure 3. *Sexual dimorphism in head-bill and wing lengths in Hall's Babbler. Males are shown as solid black circles, females as open circles. Probability contour lines represent the probability of an individual being male, expressed as a percentage.*

Nest sites and breeding estimates of the Black Noddy *Anous minutus* on Lady Elliot Island

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The Black Noddy *Anous minutus* breeds on vegetated islands off the coast of Queensland, Australia, including Lady Elliot Island, the southern-most island in the Great Barrier Reef. An estimate of breeding pairs on Lady Elliot Island shows an increase on earlier estimates and approaches 30 000 pairs. Nests were found in ten species of tree/shrub. The highest density of nests (nests per tree) was in *Pisonia grandis* (45.2), followed by *Ficus opposita* and then *Heliotropium foertherianum* with the lowest in *Cocos nucifera* (5.9). More nests occurred in protected trees and shrubs than exposed. There was no relationship between the heights of plants and the height of nests. Nests were closest together in *H. foertherianum* but distances between nests varied with the habit of the tree/shrub.

INTRODUCTION

Although the Black Noddy *Anous minutus* is distributed widely across wooded tropical or subtropical islands, most of its Australian breeding records have come from islands off the coast of Queensland (Higgins and Davies 1996) including Lady Elliot Island (24º07' S; 152º43' E), the southern-most island in the Great Barrier Reef. Lady Elliot and islands of the nearby Bunker Group are coral cays with distinct natural vegetation. Dominant species of the outer forest are *Heliotropium foertherianum* (previously *Argusia argentea*) and *Casuarina equisetifolia* while the inner forest is dominated by *Pisonia grandis* (Wood 1984).

Walker (1986, 1989) stated that prior to 1985 few Black Noddies visited Lady Elliot Island and that the first Black Noddy colony on Lady Elliot Island consisted of 30 nests (1985–86). This number increased to 427 (1986–7), 455 (January 1988) and 570 (January 1989); most nests were in *C. equisetifolia* trees that covered almost half of the island (Walker 1989). Estimates for Heron Island (less than 100 km to the north-west and within the Capricorn Group of islands) show similar, though much larger, increases: around 8 500 breeding pairs (1975) (Kikkawa 1976), 29 000 (1982–3), 37 000 (1983–4) (Hulsman's 1983 and 1984 estimates adjusted by Barnes and Hill (1989)), 40 000 (1985) to around 70 000 (1989) (Hill *et al.* 1997), with a dip to about 63 000 (1992) (Ogden 1993b) and peaking to over 70 000 (1996–97) but dropping in the two subsequent years (1998–99: around 23 000; 1999–2000: around 30 000) (Dyer *et al.* 2005). No recent estimates of the number of breeding birds have been made for Lady Elliot Island.

On Heron Island, in one 5-metre tall *Ficus opposita* tree with 12 nests, the mean distance to the closest nest was 0.5 metres but as close as 12.7 centimetres and as far as 14 metres (Braithwaite 1973). In 1985, nests on Heron Island were in *P. grandis* (75%) as well as *F. opposita*, *Celtis paniculata*, *Cordia* sp.*, H. foertherianum*, *Pandanus tectorius*, *C. equisetifolia* and

other plants (Barnes and Hill 1989). The number of nests in *P. grandis*, *F. opposita* and *C. paniculata* generally increased with the height of the tree (Hulsman *et al.* 1984). The average number of nests per tree was from 1.5 ± 0.5 in *C. equisetifolia* to 25.9 ± 1.8 in large *P. grandis* trees (Barnes and Hill 1989).

On Masthead Island (~20 km SW of Heron Island), taller trees contained more nests than smaller trees while the highest nesting densities were found in *F. opposita* and *C. paniculata* (Hulsman *et al.* 1984); most nests (49.4%) were in *P. grandis* forest 6–8 metres tall (Dale *et al.* 1984, Hulsman *et al.* 1984).

Lady Elliot Island was cleared of almost all its vegetation from 1863–1873 to allow guano mining and then kept bare by the lighthouse keepers' goats until 1969. An active tree planting program of a variety of species, following the removal of goats, began in 1969 (Heatwole 1984). Dominant tree/shrub species are *C. equisetifolia*, *H. foertherianum*, *C nucifera*, *P. tectorius*, *P. grandis*, *Hibiscus tiliaceus* and *F. opposita*; the occurrence of *P. grandis* is lower than on Heron and Masthead islands that did not suffer from the effects of guano mining (Wood 1984). Despite the inclusion of weed control in the plan of management (V. Mullins, pers. comm.), from observations made during repeated trips over the previous five years, there is no apparent control of weeds that include *Lantana camara* as well as numerous herbs (see also Batianoff 1998).

This study aimed to determine the following for the Black Noddy on Lady Elliot Island:

- an estimate of the number of breeding pairs

- nest densities (nests/plant species) in sheltered and exposed trees/shrubs

- relationships between tree heights, nest heights and nest densities

- internest distances

TABLE 1

Black Noddy nests in immature (I) and mature (M) trees/shrubs, south-eastern Lady Elliot Island.

Tree/shrub	Total nests [nests/tree] (% nests occupied)	Number of nests per		Nest heights in	
		exposed tree	protected tree	exposed trees (m) mean ± SD	protected trees (m) mean ± SD
Casuarina equisetifolia (*n*=101)	891	95 nests; 73 trees = 1.3	796 nests; 28 trees = 28.4	Range: 1.5-16	Range: 1.1-16
All mature	[8.8]	27.4% trees had nests	89.3% trees had nests	Low = 9.2 ± 3.8 (*n*=15)	Low = 4.5 ± 3.7 (*n*=24)
	(95)			High = 9.7 ± 3.5 (*n*=22)	High = 8.5 ± 3.7 (*n*=25)
Cocos nucifera (*n*=94)	563	No exposed trees	563 nests; 94 trees = 5.9: (none <5m had nests)	No exposed trees	Range: 3-11
I=40.4%; 47.4% had nests	[5.9]		68.1% of trees had nests		Low = 5. 6 ± 2 (*n*=57)
M=59.6%; 85.7% had nests	(97)				High = 6.1 ± 2 (*n*=61)
Heliotropium foertherianum (*n*=54)	907	4 nests; 12 shrubs = 0.3	903 nests; 42 shrubs = 21.5	Range: 1.5-1.7	Range: 0.5-3.7
All mature	[16.8]	33% shrubs had nests	73.8% of shrubs had nests	High = 1.6 ± 0.1 (*n*=4)	Low = 1 ± 0.5 (*n*=31)
	(89)				High = 2.4 ± 0.8 *n*=31)
Pandanus tectorius (*n*=44)	319	123 nests; 24 trees = 5.1	196 nests; 9 trees = 21.8	Range: 1.5-7.5	Range: 1-5.5
I=25%; none had nests	[7.3]	87.5% trees had nests	100% trees had nests	Low = 3 ± 1.1 (*n*=21)	Low = 1.8 ± 0.6 (*n*=9)
M=75%; 97% had nests	(95)			High = 4.3 ± 1.4 (*n*=21)	High = 4.8 ± 0.7 (*n*=9)
Pisonia grandis (*n*=15)	678	No exposed trees	678 nests; 15 trees = 45.2	No exposed trees	Range: 0.5-13
All mature	[45.2]		93.3% trees had nests		Low = 3.7 ± 2.9 (*n*=13)
	(95)				High = 9.6 ± 2.9 (*n*=14)
Ficus opposita (*n*=7)	94	No exposed trees	94 nests; 7 trees = 19.4	No exposed trees	Range: 1-6
All mature	[19.4]		100% had nests		Low = 1.9 ± 0.7 (*n*=7)
	(100)				High = 2.9 ± 1.4 (*n*=7)

METHOD

During 10–15 January, 2012, all Black Noddy nests in all individuals of each species of tree in the south-eastern quadrant of Lady Elliot Island were counted and scored whether occupied or unoccupied. The south-eastern quadrant was chosen because it contained the greatest diversity of plants (including *C. nucifera*) and because most of the north-eastern and much of the north-western quadrants comprised low bushes/herbs not utilised at all by the Black Noddy. Dyer *et al.* (2005) suggest that estimating density per unit area is unacceptable in patchy distributions as occurs on Lady Elliot Island. As well, it is possible that the higher occurrence of people in the south-eastern quadrant may have had a deleterious effect on the breeding behaviour of the Black Noddy (see also Dyer *et al.* 2005) and it was considered better to under-project rather than over-project the number of nests for the whole island. If an unoccupied nest had a clear form and deposits of guano or a juvenile bird nearby, it was considered to be that of a breeding pair from the current season (and hence included in the projected estimate of number of breeding pairs) (also see Ogden 1979). For each tree, estimates of tree height, lowest and highest nests were made by projecting upwards from a ground-2 metres reference height. Trees were scored as being exposed (on the edge of the island) or protected (on the inner parts of the island or protected by other vegetation), mature (with fruits) or immature (without fruits). Up to ten estimates of internest distance were recorded in each species of tree/shrub. During the study period, any intra-specific interactions between adult birds on adjacent nests were noted. Where there was only one nest in a tree/shrub, it was treated as the 'highest nest'. Where nests occurred only on the leeward side of exposed trees/shrubs, these nests were classed as 'sheltered'. To compare with other studies, dead chicks were counted to determine whether the sticky fruits of *P. grandis* contributed to any deaths.

TABLE 2

Projected totals of Black Noddy nests in tree/shrub species selected and actual inter-nest distances measured in sample quadrant, Lady Elliot Island.

Tree/shrub	Total nests	Mean distance ± SD (m)	[n]	(Range) (m)
Casuarina equisetifolia	18 787	0.58 ± 0.42	[155]	(0.2-5.0)
Heliotropium foertherianum	7807	0.46 ± 0.2	[213]	(0.1-1.5)
Pisonia grandis	2147	0.71 ± 0.4	[133]	(0.3-2.2)
Pandanus tectorius	320	0.75 ± 0.43	[102]	(0.2-2.0)
Ficus opposita	94	0.52 ± 2.43	[41]	(0.2-1.3)
Terminalia arenicola	26			
Hibiscus tiliaceus	24			
Araucaria cunninghamii	8			
Lantana camara	3			
S. actinophylla	1			
TOTAL	**29 217**			

From an aerial photograph (taken November, 2011), it was possible to identify the different tree species used for nesting on the island and ground truthing confirmed this. The outlines of each of *C. equisetifolia, H. foertherianum* and *P. grandis* were cut out for the southeastern quadrant and the rest of the island. The weights of these were measured using an Adam Equipment™ analytical balance (accurate to 0.0001g). Projections of the season's nests in each of these species for the whole island were made by algebraic calculations from the known totals in the south-eastern quadrant. Absolute nest counts were obtained for *C. nucifera* (that only occurred in the south-eastern quadrant) as well as *F. opposita, L. camara, Schleffera actinophylla, H. tiliaceus, Araucaria cunninghamii, Terminalia arenicola* and *P. tectorius* because all individuals of these species could be searched for nests.

Where appropriate, statistical tests were carried out using *Excel* in Microsoft Office 2007. Only significant differences (P<0.05) are reported unless comparing with other studies. Observations following a major storm event affecting the island a month prior to the study were obtained from Ryan Jeffery (pers.comm.).

RESULTS

The stages of breeding of Black Noddies ranged from nest-building to fledged young that remained within the nest tree, frequently close to an unoccupied nest. Only one dead chick was found, hanging from a *P. grandis* twig but not in contact with any fruits. In the month prior to this study high winds knocked many chicks from nests (7–8 December, 2011, cyclonic winds to 48 knots; 24–25 December, 2011, winds to 25 knots, sea 3–4 m swell). Staff on the island replaced fallen chicks onto remaining nests and observed adults feeding more than one young (Ryan Jeffery pers.comm.). It is not known whether any nesting activity during the study period was due to re-nesting following failure resulting from the December storms.

On plants with nests, few had only one nest per tree/shrub: *C. equisetifolia* (*n*=8); *Cocos* sp. (*n*=3); *H. foertherianum* (*n*=3); *P. grandis* (*n*=1). Trees were mature with the exception of *C. nucifera*, in which about half of the immatures had nests, and *P. tectorius* with none of the immature trees (about a quarter) having nests (Table 1). The highest number of nests per tree/shrub was in *P. grandis* (45.2), followed by *F. opposita* and then *H. foertherianum* with the lowest in *C. nucifera* (5.9) (Table 1).

Almost all nests had an adult sitting (89–100%) (Table 1), the remainder had a juvenile bird nearby. Only *C. equisetifolia, H. foertherianum* and *P. tectorius* occurred in exposed and protected locations: more nests occurred in protected trees/shrubs than exposed (Table 1). There was no relationship between the heights of plants and the height of nests. In *C. equisetifolia,* higher trees contained more nests (Pearson's *r*=0.31, p=0.01).

Nests were closest together in *H. foertherianum.* Distances between nests varied with the habit of the tree/shrub with large standard deviations about the mean for all trees/shrubs (Table 2). During the study period (daylight hours), there was no intra-specific interaction between adult birds on adjacent nests at any of the sites.

Nests were found in ten species of tree/shrub but, from the projection calculations, most were in *C. equisetifolia,* then *H. foertherianum* and *P. grandis* (Table 2). A total of 29, 217 nests was projected, indicating the same number of breeding pairs of Black Noddies.

DISCUSSION

Black Noddies breed from October to March with most chicks present from December to February on Heron Island (Kikkawa 1970). Given the relatively close proximity of Heron Island, it is likely that the breeding period is similar on Lady Elliot Island so that the estimate of the number of breeding pairs found during this study represents a satisfactory estimate of the total. It is possible that the projection is an over-estimate compared with Heron Island because of the effect of the storms reported for December 2011 but fragmented nests were not included in this study.

The findings from this study confirm those of Walker (1989) who found that Black Noddy nests were mostly in *C. equisetifolia* followed by *H. foertherianum* though his estimate of the cover of *C. equisetifolia* (about half the cay) was found to be lower (36%). The higher cover of *C. equisetifolia* estimated in this study may be due to rehabilitation and natural regrowth in the intervening period. Walker did not describe his method for determining the number of nesting birds. His comment 'thousands roost in trees at night during summer' suggest a large pool of potentially breeding birds at that time and may partially account for the increase in nests he reported following the first count in 1985–6. This study's findings contrast with those on

Heron Island where *C. equisetifolia* and *P. grandis* were under-utilised as nest sites despite them being the dominant tree species; *F. opposita* was also little utilised on Heron Island (Barnes and Hill 1989). The differences may be attributable to the vegetation history of Lady Elliot Island where *C. equisetifolia* was planted extensively during the re-vegetation that commenced in 1969. On Heron Island, 75 per cent of nests were in *P. grandis*. Given the nesting densities in *P. grandis* and *F. opposita* on Lady Elliot Island, it is possible that if weeds were controlled to give these species a better chance to regenerate, numbers of breeding birds could continue to increase, particularly in *P. grandis*. Although agonistic intraspecific interactions can occur between adults during the establishment of nest sites (Higgins and Davies 1996 and references there-in), the variation in internest distances and lack of intraspecific interaction between adults at nest sites suggests that distances between nests, once sites are established, are a function of the habit of the tree/shrub rather than behavioural mechanisms.

It is possible that breeding adults were lost during the cyclone though Ogden (1993a) suggests that this appeared to average one per cent per annum. If this is the case, the estimate of breeding pairs in this study is probably an under-estimate and the number of breeding pairs could be approaching 30 000. In the far northern region of the Great Barrier Reef, Black Noddies were found to nest during ten months of the year with peaks in April, July and November but population counts fluctuated (Blaber *et al.* 1998). This may be a tropical phenomenon and contrasts with the southern region of the Great Barrier Reef where numbers of breeding pairs increased on Heron Island over a 75-year period, apart from the 1992 dip (Ogden 1993b), until 2000 (Dyer *et al.* 2005) and on Lady Elliot Island over a 25-year period. Barnes and Hill (1989) demonstrated an approximately exponential increase in the Black Noddy nesting population over 75 years on Heron Island despite major differences in survey techniques; Dyer *et al.* (2005) suggest that the decrease during 1997–98 and 1998–99 may be cyclical. Barnes and Hill (1989) found that the density of Black Noddy nests was similar in the developed and un-developed areas of Heron Island. The developed area is small on Lady Elliot compared with Heron Island but ground truthing suggested that the densities were similar elsewhere on Lady Elliot to the area sampled supporting the method used in this study. A weakness of this study is the short period over which it was conducted and it is recommended that future estimates of breeding populations are carried out for longer periods or there is an increased number of visits (see Walker 1989). For more meaningful comparisons to be made between breeding populations in the same geographic location, for example, the southern Great Barrier Reef, methods for estimating populations should be standardised.

It is recommended that there is active weed control in the inner parts of the Island and that more *P. grandis* forest is developed to reflect the natural vegetation patterns of coral cays in the region. Despite the number of native coral cay species staying roughly constant for 100 years, Batianoff (1998) found that they decreased by about 17 per cent from 1988 to 1997 on Lady Elliot Island and that about 40 per cent of the island was covered by the woody species *L. camara* and *Bryophyllum tubiflorum*. Reversing this trend and replacing weeds with flora that provide secure breeding sites will enhance the opportunities for the number of breeding pairs on the Island to increase in the future.

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Raptor Studies

ABSA/BirdLife Southern NSW Conference
Canberra National Botanic Gardens

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ABSTRACTS

Compiled by: Stephen Debus

BirdLife Australia's Powerful Owl Project

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The Powerful Owl Project has now been running with BirdLife Australia for three years. In this time it has gathered a significant following and is proving to be an exciting and well-received citizen science project by the community and land managers. The project has reached a huge audience, in the order of 1650 community members through direct face-to-face contact, 50 land managers and an audience of over 1 000 000 through radio and media articles. A breakdown of volunteers has been interesting: approximately 30 percent are active in other volunteer or conservation groups; over 70 percent consider themselves birdwatchers; almost all had a reasonable understanding of threats to birds; approximately 50 percent had specific knowledge of the Powerful Owl, increasing to 80 percent following involvement in the project; and there was some discrepancy between the perceived threats to owls held by volunteers and actual threats to owls.

Some preliminary landscape analysis work has begun. Owl density is much higher in the urban area than previously reported in non-urban areas. A range of environmental variables has been investigated on nesting locations, showing that the owls preferring those gullies with the wider mesic areas, a higher percentage of larger trees (a surrogate for hollows) and areas with higher prey densities. There was no correlation between distance from the nest to disturbance (anything urban such as houses or roads) and fledging success, although it is acknowledged that this is only a crude measure of disturbance at this stage. The project is just entering a data-analysis phase, and more outcomes will come to light in the near future. The most significant outcomes so far with the project are (1) the identification nest tree locations; and (2) the reach of the project in promoting urban conservation throughout Australia's biggest city.

Rabbits, kangaroos and Wedge-tailed Eagles

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There is wide debate about the importance of rabbits in the diet of Wedge-tailed Eagles. Some researchers believe that rabbits have become almost essential prey, given the loss of 'critical weight range' small mammals (0.5–5 kg) due to fox and cat depredation. Rabbits, weighing 1–2 kilograms, are seen as their ecological replacement. However, this concept needs to be questioned because, if wrong, it will lead to poor conservation policies. Rabbits cause widespread ecological harm, especially to plant communities, and any thought of leaving rabbits uncontrolled or promoting them as essential for Wedge-tailed Eagles would come at the cost of long-term environmental degradation. New information on the Australia-wide distribution of rabbits as well as their interactions with other wildlife species shows that excessive rabbit numbers significantly reduce the abundance of kangaroos, for instance; and these are also an important prey species for eagles. Data from north-eastern South Australia and Western New South Wales will be presented to illustrate this point. On that basis we need to be careful of simplistic, popular ideas and develop a more robust, carefully argued framework as a basis for future decision-making. There has been no major evidence that the Wedge-tailed Eagle population was heavily compromised by rabbit haemorrhagic disease (RHD), which reduced rabbits by 60 percent nation-wide. Furthermore, the Invasive Animals CRC is directing a new program called RHD-Boost to maintain the effectiveness of this bio-control agent. The question is: are we just going to chew over the same old ideas again, and worry whether eagles will have enough to eat, or is it time to move on and to present a more carefully thought-out framework to help in future decision-making on rabbit control programs?

Results from raptor banding

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The Australian Bird and Bat Banding Scheme (ABBBS) coordinates all bird-banding research projects in Australia, and curates all historical movement and longevity data collected as part of these studies. The talk will illustrate some of the remarkable movements and lifespans made by Australian raptor species, using historical band recovery data. Species will include lesser known but common species such as the Swamp Harrier *Circus approximans*, Brown *Goshawk Accipiatus fasciatus*, Nankeen Kestrel *Falco cenchroides*, Spotted Harrier *Circus assimilis*, Whistling Kite *Haliastur sphenurus* and Black-shouldered Kite *Elanus axillaris*.

Breeding behaviour of the Parramatta River White-bellied Sea-Eagles

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Over the years, several White-bellied Sea-Eagles *Haliaeetus leucogaster* have been found dead in the Parramatta River area. Until 2004, only one chick in 15 years had been successfully raised. Following the death of a pair of breeding eagles in 2004, necropsy and chemical analysis of tissues was undertaken in order to determine the cause of death. This report recommended further study.

The current eagles live and interact in close proximity to urban life. The location of the nest, within the restricted-access Nature Reserve, means that their breeding site itself is undisturbed. Breeding behaviour is studied using video CCTV cameras and by limited physical observation. Breeding diet is being studied by observations at the nest from the cameras, incidental observations along the river and in Homebush Bay, and by collecting prey remains in the nest area. Although this pair raised young to fledging in five consecutive years, in 2013 neither of the two incubated eggs hatched within the expected period. The eggs were retrieved and both were found to be infertile. Analysis at the National Measurement Institute showed elevated levels of Persistent Organic Pesticides (POPs) in the egg, similar to that detected in body fat in eagle bodies from the previous study. High levels of DDE, in particular, may have an impact on the success of eggs, as shown in studies of White-tailed Sea-Eagles *H. albicilla*, though further research is needed.

During the nest-renovation and incubation periods, the main prey brought to the nest is fish. Later, the hatchlings are fed mainly on fish and gulls. Studies in Homebush Bay of both fish and gulls have indicated elevated levels of POPs. Other threats include contaminated prey and discarded fishing line and tackle.

The raptors of Sydney Olympic Park

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Nesting White-bellied Sea-Eagles are special, but there are many more about in this urban area. EagleCAM is revealing a lot about the resident Sea-Eagles, but also some surprising visitors to the eagle nest, including a white-morph Grey Goshawk *Accipiter novaehollandiae*, a new record for SOPA, and a Southern Boobook *Ninox novaeseelandiae*, not common in the area.

Other resident breeding raptors nearby are the Brown Goshawk *Accipiter fasciatus*, Collared Sparrowhawk *A. cirrocephalus*, Nankeen Kestrel *Falco cenchroides* and Black-shouldered Kite *Elanus axillaris*, as well as Peregrine Falcon *Falco peregrinus*. Other species are occasionally recorded in regular surveys or by visitors to the area, e.g. Eastern Osprey *Pandion cristatus*, Pacific Baza *Aviceda subcristata*, Whistling Kite *Haliastur sphenurus*, Spotted Harrier *Circus assimilis*, Swamp Harrier *C. approximans*, Little Eagle *Hieraaetus morphnoides*, Australian Hobby *Falco longipennis*, Barn Owl *Tyto alba*, and a Black Falcon *Falcon subniger* (the last photographed by Ákos Lumnitzer). Black Kites *Milvus migrans* were observed for the first time, during fires in the Blue Mountain region. Diverse habitats at SOP proved shelter for breeding raptors as well as ample prey opportunities. A total of 16 diurnal raptor species has been recorded, and two nocturnal species.

Declining Little Eagles near Canberra, Australia: The link between rabbits and eagle breeding success is a myth, but is poisoning from Pindone a problem?

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The Little Eagle *Hieraaetus morphnoides*, a rabbit predator, is declining in parts of southeast Australia, including the Australian Capital Territory (ACT). Some researchers have blamed the Little Eagle decline on the Rabbit Haemorrhagic Disease Virus (RHDV), introduced to control numbers of European rabbits *Oryctolagus cuniculus*. However, no Australian raptor has shown changes in breeding densities or breeding performance with increasing or decreasing rabbit numbers. Furthermore, the claim that Wedge-tailed Eagle *Aquila audax* clutch size decreased after myxomatosis decimated rabbit numbers in 1951 is probably a myth. Clutch size remained constant in the 1950s when rabbit numbers fell to their lowest, then decreased in the 1960s–1990s after rabbit numbers increased. Moreover, European rabbits in the ACT have been increasing, not decreasing, apparently because a non-pathogenic lagovirus related to RHDV, termed Rabbit Calicivirus Australia 1 (RCV-A1), is protecting rabbits from RHDV in higher elevations and cooler areas of southeastern Australia. To counter the failure of RHDV to control rabbit numbers, the chemicals Pindone (2-pivalyl, 3-indandione) and 1080 (sodium fluoroacetate) are used to poison rabbits. The toxicity of 1080 to wildlife is well known and well tested, but Pindone was introduced with little or no testing. Pindone may disable raptors and/or be fatal to them. Little Eagles take proportionally more rabbits than do Wedge-tailed Eagles, so Little Eagles may be more affected by secondary poisoning.

Raptor migration patterns and trends in the Indo-Malayan Archipelago: a review of current knowledge

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Until recently, next to nothing was known about the movement of migratory raptors in South-East Asia. Interest in raptor migration biology in the last five years has improved knowledge of routes and migratory populations of raptors in transit through the

Indo-Malayan Archipelago, mainly due to citizen-science surveys at migration hotspots in southern Thailand, Peninsular Malaysia, Singapore, Mindanao (Philippines), Java, and multiple locations in Wallacea (Indonesia). Cumulatively, the most abundant species on passage in the region are the Oriental Honey-Buzzard *Pernis ptilorhyncus*, Black Baza *Aviceda leuphotes*, Chinese Sparrowhawk *Accipiter soloensis* and Japanese Sparrowhawk *Accipiter gularis*. Two major routes were documented, one via the Malay Peninsula and Greater Sunda Islands, and a smaller route through the islands of Wallacea. Recent surveys also suggest that some species overwinter farther east than thought, particularly the Chinese Sparrowhawk, for which wintering populations are now known from Timor and New Guinea. I review the efforts of these surveys, their key findings and scope for future research in the biology of migrant raptors.

Posters:

Sexual dichromatism and age-related colour change in the Pacific Baza: a photographic study

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This poster investigates, photographically, the *HANZAB* statements on differences between male and female Pacific Bazas A*viceda subcristata.* *HANZAB* stated that bands on female Bazas 'extend across the width of all feathers,' and that the black terminal tail band on mature female Bazas is slightly narrower, than the terminal tail bands of males. I photographed Bazas that are part of a close study of breeding and behaviour, at Stokers Siding, northern NSW. I also photographed Bazas encountered in the region that are not part of the Stokers Siding study, and photographed specimens from the Australian museum. With Faye Hill, I measured the tail bands of Bazas from the Queensland Museum and Australian Museum. I have also included photographs of Bazas of juvenile and immature birds to show some of their main features, and included some questions for future work.

A descriptive and photographic study of Pacific Baza *Aviceda subcristata* behaviour and breeding in northern NSW

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This poster presentation gives some information from a proposed paper for *Australian Field Ornithology* on the Pacific Baza, based on observations that began in 2007 in the study zone of Stokers Siding, northern NSW, and are ongoing. Intensive observations during the successful 2010/11 breeding season revealed behaviours and vocalisations that add to the current literature. We present descriptions and quantifications of the breeding, diet and social behaviour of one focal pair, along with chick development and behaviour from hatching up until two months post-fledging. Intraspecific behaviours of this pair with Bazas from unknown territories during the breeding season are outlined. Intraspecific social behaviours in the off-season are also included.

The 2010/11 season was notable for nest-building behaviour by the focal adult male on the remains of a Baza nest from the previous season, located approximately 40 m from the 2010/11 nest. This event occurred only one week post-fledging of the two 2010/11 chicks. Six weeks post-fledging a third chick joined the focal two, having evidently fledged synchronously from a breeding site that was not found. These three young Bazas foraged and roosted briefly together, and imitated nest-building behavior on the 2009 nest, before all Bazas left the study area for several days. A fascinating, but unsuccessful breeding attempt in 2011/12 by a pair, assumed to be the focal adult male with a new female, is also commented upon.

Breeding diet and behaviour of a pair of Grey Falcons *Falco hypoleucos* and their offspring in north-western New South Wales

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The diet of a pair of Grey Falcons *Falco hypoleucos* was investigated in Sturt National Park, arid north-western New South Wales, by analysis of pellets and orts collected beneath a nest (riparian Coolibah *Eucalyptus coolabah* beside a gibber plain) in October–December 2003. The Falcons fledged a brood of four young in an above-average rainfall year, from an estimated egg-laying date of early August. The Falcons' breeding diet (*n* = 62 prey items from 58 dietary samples) consisted, by number, mainly of birds (99%, 63% being parrots, and one mammal); parrots formed most of the biomass (90%) of identified avian prey. Geometric Mean Prey Weight was 29.6 grams, and dietary diversity (Shannon Index) was 1.98. Small–medium (<100 g) granivorous birds were selected as prey (*P* <0.01). The Falcon pair and offspring, with juveniles accompanying the hunting parents, associated until at least five months post-fledging.

Similar habitat but minimal dietary overlap: Comparisons between the Black-shouldered Kite and Nankeen Kestrel

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Both the Black-shouldered Kite *Elanus axillaris* and the Nankeen Kestrel *Falco cenchroides* are taxonomically distinct birds of prey (Accipitriformes and Falconiformes, respectively). They differ physically, with the kite's ability to rotate the outer toe at will to utilise a two toes facing forwards, two backwards arrangement, whereas the kestrel possesses the anisodactyl form of three toes forward, one hind toe behind (more common among raptors). Despite different morphologies, they share similar ecological traits. Both can be found hunting in similar habitats, are active during daylight, and both hunt terrestrial vertebrate and invertebrate prey. Despite this similarity, the kite is more crepuscular and has a strong preference for mammals; the kestrel is active during the day yet prefers invertebrates. What might have influenced the development of the different pedal morphologies as seen in these two raptors? Here we analyse dietary data to provide possible explanations.

Book Review
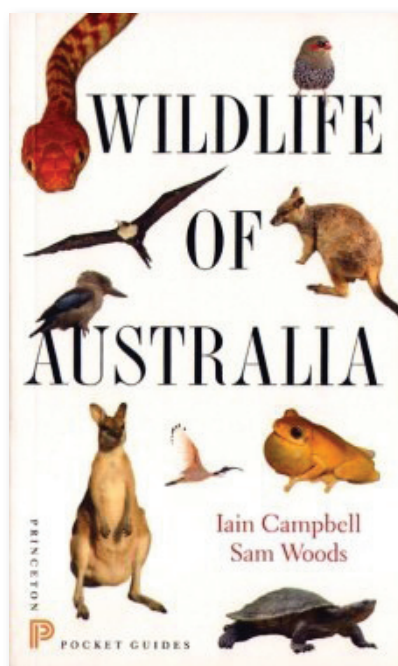
Wildlife of Australia (Princeton pocket guides).

Iain Campbell and Sam Woods. 2013. Princeton University Press. Paperback, 438 colour photographs, 286 pp. ISBN 9780691153537. RRP $19.95

Wildlife of Australia is a photographic pocket guide to the most widely seen birds (350 species), mammals (70), reptiles (30) and amphibians (16) of Australia. The aim of the guide is to assist people visiting popular tourist destinations, such as Kakadu National Park, the Great Barrier Reef and the Blue Mountains, to identify the animals that they are most likely to encounter.

The pocket guide begins with a map of Australia indicating the approximate distribution of vegetation "associations" (which are really vegetation formations) such as heathlands, rainforest, mallee and mulga. The very small scale map, necessarily, means that map units are very generalised and, somewhat annoyingly, one of the 11 "associations" (the light blue one) is missing in the map key. Presumably this map unit, which stretches from Broome, to around Darwin and Cairns, refers to tropical woodland. Such a lack of attention to detail detracts from the credibility of the book. Written description of 23 habitats, each with a colour photo, follow and provide a better idea of the diversity of fauna habitats to be found in Australia. The photos and the mention of typical fauna to be found in each habitat should inspire the tourist with an interest in natural history to go looking. The habitat descriptions are very brief and aimed at the interested lay person, but again should whet a tourist's appetite. The scientific names of only three plant species are provided, which is perhaps just as well as each is incorrectly spelled: *Banksia eriquofolia*, *Banksia serrate* and *Banksia intergefolia* for *B. ericifolia*, *B. serrata* and *B. integrifolia*. On the subject of names, I find that the substitution of "gray" for "grey", as

in Eastern "Gray" Kangaroo and "Gray" Butcherbird, grates, but it also re-inforces that the target audience for the book is tourists.

Each of the over 400 species is illustrated with a colour photograph. On the whole, photographs are clear and sufficient to allow identification but a few, such as the Estuarine Crocodile and Australian Raven, have been cropped rather carelessly, and others, such as the Eastern Brown Snake, Burton's Snake Lizard, White-winged Chough and Cockatiel, are unclear or provide inadequate glimpses of only parts of the animals.

Photographs are supplemented by brief written accounts for each species. Sizes are provided in both metric and imperial units (handy for those not accustomed to metric units). Each species account includes a description of the appearance of the animal, some with identification tips, bits and pieces about behaviour, information as to geographic regions in which the animal is likely to be found, and its preferred habitats. The written accounts tend to be chatty, with some interesting asides, and seem designed to keep the visiting amateur naturalists informed but not taxed. While a number of the species accounts suggest a lack of true familiarity with the species, they are probably sufficient for the lay tourist who wants a quick, interesting introduction to our fauna. A small map showing distribution might have been easier to understand than the written descriptions of distributions provided. Suggestions provided as to where to spot the fauna described appear useful and could easily be made more comprehensive.

The guide is a handy size for carting about in a day pack, fairly light and with seemingly robust binding. An index is provided but why it includes bold faced numbers which supposedly indicate plates when the plates are not numbered is beyond me.

I have recently "test run" the pocket guide with a visiting Swiss tourist with a keen lay interest in fauna and a good grasp of spoken English. She was impressed by the multitude of photos and, coming from a non-English speaking background, much preferred this guide to another with fewer photos but more written information. The accuracy of any information provided was not an issue for her. Her one wish was for a German language version. After my "test run" I would recommend this book for tourists with an interest in fauna, as it provides a good and easy introduction to the wonderful variety of our fauna. I would be less inclined to recommend this book for the more experienced visiting naturalist. One of the many very good standard field guides available would be a far better option for the serious naturalist.

While the book is obviously designed for tourists, (while reading it I at times felt as if I was aboard a coach tour), it may well also appeal and be useful to local beginner naturalists or children with an interest in fauna.

Judy Smith
Blaxland, NSW

Book Review
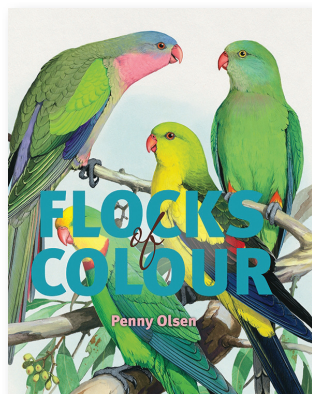
Flocks of Colour

Penny Olsen. 2013. National Library of Australia. Softback, vii+216 pp. ISBN: 9780642278067. RRP $39.95

Flocks of Colour is the latest collaboration between Penny Olsen and the National Library of Australia. The Library's collection contains many hidden treasures and these publications help reveal these to the public's eye. Non-bird topics have included botany, butterflies and the impressions of early Europeans on the strange Australian wildlife. An earlier publication, *A Brush with Birds: Australian Bird Art from the National Library of Australia* (2009) showcased a range of bird illustrations held by the Library. This new publication deals only with parrots, a very suitable subject given the popularity of these birds, their familiarity to almost all Australians and this country's status as Psittacorum Regio—Land of Parrots. *Flocks of Colour* contains over 150 full colour illustrations by 40 artists covering 56 species of Australian parrots, including some now extinct species, such as the iconic Paradise Parrot.

This is not a reference book on either the birds or the painters. There is, however, enough concisely presented information in Olsen's two introductory essays to whet the appetite to search further. The first provides a short history of the principal European artists who painted Australian parrots, starting with those of the first exploring ships, moving through the Europe-based ones working from skins and written accounts (and occasionally the work of artists before them) to the more recent Australian-based artists. An appendix gives a short biography of each of the painters represented in the book. (For a detailed treatment of the painters, readers will be rewarded by consulting Olsen's Whitley Award winning book *Feather and Brush: Three Centuries of Australian Bird Art*.) The second essay is a brief overview of Australian parrots, their diversity, physical characteristics and aspects of their biology. The foreword by world parrot expert Joseph Forshaw provides some additional historical details on the first European encounters with parrots in general.

The primary purpose of *Flocks of Colour* is to show off the paintings, with everything else reduced to a minimum. Information on each species is limited to the person who made the first scientific description, the derivation of the name and a short snippet or two about the bird. The focus of each species account is the illustrations. There are usually at least two, usually three, from early representations to much more recent. Where possible, Olsen has included the earliest known depiction of each species.

The earliest picture is by Pierre Brown of a Rainbow Lorikeet that was captured by Joseph Banks on Captain Cook's voyage in 1770 and taken alive back to Europe. This was the first published illustration of any Australian bird, not just a parrot. From this early start, there are examples up to the present—well over two centuries of paintings of Australian parrots.

Early renderings were often by people with little artistic training, at least for birds, and it shows in the distorted shapes and awkward postures. Probably the most guilty of this was John Hunter, a commander in the First Fleet. Although he was a trained naval draughtsman, his birds, while identifiable, are rather sorry. Of interest is his Norfolk Island Kaka. When Hunter was ship wrecked on Norfolk Island in 1790, he painted this bird, perhaps the only illustration of this now extinct species taken from living birds.

As collections of Australian animals arrived in Europe, artists began to paint them, but had to base their images on preserved specimens of birds they had never personally observed. There were often problems in the presentation, as evident in a round, short-tailed Swift Parrot (between 1801 and 1805) and an 1820 portrait of a Blue-winged Parrot that depicts quite accurately a rather poorly mounted specimen on a perch. Such difficulties did not plague all artists at this time, however, and many fine efforts were produced from then through the late 1880s, most notably by John Gould and his collaborators. These continued through the 20th century to the present day with Neville Cayley's plates from *What Bird is That?*, Lillian Medland and Betty Temple Watts, among others. Special mention must be made of the glorious portraits by William Cooper, arguably the best bird painter working in Australia, if not the world. The National Library holds his complete set of originals for *Parrots of the World* and 26 of his paintings appear here.

Some pictures or artists will be familiar to many readers, such as the works by Gould, Cayley and Cooper. Others will be less familiar. Many readers will not be acquainted with the work of Ebenezer Edward Gostelow. He was a school teacher who was primarily a botanical illustrator, but also painted 730 species of Australian birds. These were never published and they have remained away from the attention of most public. The National Library holds his works and it is pleasing that selection of Gostelow's parrot paintings is included here.

As a medium for showing off the National Library's largely hidden pictorial assets, this attractively presented book very successfully meets its goal. Its large format is quite appropriate to show off the images and the colour reproduction is vivid. I recommend it as a first-rate addition to a personal library or as a fine gift.

Walter Boles
Australian Museum
Sydney

RECOVERY ROUND-UP

This section is prepared with the co-operation of the Secretary, Australian Bird and Bat Banding Schemes, Australian Nature Conservation Agency. The recoveries are only a selection of the thousands received each year; they are not a complete list and should not be analysed in full or part without prior consent of the banders concerned. Longevity and distance records refer to the ABBBS unless otherwise stated. The distance is the shortest distance in kilometres along the direct line joining the place of banding and recovery; the compass direction refers to the same direct line. (There is no implication regarding the distance flown or the route followed by the bird). Where available ABBBS age codes have been included in the banding data.

Recovery or longevity items may be submitted directly to me whereupon their merits for inclusion will be considered.

Hon. Editor

The following abbreviation appears in this issue:

AWSG - Australasian Wader Study Group.

WBRG – Wild Bird Rehabilitation Group

Crested Pigeon *Ocyphaps lophotes*

082-98300. Immature (1) banded by the WBRG at the Narara Grid Block, near Gosford, NSW on 2 Dec. 1996. Recovered dead at Orinda Drive, North Gosford, NSW on 27 July 2013, over 16 years, 7 months after banding. 4 km S.

Shy Albatross *Thalassarche cauta*

280-04201. Adult (1+) banded by N.P. Brothers on Albatross Island, Tas. on 22 Sep. 1984. Recovered dead, beachwashed, at Mogg's Creek, Vic. on 25 Nov. 2013, over 29 years, 2 months after banding. 219 km NNW.

Wedge-tailed Shearwater *Ardenna pacifica*

162-17772. Juvenile banded by S.G. Lane on Mutton Bird Island, Coffs Harbour, NSW on 8 May 1994. Recovered sick, later died at Pottsville Beach, NSW in Feb. 2014, over 19 years, 8 months after banding. 217 km N.

Australian Pied Oystercatcher *Haematopus longirostris*

100-92325. Adult (1+) banded by A.F.C. Lashmar at Strawbridge Point Beach, Kangaroo Island, SA on 17 June 1987. Recovered dead, tangled in fishing line at American River, Kangaroo Island, SA on 5 March 2014, over 26 years, 8 months after banding. 4 km N.

Greater Sand Plover *Charadrius leschenaultii*

051-85866. Immature (1) banded by AWSG at Beaches Crab Creek Road Roebuck Bay, Broome, WA on 23 March 1996. Recaptured, released alive with band at banding place on 18 Feb. 2014, over 17 years, 11 months after banding.

Bar-tailed Godwit *Limosa lapponica*

072-32934. Adult (2+) banded by AWSG at Beaches Crab Creek Road Roebuck Bay, Broome, WA on 5 March 1994. Recaptured, released alive with band at banding place on 24 Feb. 2014, over 19 years, 11 months after banding.

Grey-tailed Tattler *Tringa brevipes*

062-08852. Immature (1) banded by AWSG at Beaches Crab Creek Road Roebuck Bay, Broome, WA on 16 March 1994. Recaptured, released alive with band at banding place on 22 Feb. 2014, over 19 years, 11 months after banding.

(This is the oldest recorded for the species.)

Great Knot *Calidris tenuirostris*

(a) K50-01064*. Juvenile (J) banded at Kunsan, South Korea (35º53'N 126º41'E) on 3 Sep. 1997. Recaptured, released alive with band four times at Beaches Crab Creek Road, Roebuck Bay, Broome, WA (18º00S 122º22'E) on 4 Aug. 2000; 2 March 2005; 11 March 2011 and 20 Feb. 2014, over 16 years, 5 months after banding. 6000 km S.

*Korean Banding Scheme band.

Bird also banded with ABBBS band no. 062-79632.

(a) 061-90557. Adult (2) banded by AWSG at Beaches Crab Creek Road Roebuck Bay, Broome, WA on 12 March 1992. Recaptured, released alive with band at banding place on 24 Feb. 2014, over 21 years, 11 months after banding.

(This is the oldest recorded for the species.)

(a) 062-13829*. Immature (1) banded by AWSG at Beaches Crab Creek Road Roebuck Bay, Broome, WA on 6 March 1996 Recaptured, released alive with band at banding place on 20 Feb. 2014, over 17 years, 11 months after banding.

(b) 062-13844*. Immature (1) banded by AWSG at Beaches Crab Creek Road Roebuck Bay, Broome, WA on 6 March 1996 Recaptured, released alive with band at banding place on 20 Feb. 2014, over 17 years, 11 months after banding.

* Both birds were banded in the same Cannon Net catch in 1996 and recaptured in the same catch in 2014.

Kelp Gull *Larus dominicanus*

111-04318. Nestling banded by W.C. Wakefield on Green Island, D'Entrecasteaux Channel, Tas on 9 Dec. 1990. Recovered dead at South Hobart, Tas. on 22 Feb. 2014, over 23 years, 2 months after banding. 35 km N.

(This is the oldest recorded for the species.)

Western Spinebill *Acanthorhynchus superciliosus*

017-15365. Adult (1+) female banded by A. Morrison at Torndirrup National Park, WA on 12 June 1993. Recaptured, released alive with band at banding place on 7 Feb. 2004, over 10 years, 7 months after banding.

(This is the oldest recorded for the species.)

Hall's Babbler *Pomatostomus halli*

052-14106. Adult (1+) banded by D. Portelli at Bowra, 16 km W of Cunnamulla, Qld. on 14 July 2006. Recaptured, released alive with band at banding place four times the last occasion on 25 May 2010, over 3 years, 10 months after banding.

(This is the oldest recorded for the species.)

Australian Magpie *Cracticus tibicen*

091-30536. Juvenile banded by C.J. Parmenter at Rockhampton, Qld. on 4 Oct. 1993. Recovered sick, later died at Rockhampton, Qld. on 16 Dec. 2013, over 20 years, 2 months after banding. 5 km SW.

Willie Wagtail *Rhipidura leucophrys*

034-37392. Adult (1+) banded by A.J. Leishman at the Australian Native Botanic Garden, Mount Annan, NSW on 10 Nov. 2007. Recaptured, released alive with band at banding place twice, the last occasion by T. Greenaway on 11 March 2014, over 6 years 4 months after banding.

Notice to Contributors

Manuscripts relating to any form of avian research will be considered for publication. Field studies are preferred particularly where identification of individual birds, as by banding, has formed an integral part of the study. Some broad areas of research which do not necessarily require individual identification include morphometric analyses, techniques, species diversity and density studies as well as behavioural investigations. Behavioural, plumage and breeding studies can be conducted in captivity but must provide basic ornithological knowledge rather than avicultural interest.

Manuscripts are classified as either major articles (more than 1,500 words) or minor articles (500 to 1,500 words). Minorarticles need no summary. Shorter notes relating to almost any aspect of ornithology are welcomed but must adhere to the aims of the Association. Species lists or sightings which are not discussed in relation to historical evidence or scientific parameters are not suitable for publication in *Corella*. Authors proposing to prepare Seabird Island items should contact the Assistant Editor,Seabird Islands, and obtain a copy of the guidelines.

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Contributors are requested to observe the following points when submitting articles and notes for publication in *Corella*.

Manuscripts:

A guide to the format required for tables, figures and manuscripts can be attained by reference to a recent edition of the journal and more specifically to the Publication Style found on the ABSA website.

Articles or notes should be sent via email to the editor as a .doc or .rtf file or typewritten and submitted in triplicate via post. Double spacing is required with typing on one side of the paper only. Margins of not less than 25 mm width at the left hand side and top, with similar or slightly smaller at the right hand side of the page are required.

All pages of the manuscript must be numbered consecutively, including those containing references, tables and captions to illustrations, the latter placed in after the text. No underlining and no abbreviations should be used within the text.

The *Style Manual for Authors,Editors and Printers* (6th edition 2002; John Wiley & Sons Australia, Ltd.) is the guide for this journal. Spelling generally follows the Macquarie Dictionary.

Nomenclature and Classifications follow:

Christidis, L. and Boles, W. E. (2008). 'Systematics and Taxonomy of Australian Birds'. (CSIRO: Collingwood, Victoria).

Proper nouns, particularly place and bird names must commence with a capital letter.

Headings are as follows: **HEADING – capitals and bold** (e.g. **RESULTS**)

Sub Heading – lower case and italics (e.g. *Ecology*)

Referencing:

References to other articles should be shown in the text – '. . . Bell and Ferrier (1985) stated that . . .'or '…. this is consistent with other studies (Jones 1983; Bell and Ferrier 1985).'– and in the Reference Section as:

Bell, H. L. and Ferrier, S. (1985). The reliability of estimates of density from transect counts. *Corella* 9: 3-13.

Jones, J. C. (1983). 'Sampling Techniques in Ornithology.'(Surrey Beatty and Sons: Chipping Norton, NSW.)

Figures (Maps and Graphs) and Tables:

The printable area of the page is 18 cm x 27 cm; double column figures/tables will be 18 cm across; single column figures/tables will be 8.5 cm across; widths between one column and double column can also be accommodated.

The captions for figures should be typed up onto a page separate from the figure.

Maps

Maps should be clear and relevant to the study and can be submitted in a variety of formats (.tif, .eps, .pcx) but there commended one is a high resolution .jpg file (colour is acceptable). In some instances simply listing the latitude and longitude may suffice instead of a published map. Maps should only show necessary information. Excessive labelling(including names of towns, roads, rivers) will clutter the figure making it difficult to locate key place names. Photocopies of original hand drawn maps are not suitable for publication. They should be submitted only initially. When the paper is accepted for publication, the originals must be submitted so that they can be scanned into an appropriate electronic format.

Graphs

Lines should be thick and dark and any fill used should show a clear distinction between sets of data (colour fills are acceptable). Borders around the graph and the key are not necessary. The recommended format is an .xls file – this makes it very easy to adjust fills, thickness of lines etc, if necessary.

Where possible, please present the figure at final size. Figures that seem satisfactory when they are large, can present problems when they are reduced. Remember that if the figure has to be reduced for publication the figure will reduce equally in all dimensions i.e. both width and height will reduce. This can cause some problems, such as: (i) Line graphs where the lines are very close together can lose clarity. (ii) The typeface will reduce. Please ensure that the final typeface size AFTER reduction will be a minimum of 10 times Times New Roman typeface.

Tables

The recommended format is an .xls file but tables created in Word are acceptable. These should normally have a maximum size of one page but larger tables can be accommodated, if necessary.

FOR MORE DETAILED INFORMATION OR ASSISTANCE IN THE PREPARATION OF FIGURES PLEASE
CONTACT THE PRODUCTION EDITOR.