The Whistler

Features

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Rufous Scrub-bird studies
Painted-snipe foraging
Azure Kingfisher observations
Double-banded Plover
Lewin's Honeyeater tracking
White-bellied Sea-Eagle
Results from long-term studies

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- ***To encourage bird observing as a leisure-time activity***

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Front cover: Azure Kingfisher *Ceyx azureus* - Photo: Alan Stuart
Back cover: Double-banded Plover *Charadrius bicinctus* - Photo: Steve Merrett
Spine: Sharp-tailed Sandpipers *Calidris acuminata* - Photo: Rob Palazzi

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Editorial

This edition of *The Whistler* deals with an eclectic mix of Hunter Region species – some rare, some relatively common. The thirteen articles herein are similarly varied – some of them report results from medium- to long-term studies, often dealing with multiple species; many others present findings from observations of a single species over shorter time frames.

One long-term study location is the Hunter Estuary, which has been surveyed monthly for shorebirds and waterbirds since 1999 and with participation by almost two hundred Hunter Bird Observers Club members during that time period. In this issue, Alan Stuart and Ann Lindsey present the results for waterfowl, grebes, crakes, and rails. They show that many of those species have prospered in the estuary and suggest this to be the result of the restoration of tidal flushing at several local wetlands.

Mike Newman and Glenn Ehmke used the results from Mike's long-term study of birds at *Yaraandoo*, a property near Paterson, to make population density estimates for the species that he regularly encountered. The method they used is novel; the results aligned well with estimates for elsewhere which had been developed by other means. This type of data has not generally been available for the Hunter Region and the methodology used is readily adaptable to any suitably collected data sets.

Ann Lindsey and Neil Fraser used the results from long-term studies of the Hunter Region's many estuaries and shorelines to analyse the status of the Double-banded Plover in our region. It has been a mixed outcome for this New Zealand migrant; a substantial decline in numbers at sites where the levels of human disturbance are high, and stable populations elsewhere in the region. They found that two sites in the region were nationally significant for the species.

Kim Pryor found that human disturbance also had a major impact on the breeding success of two pairs of White-bellied Sea-Eagles in the Maitland area. Sadly, one breeding attempt failed because of ongoing disturbance, while the successful second pair's nest tree has since been removed to facilitate housing development. It is to be hoped that Kim's report of her careful observations will lead to better outcomes for threatened species attempting to breed near large population centres. Copies of the article will be sent to relevant Hunter Region councils for their consideration when planning developments in wooded areas with potential raptor nesting sites.

Also in this edition, Neil Fraser has taken Citizen Science to a new level by using video recordings made by scores of amateur birdwatchers to develop insights into the foraging behaviour of the Australian Painted-snipe and its close relative, the Greater Painted-snipe. The cryptic nature of these two species has made them difficult for ornithologists to study. Neil obtained video recordings from widespread locations and identified many common behaviours, which had not previously been documented.

Last year's issue included several articles about birds of the Broughton Island Group. Greg Little and Alan Stuart have continued this theme, with a report summarising results from a five-year bird-banding project on the main island. This is the sixth article in *The Whistler* about birds of the Broughton Island Group – there is no doubt that the long-term study there is proving fruitful. Likewise, the two reports in this issue about Rufous Scrub-birds in the Gloucester Tops comprise the sixth and seventh articles in this journal about that cryptic species, which are slowly unveiling some of its secrets.

Although there are twelve different authors for this edition, which implies healthy author diversity, the majority of the content has involved just a handful of people. For that reason, we are very pleased that there are six short notes in this issue of the journal, in addition to the seven full papers discussed earlier. These briefer articles are relatively easy to write, and to read. As such, they are a forum for less-experienced writers to document their observations in a manner which is more readily assimilated by the average birdwatcher i.e., someone without any scientific background. Our aim in each issue is to have a balance of short notes and longer, more scholarly, papers. We encourage you, the reader, to give it a go sometime. It's not hard once you get started.

As with every edition of *The Whistler*, there are many people to be thanked – starting with the authors, of course; the referees whose constructive comments always lead to better articles; Liz Crawford who formats and proof-reads every article; and Rob Kyte who puts everything together for the hard copy and arranges its printing. We also thank the Newcastle Coal Infrastructure Group for their continuing financial support for publication of this journal.

Alan Stuart and Neil Fraser
Joint Editors

PIED BUTCHERBIRD
Cracticus nigrogularis

Illustration by Rob Kyte

Large birds as unusual prey items for butcherbirds

Graeme Stevens

Salamander Bay NSW 2317, Australia. gestev45@hotmail.com

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This note describes Pied Butcherbird *Cracticus nigrogularis* predation on bird species of unusual size and compares that with the behaviour of the Grey Butcherbird *Cracticus torquatus*.

OBSERVATIONS

On 28 September 2021 Mr Les Sharpe of Martinsville, on the eastern edge of the Watagans, reported to me a persistent Pied Butcherbird attack on a Peaceful Dove *Geopelia placida* (LS pers. comm.). The attack was interrupted and there was no opportunity for the butcherbird to subsequently feed on the dove which died shortly after being taken into care.

The following day, Les reported that a Pied Butcherbird persistently attacked and killed a Bar-shouldered Dove *G. humeralis,* later returning to apparently feed briefly on the intestines of the bird (LS pers. comm.). This was possibly the same bird observed the previous day as the observation was at the same location, but there can be no positive proof.

Feeding took place on the ground and there was no attempt to move the prey. A second butcherbird joined the first some minutes later. It did not feed, but it turned the dead bird over.

BACKGROUND

Pied Butcherbird

Higgins *et al*. (2006, "HANZAB"), described food for the species as invertebrates (mainly insects) and small vertebrates (frogs, lizards, snakes, small rodents and birds) and occasionally fruit, seeds and nectar. There are records of the species occasionally feeding on road-killed carcasses and the species is also recorded, as are other species such as ibis, as a "friend of the farmer" for sometimes eating pests such as grasshoppers and rodents.

In relation to specific bird predation, nestlings and fledglings of several species were noted as being taken, but in terms of adult bird predation, only smaller passerine species such as House Sparrow *Passer domesticus*, Silvereye *Zosterops lateralis* and Double-barred Finch *Taeniopygia bichenovii* were described, with the largest species mentioned being an adult Willie Wagtail *Rhipidura leucophrys*. The latter apparently was not taken for food - it had been harassing the butcherbird that had just taken three recently-fledged chicks, and it was killed during its defence of the nest and young.

There are also HANZAB reports of Pied Butcherbirds hunting in association with an Australian Hobby *Falco longipennis* and attempting to catch Common Starlings *Sturnus vulgaris* and smaller honeyeaters when flushed; but success with that technique is not recorded.

David Stuart from west of Dungog reported that Pied Butcherbirds frequently were taking Crested Pigeon *Ocyphaps lophotes* young from the nest just prior to fledging (DS pers. comm.). Though a substantial prey item, the butcherbird did not appear to eat much of the carcasses, just picking holes in their backs.

In HANZAB there are no records of a Pied Butcherbird taking larger adult birds of the size of a Bar-shouldered Dove.

Agonistic behaviour for the species is described in terms of aggressive pursuit and mobbing of actual or perceived predators and aggressive territorial and nest defence, but there is no record of this behaviour resulting in bird fatalities.

Grey Butcherbird

For this closely-related species, the record is quite specific about the many prey species taken which were of quite considerable size. A similar diet range is recorded as for *C. nigrogularis*, and David

Stuart has recorded them taking a just-fledged Willie Wagtail chick which was 2-3 days out of the nest (DS pers. comm.).

As well as a similar nest-robbing diet and a range of small adult passerines, Grey Butcherbird are recorded as also taking Brown Quail *Coturnix ypsilophora*, Laughing Dove *Spilopelia senegalensis,* Mulga Parrot *Psephotellus varius*, Bassian Thrush *Zoothera lunulata* and Common Starling.

David Clark from Box Hill in Victoria has reported Grey Butcherbirds taking Spotted Dove *S. chinensis* and Common Blackbird *Turdus merula* (DC pers. comm.). He noted that given the size of those prey species it was a drawn-out affair until the prey was dispatched. In his observations, the prey was generally positioned on its back with the butcherbird feeding on the breast. He also reported a recent Victoria Birders account of a Grey Butcherbird persistently attacking and killing an adult Dusky Woodswallow *Artamus cyanopterus* on the ground before carrying it away.

DISCUSSION

For prey species such as Bar-shouldered and Spotted Dove there seems no doubt that they were targeted for food by the two butcherbird species. It seems most unlikely that they would initiate nest or territory defensive behaviours or be mistaken for predators, and in these observations, feeding activity followed the attack. The effort required would be considerable given the broadly equivalent sizes and body weights of predator and prey and success required repeated and persistent attack as recorded.

It seems that both species may have similar behaviours and at times target large prey, but that fewer records are available for *C. nigrogularis.*

An additional observation from the reports is how little of these larger prey items appears to have been consumed, an interesting behaviour given the extreme effort required to make the kill.

ACKNOWLEDGEMENTS

I thank Les Sharpe for the detailed observations from Martinsville and David Stuart and David Clark for their personal contributions and valuable observations.

REFERENCES

Higgins, P.J., Peter, J.M. and Cowling, S.J. (2006). ‘Handbook of Australian, New Zealand & Antarctic Birds Volume 7 Boatbill to Starlings’. (Oxford University Press: Melbourne.)

What time of day does a Rufous Scrub-bird sing?

Alan Stuart[1], Margaret O'Leary[1] and Robyn Stuart[2]

[1]81 Queens Rd, New Lambton NSW 2305, Australia almarosa@bigpond.com
[2]106 Palace St, Petersham NSW 2049, Australia

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The daily pattern of male Rufous Scrub-bird *Atrichornis rufescens* singing behaviour in the New South Wales Gloucester Tops was investigated for each month of the year as part of a 4-year study at five scrub-bird territories. It was found that time of day did not significantly affect singing behaviour. However, singing activity during the day was unpredictable in the period January-August. Between September and December acoustic monitoring programs for scrub-birds can be conducted at any time of day.

INTRODUCTION

The southernmost population of the Rufous Scrub-bird *Atrichornis rufescens* lives in the New South Wales Gloucester Tops (Ferrier 1984). These cryptic birds are heard more often than they are seen. Males make a variety of calls, including mimicry (Gole & Newman 2010). Some of the calls are difficult for inexperienced surveyors to correctly identify which species produced them. However, scrub-birds have a characteristic song – a series of loud monosyllabic "chips" delivered in rapid succession. In survey work, the chipping song is taken as definitive evidence that a scrub-bird is present (Newman *et al*. 2014). The number of syllables varies, but typically the subspecies *ferrieri* (the subspecies present in the Gloucester Tops) produces 2-8 syllable songs in each singing event.

Because monitoring programs for the Rufous Scrub-bird are reliant upon hearing singing male birds (Newman *et al*. 2014; Andren 2016; Stuart & Newman 2018), we have been studying the singing behaviour of male scrub-birds in the Gloucester Tops. Our initial focus was to examine how the daily average singing activity varied during the year. We showed that the activity increased markedly from mid-September and remained at a high level for the rest of the year. Rufous Scrub-bird singing activity declined significantly during January and February. From then onwards, until mid-September, the birds sang unpredictably but, on average, their singing activity was significantly lower than for the other months (O'Leary & Stuart 2021).

For the design of effective monitoring programs, another important aspect of Rufous Scrub-bird singing behaviour is whether scrub-birds call more frequently at certain times of the day or, conversely, whether there are any times of the day when scrub-birds are less likely to sing. For example, if males were found to sing more frequently in the morning, then surveys in the afternoon perhaps should be excluded from plans.

Ferrier (1984) investigated this aspect at two locations (Border Ranges National Park, Gloucester Tops) and concluded there were no significant singing activity differences between times of day at either study site. In the Gloucester Tops, Ferrier conducted transect surveys on 18 occasions over two years, but only for six months of the year (and mostly his surveys were done in Spring).

In this current study we investigated how the singing behaviour of scrub-birds in the Gloucester Tops varied throughout the course of a day. We did that by collecting and analysing a large data set of recordings for each month of the year.

METHODS

Data collection

We selected five known scrub-bird territories for the study (Stuart 2020; Stuart & Newman 2018). The territories were well-separated; the shortest distance between any two territories was ~1 km. Data collection activities commenced in January 2015 and continued until March 2019. On numerous occasions within those dates, we recorded for periods spanning 3-8 days in at least one scrub-bird territory, and often at 1-2 additional territories at the same time. We used automated recording units (ARUs), programmed to record daily from 30 minutes before dawn until 30 minutes after dusk for as long as there was sufficient remaining battery power. Typically, we obtained 6-8 full days of recordings from each deployment of an ARU before the batteries failed. Details about the ARUs and how we positioned them have been described elsewhere (Stuart & O'Leary 2019; O'Leary & Stuart 2021).

Data analysis

We recorded data onto SD cards, which later we transferred to computer and analysed using Raven Pro 1.5 software operated under licence from the Cornell Laboratory of Ornithology. We used the conditions previously developed for rapid semi-automated analysis of recordings of the scrub-bird's chipping call (Stuart & O'Leary 2019).

We analysed the recordings in 20-minute periods, noting the number of singing events per period. For this study, a singing event was defined as each instance of the scrub-bird producing its territorial "chipping" song regardless of how many syllables were uttered. We used Australian Eastern Standard Time throughout the study i.e., we did not adjust the ARU clocks for the period when daylight saving time was in operation. We exported the results from the Raven Pro analyses into Microsoft Excel for further processing, and then into the statistical software R for statistical analysis and to generate graphs using the ggplot2 package. For each month we calculated the mean number of calls made in each 20-minute time period of the day, using the results from every day of that month for which we had data for that 20-minute period. Within any month, we ignored that there sometimes were differences in the number of daylight hours per day between the beginning and end of the month.

RESULTS

At the five territories combined, we obtained 432 full days of recordings plus for an additional six days there were recordings spanning at least four hours. We used all the data from those 438 days. Thus, we analysed *c* 4,500 hours of recordings for this study. About 45% of the recorded hours were from one territory and about 22% were from another territory. Each of the three other territories contributed *c*10% of the total recordings.

In **Figure 1** we show, for each month, box and whisker plots summarising the number of singing events for each daily 20-minute period for that month. To assist with comparisons between months, all the plots have been set to the same scale on both the X and Y axes.

During September to December, the mean numbers of singing events per 20-minute period were greater in the first 2-3 hours of the morning and they rose to similar levels in the 2-3 hours before dusk. However, there were no statistically significant differences in scrub-bird singing behaviour at any time of day.

The pattern for January was similar to that for September-December but the mean singing activity levels were lower. Also there were more outliers i.e. occasions when a scrub-bird sang considerably more often than was the average for that particular 20-minute time period. Similarly, the proportion of outlier results was high throughout the February-August period.

In June and July, when the singing activity levels on average were low, the mean numbers of singing events per 20-minute period were highest in the 1-2 hours before dusk. However, throughout the February-August period, there were no statistically significant differences in singing activity at any time of day.

DISCUSSION

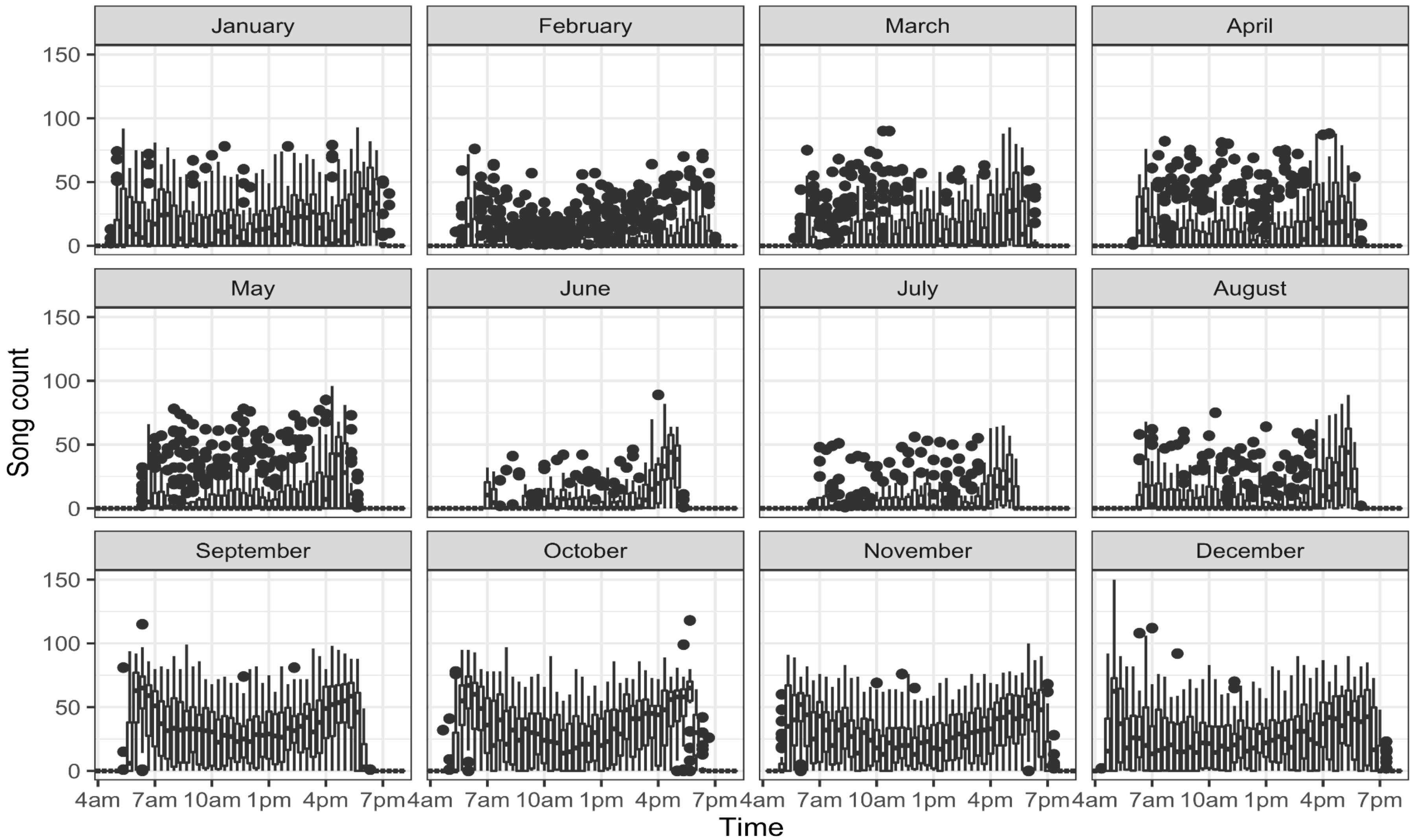
The pattern for singing events per 20-minute period during the day for any given month reflected the findings of the earlier study of daily average singing activity (O'Leary & Stuart 2021). Scrub-bird singing activity rose significantly for the period September-December because there were, on average, more singing events per 20-minute period and more 20-minute periods when the scrub-bird was actively singing. Also, there were more daylight hours than for the preceding months i.e. more opportunity for the scrub-bird to sing. February and June/July had the least amount of singing activity.

Little is known about Rufous Scrub-bird breeding biology in the Gloucester Tops; however, September-December spans the putative breeding season (O'Leary & Stuart 2021).

Previous studies have shown that scrub-birds do not sing at night (Stuart *et al*. 2012; O'Leary & Stuart 2021). The current study supports that conclusion. There were no instances of a scrub-bird singing before dawn. Occasionally a bird sang at around dusk; however, when it did so it was only for a brief period of time.

During September to December, scrub-birds were likely to sing at any time of the day, and often their singing activity in the middle of the day exceeded the average post-dawn and pre-dusk singing activity.

Figure 1. Box and whisker plots of daily singing activity per month, in 20-minute increments, by Rufous Scrub-bird in the Gloucester Tops. Time units are not adjusted for daylight saving. The medians are represented as horizontal lines between the interquartile ranges (boxes) and 1.5 x interquartile ranges by whiskers. Outlier values are presented individually (as ●). The months from February to August had many outlier results.



The large number of outlier results each month for January to August arose because of a combination of two effects:

- For each month the median number of singing events in any given 20-minute time period was low.
- In any given 20-minute time period, sometimes the scrub-bird sang prolifically i.e. it was considerably more active than on average for that time period in that month.

The many outliers for January-August highlight the unpredictable singing behaviour by scrub-birds outside of the supposed breeding season.

As well as singing, scrub-birds have many other vocalisations, including mimicry (Gole & Newman 2010). Establishing behavioural patterns for these other vocalisations using ARUs is problematic, because of the difficulty in most cases of differentiating them from the calls of other species inhabiting the same area. The difficulty is compounded from the absence of directional information from automated recordings. A listener in the field is able to identify when a variety of calls are from the same location and that their source therefore is likely to be a Rufous Scrub-bird.

CONCLUSIONS

This study has shown that, at any given time of the year, male Rufous Scrub-birds in the Gloucester Tops are about as likely to sing at any time of the day. Thus, in monitoring programs for them, the survey work can be carried out any time between dawn and dusk. However, the period January-August should be avoided because singing activity is variable and seemingly unpredictable.

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REFERENCES

Andren, M. (2016). Monitoring the Rufous Scrub-bird *Atrichornis rufescens* in the New England region. *Corella* **40**: 53-60.

Ferrier, S. (1984). 'The Status of the Rufous Scrub-bird Atrichornis rufescens: habitat, geographical variation and abundance'. PhD Thesis, University of New England, Armidale, New South Wales.

Gole, C. and Newman, M. (2010). Master mocker of the forest: Rufous Scrub-birds. *Wingspan* **20**: 16-19.

Newman, M., Stuart, A. and Hill, F. (2014). Rufous Scrub-bird *Atrichornis rufescens* monitoring at the extremities of the species' range in New South Wales (2010–2012). *Australian Field Ornithology* **31**: 77-98.

O'Leary, M. and Stuart, A. (2021). Singing behaviour of male Rufous Scrub-birds in the New South Wales Gloucester Tops. *Corella* **45**: 23-29.

Stuart, A. (2020). Rufous Scrub-bird population trend in the Gloucester Tops: results from 2010-2019 monitoring program. *The Whistler* **14:** 28-34.

Stuart, A., Newman, M., Struik, P. and Martin, I. (2012). Development of a non-intrusive method for investigating the calling patterns of Rufous Scrub-birds. *The Whistler* **6**: 24-34.

Stuart, A. and Newman. M. (2018). Rufous Scrub-birds (*Atrichornis rufescens*) in the Gloucester Tops of New South Wales: findings from surveys over 2010-2016. *Australian Field Ornithology* **35**: 13-20.

Stuart, A. and O'Leary, M. (2019). A method for investigating Rufous Scrub-birds using automated recording and rapid, semi-automated data analysis. *Corella* **43**: 57-64.

An observation of agonistic behaviour by a Dollarbird

Neil Fraser

8 Flannel Flower Fairway, Shoal Bay NSW 2315, Australia. neil8fff@gmail.com

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Around 7.15 pm on the evening of 15 October 2021, I observed an agonistic display by a Dollarbird *Eurystomus orientalis* towards a Masked Lapwing *Vanellus miles* in the grounds of Shoal Bay primary school (32º 43' 43"S, 152º 10' 24"E). The Dollarbird was executing a number of diving swoops towards a single Masked Lapwing, foraging in the school grounds. The Dollarbird was launching its attacks from a lower branch of a tall Smooth-barked Apple *Angophora costata*. The branch was about five metres above the ground. The attacks were around 10 seconds apart and continued for about two minutes. As it swooped, the Dollarbird uttered a single drawn-out scolding 'kek' call. This call is described by Marchant *et al*. (1999) as an alarm call. On ceasing its attacks, the Dollarbird alighted on a branch in the top of the tree. The Masked Lapwing called repeatedly during the attacks while facing off its attacker, but made no effort to leave. After the attacks ceased, the lapwing flew off unhurriedly to another part of the school grounds, calling as it departed. The Dollarbird subsequently flew from the tree and I did not see it again around the school grounds that evening.

The reasons for the Dollarbird's behaviour could include breeding territory defence, nestling protection, feeding resource defence or a combination of these. The species defends its breeding territory vigorously, excluding other Dollarbirds, and they are commonly seen escorting other avian intruders out of their territory (Marchant *et al*. 1999). They have been observed excluding many larger species including Pied Currawong *Strepera graculina* and Laughing Kookaburra *Dacelo novaeguineae* (Marchant *et al*. 1999). The size of Dollarbird territories has not been reported.

I have walked past the school several times a week for the past 15 years, usually around dusk. The Masked Lapwing is part of a 'resident' family that is usually observed in the grounds or on nearby lawns and footpaths. They breed each year in the school grounds. The Dollarbird is the first I have encountered at this location. The school grounds are surrounded by tall Smooth-barked Apple and Blackbutt *Eucalyptus pilularis* both of which would provide excellent vantage points for perching, or from which to conduct foraging forays. They could also potentially provide nesting sites.

Dollarbirds nest in natural tree hollows, usually at height. They arrive late-September to early-October, breed from October to January and chicks fledge from December to February (Marchant *et al*. 1999). Adult birds depart the Hunter Region in late February and most juvenile birds depart in early March (Newman 2013). An inspection of the tree, which was around 20-25 m tall, did not identify any potential nesting hollows. I have not observed this species previously in the school grounds and have not seen it there subsequently. There are no indications that the birds nested elsewhere in the school grounds or established a territory there. Dollarbirds are known to use the same nest-tree or a nearby site each year and some territories have been known to be occupied annually for at least 10 years (Marchant *et al*. 1999). My observation was made in mid-October, which is at the start of the breeding season, so it is possible the bird was undertaking an exploratory investigation of a possible new nest location in the school grounds. However, I did not see a second Dollarbird in the area.

Dollarbirds feed almost exclusively on flying insects. They search for food from a conspicuous perch and capture it by 'hawking', before returning to the same perch. Their food consists of large flying insects such as cicadas, beetles and moths. They are most active in late afternoon and early evening when crepuscular insects become active (Marchant *et al*. 1999). My observation was within this foraging window and the bird may have been feeding from the tree prior to the Masked Lapwing's arrival. However, the Masked Lapwing, which forages for invertebrates on the ground, should not have been a competitor for the Dollarbird's foraging resource.

Agonistic encounters between a Dollarbird and two separate Brown Goshawk *Accipiter fasciatus* at Wingen were described by Newling (2013), on two mornings in January 2013. Dollarbirds were resident in that area at that time, although there were no reports of their having a nest or feeding dependent young. The reason for the attack appeared to be entirely territorial. The goshawks were reported to have possibly been nesting nearby.

This agonistic behaviour in the Shoal Bay school grounds did not appear to be driven by breeding territory defence, nestling protection or feeding resource defence. This suggests that, in some instances, Dollarbird's agonistic behaviour toward other avian species may be instinctive, regardless of territorial bounds or other drivers.

REFERENCES

Marchant, S., Higgins, P.J. and Davies, S.J.J.F. (1999). Handbook of Australian, New Zealand and Antarctic Birds Volume 4, Parrots to Dollarbird. (Oxford University Press: Melbourne.)

Newling, G. (2013). Angry Dollarbird attacking Brown Goshawks. *The Whistler* **7**: 60.

Newman, M. (2013). Dollarbird departure from the Hunter Region in 2013. *The Whistler* **7**: 50-53.

Rufous Scrub-bird studies: an assessment of the feasibility of capturing, colour-banding and resighting scrub-birds

Rob Kyte[1] and Alan Stuart[2]

[1]3/17 Guna Street, Charlestown NSW 2290, Australia robertkyte@bigpond.com
[2]133 Barrenjoey Road, Ettalong Beach, NSW 2257, Australia alanstuart400@gmail.com

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A method is described for capturing a male Southern Rufous Scrub-bird *Atrichornis rufescens ferrieri* during its breeding season. Three scrub-birds were captured and individually marked by attaching a metal band to one leg and a coloured band to the other. One of those scrub-birds has been resighted twice, while there have been twenty confirmed resightings of another marked individual. To date the longest interval between capture and resighting of an individual scrub-bird has been 22 months. Colour-banding has been shown to be a viable means for identifying individual scrub-birds in the field.

INTRODUCTION

The endangered Rufous Scrub-bird *Atrichornis rufescens* exists as small, isolated populations in northern NSW and southern Queensland (Stuart *et al*. 2021; Stewart *et al*. 2021). The status of most of those populations is monitored by means of annual surveys in spring (G. Maurer pers. comm.). However, relatively little is known about many aspects of the biology of this species. Improving the long-term outlook for the Rufous Scrub-bird should be helped by a better understanding of how individual birds live.

The purpose of the current study was to investigate if it was possible to trap and apply a coloured band to a Rufous Scrub-bird, and to assess how feasible it would be to resight the band during fieldwork. The Rufous Scrub-bird mostly forages at or near ground level in dense vegetation, which suggested that sightings of a coloured band might be problematic. We targeted scrub-birds in the NSW Gloucester Tops, where they are the southern subspecies *ferrieri* (Southern Rufous Scrub-bird), to complement other studies being undertaken in that area (e.g. Stuart 2018; Stuart 2020; O'Leary & Stuart 2021).

Trapping scrub-birds

The Australian Bird and Bat Banding Scheme (ABBBS) had two records of a Rufous Scrub-bird being caught and banded: in 1980 and 1987. The latter record involved an accidental capture.

In his study of the Rufous Scrub-bird in the early 1980s, Simon Ferrier tried many techniques for catching scrub-birds, with almost no success (Ferrier 1984: 64). Only one bird was caught, a male at Mt Banda Banda (in the Hastings Range) in August 1980. A numbered metal band was applied to the bird, and there were two resightings, in October 1980 and October 1981.

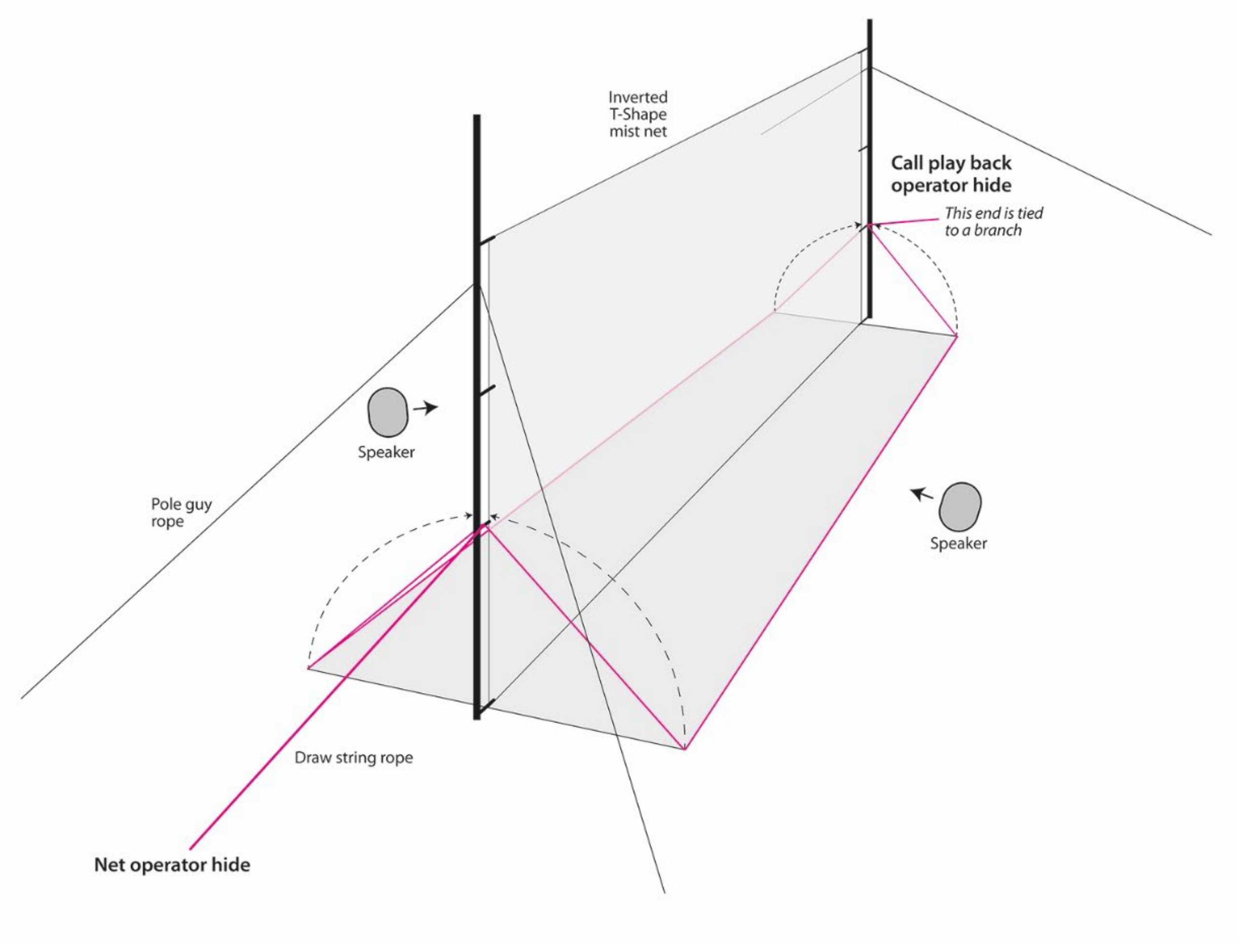
Ferrier did not elaborate on the trapping techniques which were trialled. However, he was sometimes assisted by Richard Noske who later commented that mist nets were ineffective because birds did not entangle in the bottom pocket – the successful capture in 1980 involved dropping a butterfly net over a bird (R. Noske pers. comm.).

Despite Noske's comments, an immature female Rufous Scrub-bird was caught in a mist net at Pappinbarra (west of Port Macquarie, 240 m altitude) in 1987 (Boles & Tynan 1994). The habitat, a disused orchard, was atypical for scrub-birds which possibly improved the effectiveness of the mist net. The location was approximately 20 km from where there is a known population. A numbered metal band was applied to the bird but there were no resightings.

Although the ABBBS had no other records of the banding of a Rufous Scrub-bird, there were many such records for the Noisy Scrub-bird *A. clamosus*, which has been the subject of major studies since its rediscovery in 1961 (Danks 1997; Comer *et al.* 2010). The recovery plan for the Noisy Scrub-bird includes capture and translocation of birds whenever wildfires destroy isolated populations (Cowen *et al*. 2021). We contacted the Noisy Scrub-bird recovery project team and later visited them for training in the capture method that they recommend. They reported that mist nets had proven ineffective because scrub-birds did not entangle in them, and that many other ideas for capture methods had been trialled without success, until they developed a novel trapping method involving an inverted T-net (Comer *et al*. in prep).

Although the original T-nets were modified mist nets, they are a form of trap. When set up in a scrub-bird territory, a horizontal section of net is stretched out on the ground, connected by drawstrings to the vertical section (**Figure 1**). Two operators attend the trap. One operator manipulates a call playback system, directing calls to one of two speakers which are placed on either side of the T-net, each about 1m away from it. The aim is to have call playback coming from the speaker on the opposite side of the T-net to where the scrub-bird is known to be (from the operator seeing or hearing it). The intention is to lure the scrub-bird onto the horizontal section of the net. The second operator watches until that happens and then pulls the drawstrings, which bring the horizontal part of the net up against the vertical part of it. The scrub-bird thus becomes caught between two sections of net. The Noisy Scrub-bird team has captured many birds using this method.

Figure 1. Schematic of the T-shaped net used for trapping scrub-birds. The two operators use hides constructed at each end of the net.



An unknown until this study was how well the T-net method would work for Rufous Scrub-birds. Their habitat (at least in the Gloucester Tops) comprises considerably more low-level structure – such as vegetation, fallen timber, leaf litter, rocks, and pot holes - than the habitat of the Noisy Scrub-bird (authors pers. obs.).

METHODS

All of the necessary permits for the trapping/banding project were obtained from the relevant authorities: the Australian Bird and Bat Banding Scheme (approvals 2951, 2951-CMA); NSW Animal Care and Ethics Committee (approval TRIM 18/572); and the NSW National Parks and Wildlife Service (Scientific Licence plus approval from the Gloucester regional office to operate in the Barrington Tops National Park). T-nets were purchased from Ecotone in Poland; the design for those nets being based on the Noisy Scrub-bird project team's innovation. A purpose-built dual-outlet call-playback system was used. In most of the trapping attempts, the pre-recorded territorial song of the targeted scrub-bird was played, and occasionally some other of its vocalisations. Sometimes, towards the end of an unsuccessful trapping attempt, the territorial songs of a neighbouring bird were played but these were ineffective.

At least two net lanes were prepared within a Rufous Scrub-bird territory, removing all vegetation and removing or burying any obstructions such as rocks or roots. Each net lane was 80 cm wide (the horizontal section of the T-net is 40 cm on each side) and 8 m long. Two rudimentary hides were also built, one at each end of the net lane. An interval of at least four weeks was then allowed before any attempt at trapping, to allow time for the scrub-bird to become accustomed to the changes.

Attempts at capturing a scrub-bird involved teams of 3-4 people. The teams listened from outside of the scrub-bird territory until a vocalising bird was heard, and then decided which net lane would be the better one to use. All members of the team assisted in installing the equipment, working as quietly as possible. When the two operators were in position in their hides, the other team members departed from the territory, somewhat noisily so that the bird might think that the intrusion had finished. The operators then waited quietly for about ten minutes. After that, once they had confirmed the bird's current whereabouts, they initiated call playback from the speaker on the opposite side of the net to the scrub-bird. Call playback was only done in short bursts, with intervals of several minutes. If the scrub-bird had not been caught within approximately an hour, the attempt was abandoned.

When captured, the scrub-bird was placed into a clean calico bag and taken to a banding station, located nearby but outside of the bird's territory. The banding station was set up inside a nylon mesh tent, so that it was fully enclosed. Each captured bird was fitted with a uniquely-identifying metal band on one leg and a coloured band on the opposite leg (ABBBS Schema I – coloured band on left leg – and ABBBS Schema II – coloured band on right leg). Birds were placed into a fresh calico bag after they had been processed, and then returned to their territory for release. The processing time was approximately 30 minutes.

RESULTS

Between November 2018 and December 2020 T-nets were operated at six Rufous Scrub-bird territories in the Gloucester Tops (arbitrarily numbered below as Territories 1-6). Male scrub-birds were captured at three of those territories. In each case, the scrub-bird re-commenced singing within about five minutes of being released after banding and processing, and it sang regularly during the remainder of the day (and when checked on subsequent days).

The successful captures occurred during September-December, which is the supposed breeding season (O'Leary & Stuart 2021). All of the attempts at other times of the year failed, mainly because the non-breeding male approached the T-net cautiously and did not step onto the horizontal section of the T-net. Also, all the attempts in September-December 2019 were unsuccessful.

The first successful Rufous Scrub-bird capture (in Territory 1) was in November 2018. During 2019-2020 there were two confirmed sightings of the bird, when the yellow band was clearly seen (**Figure 2**). The second sighting occurred 22 months after the bird was banded. On four other visits to the territory a scrub-bird was seen briefly but its legs were obscured by vegetation.

A scrub-bird from Territory 2 was captured in December 2018. There were no subsequent sightings of that bird nor of any other scrub-bird in that territory, despite several attempts at tracking down a singing bird. A study of Rufous Scrub-bird singing behaviour, based on automated sound recordings (O'Leary & Stuart 2021), showed that a scrub-bird sang regularly in the territory until at least May 2019, when the recording program was completed. Since then there has never been any indication that a scrub-bird continues to occupy the territory. However, from September 2019 a scrub-bird began to sing regularly from an area 150-200m away from the original territory. We have been unable to establish if it is the same bird, and so the new territory is designated as Territory 2A.

In September 2020, a scrub-bird at Territory 3 was caught. Between November 2020 and March 2022 there were 20 confirmed resightings of the bird (i.e. pink band clearly seen) (**Figure 3**). The most recent of those, in February 2022, was almost 17 months after the bird was banded. All of the resightings in Territory 3 were achieved using trail cameras. In that same period there were at least 40 additional observations of scrub-birds within the territory but with a band not sighted. Those additional sightings were achieved from a combination of field work and trail cameras.

It was the fourth attempt at capturing the bird at Territory 3 using a T-net but only the second attempt during a breeding season. In an attempt in the 2019 breeding season (in mid-October) the bird approached the T-net warily and would not step onto the horizontal section of it.

Table 1 summarises the overall results for captured birds and confirmed resightings. **Figures 2** and **3** show colour-banded Rufous Scrub-birds within their territories.

Table 1. Rufous Scrub-bird capture/resighting results.

Territory	Date banded	Banding outcome	Dates of resightings
Territory 1	17 November 2018	Schema II, yellow band on right leg	14 April 2019, 16 September 2020
Territory 2	3 December 2018	Schema I, yellow band on left leg	Nil
Territory 3	23 September 2020	Schema I, pink band on left leg	20 resightings from November 2020 to February 2022

There was one attempt, in early December 2020, at capturing a scrub-bird in Territory 4 using the T-net. The bird responded aggressively to call playback but avoided capture because it leapt from a log into the vertical section of the T-net and bounced off it, rather than standing upon the horizontal section. After that incident it would not approach the net lane again that day.

Figure 2. A Gloucester Tops Rufous Scrub-bird singing in its territory on 14 April 2019, with yellow band visible on right leg (photo: A. Stuart).

During 2020 there were three unsuccessful attempts to trap a scrub-bird in Territory 5 and one unsuccessful attempt to re-capture the bird in Territory 1. All of the attempts were made within the presumed breeding season. At both territories, the scrub-bird approached cautiously each time in response to call playback and would not step onto the horizontal section of the T-net.

During 2019 there were multiple attempts at capturing scrub-birds in Territory 2A and Territory 6 using the T-net, including several attempts at each territory during the 2019 breeding season.

Various styles of walk-in trap were tried in Territory 3 and Territory 4 during 2019-2020, all without success.

Figure 3. A Gloucester Tops Rufous Scrub-bird within its territory on 7 October 2021, with pink band visible on left leg (photo: A. Stuart using a trail camera).

DISCUSSION

This study has confirmed that the T-net capture method developed for Noisy Scrub-birds is also successful with Rufous Scrub-birds. However, the capture method was only successful in the breeding season, probably because male scrub-birds were prepared to aggressively defend their territory from supposed intruders. At such times they were more likely to rapidly approach the call-playback speaker. However, at two territories, the male scrub-birds behaved cautiously during the breeding season. One of those territories is well-known to birdwatchers as a site for Rufous Scrub-birds, and call playback is often used there. It is possible that the scrub-bird has become habituated to hearing call playback and has learnt to respond more cautiously to it. At the other territory, the scrub-bird reacted aggressively to call playback when it was captured in 2018 but reacted cautiously in 2020. A possible explanation is that it could recall the capture event. However, during 2019-2020 the territory location had become better known to birdwatchers and call playback there had probably become more common.

No scrub-birds were captured in September-December 2019, which was during a prolonged drought. That year's monitoring program produced the lowest-ever count of territories. It is likely that male birds had either abandoned their territories or ceased to advertise them (Stuart 2020). It may have been that the scrub-birds did not breed that season, and thus the males were less interested in defending their territories.

Methods for capturing male scrub-birds outside of the breeding season are yet to be identified, as are any methods for capturing female or young birds. The Noisy Scrub-bird team has been able to catch females because they maintain territories and they have a territorial song which can be used for call playback (Berryman 2007). The calls of female Rufous Scrub-birds are infrequently heard. Ferrier mentioned a soft "tick-tick" call and some instances of soft duetting with male birds (Ferrier 1984: 188). The female's calls appear not to have been recorded until recently (Stuart unpublished).

The Rufous Scrub-bird has powerful legs which makes it a difficult species for a bird bander to hold whilst handling it. Two of the captured birds escaped whilst being handled, justifying the use of a fully-enclosed banding station. The birds were easily re-caught using a fine butterfly net.

Information about topics such as home range and the longevity of scrub-birds rely upon recaptures or resightings. Both of those are difficult to achieve. To date there have been no recaptures of a banded Rufous Scrub-bird. Ferrier had two resightings of the Hastings Range (Mt Banda Banda) bird, because he saw a metal band on both occasions. Unsurprisingly, he was unable to read the band number in the field but at the time it was the only banded Rufous Scrub-bird in existence (Ferrier 1984: 64).

Ferrier's longest resighting record was 14 months after banding. In the Gloucester Tops study reported here, there was a confirmed sighting of the Territory 1 bird 22 months after it was banded. The bird when captured was identified as an adult male bird at least one year old. Therefore, it was at least an almost three-year-old bird at the most recent resighting. Similarly, the bird in Territory 3 was at least two-and-a-half years old at the most recent resighting.

The two resightings of the Territory 1 scrub-bird were achieved by patiently following the bird while it was vocalising, until a view of its right leg was achieved. In four other attempts, the bird stopped calling before the right leg could be seen properly and its whereabouts after that were unknown. A different approach has been trialled for the scrub-bird in Territory 3, with motion-activated cameras ("trail cameras") being placed at some locations within the territory. The preliminary results from that program are encouraging; they include the resightings of the bird's pink band described in this report and they are beginning to yield behavioural information (Stuart in prep.).

CONCLUSIONS

We have shown that it is possible to capture male Rufous Scrub-birds in their breeding season in the Gloucester Tops using a modified mist net (T-shaped net) coupled with call playback. We have also shown that a Rufous Scrub-bird is resilient to the process of being captured and handled, and that the presence of bands (on both legs) does not affect the bird's ability to survive in its environment. Finally, we have shown that coloured bands on a Rufous Scrub-bird can be seen in the field, albeit sometimes with difficulty. The coloured bands provide a means for identifying individual birds without having to recapture them. We expect that the ability to identify individual birds will eventually lead to improved understandings about the biology of the Rufous Scrub-bird.

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REFERENCES

Berryman, A. (2007). 'Song sharing and repertoire change as indicators of social structure in the Noisy Scrub-bird'. PhD Thesis. Murdoch University, Perth, WA.

Boles, W. E. and Tynan, B. (1994). Low altitude record of Rufous Scrub-bird *Atrichornis rufescens*. *Corella* **19**: 91.

Comer, S., Danks, A., Burbidge, A.H. and Tiller, C. (2010). The history and success of noisy scrub-bird re-introductions in Western Australia, 1983-2005. In *Global Re-Introduction Perspectives, 2010: Additional Case Studies from Around the Globe.* IUCN SSC Re-Introduction Specialist Group, Abu Dhabi. Pp 187–192.

Comer, S., Burbidge, A.H. and Danks, A. (in preparation). Capture methods for the Noisy Scrub-bird.

Cowen, S.J., Comer, S., Wetherall, J.D. and Groth, D.M. (2021). Translocations and their effect on population genetics in an endangered and cryptic songbird, the Noisy Scrub-bird *Atrichornis clamosus*. *Emu – Austral Ornithology* https://doi.org/10.1080/01584197.2021.1888125.

Danks, A. (1997). Conservation of the Noisy Scrub-bird: a review of 35 years of research and management. *Pacific Conservation Biology* **3**: 341-349.

Ferrier, S. (1984). 'The Status of the Rufous Scrub-bird *Atrichornis rufescens*: Habitat, Geographical Variation and Abundance'. PhD Thesis. University of New England, Armidale, NSW.

O'Leary, M. and Stuart, A. (2021). The singing behaviour of male Rufous Scrub-birds in the Gloucester Tops. *Corella* **45**: 23-29.

Stewart, D.A., Newman, O.M.G., Ehmke, G. and Garnett, S.T. (2021). Northern Rufous Scrub-bird *Atrichornis rufescens rufescens*. In *The Action Plan for Australian birds 2020*. (Eds S.T. Garnett and G.B. Baker) Pp 477-480. (CSIRO Publishing: Melbourne.)

Stuart, A. (2018). Sizes of some Rufous Scrub-bird singing areas in the Gloucester Tops. *Aust. Field Ornithology* **35**: 107-110.

Stuart, A. (2020). Rufous Scrub-bird population trend in the Gloucester Tops: results from 2010-2019 monitoring program. *The Whistler* **14**: 28-34.

Stuart, A. (in preparation). Studying Rufous Scrub-birds using motion-activated cameras: a preliminary assessment.

Stuart, A., Newman, O.M.G., Ehmke, G. and Garnett, S.T. (2021). Southern Rufous Scrub-bird *Atrichornis rufescens ferrieri*. In *The Action Plan for Australian birds 2020*. (Eds S.T. Garnett and G.B. Baker) Pp 474-477. (CSIRO Publishing: Melbourne.)

Hunter Estuary surveys: results for waterfowl, grebes, crakes, rails and gallinules

Alan Stuart and Ann Lindsey

133 Barrenjoey Rd, Ettalong Beach, NSW 2257, Australia alanstuart400@gmail.com
37 Long Crescent, Shortland, NSW 2307, Australia ann.lindsey@bigpond.com

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The Hunter Estuary at Newcastle, New South Wales is a well-known site for migratory shorebirds, but its utilisation by other types of waterbirds is not well understood. This report presents the results for 27 species, representing three families of waterbirds, Anatidae (waterfowl), Podicipedidae (grebes) and Rallidae (crakes, rails and gallinules), from a 22-year study involving monthly surveys of the estuary.

Most of the species were found to have stable populations or the changes over 22 years were modest. The populations of eight species increased - Black Swan *Cygnus atratus*, Australian Wood Duck *Chenonetta jubata*, Pacific Black Duck *Anas superciliosa*, Grey Teal *A. gracilis*, Chestnut Teal *A. castanea*, Australasian Grebe *Tachybaptus novaehollandiae*, Purple Swamphen *Porphyrio porphyrio* and Eurasian Coot *Fulica atra*. These species have benefitted from local rehabilitation projects which have restored tidal flushing to wetlands located at Ash Island, Hexham Swamp and Tomago.

Five species had greater populations in the estuary in summer and/or autumn: Australasian Shoveler *Spatula rhynchotis*, Pacific Black Duck, Grey Teal, Chestnut Teal and Australasian Grebe. The population of Black Swan rose in winter.

Most of the species had fluctuating populations in the estuary. However, five species had notable irruptions interspersed with periods when they were absent or present only in low numbers: Pink-eared Duck *Malacorhynchus membranaceus*, Grey Teal, Hardhead *Aythya australis*, Australasian Shoveler and Eurasian Coot. The populations of Hoary-headed Grebe *Poliocephalus poliocephalus* and three crake species also displayed irruptive tendencies but the peak counts for all of them were relatively low.

The Hunter Estuary was confirmed to be important for Chestnut Teal. At least 1% of its total population was often present and the peak count of 3,856 birds in March 2017 represented almost 4% of the population. All counts exceeding 1,000 birds were in summer or autumn, with the majority of them occurring in autumn.

INTRODUCTION

This is the fourth and final report in a series documenting the results of 22 continuous years of monthly surveys of shorebirds and waterbirds in the Hunter Estuary by members of Hunter Bird Observers Club. Previous reports dealt with shorebirds (Stuart & Lindsey 2021), large waterbirds (Lindsey & Stuart 2021) and gulls and terns (Lindsey & Stuart 2022). In this report we present the results for waterbirds from three families: Anatidae - waterfowl; Podicipedidae - grebes; and Rallidae - crakes, rails and gallinules.

During the surveys all shorebirds and waterbirds observed were counted. Most of the sites monitored were in Hunter Wetlands National Park, the Ash Island section of which is affected by a number of public utilities (Lindsey & Stuart 2021). Some ponds on Kooragang Island on land owned by Newcastle Coal and Infrastructure Group (NCIG) were also surveyed. Because the focus was to ascertain usage by shorebirds, tidally-influenced sites where shorebirds were most likely to be found were chosen. Some sites which were initially important have since disappeared e.g. Big Pond on Kooragang Island (Stuart & Lindsey 2021). Sites monitored included some but not all freshwater wetlands in the lower Hunter Valley. Many of the species mentioned in this article prefer freshwater wetlands. The main omissions were the wetlands around Shortland, which often host considerable numbers of waterbirds (Stuart 2018). In the same time frame (1999-2021) as the surveys analysed in this report, some of the Shortland wetlands were monitored regularly (Stuart 2018), but not all of them and the surveys were not done on the same day as the Hunter Estuary surveys. Thus it is difficult to merge the results and analyse them together. Other important freshwater wetlands, such as those around Tarro and Woodberry, were surveyed irregularly at best.

METHODS

Once each month, coinciding with a Saturday morning high tide in the estuary, multiple teams simultaneously visited sites where shorebirds could be expected to be found. At those sites, counts were made of all the shorebirds present and of all other waterbirds. A detailed description of the survey methodology has been prepared (BirdLife Australia 2021).

Each month the results from each individual site were entered into Birdata (www.birdata.com.au). The monthly total numbers were also entered into a Microsoft Excel spreadsheet along with general notes (e.g. if any site had not been able to be surveyed that month). We used that spreadsheet as the basis for this report. To analyse the results, we used standard Excel graphing and data analysis tools. When comparing populations for two time periods we assessed if the changes were statistically significant by carrying out two-tailed t-tests assuming unequal variances ($\alpha < 0.05$) and determining the probability P of the change being significant. For P values below 0.05 we classified the differences as significant, and as highly significant for $P < 0.01$. We consider our use of t-tests to be justified as the count data were normally distributed and therefore the data can be treated as continuous; also the standard deviation was known and the sample size was above 30 (https://vitalflux.com/when-to-use-z-test-vs-t-test-differences-examples/, accessed 14 June 2022).

To assess long-term population trends, we compared the counts for two time periods - those for the first 11 years of surveys and those for the subsequent 11 years. For seasonal comparisons, we grouped the data into December-February ("summer"), March-May ("autumn"), June-August ("winter") and September-November ("spring"). We also compared seasonal data for the two 11-year time periods.

RESULTS

There were 263 surveys done in the 22-year period, of the 264 possible. In some surveys not every site was visited, because of access problems on the given day. When we assessed shorebird and gull and tern populations in the estuary (Stuart & Lindsey 2021; Lindsey & Stuart in preparation), some of those surveys were excluded from analysis. However, for the present study we concluded that the total waterbird counts would not have been greatly affected, and thus we have used the results from all 263 surveys.

Twenty-seven species of small waterbird were recorded in the estuary during 1999-2021. **Table 1** lists the species, the number of records for each and their Reporting Rate (RR, the ratio of number of records to number of surveys, expressed as a percentage).

Three species had RRs above 90% - Black Swan *Cygnus atratus*, Pacific Black Duck *Anas superciliosa* and Chestnut Teal *A. castanea* - and seven other species had RRs above 50%. Status summaries for all 27 species are detailed below. Only the species with more than 60 records were analysed for trends. Results from two-tailed t-tests for species with complex patterns of occurrence are presented in the **Appendix** (available on-line at https://www.hboc.org.au/the-whistler/the-whistler-volume-16/).

Table 1. Waterfowl, grebe, crake, rail and gallinule species recorded in monthly surveys of the Hunter Estuary spanning 1999-2021, with their number of records and Reporting Rates (RR).

Species	Times recorded	RR (%)	Max. count
Magpie Goose	9	3.4	36
Wandering Whistling-Duck	10	3.8	18
Blue-billed Duck	5	1.9	4
Musk Duck	116	44.1	12
Pink-eared Duck	66	25.1	338
Freckled Duck	6	2.3	6
Black Swan	255	97.0	429
Australian Shelduck	5	1.9	4
Australian Wood Duck	151	57.4	101
Hardhead	167	63.5	823
Australasian Shoveler	152	57.8	382
Pacific Black Duck	241	91.6	480
Mallard	13	4.9	5
Grey Teal	216	82.1	3659
Chestnut Teal	259	98.5	3856
Australasian Grebe	179	68.1	131
Hoary-headed Grebe	149	56.7	146
Great Crested Grebe	3	1.1	2
Lewin's Rail	6	2.3	2
Buff-banded Rail	35	13.3	4
Australian Spotted Crake	25	9.5	10
Baillon's Crake	12	4.6	4
Spotless Crake	13	4.9	2
Purple Swamphen	191	72.6	149
Dusky Moorhen	102	38.8	36
Black-tailed Native-hen	3	1.1	3
Eurasian Coot	126	47.9	1339

Musk Duck

During 2005-13 there were frequent records of Musk Duck *Biziura lobata* (mainly from Deep Pond) including several of 10-12 birds (see **Figure 1a**). Prior to that, some birds were present during 2000-01. After 2014 there were intermittent records of 1-4 birds. There were no significant seasonal differences.

Pink-eared Duck

There were several influxes of the Pink-eared Duck *Malacorhynchus membranaceus*, when 100 or more birds were in the estuary, and often for periods of many months (see **Figure 1b**). The main influxes occurred in 2005-09, 2013-15, 2017 and late 2018. There were no statistically significant differences in the overall or seasonal results.

Black Swan

Black Swan were absent in only eight of the surveys, and most records were of at least 50 birds (**Figure 1c**). In 2000-01 and in 2014-2021 there were many records of more than 200 birds. Swans were more abundant in winter, with a mean count of 101 birds for the 22 years of winter surveys compared with 62-89 birds for the three other seasons. The differences between winter and summer (mean count of 62 birds) was statistically highly significant ($P < 0.01$) - see **Appendix** for details.

The overall numbers in the estuary rose in the second 11-year time period (**Figure 2a**). For spring the differences for the two time periods were small but for the three other seasons the differences were assessed to be statistically highly significant ($P < 0.01$ in all three cases - see **Appendix** for details). For example, for autumn the mean count rose from 53 to 127 birds.

Australian Wood Duck

Records for Australian Wood Duck *Chenonetta jubata* were infrequent in 1999-2004 but after that birds were present in more than 60% of the surveys. The typical numbers were of 15-30 birds but there were several records of more than 50 birds and two records of *c*100 birds (**Figure 3a**). There were no significant seasonal patterns. For every season, there was an increase in the numbers of birds present between the first and the second 11-year time periods (see **Figure 2b**). For summer and winter, the changes were not significant (although P 0.057 for summer). For autumn and spring, the changes were statistically significant, with the autumn means rising from five to 16 birds across the two time periods and the spring means rising from four to ten birds (see **Appendix** for further detail).

Hardhead

For Hardhead *Aythya australis*, there were no significant seasonal patterns nor any significant long-term population changes. However, there were many shorter-term changes (**Figure 3b**). When present, the typical counts were of 50-100 birds but there were several influxes involving hundreds of birds. In 2005-2007, there were many records of more than 100 birds and the peak counts were 611 birds in May 2005, 550 birds in October 2006 and 823 birds in May 2007. After that the influxes were smaller, but 452 birds were recorded in December 2018. There were very few records during 1999-2004, 2010, 2016 and 2019-2021.

Australasian Shoveler

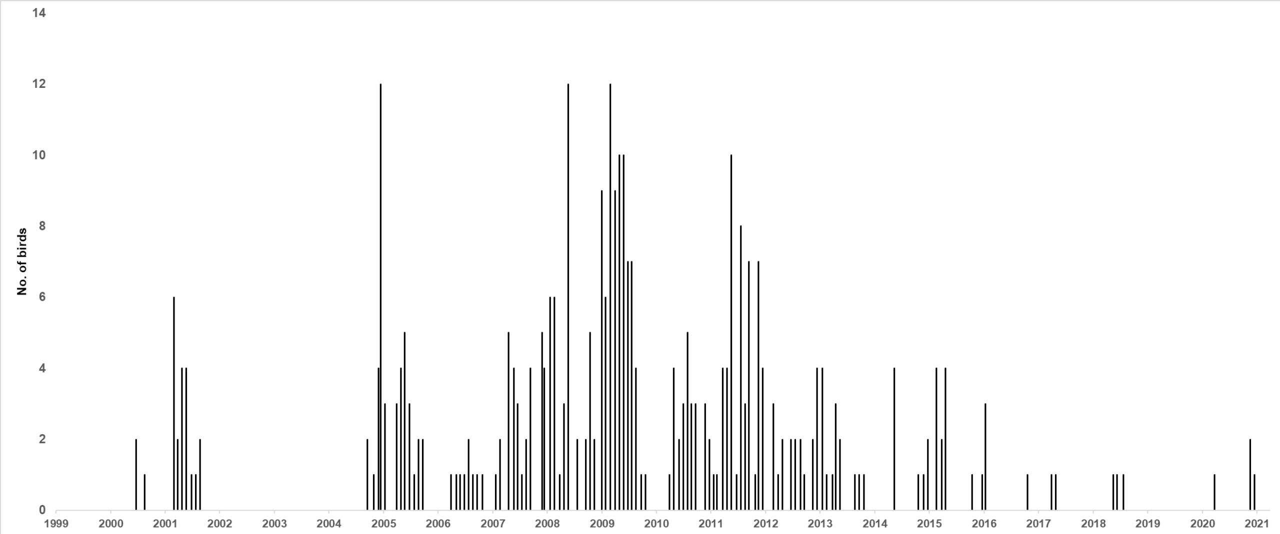
When present, the typical counts for Australasian Shoveler *Spatula rhynchotis* were of 20-50 birds but there were very few records during 1999-2000, mid-2010 to mid-2013 and 2019-2020. There were several influxes involving hundreds of birds, with a peak count of 382 birds in April 2015 (**Figure 3c**).

There were many seasonal differences, as shown in **Figure 2c**. For the full 22-year period, numbers peaked in autumn and the differences in numbers were significantly different for every season except for autumn and winter. However, in the second 11-year period the autumn and winter counts were found to be statistically significantly different but not the summer and winter counts - see **Appendix** for details.

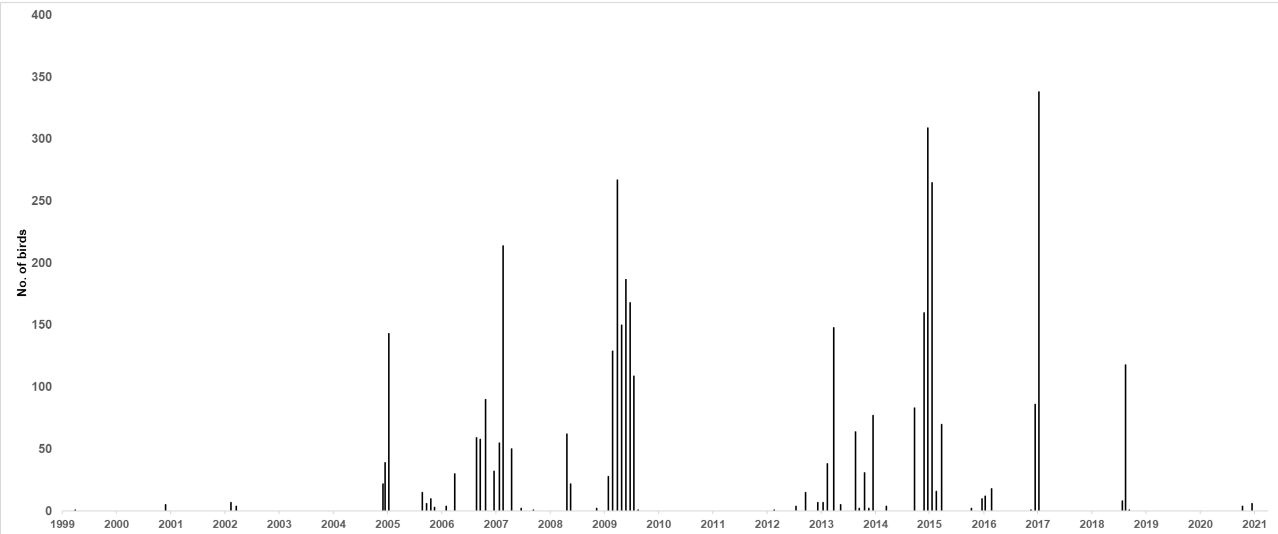
Pacific Black Duck

Of the waterfowl, Pacific Black Duck was the third most commonly recorded species in the estuary over 1999-2021. Prior to 2005 it was recorded only in low numbers; however, the second-highest count, of 447 birds, occurred in March 2005. The highest count was 480 birds in January 2017 and there were several influxes where more than 100 birds were present (**Figure 4a**).

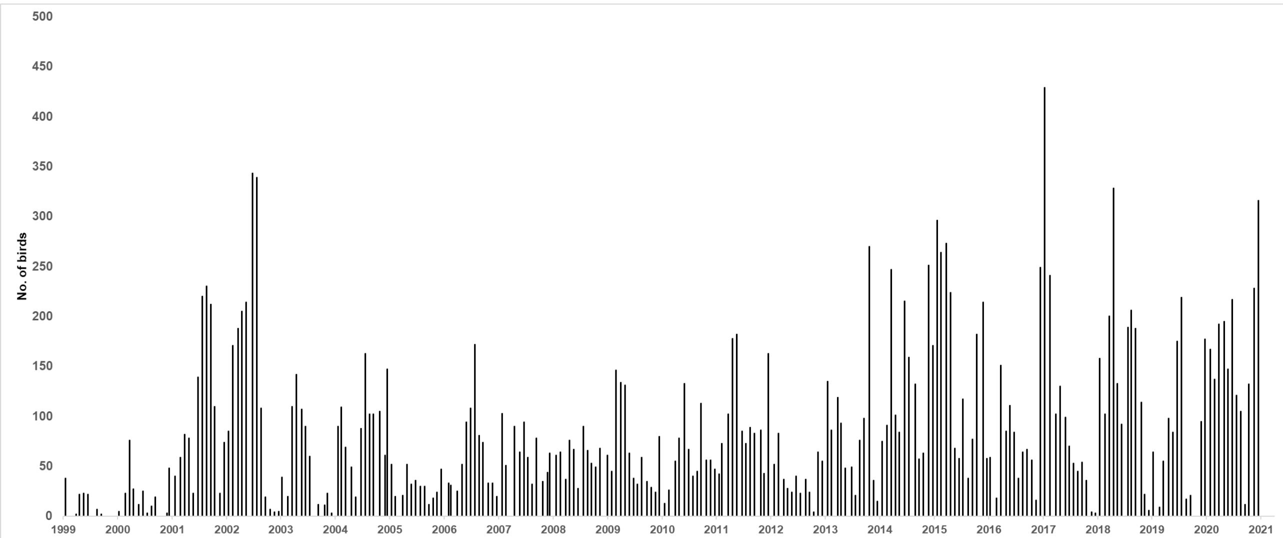
Since 2005, the population has been stable over the long term. However, there have been notable seasonal differences, as **Figure 2d** indicates. Numbers have been greatest in the summer and autumn periods (22-year means of 67-75 birds compared with 31-38 birds, and similar seasonal patterns for the two 11-year time periods). Many of the differences were statistically significant or highly significant (see **Appendix** for details). The summer population was stable across the two 11-



(a) Musk Duck



(b) Pink-eared Duck

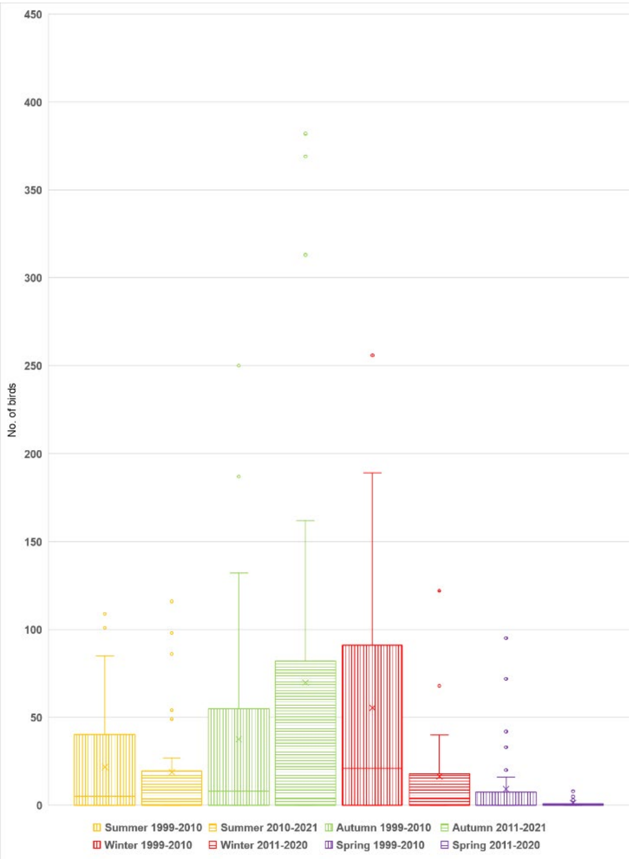


(c) Black Swan

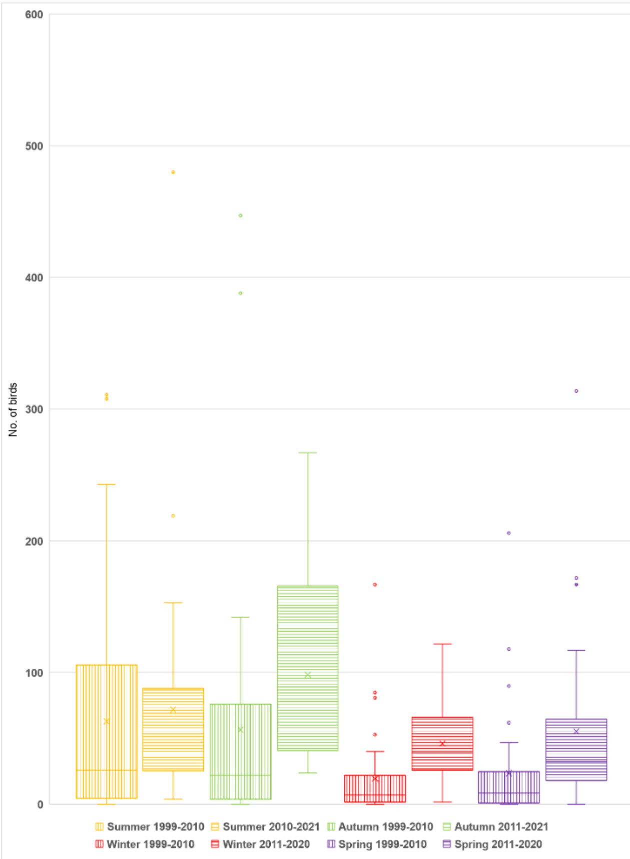
Figure 1. Monthly counts for a) Musk Duck, b) Pink-eared Duck and c) Black Swan in the Hunter Estuary 1999-2021.

(a) Black Swan

(b) Australian Wood Duck



(c) Australasian Shoveler



(d) Pacific Black Duck

Figure 2. Box and whisker plots for seasonal counts for a) Black Swan, b) Australian Wood Duck, c) Australasian Shoveler and d) Pacific Black Duck in the Hunter Estuary for two time periods: 1999-2010 and 2011-2021.

year time periods but the autumn, winter and spring populations all rose. The differences for winter were statistically significant, and they were highly significant for spring.

Grey Teal

The numbers of Grey Teal in the estuary fluctuated considerably. Sometimes birds were absent or were present only in low numbers, but there were also many influxes when 1,000 or more birds were present (**Figure 4b**). More than 2,000 birds were recorded in April 2005 and frequently during 2014-2018.

The seasonal pattern of occurrence changed over time (see **Figure 5a**). In the first 11-year period of surveys, the numbers present in summer, autumn and winter were similar and there was a statistically significant decrease in spring (mean counts of 55 birds for spring compared with 130-260 birds in the other seasons). In the second 11-year period, the counts for every season increased substantially. The differences for autumn, winter and spring across the two 11-year time periods were statistically significant or highly significant - see **Appendix** for details. There was no longer a trend for birds to depart in spring. The lowest counts occurred in summer even though the summer counts had risen. The difference in summer and autumn counts was statistically significant (mean counts of 309 birds for summer compared with 797 birds in autumn).

Chestnut Teal

Chestnut Teal were recorded in all except four of the 263 surveys. Their numbers fluctuated but it was common for at least 500 birds to be present (**Figure 4c**). On 22 surveys, there were more than 1,000 birds, i.e. more than 1% of the estimated south-eastern population of Australia, and the peak count of 3,856 birds in March 2017 represented almost 4% of that population. All of the counts exceeding 1,000 birds were in summer or autumn, with the majority of them occurring in autumn. The differences between the summer and autumn numbers and those for winter and spring were statistically highly significant (22-year mean counts of 453 birds (summer) and 656 birds (autumn) compared with 173 and 123 birds for winter and spring respectively) - see **Appendix** for details.

The mean counts for autumn and spring rose across the two 11-year time periods but only the spring change was statistically significant (see **Appendix**). **Figure 5b** shows the seasonal counts for the two 11-year time periods.

Australasian Grebe

Birds were absent or present in low numbers from 1999 to mid-2005, and in 2010 and 2019-20. At other times, there were periods during which more than 50 birds were often present (**Figure 6a**), in particular mid-2005 to 2009 and 2011 to 2013. The peak count of 131 birds was in May 2012. In general, when there were many birds in the estuary, most of them were at Deep Pond.

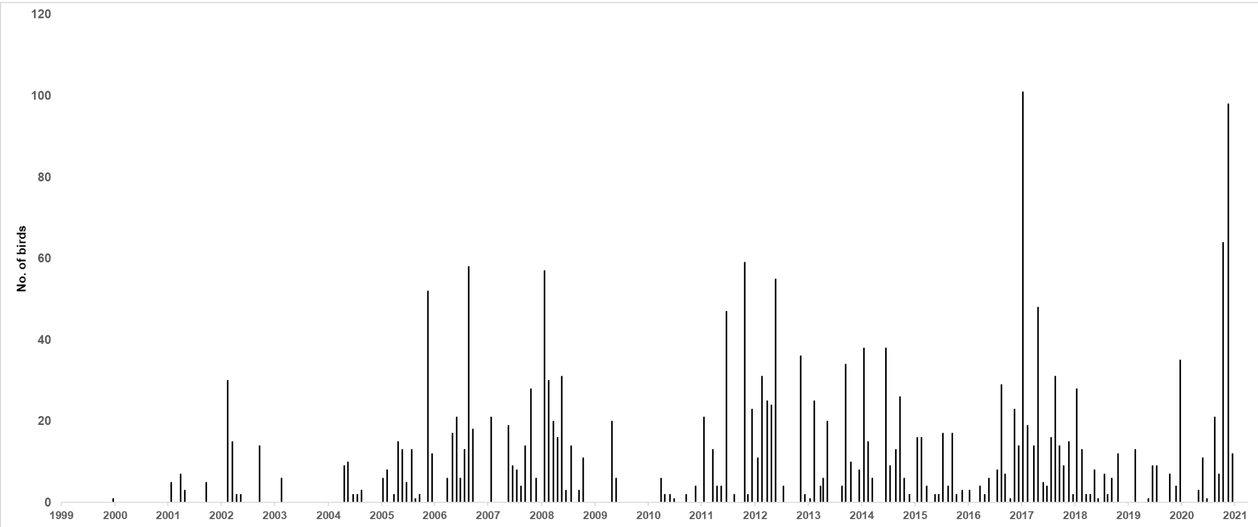
There were fewer birds present in summer than any of the other three seasons (**Figure 5c**). The differences between the summer and either the autumn or winter 22-year means were statistically significant (mean counts of nine birds compared with 18 and 15 birds respectively) - see **Appendix** for details.

For every season, the mean counts for the second 11-year period were greater than for the first 11-year period. However, the changes were only statistically significant for autumn (for which the mean rose from 11 birds to 26 birds) - see **Appendix** for details.

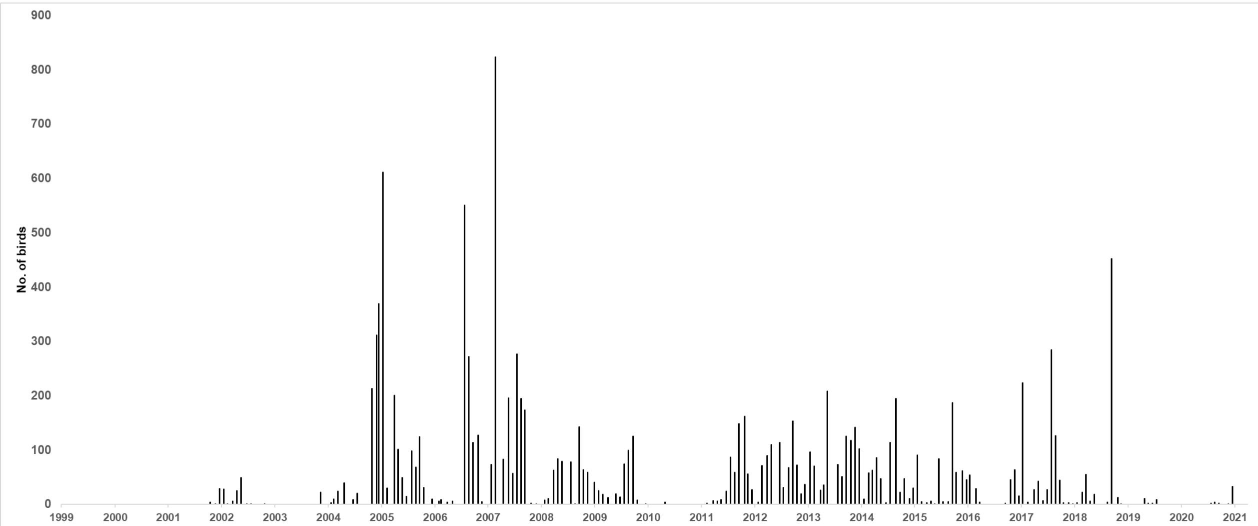
Hoary-headed Grebe

The pattern of records for Hoary-headed Grebe *Poliocephalus poliocephalus* (**Figure 6b**) was broadly similar to that for Australasian Grebe. Birds were absent or present in low numbers from 1999 to mid-2005, and in 2010 and 2019-20, while for 2005 to 2009, 30 or more birds often were present. However, the numbers rose from the beginning of 2005, not from mid-year, and the second period of sustained high numbers spanned 2014 to mid-2017, not 2011-2013 (although some birds had returned by October 2011). In general, when there were many birds in the estuary, most of them were at Deep Pond.

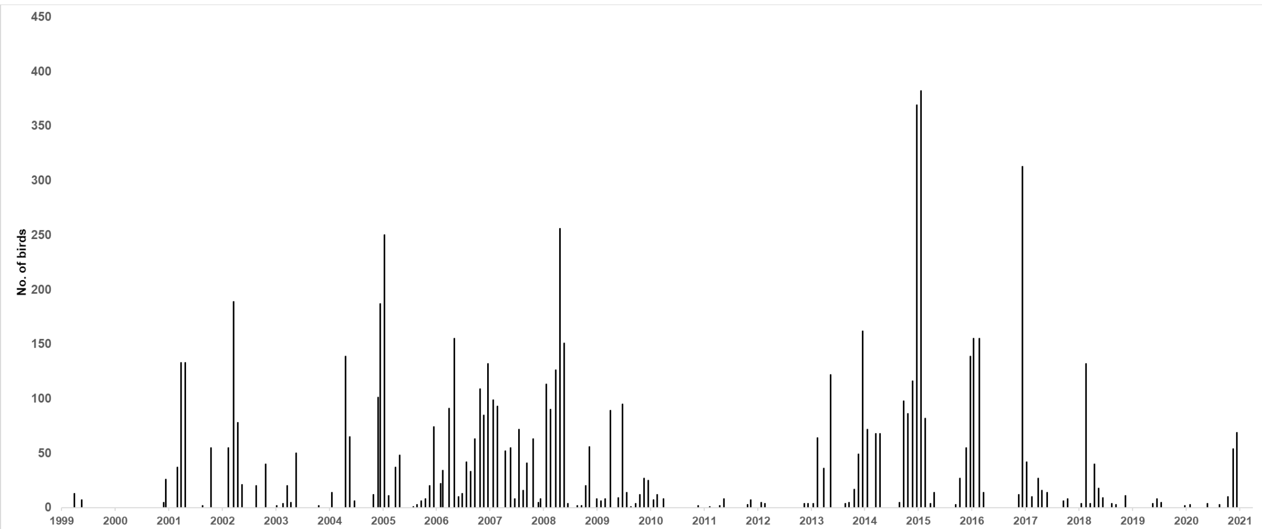
For the first 11-year period there were no significant seasonal differences (**Figure 5d**). In the second 11-year period, the counts rose for autumn and fell for winter and spring. As a result, there was a statistically significant difference to the mean count for autumn (16 birds) compared with either winter or spring (both with means of five birds). Only the changes for spring across the two 11-year periods were statistically significant - see **Appendix** for details.



(a) Australian Wood Duck

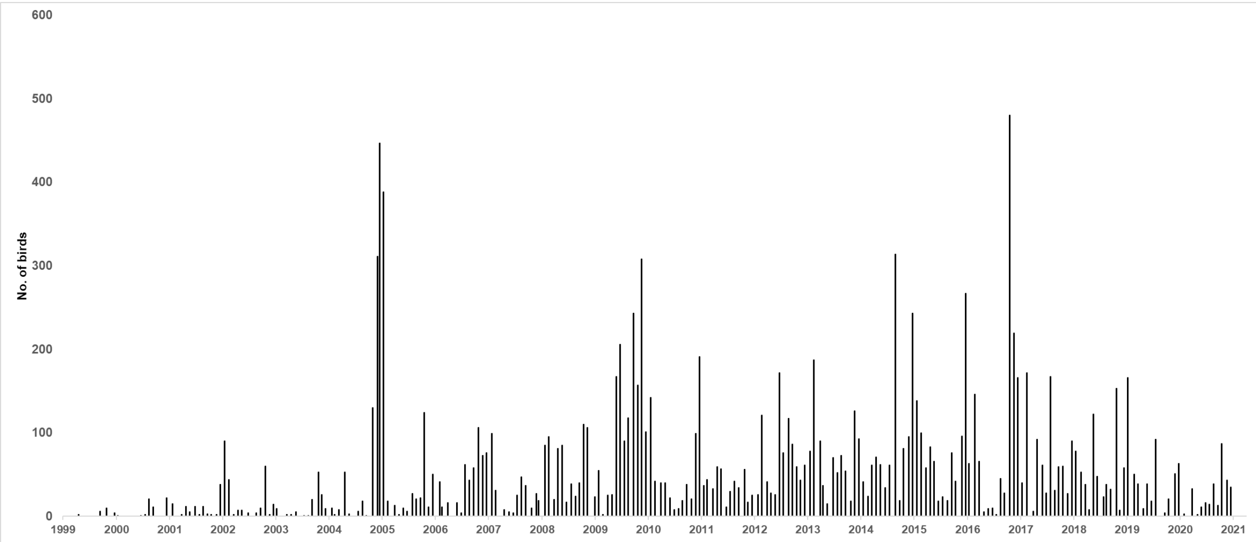


(b) Hardhead

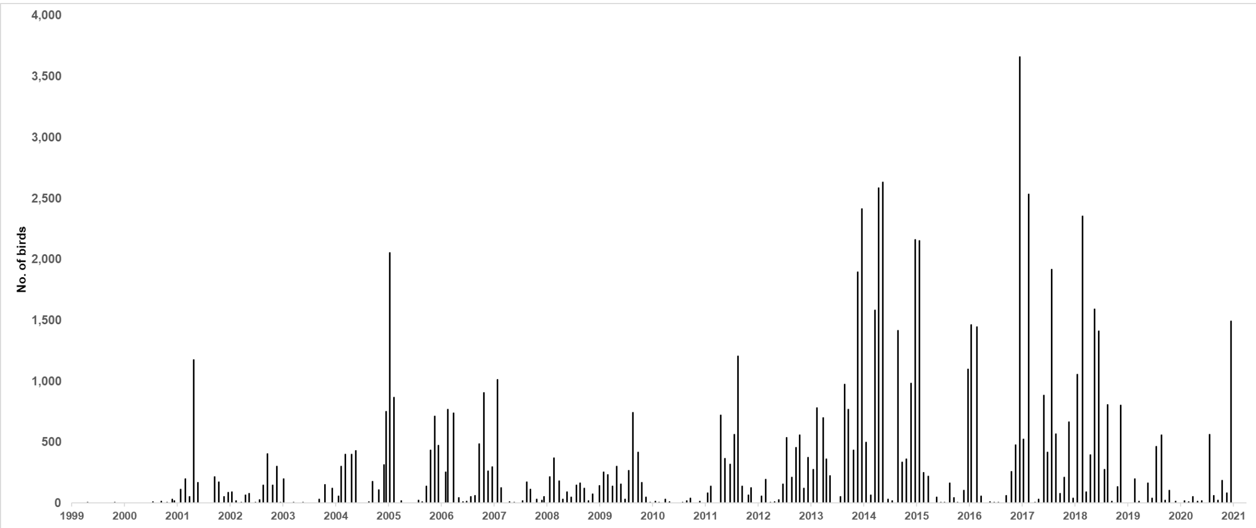


(c) Australasian Shoveler

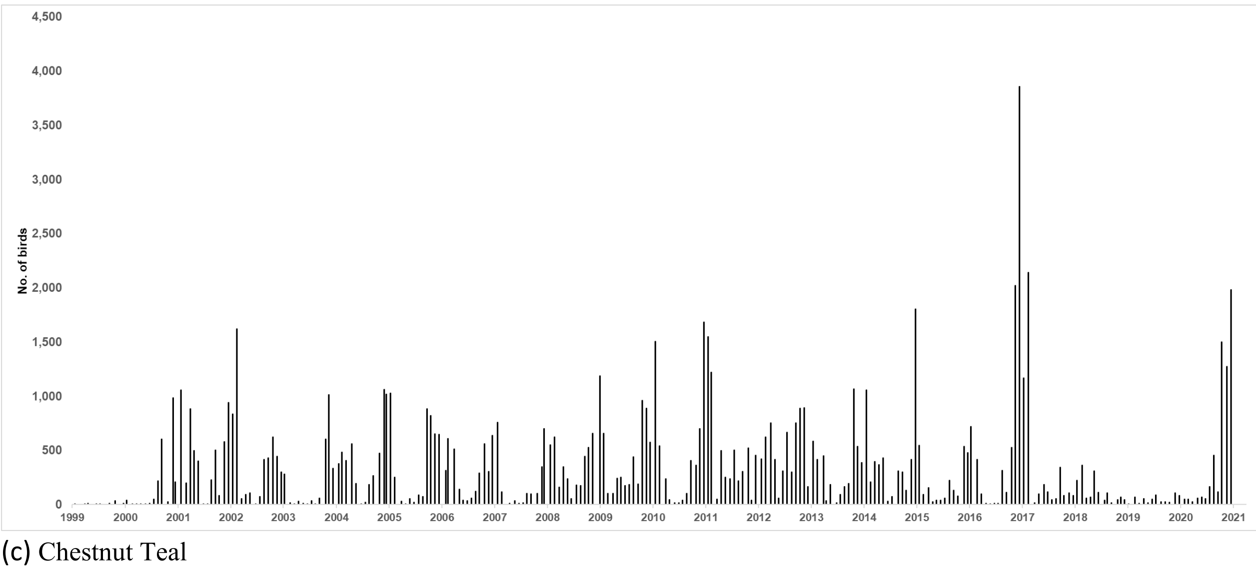
Figure 3. Monthly counts for a) Australian Wood Duck, b) Hardhead and c) Australasian Shoveler in the Hunter Estuary 1999-2021.



(a) Pacific Black Duck



(b) Grey Teal



(c) Chestnut Teal

Figure 4. Monthly counts for a) Pacific Black Duck, b) Grey Teal and c) Chestnut Teal in the Hunter Estuary 1999-2021.

Purple Swamphen

Records of Purple Swamphen *Porphyrio porphyrio* were infrequent prior to 2005. After that, up to 40 birds often were present (**Figure 6c**). During 2011-16 the counts frequently were higher, particularly in 2013-14 which included the peak count of 149 birds in December 2013. There were no statistically significant seasonal differences; however, for every season there was a statistically highly significant increase in numbers for the second 11-year time period compared to those for the first eleven years (as evident in **Figure 7a**; see **Appendix** for details).

Dusky Moorhen

Dusky Moorhen *Gallinula tenebrosa* were recorded less frequently than most of the common waterbirds and usually with fewer than ten birds (**Figure 8**). The peak counts of 36 birds occurred in April 2005 and May 2012. The mean counts for every season were of just 1-3 birds and there were no seasonal trends. The numbers present in any season rose somewhat in the second 11-year period (see **Figure 7b**) but no differences were statistically significant.

Eurasian Coot

Eurasian Coot *Fulica atra* were recorded infrequently until 2012 although with occasional periods of several months where up to c200 birds were present (**Figure 9**). From late 2011 until mid-2016, large numbers were often present including several records of more than 400 birds. The peak count, 1339 birds, was in January 2014. Another influx, of shorter duration, occurred in late 2018 and early 2019.

There were no significant seasonal differences but, for every season the differences in numbers for the first and second 11-year periods were statistically significant or highly significant (**Figure 10**, and see **Appendix** for details). The seasonal means rose from 17-28 birds, to 119-208 birds.

Uncommon waterfowl

Seven of the nine records of Magpie Goose *Anseranus semipalmata* were in summer, with one autumn record (13 March 2021, six birds) and by far the greatest count, of 36 birds, occurring in spring (13 October 2012). All the records were from 2007 onwards.

There were two records of Wandering Whistling-duck *Dendrocygna arcuata* in 2005 (February-March) and one in February 2012; the other seven records spanned 2016-2018. Six of the ten records were in summer months and none were in winter.

A few Blue-billed Duck *Oxyura australia* were recorded in July-September 2005 (the maximum count of four birds was in August) and 2-3 birds were present in July-August 2007.

All six records of Freckled Duck *Stictonetta naevosa* were in summer months, with peak counts of six birds in December 2006, five birds in December 2018 and three birds in January 2006. The three other records were of single birds (in January-February 2014 and December 2017).

Three of the five records for Australian Shelduck *Tadorna tadornoides* occurred in December (one to two birds in 2006 and 2007; four birds in 2020). The other two records were in winter - two birds in May 2012 and a single bird in June 2020.

Of the 13 records for Mallard *Anas platyrhynchos*, eight of them occurred between May 2015 and May 2016 including up to five birds present for May-July 2015. The other five records were of single birds, present intermittently and only briefly each time.

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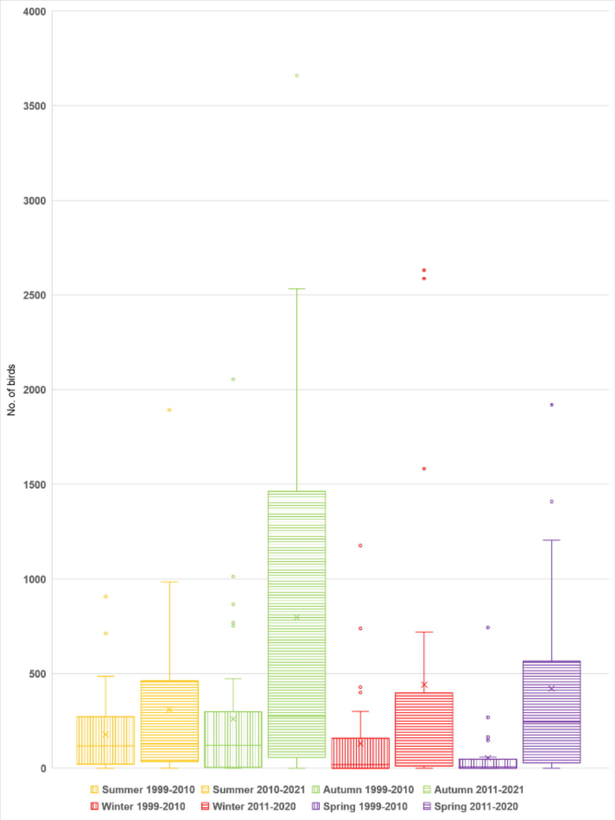
The three records of Great Crested Grebe *Podiceps cristatus* all occurred in late 2007, with two birds present in September-October and one bird in December. All the birds were at Deep Pond.

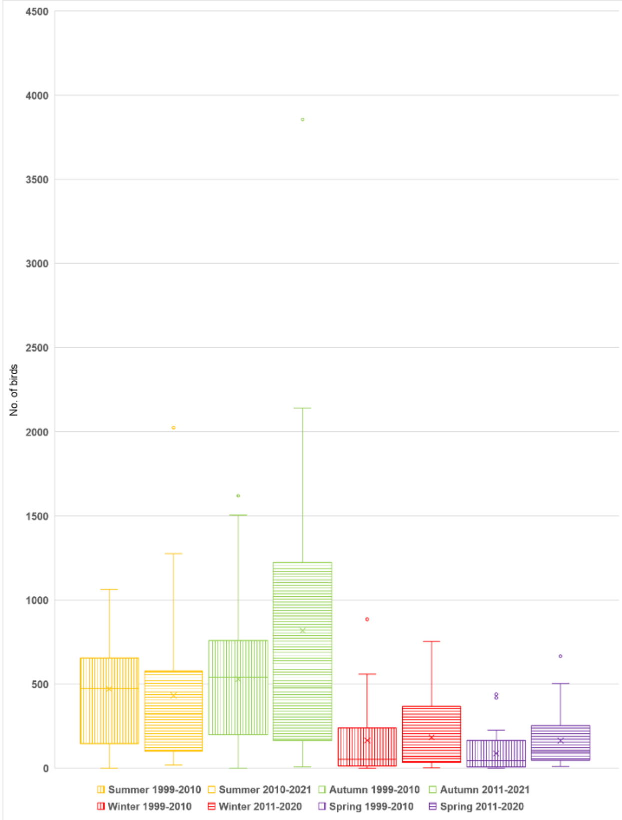
Uncommon crakes and rails

The six records of Lewin's Rail *Lewinia pectoralis* were in spring-summer. They mostly were of single birds; two birds were recorded in January 2021.

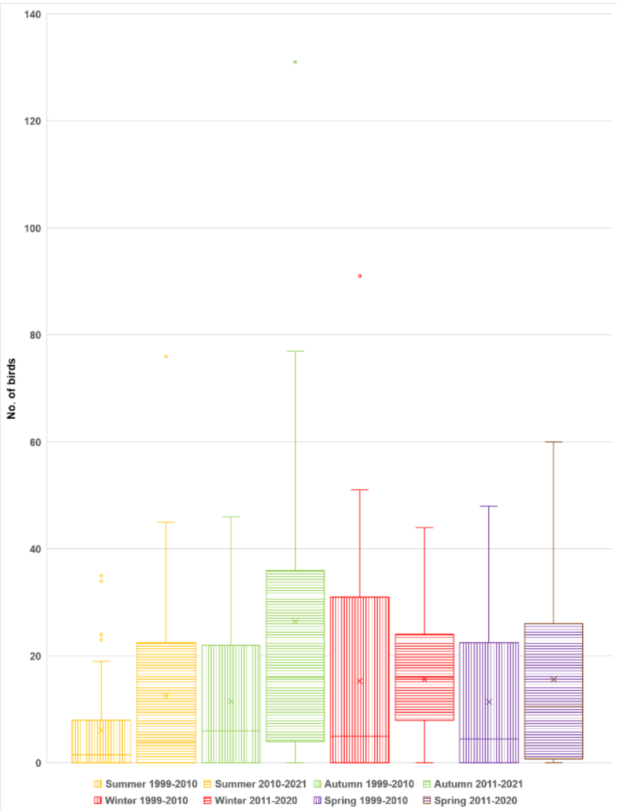
There were 35 records of Buff-banded Rail *Hypotaenidia philippensis*, usually of one to two birds but four birds were recorded in December 2011. There were about twice as many records in summer (with 15 records compared with 6-7 records for any other season). That was also the case for Australian Spotted Crake, with ten of the records being for summer and 4-6 records in each of the other seasons. Sometimes this species was recorded in relatively high numbers, with ten birds found in July 2014 and six birds in September 2014; there were five additional records of three to four birds.



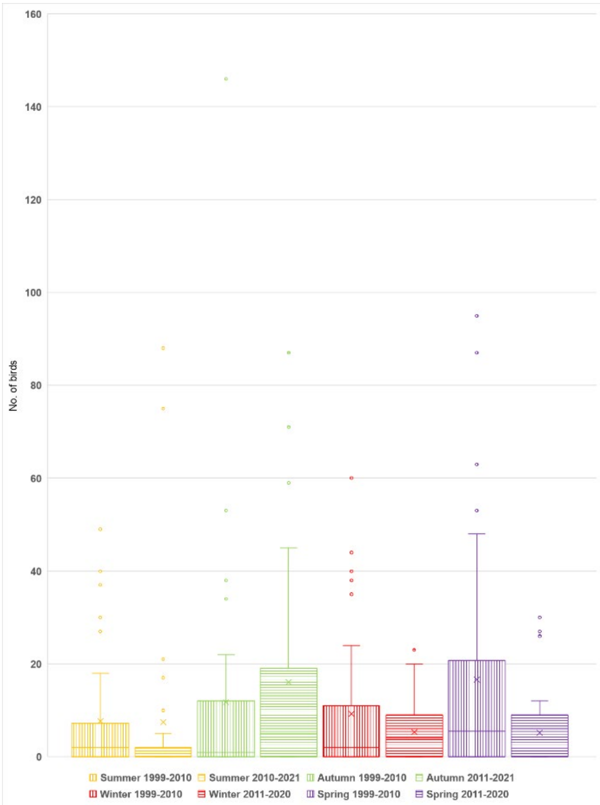
a) Grey Teal



b) Chestnut Teal

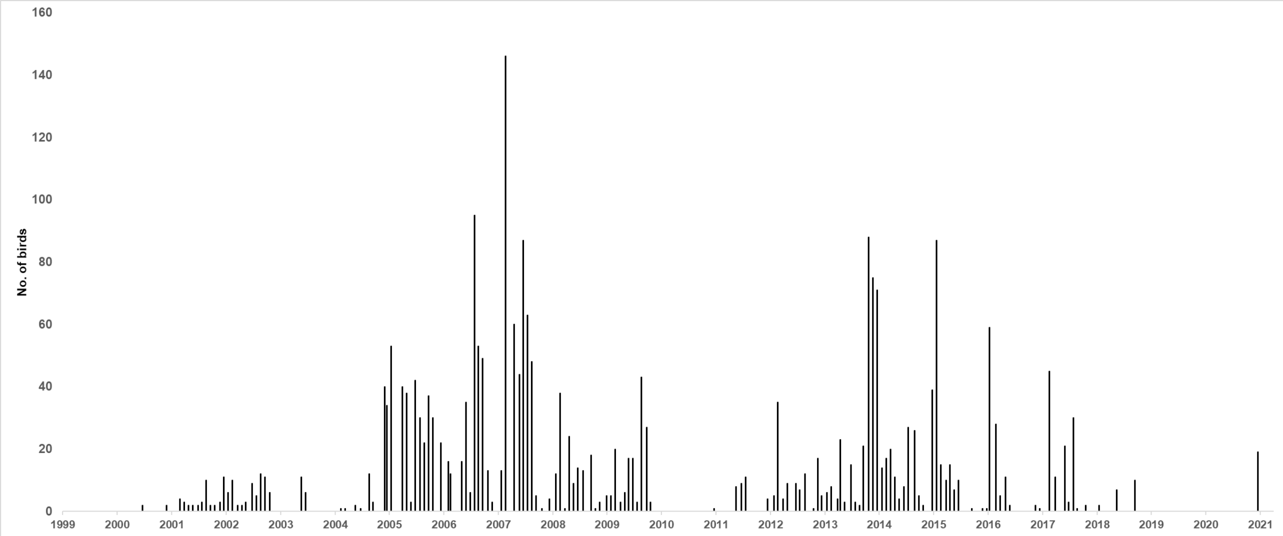


c) Australasian Grebe

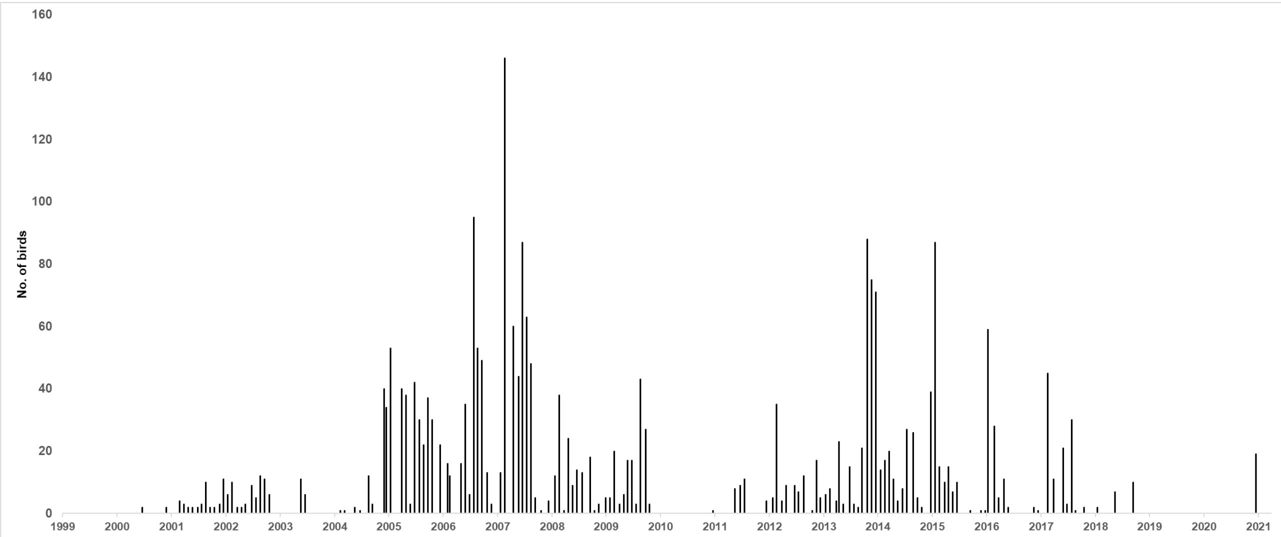


d) Hoary-headed Grebe

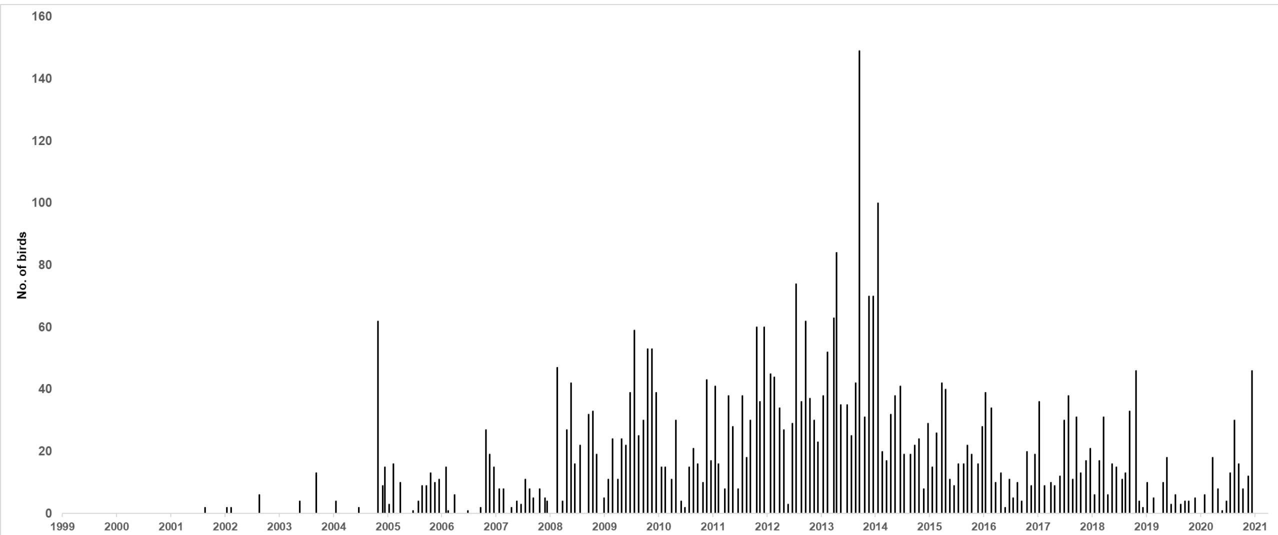
Figure 5. Box and whisker plots for seasonal counts for a) Grey Teal, b) Chestnut Teal, c) Australasian Grebe and d) Hoary-headed Grebe in the Hunter Estuary for two time periods.



(a) Australasian Grebe



(b) Hoary-headed Grebe

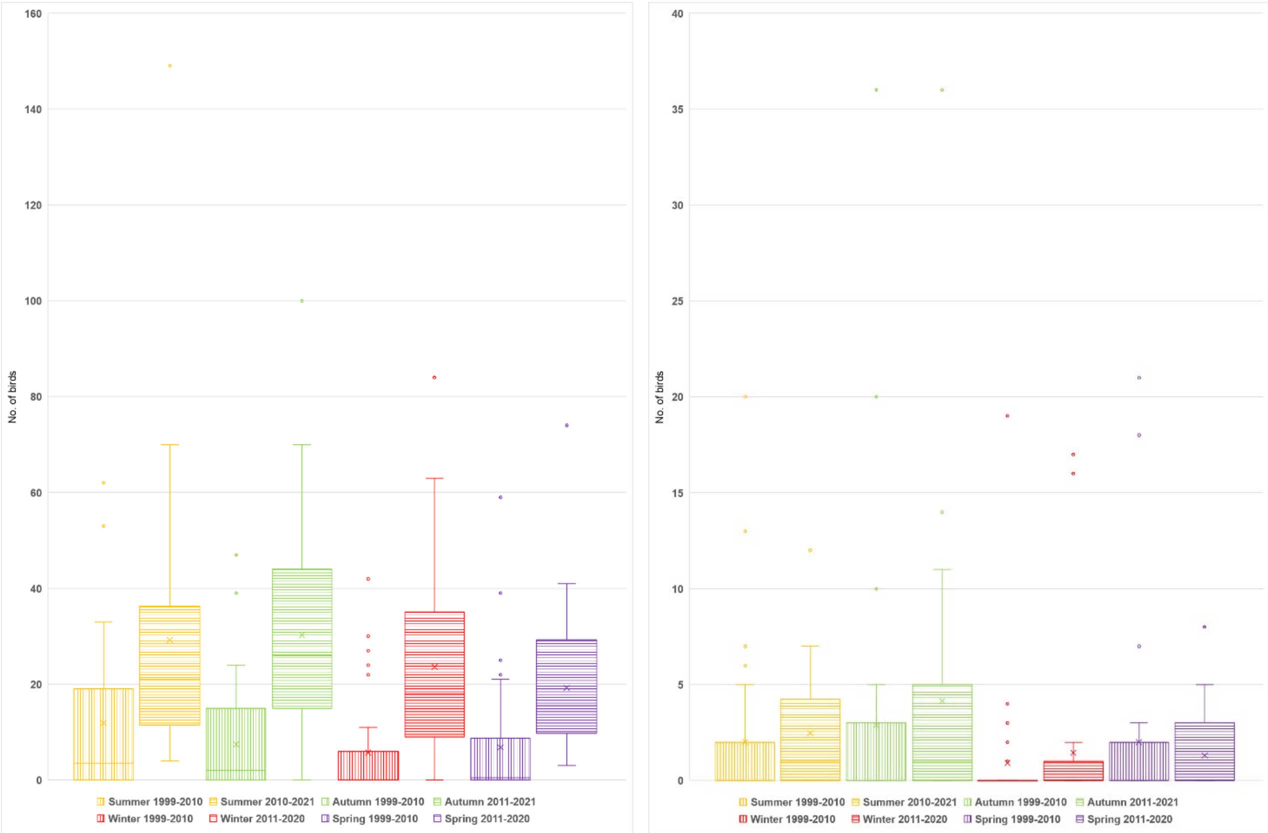


(c) Purple Swamphen

Figure 6. Monthly counts for a) Australasian Grebe, b) Hoary-headed Grebe and c) Purple Swamphen in the Hunter Estuary 1999-2021.

For Baillon's Crake *Zapornia pusilla* there *was* one winter record (in mid-August 2015). All other records were from spring or summer, with four birds recorded in December 2006 and one to two birds in all other records. For the Spotless Crake *Zapornia tabuensis*, there was one summer record, of a single bird in January 2018, and one winter record, of two birds in July 2014. All other records, which were of one to two birds were from autumn (six records) and spring (five records).

The three records of Black-tailed Native-hen *Tribonyx ventralis* involved two occurrences at Ash Island - three birds in May 2005 and a single bird during November-December 2009.



a) Purple Swamphen b) Dusky Moorhen

Figure 7. Box and whisker plots for seasonal counts for Purple Swamphen and Dusky Moorhen in the Hunter Estuary for two time periods.

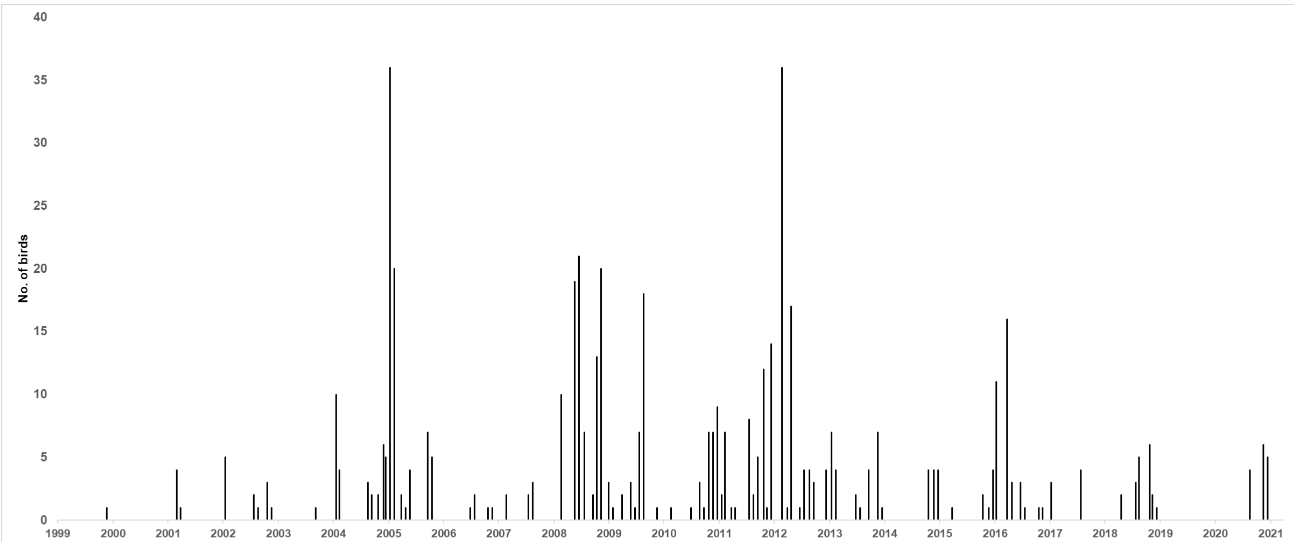


Figure 8. Monthly counts for Dusky Moorhen in the Hunter Estuary 1999-2021.

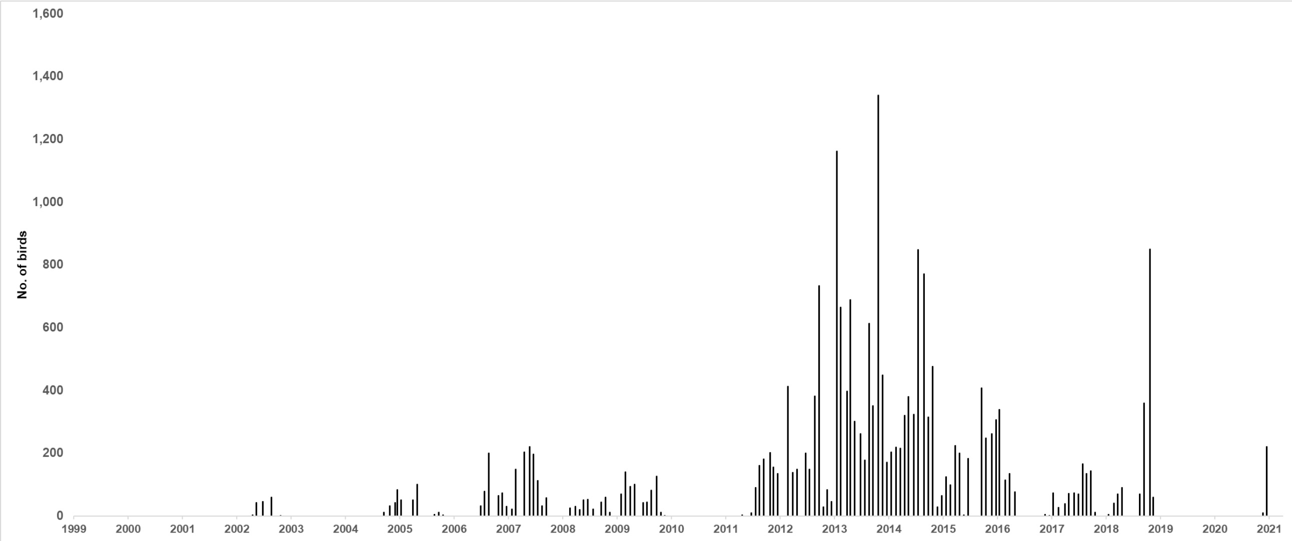


Figure 9. Monthly counts for Eurasian Coot in the Hunter Estuary 1999-2021.

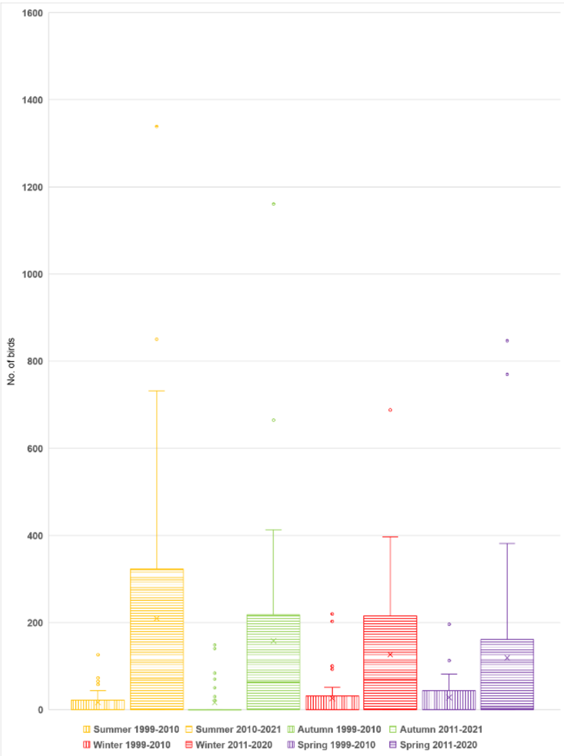


Figure 10. Box and whisker plots for seasonal counts for Eurasian Coot in the Hunter Estuary for two time periods.

Combined results

For the waterfowl, grebe, crake, rail and gallinule species considered in this report, it was common for there to be 500-1,000 birds in total in the estuary and there were many records of considerably more than 1,000 birds. The counts exceeded 4,000 on six occasions, with the peak count being 8,385 birds in March 2017.

Seven species dominated the records. They were Black Swan, Australasian Shoveler, Australian Wood Duck, Pacific Black Duck, Chestnut Teal, Grey Teal and Eurasian Coot. Australasian Shoveler and Eurasian Coot were the least important of those seven species, although still recorded in relatively high numbers (at times) compared with the 20 less abundant species. **Figure 11** is a histogram showing how those seven species dominated the records: for example, on 219 occasions (from 263 surveys) they comprised more than 80% of the total numbers of the waterfowl, grebe, crake, rail and gallinule species recorded in the estuary on that day.

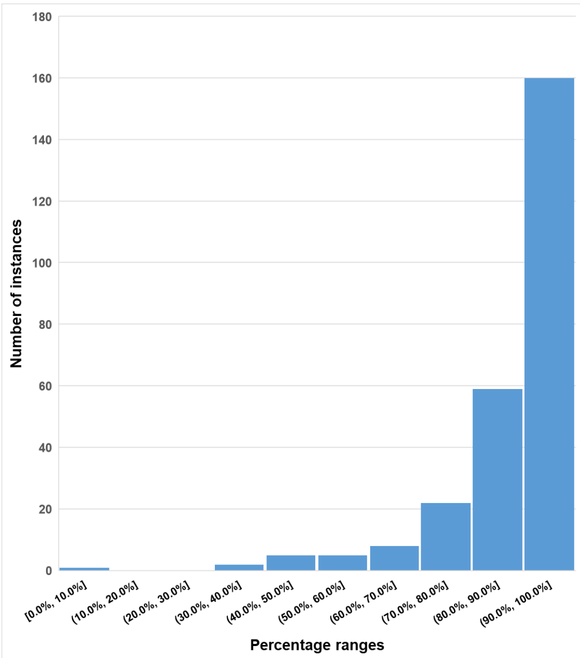


Figure 11. Histogram of records of the seven most abundant waterfowl, grebe, crake, rail and gallinule species in the Hunter Estuary as a percentage of the total numbers of all such species in the estuary, per month.

Seasonal differences

Figure 12 shows the monthly counts for all waterfowl, grebe, crake, rail and gallinule species, for each season. The summer counts were mostly of 500-1,500 birds, with lows in 1999/2000, 2007/08 and 2019/20 and highs (of more than 2,000 birds) in 2004/05, 2006/07, 2012/13-2014/15 (i.e. three summers in a row), 2016/17 and 2020/21. The autumn counts were generally of 1,000-2,000 birds, with low counts in 1999-2000, 2003-04 and 2019-20 and highs (of more than 3,000 birds) in 2005 and 2014-17 (i.e. three autumns in a row). Around half of the winter counts were of 500-1,500 birds but there were seven years with fewer than 500 birds recorded; conversely in five years there were more than 1,500 birds present and the peak winter counts in 2014 were of more than 3,000 birds. Similarly, in nine spring years there were fewer than 500 birds recorded while in six other years the counts exceeded 1,500 birds, peaking at 3,216 birds for spring 2014.

There was a strong bias towards autumn records, as the box and whiskers plots in **Figure 13** show. The autumn means for all waterfowl, grebe, crake, rail and gallinule species, over 22 years, were of 1,583 birds compared with means of 1,069 birds (summer) and 649-775 birds in winter and spring. All of the seasonal differences in means were assessed as being statistically significant or highly significant (see **Appendix** for details). For the first 11-year period the pattern was for summer and autumn counts to be high compared with the winter and spring counts (**Figure 14**). In the second 11-year period the autumn numbers rose substantially. The numbers for the other three seasons also rose but not to the same extent as those for autumn. The differences for autumn in the two 11-year periods were statistically highly significant (see **Appendix** for details).

DISCUSSION

An important consideration relates to the value of the information collected about this group of waterbirds in the Hunter Estuary surveys. Several freshwater wetlands which are known to be important for at least some of those species were not surveyed, e.g. the Hunter Wetlands Centre at Shortland (Lindsey & Stuart 2021). Thus, the data do not present a complete picture about the status of those waterbird species assessed in this paper in the Hunter Estuary. This issue seems more important for these guilds of birds than for the other guilds previously assessed (Stuart & Lindsey 2021; Lindsey & Stuart 2021; Lindsey & Stuart 2021). However, the data were collected systematically and for a well-defined area. Thus, it seems valid to identify trends and compare seasonal and longer-term results, all the while recognising that the information paints a picture about the status of small waterbirds within a subset of their overall habitat mosaic in the lower Hunter Valley.

Threatened species

Three species listed as Vulnerable under the NSW *Biodiversity Conservation Act 2016* were recorded in the surveys - Magpie Goose, Blue-billed Duck and Freckled Duck. All were uncommon species in the estuary. The two duck species are uncommon anywhere in the Hunter Region but there is a resident population of about 100 Magpie Goose in the lower Hunter Valley, found mainly at wetlands around Shortland (Williams 2020). This species prefers freshwater wetlands (Marchant & Higgins 1990) and most of the records from the surveys have been of birds at some freshwater swales on Ash Island. Eight of the records were in summer (December to February); however, six birds were recorded in mid-March in 2021 (at Deep Pond).

Population Trends

None of the species analysed were found to have decreasing populations, while seven species significantly increased in number over the course of 22 years of monitoring. These were: Black, Swan, Australian Wood Duck, Pacific Black Duck, Grey Teal, Chestnut Teal, Purple Swamphen and Eurasian Coot. All the increases appeared to be associated with the availability of newly-restored tidal wetlands at Hexham Swamp and Tomago Wetland, and to a lesser extent, at Ash Island, as discussed in the section *Effects of local rehabilitation projects*. However, inland rainfall patterns may also have had an effect, as is also discussed further below.

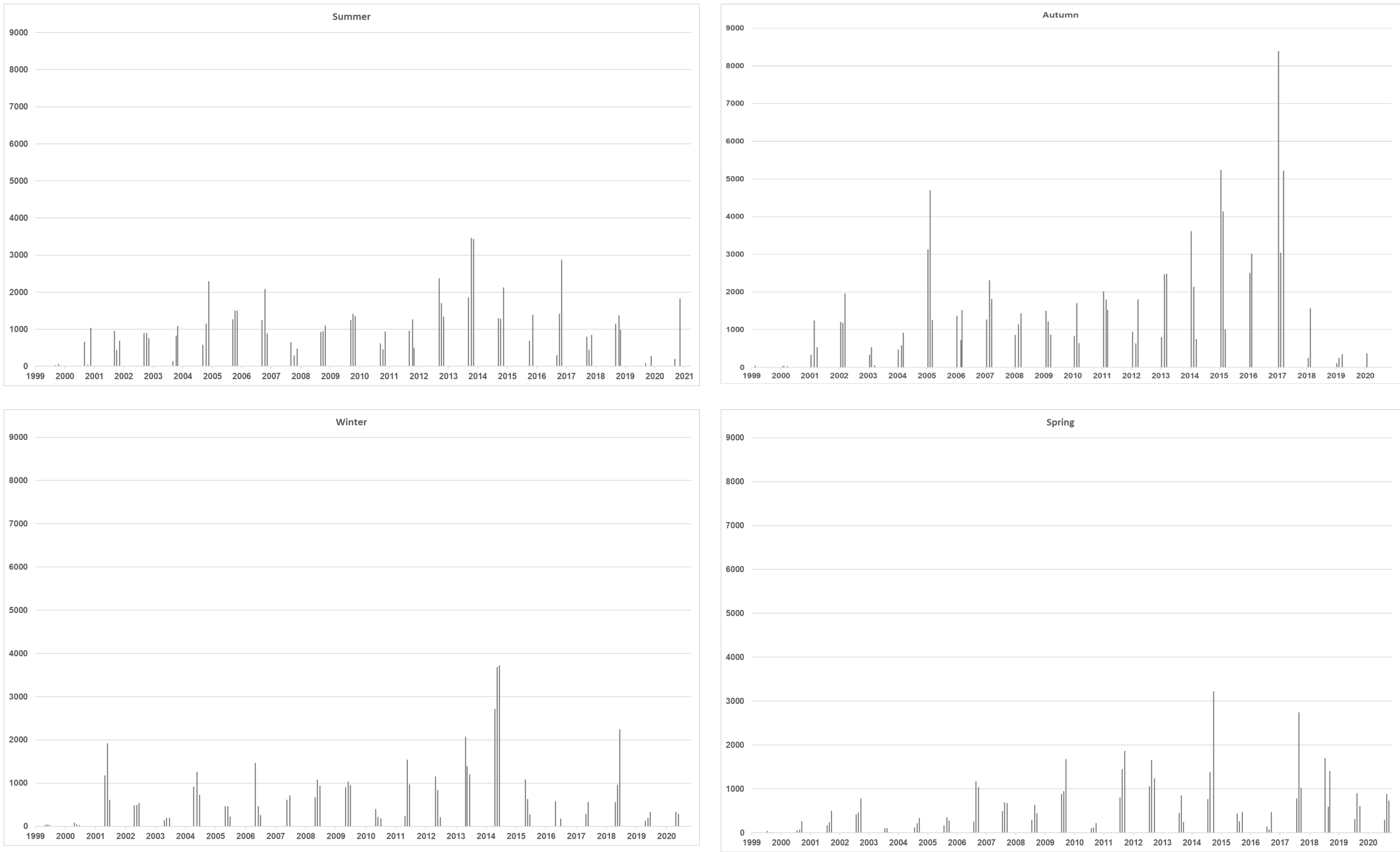


Figure 12. Monthly counts of waterfowl, grebe, crake, rail and gallinule species in the Hunter Estuary for each season.

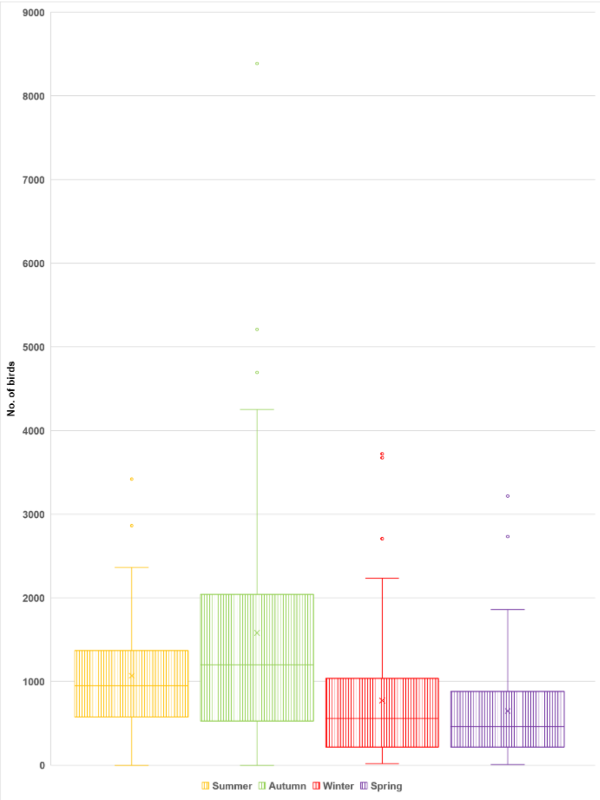


Figure 13. Box and whiskers plots showing the distribution of counts for waterfowl, grebe, crake, rail and gallinule species in each season.

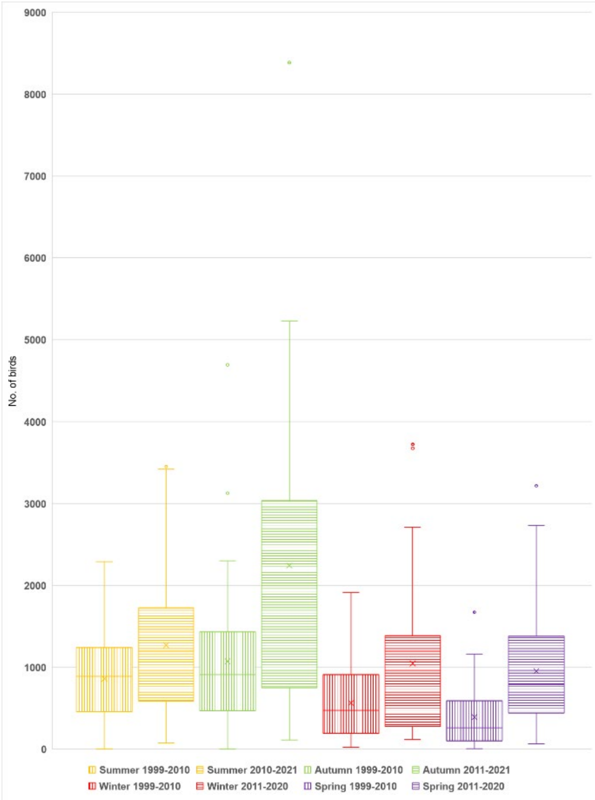


Figure 14. Box and whiskers plots showing the distribution of counts for waterfowl, grebe, crake, rail and gallinule species in each season for two successive 11-year time periods.

Seasonal Population Changes

Seven species exhibited significant seasonal changes in their populations in the estuary, as summarised in **Table 2**. Australasian Grebe numbers declined in summer, but only in the first 11-year period of the surveys, and the counts for Australasian Shoveler were much lower in spring. Five species had highest numbers in autumn (the Pacific Black Duck numbers were higher in summer as well) while Black Swan numbers peaked in winter. The presence/absence patterns have changed over time for Australasian Shoveler, Grey Teal and Australasian Grebe. Grey Teal had no strongly seasonal distribution pattern in the first 11-year period, then in the second 11-years its numbers rose in autumn. In the first eleven years the summer counts for Australasian Grebe were slightly lower than the counts for the other seasons, but in the second 11-year period the differences became statistically significant. The changes for Australasian Shoveler were discussed earlier.

Table 2. Species with significantly different seasonal populations. Symbols ✓ in the table indicate seasons where the population for that species increases significantly. Symbols X indicate seasons where there is a significant decrease.

	Summer	Autumn	Winter	Spring
Black Swan			✓	
Australasian Shoveler		✓		X
Pacific Black Duck	✓	✓		
Grey Teal		✓		
Chestnut Teal		✓		
Australasian Grebe		✓		
Hoary-headed Grebe	X			

The autumn peak for Australasian Shoveler aligns with the results from a two-year study at Western Treatment Plant in Victoria, where there was a tendency for the highest numbers to occur in late summer to early autumn (Hamilton & Taylor 2004). Gosper (1981) noted that there was a seasonal influx of Pacific Black Duck into the Hunter and Richmond valleys but he found the greater numbers were in the autumn and winter populations rather than the summer and spring ones.

Black Swan are known to breed on the coast between mid-May and October (Cooper *et al.* 2014) and it is possible that the increase in the estuary is due to birds arriving in search of breeding opportunities. However, a study of breeding at two lagoons on the New England Tableland suggested that breeding may be as much about opportunity as about season (White 1986).

Effects of local rehabilitation projects

Habitat for waterbirds is comprised of wetlands and their surrounding edges and these are among the most threatened ecosystems in the world. In common with many countries, Australia has lost extensive areas of wetland habitat (Kingsford *et al*. 2003). In NSW there has been an excessive loss of coastal swamps, and inland swamps are affected by intense grazing by stock (Cooper *et al.* 2014). To address the problem of loss of wetlands, the Ramsar Convention on Wetlands 1971 was established, the broad aim of which was to halt the worldwide loss of wetlands and to conserve, through wise use and management, those that remain (https://www.awe.gov.au/water/wetlands/ramsar). A part of the Hunter Estuary was declared a Ramsar wetland in 1984. The estuary is in a fortunate position in that, from the 1990s, three significant rehabilitation projects commenced.

The Kooragang Wetland Rehabilitation Project (KWRP) was launched in 1993. Its vision was for:

"an estuary in which healthy, restored fisheries, shorebird, threatened species and other wildlife habitat is in balance with a thriving port, the whole providing opportunities for research, education and recreation" (Svoboda 2017).

As part of this project three sites for rehabilitation were chosen – Stockton Sandspit, Ash Island and Tomago Wetland. The latter became the Tomago Wetland Rehabilitation Project and was managed by National Parks and Wildlife Service. The third major project was the Hexham Swamp Rehabilitation Project which revolved around restoring wetlands on Hexham Swamp.

Although the projects focussed on the reintroduction of tidal flushing and the expansion of estuarine habitat, the major part of the vegetation continued to be influenced by freshwater. For example of the approximately 2000 ha of habitat at Hexham Swamp, only 443 ha reverted to estuarine habitat (Baer 2017). Reinstatement of tidal flushing at selected areas was accomplished at Hexham Swamp between 2008 and 2013 and at Tomago Wetland between 2012 and 2015 (Lindsey 2021).

Overall improvement in habitat may have had positive outcomes for some species such as gallinules and coot and some species of waterfowl such as Black Swan, Pacific Black Duck and Chestnut Teal. Dusky Moorhen, Eurasian Coot, Purple Swamphen and Black Swan showed an overall increase in numbers in the second time period and Black Swan, Chestnut Teal and Pacific Black Duck had reporting rates of over 90%.

There were insufficient sightings of the crakes and rails to draw any conclusions about the effect of the projects on these species. Australian Spotted Crake seems to have disappeared from the areas which received tidal flushing at Tomago Wetland as none has been recorded since 2014. However, it continues to be recorded at Hexham Swamp even in areas which received regular tidal flushing. Lewin's Rail and Spotless Crake continue to be recorded occasionally at Ash Island and Hexham Swamp and Buff-banded Rail is still recorded at all three wetlands. All species are secretive and hard to detect (Marchant & Higgins 1993; Cooper *et al.* 2014) and are recorded more often in the warmer months (Cooper *et al*. 2014). Movements are largely unknown although it has been speculated that Baillon's Crake may undertake a northwards migration in winter (Cooper *et al.* 2014). These species are considered to be irruptive visitors in the Hunter Region and the records for the estuary are in keeping with other reports in NSW.

Some other regularly-monitored areas were not affected by rehabilitation projects e.g. five small freshwater ponds on Kooragang Island which is the industrial portion of the Ash Island/Kooragang Island complex. Of these the now-bisected Deep Pond is the largest. The majority of records for Hoary-headed and Australasian Grebes and Musk Duck are from these freshwater ponds especially from Deep Pond.

Irruptions

Waterbirds respond to changes in wetland availability at the local scale, at the scale of the catchment, and at scales that extend beyond that of individual catchments (Roshier *et al.* 2002). Therefore it is unsurprising that the populations of all waterbirds in the estuary varied considerably.

However, several species had notable irruptions interspersed with periods when they were absent or present only in low numbers. The most obviously irruptive species were Pink-eared Duck, Grey Teal, Hardhead, Australasian Shoveler and Eurasian Coot. The populations of Hoary-headed Grebe and the three crake species also displayed irruptive tendencies but the peak counts for all of them were relatively low.

Pink-eared Duck are highly nomadic and will often rapidly move vast distances to find suitable conditions. They are generally regarded as birds of the interior but will adopt coastal areas in dry conditions (Cooper *et al*. 2014). Influxes to the estuary were modest compared with some inland congregations; e.g. over 29,000 birds were counted on the Bulloo Overflow in 1990 (Cooper *et al*. 2014). The preferred sites within the estuary were freshwater and brackish ponds. The main influxes broadly coincided with influxes at Morpeth Wastewater Treatment Works (Newman 2012, Newman *et al*. 2021). Higher numbers were usually recorded at Morpeth; for instance, over 1,000 birds were present in May 2001 (Newman *et al*. 2021) but none was in the estuary at that time. However, it is likely that birds utilised both areas at different times during the periods when they were present in the lower Hunter. In 2017-2018 large numbers of Pink-eared Duck were recorded at wetlands attached to Shortland Waters Golf Course, peaking at 755 birds in August 2017 and *c* 1,500 birds in September 2018, but no birds were recorded at any sites within the rest of the estuary during either of those irruptions (Stuart 2018; Williams 2019).

Grey Teal has a nomadic existence exploiting the shallow swamps created by local flooding in the inland and then dispersing across the continent when these swamps evaporate. (Conservation, Natural Resource Management & Protected Area Policy Branch Parks and Regions 2018). In a study of their movements it was found birds moved a large distance (up to 343 km) between occupied sites in a short period (hours), and remained in the vicinity of those sites for extended periods, often months (Roshier *et al*. 2006). Irruptions into the estuary may be connected with heavy rainfall events as a result of, for example, East Coast Lows in 2014 and the remnants of Cyclone Debbie in March 2017 in years of otherwise persistent hot, dry conditions. Conversely in March 2011, when there were good conditions inland, there were almost no Grey Teal in the estuary (Lindsey & Roderick 2011).

The Hardhead is a diving duck which prefers deep, permanent lakes and swamps, many of which have been eliminated through flood mitigation works, particularly on the coast (Cooper *et al.* 2014). There is evidence from earlier writers that until 1900 this species outnumbered all other species on the coasts of New South Wales and Victoria (Pringle 1985). The irruptions into the estuary in 2005-2007 and 2019 were towards the end of extended periods of drought when many inland wetlands had dried out.

Irruptions by Eurasian Coot appear to be more complex. This species was recorded in relatively low numbers prior to 2011, and only occasionally was present. However, in the period 2012-16 it was almost continually present and often in numbers of 600-800 birds, peaking in 2013-14 at more than 1,000 birds. These high counts for four years occurred at a time when there was inland drought plus the newly-rehabilitated wetlands in the estuary had become available. That should explain the irruption, yet conditions in the following three years were broadly similar but the coot numbers dropped substantially. The numbers rose again in late 2018 towards the end of the long drought.

The pattern for Australasian Shoveler also appear to be complex. It is a dabbling duck which prefers large permanent freshwater lakes and swamps (Marchant & Higgins 1990). There were frequent records of large numbers (100-250 birds) between 2001 and 2008 which could be considered as irruptions; however, the pattern also fits for an autumn/winter visitor with fluctuating numbers. The highest counts occurred in winter in those years. In the following four years very few birds were recorded in the estuary – this time period corresponded with the breaking of the Millennium Drought and better conditions inland. During 2013-18, with another inland drought underway, birds returned to the estuary in higher numbers; the peak counts of 300+ birds were within that period. Very few birds were recorded in 2019-20 but *c* 50 birds were present in February-March 2021. Overall the pattern could be interpreted as irruptive but it also fits for an autumn visitor with fluctuating numbers. It is notable that the winter numbers were much lower than for 2001-08. Overall it seems that there has been considerable change in the patterns of occurrence of Australasian Shoveler in the estuary, probably arising from a combination of conditions locally and conditions elsewhere in Australia.

Some species accounts

Australian Wood Duck

This is a grazing species and the most widespread duck in NSW. It is associated with most freshwater habitats (Cooper *et al*. 2014) although water is less important to this species than fresh green grass and herbs (Pringle 1985). It is increasingly using small farm dams as breeding and roosting habitat (Caley *et al*. 2022). The increase in numbers in summer and autumn may be the result of its habit of forming post-breeding flocks in late summer (Cooper *et al*. 2014). The increases in numbers for the second 11-year time period, although found to be statistically significant for autumn and spring, were relatively minor and the differences probably were not due to the rehabilitation projects as this species distribution in the Hunter Estuary is largely confined to freshwater sites on Ash Island, Kooragang Island and the pasture land at Fullerton Cove (https://birdata.birdlife.org.au/ accessed 14 March 2022).

Chestnut Teal

Chestnut Teal are widespread in NSW, normally associated with freshwater habitats but they also utilise estuarine wetlands (Cooper *et al.* 2014). In the Hunter Estuary surveys they were regularly recorded at fresh, brackish and fully estuarine sites, and with many breeding records. Birds are regularly found in hundreds in thick mangroves on Ash Island (AL pers. obs.), confirming the utilisation of estuarine habitat by this species.

In Victoria at the Western Treatment Plant there was no discernible seasonal pattern for Chestnut Teal (Hamilton & Taylor 2004). However, in NSW they are reported to congregate in estuaries during autumn and winter and disperse in spring (Cooper *et al.* 2014). The results for the Hunter Estuary are in accordance with the latter observation (although the large numbers of them regularly present in the estuary probably strongly contributed towards shaping the overall NSW outlook).

There were 22 instances of more than 1,000 Chestnut Teal being recorded during the surveys, spanning eleven distinct time periods. Within any of those time periods 800+ birds often were recorded on some other surveys. The estimated population of Chestnut Teal in south-eastern Australia is 100,000 birds, with another 5,000 birds as a south-western population (Wetlands International 2022). Thus, the estuary regularly supports more than 1% of the total population. This meets criterion number six for identifying wetlands of international importance under the Ramsar Convention (https://www.awe.gov.au/water/wetlands/ramsar/criteria-identifying-wetlands). Chestnut Teal was also one of the species listed to support the nomination of the Hunter Estuary as a Key Biodiversity Area, on the basis of the estuary supporting 1% of its total population (Dutson *et al.* 2009; BirdLife Australia 2017). Undoubtedly, the estuary is important for Chestnut Teal. It should also be noted that when high numbers are present in the estuary there are only small numbers of birds at freshwater wetlands elsewhere in the lower Hunter Valley. For example, a survey in March 2011 (Lindsey & Roderick 2011) recorded 4,497 Chestnut Teal, 93% of which were in the estuary (including the freshwater site at Deep Pond).

Grebes

All three species of grebes, Australasian, Hoary-headed and Great Crested, are found throughout NSW and all form flocks from late summer to late winter (Cooper *et al*. 2014). Of the three species Hoary-headed and Great Crested are more likely to be found on more open, deeper water bodies than Australasian Grebe and the latter is less likely to be reported from saline wetlands (Cooper *et al*. 2014). In the lower estuary, however, all three are recorded on both freshwater and saline ponds.

The presence of Australasian Grebe in the estuary is consistent with this general statement with fewer birds in summer than during the other seasons over the 22 years of this study. The greater mean counts for the second 11-year period also support a conclusion that this species is likely to have recovered since the wet years of 2010 and 2011. (Cooper *et al*. 2014).

The majority of records for Hoary-headed and Australasian Grebes were from freshwater ponds on Kooragang Island. Although Great Crested Grebe was recorded only three times during the monthly surveys, there were six additional sightings recorded in Birdata all of which were from Ash Island (https://birdata.birdlife.org.au/ accessed 6 February 2022). It is intriguing to note that the first NSW record of this species with a specific locality documented was from Ash Island. It was registered into the Australian Museum collection in 1875 (Cooper *et al*. 2014).

Local and inland rainfall patterns

The long-term trends for all species analysed indicated that they had stable or increasing populations. Several species displayed regular seasonal movements. However, all species had shorter-term fluctuations in their numbers. A detailed study comparing local and inland conditions and any resultant effects on bird populations is beyond the scope of the present study. Difficulties in attempting such comparisons include that it is not generally known where birds move to or from, and there are few reliable estimates of inland populations for any given place and time. However, some examples taken at random do point to the importance of the trade-off between local coastal and inland conditions. For example, the peak counts for both winter and spring were in 2014 after a series of East Coast Lows brought heavy rain to the coast, while the peak count for autumn was associated with rain brought by Cyclone Debbie in March 2017. At that time, it had been estimated that the population of waterbirds in eastern Australia had fallen by 90% (ABC News 2019).

The summer counts had the least variability, particularly after the rehabilitated wetlands had become available. The exceptionally low counts for 2019/20 coincided with the final summer of a severe drought which affected all of south-eastern Australia and which was accompanied by a series of devastating bushfires.

Other examples include the low counts for winter and spring in 2010 - this was immediately after the Millennium Drought had broken. Presumably most waterbirds had moved to inland wetlands then and had commenced breeding.

Fullerton Cove

The shorebird species which feed in Fullerton Cove were found to have decreasing populations and we speculated that a reason for that might be the contamination of the benthic substrate by chemicals used for firefighting, with resultant effects on the food chain (Stuart & Lindsey 2021). Those chemicals were used at Williamtown Airport for several decades. None of the species considered in this report forage regularly at Fullerton Cove and the contamination seems to have had no discernible effects on their populations.

CONCLUSIONS

Twenty-seven species from three families of waterfowl, grebe, crake, rail and gallinule species were recorded in systematic surveys commencing in 1999. Of these, ten species had reporting rates of over 50% and seven of those ten species usually accounted for at least 80% of the total numbers present in the estuary in any month.

Most species were found to have stable, albeit fluctuating, populations while the populations of eight species increased. The expansion of wetland habitat through rehabilitation projects has had a positive effect. Three species, Magpie Goose, Blue-billed Duck and Freckled Duck, are listed threatened species - all three were uncommon in the estuary. Five species had greater populations in the estuary in summer and/or autumn, while the population of Black Swan rose in winter.

The monthly surveys do not cover all the freshwater wetlands in the lower Hunter Valley. Many of the species mentioned in this article utilise freshwater wetlands, and some of the species prefer such habitat. To obtain a clearer picture of the population changes of species within this grouping, the monthly surveys should be expanded to include the main freshwater wetlands of the lower Hunter Valley.

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REFERENCES

ABC News (2019). https://www.abc.net.au/news/2019-11-19/drought-and-water-policy-to-blame-for-water-bird-decline/11715412. Accessed 7 April 2022.

Baer, M. (2017). Hexham Swamp Rehabilitation Project Restoring tidal inundation to an artificially created freshwater wetland. Local Land Services Hunter. https://www.floodplainconference.com/papers2017/6D%20Michael%20Baer.pdf.

BirdLife Australia (2017). IBA-KBA FAQs. www.birdlife.org.au/projects/KBA/iba-kba-faqs (Accessed 6 April 2022).

BirdLife Australia (2021). Hunter Estuary Waterbird Survey Protocols. (Unpublished report for Hunter Local Land Services.)

Caley, P., Reid, J.R.W., Colloff, M.J., and Barry, S.C. (2022). On inferring population trends of mobile waterbirds from aerial transect surveys in variable environments. *Environmental and Ecological Statistics* **29**: 3–31. https://doi.org/10.1007/s10651-021-00510-7.

Cooper, R.M., McAllan, I.A.W. and Curtis, B.R. (2014). ‘An Atlas of the Birds of New South Wales and the Australian Capital Territory. Vol. 1- Emu to Plains-wanderer’. (New South Wales Bird Atlassers: Woolgoolga)

Conservation, Natural Resource Management & Protected Area Policy Branch Parks and Regions (2018). Assessment of Waterfowl Abundance and Wetland Condition in south-eastern South Australia. (Department for Environment and Water Government of South Australia.)

Dutson, G., Garnett, S. and Gole, C. (2009). Australia’s important bird areas. Key sites for conservation. (BirdLife Australia: Melbourne, Australia.)

Gosper, D.G. (1981). Survey of birds on floodplain-estuarine wetlands in the Hunter and Richmond Rivers in northern NSW. *Corella* **5** (1): 1-18.

Gibson, J. (2017). Habitat Selection and Calling Activity of the Lewin’s Rail (*Lewinia pectoralis pectoralis*). A thesis submitted in fulfilment of the requirements for the degree of Masters of Applied Science at the Queensland University of Technology School of Earth, Environmental and Biological Sciences

Hamilton, A.J., and Taylor, I.R. (2004). Seasonal patterns in abundance of waterfowl (Anatidae) at a waste stabilization pond in Victoria. *Corella* **28**: 61-67.

Kingsford, R.T., Brandis, K., Thomas, R., Crighton, P., Knowles, E., and Gale, E. (2003). The Distribution of Wetlands in New South Wales. (Natural Heritage Trust, National Parks and Wildlife Service and Murray-Darling Basin Commission.)

Lindsey, A. (2021). The birds of Tomago Wetland after reinstatement of tidal flushing. *The Whistler* **15**: 6-26.

Lindsey, A. and Roderick, M. (2011). Chestnut Teal count – March 2011. *The Whistler* **5**: 51-52.

Lindsey, A. and Stuart, A. (2021). Hunter Estuary surveys: results for large waterbirds. *The Whistler* **15**: 78-96.

Lindsey, A. and Stuart, A. (In preparation). Status of gull and tern species in the Hunter Estuary.

Marchant, S. and Higgins, P.J. (Eds) (1990). ‘Handbook of Australian, New Zealand and Antarctic Birds. Volume 1: Ratites to Ducks’. (Oxford University Press: Melbourne.)

Marchant, S. and Higgins, P.J. (Eds) (1993). ‘Handbook of Australian, New Zealand and Antarctic Birds. Volume 2: Raptors to Lapwings’. (Oxford University Press: Melbourne.)

Newman, M. (2012). The status of the Pink-eared Duck in the Hunter Region. *The Whistler* **6**: 46-48

Newman, M., Lindsey, A. and Brosie, G. (2021). A twenty-year study of waterfowl Anatidae at Morpeth Wastewater Treatment Works near Maitland, NSW. *The Whistler* **15**: 53-64

Pringle, J.D. (1985). ‘The Waterbirds of Australia. The National Photographic Index of Australian Wildlife’. (Angus & Robertson Publishers: North Ryde, NSW, Australia.)

Roshier, D.A., Robertson, A.I., Kingsford, R.T. (2002). Responses of waterbirds to flooding in an arid region of Australia and implications for conservation. *Biological Conservation* **106**: 399-411.

Roshier, D., Klomp, N. and Asmus, M. (2006). Movements of a nomadic waterfowl, Grey Teal *Anas gracilis*, across inland Australia – Results from satellite telemetry spanning fifteen months. *Ardea-Wageningen* **94** Vol.3.

Stuart, A. (Ed.) (2018). Hunter Region Annual Bird Report Number 25 (2017). (Hunter Bird Observers Club Inc.: New Lambton, Australia.)

Stuart, A. and Lindsey, A. (2021). Shorebird Surveys in the Hunter Estuary of New South Wales 1999 – 2021. *Stilt* **76**: 47-63.

Svoboda, P. (2017). Kooragang Wetlands: Retrospective of an integrated ecological restoration project in the Hunter River Estuary. (26th NSW Coastal Conference, Port Stephens.)

Wetlands International (2022). “*Waterbird Population Estimates*”. Retrieved from http://wpe.wetlands.org on 30 March 2022.

White, J.M. (1986). Breeding of Black Swans on Two New England Lagoons. *Corella* **10**: 17-20.

Williams, D. (Ed.) (2019). Hunter Region Annual Bird Report Number 26 (2018). (Hunter Bird Observers Club Inc.: New Lambton, Australia.)

Williams, D. (Ed.) (2020). Hunter Region Annual Bird Report Number 27 (2019). (Hunter Bird Observers Club Inc.: New Lambton, Australia.)

Some observations of the foraging behaviour of the Australian Painted-snipe and the Greater Painted-snipe

Neil Fraser

8 Flannel Flower Fairway, Shoal Bay NSW 2315, Australia neil8fff@gmail.com

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Foraging behaviour of Australian Painted-snipe *Rostratula australis* was analysed using video recordings replayed at slow speed. The dominant foraging mode identified was tactile. Techniques utilised were probing of the substrate and sweeping within the water column. Sampling, using receptors in the mandibles, was used to locate prey within the water column and detect traces of prey in the substrate. The birds were stationary when probing and wading when sweeping. Visual foraging using lunging and pecking was uncommon and was restricted to the muddy surrounds of wetlands.

Comparison was made with foraging behaviour of the Greater Painted-snipe *Rostratula benghalensis,* also analysed from video recordings. The dominant foraging mode identified was tactile. Sweeping and probing were the most frequently used techniques, the former being much more common. Sampling, using receptors in the mandibles, accompanied sweeping and preceded probing. Sweeping of the water column was conducted when wading, and probing of the substrate when birds were stationary. Visual foraging, using pecking, was conducted predominantly on the muddy surrounds of wetlands.

The range of water depth used by both species for foraging was similar and ranged from 0-80 mm. The average foraging depth for Australian Painted-snipe was 31 mm and for Greater Painted-snipe was 29 mm.

The foraging techniques used by both species were the same and there was no difference between the techniques used by males and females. Water depth did not influence whether sweeping or probing was used in the water column. Water snails were the most commonly observed prey items captured. The use of surface tension transport to move captured prey from the bill tip to the oral cavity was confirmed.

The dominant foraging mode for both species was tactile. Pits that house mechanoreceptors and possibly chemoreceptors were identified in the lower mandible of Australian Painted-snipe. It is speculated that some form of Grandry-type cells, also used to detect prey, may be present in the species' tongue or bill.

INTRODUCTION

The Australian Painted-snipe *Rostratula australis* is one of Australia's least-known endemic waders (Lane & Rogers 2000, Cooper *et al*. 2016). It has a small nomadic population that is dispersed widely across eastern and northern Australia, mainly around shallow, ephemeral, freshwater and brackish wetlands (Rogers *et al.* 2005; Garnett *et al*. 2011). The bird is cryptic, calls rarely, feeds mainly at night and roosts in dense vegetation during the day (Menkhorst *et al*. 2017). It is now recognised as endemic to the Australian mainland, having previously been considered a sub-species of the Greater Painted-snipe *Rostratula benghalensis* that occurs in Africa, India and Asia (Lane & Rogers 2000; Baker *et al*. 2007, Christidis & Boles 2008).

In their review of the status of the species, Lane & Rogers (2000) demonstrated substantial differences in measurements, plumage characteristics and some behaviours, between Australian Painted-snipe and Greater Painted-snipe. Rogers *et al*. (2005) also pointed out that as a result of the traditional lumping of the two species, assumptions that behaviours of Greater Painted-snipe also applied to Australian Painted-snipe, were probably incorrect.

The Australian Painted-snipe uses its long, slender bill for foraging. The bill is slightly decurved on the distal one-third and has a slightly bulbous tip on the upper mandible. The average bill length is 43.2 mm for adult male birds and 44.8 mm for the larger females. It is most frequently observed foraging in shallow water around the margins of wetlands but is also reported to forage on mud flats and open areas such as ploughed land or grassland. It is omnivorous, feeding on vegetation, seeds, molluscs, crustaceans, insects, worms, and other invertebrates (Marchant & Higgins 1993).

There is very little published information on the foraging techniques of the Australian Painted-snipe. It is reported to glean food at the water's edge and on mud, by probing in soft ground and by scything with its bill in shallow water (del Hoyo *et al*. 2020). This description, however, is a legacy account from earlier lumping, as it is behaviour previously ascribed to the Greater Painted-snipe by Cramp & Simmons (1983). Lindsey (2009) observed a bird foraging at Hexham Swamp, near Newcastle, by dipping its bill vertically into the water to around a quarter of its length while rapidly opening and almost, but not completely, closing it. The bird continued to wade while foraging. D'Ombrain (1944) described a captive bird eating worms, meat, and insects. Hindwood & Hoskin (1954) described seeds in the stomach of a bird collected near Box Hill, Victoria. G. Stevens (pers. comm.) observed numerous holes in soft mud where birds had been foraging around an ephemeral wetland at Lenaghans Swamp, near Newcastle in 1973, and D. Rogers (pers. comm.) observed a bird capturing earthworms by probing in moist soil at Rutherglen, Victoria in February 2006.

There is also limited foraging information for its close relative, the Greater Painted-snipe. Johnsgard (1981) described birds feeding by probing in mud and ooze for worms, insects, molluscs and crustaceans, and also eating some vegetable matter such as grains and weed seeds. He described foraging as typically done by probing and by a lateral scything movement of the bill in shallow water, in a similar manner to avocets. Cramp & Simmons (1983) described Greater Painted-snipe as gleaning from the edge of water and mudflats, probing in soft ground and scything with the bill in shallow water. Kirwan (2020) described it as probing soft ground like true snipes and using a scything action of its bill and head in shallow water.

McNeil & Rodriguez (1996) summarized the foraging habits and strategies of shorebirds. They described the foraging pattern of *Rostratula* as largely crepuscular and partly nocturnal. The foraging strategy was partly tactile by day and partly tactile by night.

This study was prompted by the presence of a juvenile male Australian Painted-snipe at Myall Quays, Tea Gardens, NSW (32º 39' 08.22"S, 152º 09' 10.47"E) in early 2020 (Fraser 2020). The bird was present for at least 27 days from mid-January to early February 2020. The site was easily accessible, and the bird's presence was widely reported on online birding blogs and databases. Consequently, it was seen by many observers, some of whom made video recordings. These recordings and reports by observers facilitated an analysis of the bird's foraging behaviour.

The objectives of this article are to describe and compare the observed foraging behaviour of the two painted-snipe species and consider adaptations that support those modes of behaviour. The study has considerable limitations, as it is based on recordings of a small number of birds, mostly present at wetland habitats in the daytime. Moreover, the behaviour of some of the birds might have been influenced by their awareness of the videographer. However, since very little has previously been documented of the foraging behaviour of either species, particularly for the Australian Painted-snipe, it seems important to place the present observations on record.

Prey detection and capture methods used by shorebirds

Long-billed shorebirds (waders) have several unique adaptations that allow them to successfully exploit their shoreline and wetland habitats. Prey detection methods used include sound, smell, taste, sight and mechanoreception. Waders mainly exploit the latter two methods. Their eyes are large and high-set, and they have well-developed optic lobes of the brain which provide excellent vision. While most of their field of view is monocular, long-billed birds have a narrow field of binocular vision commencing slightly forward of the tip of their bills (Tyrrell & Fernández-Juricic 2017).

Included among the bird's mechanoreception senses is tactile reception, an adaptation that is well-developed in waders that forage by probing for unseen prey in soft substrates. Many long-billed shorebirds such as godwits, curlews, snipe, redshanks, knots and dunlin have Herbst corpuscles housed in small pits under the keratin layer in the tips of their bills, that can detect change in pressure gradients in the substrate (Bolze 1968). These pits vary in shape, size and number between species. The pits of Red Knot *Calidris canutus* are elliptical, 112-200 µm wide, and up to 300 µm long (Piersma *et al*. 1998). In Western Sandpiper *Calidris mauri*, pits are 22-27 µm long and 6-9 µm wide, in Dunlin *Calidris alpina* 14-22 µm long and 6-10 µm wide, and in Least Sandpiper *Calidris minutilla* 11-13 µm long and 6-8 µm wide (Nebel *et al*. 2005). Sharpe (1896) reported no pits were present in the bills of specimens of Genus Rostratula at the British Museum.

This technique of prey detection relies on pore water in the substrate to transmit pressure waves. For Red Knot, the repeated probing action of the bill produces pressure waves in the substrate. Herbst corpuscles detect changes in the pressure gradient induced by the presence of solid objects such as prey. Other species use Herbst corpuscles to detect pressure waves induced by the movement of prey in the substrate or by tamping of bird's feet on the surface (Piersma *et al*. 1998).

An additional sense which shorebirds can use to identify and differentiate prey is taste (chemo-reception). Clark *et al*. (2014) reported that birds have a well-developed system for gustation (tasting) which affects their behaviour and ecology. Taste receptors are located in taste buds throughout the oral cavity and birds use these to select nutrient-rich prey and avoid toxins. Van Heezik *et al*. (1983) demonstrated that Sanderling *Calidris alba* and Dunlin used taste to determine whether prey was present or absent in a substrate and modified their foraging behaviour accordingly.

Many shorebirds forage with a slightly open bill, indicating that receptors inside the bill are involved in prey detection. The tongues of many aquatic birds have been shown to contain numerous tactile sensory structures known as Grandry corpuscles, especially in the tip of the tongue (Grandry 1869). Toyoshima (1993) described Grandry corpuscles in the tongues of ducks as composed of two or three large, hemispherical Grandry cells 40-45 μm diameter and 16-18 μm thick. These corpuscles have both chemoreceptive and mechanoreceptive functions (Toyoshima 1989). Piersma *et al*. (1998) found complexes of large sensory cells of the Grandry type under the keratin spines on the palate of Red Knot. Grandry corpuscles of geese and ducks have been described as 'rapidly adapting mechanoreceptors' (Gottschaldt 1985).

Some long-billed shorebird species have been shown to transfer prey from the bill tip to the oral cavity via surface tension transport (Rubega & Obst 1993). This mechanism employs the surface tension between keratin in the bill and the water surrounding captured prey to transport small items along the bill without the use of suction or tongue movements. After the bird seizes a food item with its bill tips, transport along the bill is accomplished by rapid partial mandibular spreading. This motion increases the free surface area of the water drop that surrounds the food item adhering to the bird's bill and drives it up the bill and into the bird's oral cavity. According to these authors, it is likely that any bird with a needle-shaped bill, foraging in water, will be capable of some degree of surface-tension transport.

Another mechanism used by long-billed waders to assist foraging for prey buried in the substrate and unable to be seen, is distal rhynchokinesis. This process allows the upper part of the bill to flex upwards independently of the rest of the bill, thus opening the tip of the bill wide enough to seize detected prey (Estrella & Masero 2007).

METHODS

Video recordings of foraging activity by Australian Painted-snipe and Greater Painted-snipe were obtained using internet-based searches and by specific requests to the birdwatching community. Only higher quality recordings that allowed accurate discrimination of foraging details were used. Recording duration varied from a few seconds to several minutes. The amount of foraging behaviour on each recording varied greatly.

Video recordings from YouTube (https://www.youtube.com/) and the Macaulay Library at the Cornell Lab of Ornithology eBird portal (https://ebird.org/) were viewed online at one-quarter speed and high definition mode while supplied recordings were viewed at one-quarter speed using VLC Media Player software. Windows Media Player software was used for frame-by-frame viewing when required. Details recorded where possible were: sex of the bird, time of day, foraging substrate, estimated depth of water, foraging mode, foraging technique, depth of probe, duration of probe, head movement, prey captured, bill movement, swallowing and eye movement.

The terminology used to describe foraging mode and technique is defined as follows:

Visual foraging: Use of visual information for guidance of the bill position when capturing prey.
Tactile foraging: Foraging guided primarily by tactile information derived from receptors located within sensory pits in the bone around the bill tips.
Lunging: Rapid forward striking motion to catch moving prey on water or in the air.
Pecking: Striking motion with the bill to capture prey on water surface or muddy substrate.
Sampling: Rapid, partial opening and closing of the mandibles when inserted into the water column. This most commonly precedes probing and accompanies sweeping.
Probing: Inserting the bill into the substrate to search for and capture prey.
Vertical Sweeping: Side-to-side movement of bill introduced vertically into water column.
Substrate Sweeping: Near-horizontal back-and-forth movement of bill over substrate at base of water column.

The sweeping technique described here is likely to be the same as the scything action of painted-snipe described elsewhere (Johnsgard 1981, del Hoyo *et al*. 2020). However, the term scything was originally used by Hamilton (1975) to describe a tactile foraging technique used by American Avocet *Recurvirostra americana* with the recurved tip of the bill placed flat on the substrate while the head was moved from side to side. The word implies a cutting action which does not occur, and consequently the term sweeping is used here. Martin & Piersma (2009) described the vertical sweeping technique as blind trawling.

Time of day could only be estimated in broad terms, except where it was specified by the videographer. Water depth was estimated by comparing the submerged length of the bird's leg while standing, with the total length of the leg. Total leg length (metatarsus + tibia) was estimated to be 65 mm, taking into account the angular presentation of the tibia in most circumstances. Depth of probe was estimated by comparing the submerged length of the bird's bill with the reported average bill length of 44 mm (Marchant & Higgins 1993).

Skin specimens of Australian Painted-snipe and Greater Painted-snipe at the Australian Museum, Sydney were examined for the presence of corpuscular pits in the mandibles.

RESULTS

Analyses of recordings revealed both species of painted-snipe to be opportunistic feeders using a variety of foraging techniques, and adapting their methods to best suit the prevailing conditions of the habitat. Both visual and tactile foraging modes were used, at times in conjunction. Visual foraging was used to capture prey that could be observed in the air, on the water surface or on the muddy surrounds. Tactile techniques were used to locate unseen prey and included sampling of the water column, probing in the substrate, vertical sweeping through the water column or near-horizontal sweeping across the wetland substrate. The recordings analysed for Australian Painted-snipe (10) are summarized in **Table 1** and those analysed for Greater Painted-snipe (55) are summarized in **Table 2**. Sixty-three recordings were of daytime foraging and two were of foraging at night. An analysis of mean water depth while foraging is presented in **Figure 1**.

Table 1. Video recordings analysed for foraging mode and technique of Australian Painted-snipe.

Foraging Mode	Dominant Foraging Technique	Sex	Water Depth (mm)	Location	Time of Day	Reference
Visual	Lunging	M	60-65	Wanganella, NSW	Night	Maher (2011a)
Visual	Pecking	M & F	0-5	Wanganella, NSW	Day	Maher (2011b)
Tactile	Probing	M	15	Lake Eda, WA	Day	Jarvis (2016)
Tactile	Probing	M	10-15	Kooralbyn, Qld	Day	Siggs (2015)
Tactile	Probing	M	20-30	Pitt Town, NSW	Evening	BIBY TV (2017)
Tactile	Probing	F	40-50	Palerang, NSW	Day	Wallace (2017)
	Sweeping		80			
Tactile	Probing	M	10-65	Tea Gardens, NSW	0639-0735	Hosken (2020)
Tactile	Probing	M	10-30	Tea Gardens, NSW	900	Kinsey (2020)
Tactile	Sweeping	M	20	Kooralbyn, Qld	Day	Laven (2009)
Tactile	Sweeping	M	10-40	Tea Gardens, NSW	1740	Parashou (2020)

Table 2. Video recordings analysed for foraging mode and technique of Greater Painted-snipe.

Foraging Mode	Dominant Foraging Technique	Sex	Water Depth (mm)	Location	Time of Day	Reference
Visual	Lunging	F	0	Western, Uganda	Day	del Hoyo (2006)
Visual	Pecking	M&F	0	Japan	Day	Birdlover.jp (2017)
Visual	Pecking	M&F	0	Tamil Nadu, India	Day	Thillainayagam (2021)
Visual	Pecking	M	10	Tamil Nadu, India	Day	Thillainayagam (2021)
Visual	Pecking	M	0	Maharashtra, India	Day	Bhagwat (2022a)
Visual	Pecking	F	0-5	Madhya Pradesh, India	Day	Tigers & Birds of India (2022)
Visual	Pecking	M&F	0-5	Perak, Malaysia	0730-0900	Amar-Singh (2020)
Tactile	Sweeping		10-55			
Tactile	Probing	F	0	Western, Uganda	Evening	Kennewell, (2004)

Tactile	Probing	M	70	Thiés, Senegal	Day	Sanabria (2007a)
Tactile	Probing	F	20-30	Nagpur, India	Day	Aditya Wildlife (2010)
Tactile	Probing	M	45	Gujarat, India	Day	del Hoyo (2011a)
Tactile	Probing	M	40-45	Gujarat, India	Day	del Hoyo (2011b)
Tactile	Probing	M	20	Central River, Gambia	Day	Jimenez (2011a)
Tactile	Probing	M	20-40	Eswatini, Swaziland	Night	Coker (2020)
Tactile	Probing	M&F	10-40	Perak, Malaysia	Day	Blake (2022a)
Tactile	Probing	M&F	20-50	Perak, Malaysia	Day	Blake (2022b)
Tactile	Probing	M&F	30-40	Rift Valley, Kenya	Day	Clibbon (2022)
Tactile	Probing	M&F	20	Rift Valley, Kenya	Day	Clibbon (2022)
Tactile	Probing	M	20	Karnataka, India	Day	Desai (2022a)
Tactile	Probing	M&F	0	Karnataka, India	Day	Lakshmi (2022)
Tactile	Probing	M	10-20	Singapore	Day	13seaeagle (2014)
	Sweeping	M	30-50			
Tactile	Probing	M&F chicks	10-30	Mai Po, Hong Kong	Day	Hilldog (2010)
	Sweeping					
Tactile	Sweeping	M	70	Thiés, Senegal	Day	Sanabria (2007b)
Tactile	Sweeping	M	70	Thiés, Senegal	Day	Sanabria (2007c)
Tactile	Sweeping	F	20-40	Central River, Gambia	Day	Jimenez (2011b)
Tactile	Sweeping	M&F	10	Japan	Day	HelloAoba5541 (2013)
Tactile	Sweeping	Juv	30-40	Rajasthan, India	Day	del Hoyo (2014a)
Tactile	Sweeping	Juv	40-60	Rajasthan, India	Day	del Hoyo (2014b)
Tactile	Sweeping	Juv	20-40	Rajasthan, India	Day	del Hoyo (2014c)
Tactile	Sweeping	M	20-40	Okavango, Botswana	Day	Sun Destinations (2016)
Tactile	Sweeping	M	30-40	Rajasthan, India	Evening	Tewari (2017)
Tactile	Sweeping	F	10-30	Naledi, South Africa	Day	Beech (2019)
Tactile	Sweeping	M&F	30-70	Karnataka, India	Day	Prince (2020)
Tactile	Sweeping	M&F	10-55	Madhya Pradesh, India	Day	Sahana (2020a)
Tactile	Sweeping	M	40-45	Karnataka, India	Day	Sahana (2020b)
Tactile	Sweeping	M&F	25-30	Karnataka, India	Day	Sahana (2020c)
Tactile	Sweeping	M&F	25-30	Karnataka, India	Day	Sahana (2020d)
Tactile	Sweeping	M	20-30	Leste, Guinea-Bissau	Day	Xeira (2020)
Tactile	Sweeping	F	20-30	Rajasthan, India	Day	Birding GuRu (2021)
Tactile	Sweeping	M&F	10-20	Kerala, India	Day	Puravankara (2021)
Tactile	Sweeping	M	40	Maharashtra, India	Day	Bhagwat (2022b)
Tactile	Sweeping	M	5-10	Maharashtra, India	Day	Bhagwat (2022c)
Tactile	Sweeping	M	0	Maharashtra, India	Day	Bhagwat (2022d)
Tactile	Sweeping	M	45-50	Maharashtra, India	Day	Bhagwat (2022e)
Tactile	Sweeping	M	40	Maharashtra, India	Day	Bhagwat (2022f)
Tactile	Sweeping	M	10-20	Maharashtra, India	Day	Bhagwat (2022g)
Tactile	Sweeping	M	30-65	Karnataka, India	Day	Desai (2022b)
Tactile	Sweeping	M	45	Karnataka, India	Day	Desai (2022c)
Tactile	Sweeping	M	40-60	Karnataka, India	Day	Desai (2022d)
Tactile	Sweeping	M	60-65	Karnataka, India	Day	Desai (2022e)
Tactile	Sweeping	M	60-65	Karnataka, India	Day	Desai (2022f)
Tactile	Sweeping	M	60-65	Karnataka, India	Day	Desai (2022g)
Tactile	Sweeping	M	10	Karnataka, India	Day	Desai (2022h)
Tactile	Sweeping	M	15	Kerala, India	Day	Karingamadathil (2022)
Tactile	Sweeping	M	45	Maharashtra, India	Day	Shenai (2022)

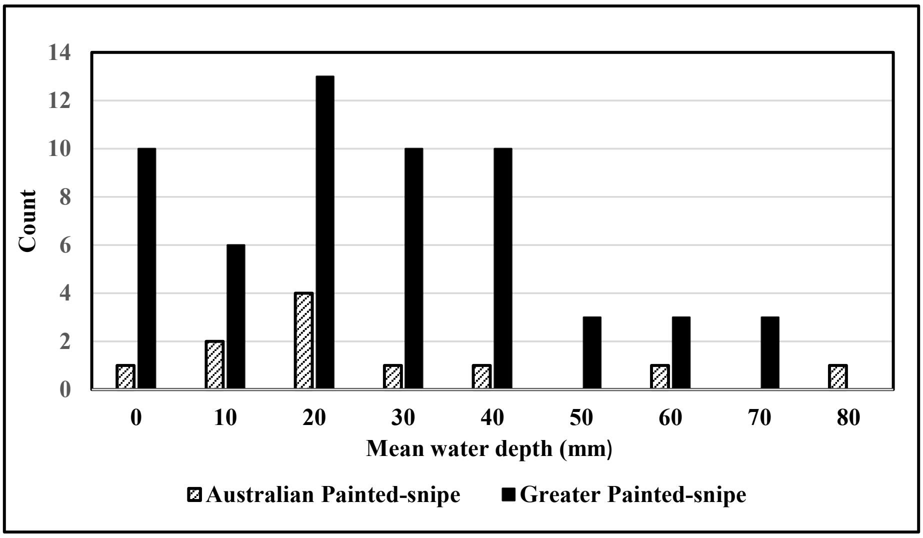

Figure 1. Mean water depth for Australian Painted-snipe and Greater Painted-snipe when foraging.

Australian Painted-snipe

Ten recordings from New South Wales, Queensland and Western Australia were analysed for foraging behaviour as summarized in **Table 1**. Both visual and tactile foraging modes were recorded. The dominant techniques used were probing and sweeping. The most common technique was probing.

Probing was observed in the soft substrate around the margins and within the shallower, near-shore parts of wetlands. Six recordings exhibited this technique (Siggs 2015; Jarvis 2016; BIBY TV 2017; Wallace 2017; Hosken 2020; Kinsey pers. comm.). The most extensive records were for the bird at Tea Gardens (Hosken 2020; Kinsey pers. comm.) This bird was wading slowly through relatively clear water 10-65 mm deep. Probing commenced with the bill thrust into the water, near vertically to a depth of 40-65 mm. In some probes, the bird's eyes and part of the head were immersed. The probing action was preceded initially by a period of sampling with side-to-side and more irregular movements of the bill, and in some instances, up-and-down movements. The bird usually remained stationary during the probe although on a few occasions it took one small step forward. The duration of the probe was generally 2-3 seconds. When the bill entered the water, the mandibles were initially slightly open, and then rapidly opened and closed while sampling the water column. The extent of mandible opening in the water column could not be estimated.

When prey were caught, the bill was withdrawn from the water and the mandibles were opened and closed rapidly five or six times as the prey was transferred to the oral cavity. This process took around 0.5 seconds. The width of mandible opening was estimated to be 1-2 mm. When no food item was captured, the bill when withdrawn from the water was closed. The bird's eyes were closed as the bill entered the water and then gradually opened as the probe continued. They were fully open as the bill was withdrawn. When the head and eyes were thrust underwater, the eyes remained closed until the bill was withdrawn. Although the water was clear, there were no indications the bird was using visual cues to locate prey or locations for probing. The bird's selection of probing sites appeared to be random. The other recordings (Siggs 2015; Jarvis 2016; BIBY TV 2017) are of birds probing in generally shallower water (10-30 mm). All other recorded details were generally similar to the above.

A recording of a female bird (Wallace 2017) initially showed probing of the substrate in water 40 mm deep, with head immersed 40-50 mm and eyes closed. The bird was subsequently probing in water 80 mm deep, with head fully immersed and eyes closed. This was accompanied by apparent side-to-side head movements which were interpreted to be a sweeping action across the substrate

Two recordings show birds using a sweeping technique to search for prey (Laven 2009; Parashou 2020). The bird at Tea Gardens (Parashou 2020) was wading slowly in relatively clear water 10-40 mm deep along the edge of a pond. The bill was held near-vertical and was swept side-to-side through the water as the bird moved steadily forward while sampling the water column. At times the bird stopped and used an up-and-down action with its bill, possibly when attempting to capture prey. The mandibles were slightly open as they entered the water and were then rapidly opened and closed as the bird advanced. The extent of mandible opening could not be estimated. When the bird's bill was withdrawn from the water it was closed indicating no prey had been captured. The eyes were closed when the bill entered the water and were partially opened towards the end of each set of actions. The depth of the bill in the water was 5-35 mm and the duration of each sweeping action was 0.5-1.0 seconds. No mandible movements with associated swallowing were observed following the sweeps. The selection of sweeping locations appeared random and there were no indications the bird was using visual cues to identify prey or foraging locations. The depth to which the bill entered the water and the lack of probing indicates the bird was using the sweeping action to search for prey, possibly larvae, within the water column. The sampling action could also have been used to detect the chemical signature of prey in the substrate.

There were no differences observed in the probing and sweeping techniques of male and female birds.

Visual foraging was observed in two recordings (Maher 2011a; Maher 2011b). Lunging was observed in a recording of a bird attempting to capture small flying insects at night (Maher 2011a). The bird was wading slowly through water about 60-65 mm deep, and was closely watching insects alighting on and moving across the surface of the water. An initial lunge with opened mandibles in the direction of an insect was followed by a period of rapid irregular head movements in the water. This was accompanied by rapid opening and closing of the mandibles as the bird attempted to secure its prey. The mandibles were opened 5-10 mm at their distal end. The bird's eyes were closed when the lunge commenced and gradually opened towards the end of the action. The bill was inserted into the water about 10 mm and each capture attempt was 0.25-0.75 seconds. One unsuccessful attempt was made to snatch an insect on the wing. These foraging attempts appeared to be unsuccessful.

The other recording (Maher 2011b) shows a male and female bird walking around the sandy edge of a wetland and pecking at prey on the surface as they advanced. This was the only recording which showed birds foraging on a substrate surrounding a wetland.

An analysis of mean foraging depth is shown in **Figure 1**. It varied from 0-80 mm and the average depth was 31 mm.

Captured prey was identified in one recording (Wallace 2017) where the bird was using probing and substrate-sweeping techniques to capture small snails. The snails were held at the distal end of the bill as it was withdrawn from the water, and were moved rapidly to the oral cavity by surface tension transport. The bird at Tea Gardens was also observed foraging briefly on the leaves of Brahmi *Bacopa monnieri* growing at the water's edge (Hosken 2020).

Greater Painted-snipe

Fifty-five recordings from Africa, India, Hong Kong, Malaysia, Singapore and Japan were analysed for foraging behaviour as summarized in **Table 2**. Both visual and tactile foraging modes were recorded. The dominant techniques used were lunging, pecking, probing and sweeping. The most common technique was sweeping.

A bird in Western Uganda, was recorded lunging unsuccessfully at flying insects (del Hoyo 2006). During the lunge which was 0.1-0.2 seconds duration, the eyes remained open and the mandibles were widely extended. The bird was foraging on partially vegetated mud.

Pecking was observed in six (10%) of the recordings. In all instances it occurred on the muddy surrounds of a wetland or the surface of shallow water. It was best illustrated at the start and at the end of a recording from Perak, Malaysia (Amar-Singh 2020). The bird was capturing snails in shallow water at the edge of a wetland by pecking with open eyes. The bill was open around 5-8 mm at the commencement of the peck. It remained open during the peck, although several rapid partial closures of 1-2 mm accompanied the action. The bill was rarely inserted more than 10 mm into the water. When snails were captured, the bill was withdrawn and the snails transported to the oral cavity. In some instances, the bill was not withdrawn from the water while the transport process occurred. The bird used surface tension transport to transport the snail from the distal tip of the bill to the oral cavity. This is illustrated in **Figure 2** which shows the transport process taking around 0.6 seconds. A female bird was recorded capturing prey by pecking with open eyes on partially vegetated dry mud, but the type of prey could not be determined (Birdlover.jp 2017). Surface tension transport was used to move the prey from the distal bill tip to the oral cavity.

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Figure 2. Female Greater Painted-snipe using surface tension transport to transfer captured snail from distal tip of bill to the oral cavity. Frame sequence total 0.6 seconds. Note incremental increasing separation of mandibles between frames. Filmed at Ipoh, Perak, Malaysia, by Amar-Singh HSS, 7 May 2020

Probing was observed in 15 (27%) recordings. The most extensive record was from an artificial wetland in Singapore with a muddy substrate and a rocky shoreline (13seaeagle 2014). Probing and sweeping were the dominant techniques used, plus a short period of pecking. Probing was mostly in the deeper sections where the water depth was 10-50 mm. At the commencement of each probe, the bill was thrust near vertically to a depth of 40-55 mm, at times immersing the eyes. Probing mainly involved short side-to-side movements of the bill with occasional more irregular movements. The bird usually remained stationary during the probe but on a few occasions took a small step forward. The duration of each probe was 2-3 seconds. The mandibles were slightly open as the bill entered the water and they were rapidly opened and closed as the probing continued and the water column was sampled. The extent of mandible opening in the water could not be estimated. The bird was not observed to swallow any prey and when the bill was withdrawn from the water it was already closed. The eyes were closed when the probing action commenced and were opened gradually as it continued. The bird's eyes were fully open when the bill was withdrawn. The eyes remained closed when thrust underwater.

A male and female bird were recorded probing on wet, algae-covered mud at Karnataka, India (Lakshmi 2022). The open bill was inserted into the wet substrate between 10 and 40 mm and 2-6 rapid up-and-down vertical probes were made over 0.5-1.0 seconds. Eyes were closed initially and were opened as the probe proceeded. The bird remained stationary during the probe. Some probe sites were explored again or one or two rapid steps were made before commencing another probe. Prey was observed being swallowed but capture could not be observed.

Sweeping was present in 36 (65%) recordings. This technique was best illustrated in recordings from Singapore (13seaeagle 2014) and Perak, Malaysia (Amah-Singh HSS 2020). Birds were foraging in water 30-55 mm deep. During the sweeping action, the bill was held near-vertical and swept from side to side with accompanying head-tilting while the bird moved slowly forward. The mandibles were already slightly open when the bill entered the water and were then rapidly opened and near-closed as the bird advanced while sampling the water column. The extent of mandible opening was around 5 mm at the distal end. The bill was closed when it was withdrawn from the water after each sweep. The eyes were closed as the bill entered the water and partially opened towards the end of each sweep. The depth that the bill was inserted in the water was 10-45 mm and the duration of each sweeping action was 0.25-3 seconds. When snails were captured, the bill was withdrawn with slightly-open mandibles, which were then rapidly opened and closed as the prey was transferred to the oral cavity and swallowed.

A recording at Rajasthan, India (Birding GuRu 2021) shows a bird using vertical sweeping accompanied by rapid opening and closing of the mandibles and capturing snails. In other instances, surface tension transport action was observed followed by swallowing, but prey could not be observed in the bill. This occurred following a period of sampling of the water column. Some translucent prey, thought to be larvae, were observed falling from the bill. The bird's tongue appeared to have been involved in the transfer process.

In a number of the recordings, insects could be seen moving around the shores of the wetlands (del Hoyo 2014a & 2014c; Bhagwat 2022b; Desai 2022d). The birds must have been aware of the presence of these insects which occasionally walked immediately in front of them. However, the birds displayed no interest. This indicates the birds have specific prey preferences that do not include these readily-observable and easily-captured terrestrial invertebrates.

A recording of birds at Mai Po, Hong Kong, shows foraging by probing and sweeping (Hilldog 2010). A male bird was using its bill to remove dead vegetation from mud in search of underlying prey. Another male bird, accompanied by four chicks, was foraging by probing in shallow water. On capturing prey, the adult allowed a chick to take the prey from its bill. Subsequent recordings of the young birds as chicks and as juveniles, show them capturing snails by probing and pecking, but being unable to transport them up the bill to the oral cavity.

Eight recordings show birds foraging on other substrates. In all instances the locations were mud, or partially vegetated muddy surrounds of wetlands, or possibly unplanted rice fields. The birds were using pecking or probing.

One recording shows a bird foraging at night at Eswatini, Swaziland (Coker 2020). Although the habitat was difficult to observe, the bird appeared to be probing in water 20-40 mm deep. The probing action, with bill open, was preceded by an initial closing of the eyes, followed by opening. The bird made a single unsuccessful lunge at a flying insect with eyes closed.

The birds were observed capturing prey in the majority of recordings but in many instances the prey item could not be seen and only swallowing was noted. Birds were observed capturing small snails (1-2 mm) in 16 recordings. Worms were observed being captured in two recordings (Sanabria 2007a; Blake 2022b). An analysis of mean foraging depth is shown in **Figure 1**. It varied from 0-70 mm and the average depth was 29 mm.

Examination of specimens

Specimens of male and female Australian Painted-snipe were examined at the Australian Museum, Sydney in May 2022. The upper and lower mandibles of most specimens were covered by a layer of dark-brown keratin and the underlying bone structure could not be observed. However, some specimens had very pale and/or thin keratin or small areas where the keratin was absent, allowing partial examination of the underlying bone. Hundreds of small, roughly circular structures were observed in the lower mandible of three Australian Painted-snipe specimens. The structures were restricted to the distal 5-8 mm of the mandible and were more densely clustered towards the distal end. The structures were observed with a binocular microscope at x50 magnification and were estimated to be 10-20 µm in diameter. Structures could not be observed in the upper mandibles of these specimens due to the thick layer of dark brown keratin.

The specimens examined were prepared skins. Although labelled Australian Painted-snipe and Greater Painted-snipe, all specimens had been taken within Australia. Skeletal specimens may have provided an unobstructed view of the bones of both mandibles but were unavailable at the time of the visit.

DISCUSSION

The data set used here was uncontrolled and cannot be considered to be a representative sample of the behaviour of either species. The recordings are of variable duration and some had been edited or were a series of compiled clips. Less than one half of the recordings reviewed featured foraging behaviour. The exact time of recording and details of locations and prevailing conditions generally were not available. The slowest playback speed of some recordings that could be achieved was one-quarter normal which was insufficient to fully view some actions and accurately determine their duration. However, the consistency of behaviour that the birds demonstrated was considered to provide a sufficiently-sound basis for analysing their foraging techniques.

The influence of the presence of a videographer on the bird's foraging behaviour could not be assessed. In some instances, the bird's behaviour indicated they were aware of the videographer – for example, they ceased foraging and exhibited threat displays and/or made alarm calls. There are many other factors that could potentially influence foraging behaviour. These could include the type of substrate, its physical properties and the availability and type of prey. Data on these topics could not be obtained from the recordings and could not be assessed as part of this study. There are insufficient records to make any meaningful assessment of night-time foraging techniques although both visual and tactile modes were briefly observed.

Most of the recordings were of Greater Painted-snipe due to its more widespread occurrence, greater abundance and somewhat less-elusive nature. Tactile foraging was used more frequently than visual. No differences were identified in the probing and sweeping foraging behaviour of the two species in wetland habitats. The recordings of the Greater Painted-snipe showed it made more extensive use of the sweeping technique, but this possibly reflects the limited nature of the Australian data set. Lunging to capture flying insects was uncommon, although the few recorded instances may reflect the limitations of the data set. Lunging does not appear to be a very successful foraging technique. This was probably due to the bird's limited field of binocular vision. Habitat was observed to influence foraging technique with pecking being most common on muddy substrates and sweeping and probing occurring mainly in water-covered wetland habitats.

The range of water depth used for foraging was similar for both species and the average foraging depth was only marginally different. There were more recordings of Greater Painted-snipe foraging on muddy substrates, but again, this may reflect the larger data set for the species.

Although both species are reported to be largely crepuscular (Marchant & Higgins 1993; McNeil & Rodriguez 1996), all but two of the foraging recordings, and all of the non-foraging recordings, show birds active during the day. While this may reflect the unrepresentative data set, crepuscular behaviour may be an oversimplification of the temporal foraging behaviour of both species.

The presence of small pits in the distal section of the bill of the Australian Painted-snipe that probably house Herbst-type corpuscles, indicates that mechanoreception and possibly chemoreception were being used to assist tactile foraging. The sampling process of rapid opening and closing of the mandibles when probing and sweeping utilizes these receptors to detect prey. The receptors could be used to physically detect the presence of prey in the sampled water column or substrate, or to detect its chemical signature indicating its presence. The presence of Grandry-type cells in the tongue may also assist in the physical detection of prey in the sampled water column.

This study confirmed the birds' use of the surface tension transport mechanism described by Rubega & Obst (1993) to move captured prey from the distal tip of the bill to the oral cavity. A video frame sequence provided by Amar-Singh HSS (2020) illustrated a female Greater Painted-snipe transferring a snail to the oral cavity in 0.6 seconds (**Figure 2**). A recording by Hilldog (2010) of birds at Mai Po, Hong Kong, shows chicks, about two months old, capturing snails but unable to transport them up the bill to the oral cavity. This suggests that surface tension transport in this species was a learned skill acquired at a later age when the bill is fully developed. This video also showed a chick taking captured prey from the bill of a male bird. This may indicate chicks are not entirely precocial as stated in Marchant & Higgins (1993). There was no evidence in the recordings that indicated that Greater Painted-snipe used distal rhynchokinesis to capture its prey.

CONCLUSIONS

This study should be considered preliminary as it involved an unrepresentative data set of relatively short periods of observation. It has, however, yielded new information about the behaviour of one of Australia's least known endemic waders and of the closely-related Greater Painted-snipe.

Australian Painted-snipe use both visual and tactile foraging modes, with tactile foraging being dominant. The species uses probing and sweeping techniques to search for prey. There were insufficient records to determine a preferred technique or the factors driving their use.

Greater Painted-snipe also use both visual and tactile foraging modes. Visual foraging, using lunging and pecking was used dominantly on the muddy surrounds of wetlands. Tactile foraging used both probing and sweeping techniques, with sweeping being dominant. Probing was performed when the bird was stationary while sweeping was usually used when moving. Water depth did not appear to influence whether probing or sweeping was used, although sweeping was more common.

There were no observed differences between the sweeping or probing techniques as used by Australian Painted-snipe and Greater Painted-snipe.

Small water snails were the most commonly observed prey captured. Both visual and tactile techniques were used in their capture. Worms were captured by probing. Insect larvae in the water column may also have been captured by sweeping and sampling.

The presence of small pits under the keratin layer, clustered near the distal tip of the mandible indicates that Herbst-type corpuscles are probably present in Australian Painted-snipe. The sampling action of rapidly opening and partially closing the mandibles during sweeping and probing is probably part of the prey detection process using mechanoreception and possibly chemoreception.

Several directions for future research were identified. Detailed examination of specimens with keratin removed from upper and lower mandibles is required to accurately determine the distribution, number, size and shape of the structures observed in this study. Examination of confirmed Greater Painted-snipe specimens is also recommended to check for the presence of receptor pits in the mandibles. Investigations of the anatomy of the tongue is recommended to confirm the presence of Grandry-type receptors.

The use of frame-by-frame analysis of videography to obtain a more detailed and temporally accurate analysis of foraging techniques, prey captured and the prey-transfer mechanisms is recommended. The behaviour of birds foraging on other types of habitat and for other food items, such as plants and seeds, should be recorded and analysed. Infra-red video recording may provide more detailed information for analysis of nocturnal foraging.

The availability of thousands of hours of videography of most avian species on on-line platforms constitutes a relatively underutilised resource for the detailed study of avian behaviour.

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REFERENCES

Aditya Wildlife. (2010). Greater Painted-snipe. https://www.youtube.com/watch?v=oXkTxGSj9hI. Accessed 9/04/2020.

Amar-Singh HSS. (2020). Greater Painted-snipe. https://www.youtube.com/watch?v=KLVEnn5ncHY. Accessed 28/07/2020.

Baker, A.J., Pereira, S.L., Rogers, D.I., Elbourne, R. and Hassell, C.J. (2007). Mitochondrial-DNA evidence shows the Australian Painted-snipe is a full species, Rostratula australis. *Emu* **107**:185-189.

Beech, A. (2019). Greater Painted-snipe. https://www.youtube.com/watch?v=bUlWr4wL7fw. Accessed 8/08/2020.

Bhagwat, N. (2022a). Greater Painted-snipe Rostratula benghalensis. https://ebird.org/species/grpsni1, ML 441773561. Accessed 29/07/2022.

Bhagwat, N. (2022b). Greater Painted-snipe Rostratula benghalensis. https://ebird.org/species/grpsni1, ML 452093521. Accessed 28/07/2022.

Bhagwat, N. (2022c). Greater Painted-snipe Rostratula benghalensis. https://ebird.org/species/grpsni1, ML 448293031. Accessed 28/07/2022.

Bhagwat, N. (2022d). Greater Painted-snipe Rostratula benghalensis. https://ebird.org/species/grpsni1, ML 448292981. Accessed 28/07/2022.

Bhagwat, N. (2022e). Greater Painted-snipe Rostratula benghalensis. https://ebird.org/species/grpsni1, ML 448291111. Accessed 28/07/2022.

Bhagwat, N. (2022f). Greater Painted-snipe Rostratula benghalensis. https://ebird.org/species/grpsni1, ML 448291111. Accessed 28/07/2022.

Bhagwat, N. (2022g). Greater Painted-snipe Rostratula benghalensis. https://ebird.org/species/grpsni1, ML 442456481. Accessed 29/07/2022.

BIBY TV. (2017). Australian Painted-Snipe. https://www.youtube.com/watch?v=JwcYQVzGQKE . Accessed 28/03/2020.

Birding GuRu. (2021). https://www.youtube.com/watch?v=tivro-K9p88. Accessed 30/07/2022.

Birdlover.jp, (2017). Greater Painted-snipe https://www.youtube.com/watch?v=vAjdLg2zodI&vl=ja. Accessed 8/08/2020.

Blake, Y. (2022a). Greater Painted-snipe couple. https://www.youtube.com/watch?v=h9LX7wdV5FY. Accessed 29/07/2022.

Blake, Y. (2022b). Greater Painted-snipe couple. https://www.youtube.com/watch?v=usEN38D_za4. Accessed 29/07/2022.

Bolze, G. (1968). Anordnung und Bau der Herbstche Körperchen in Limicolenschnabeln im Zusammenhang mit der Nahrungsfindung. *Zoologischer Anzeiger* **181**: 313-355.

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

Clarke, L., Hagelin, J. and Werner, S.J. (2014). The Chemical Senses in Birds. USDA National Wildlife Research Center - Staff Publications, 1618. https://digitalcommons.unl.edu/icwdm_usdanwrc/1618. Accessed 9/08/2020.

Coker, M. (2020). Greater Painted-snipe Rostratula benghalensis. https://ebird.org/species/grpsni1, ML 251616851. Accessed 29/07/2022.

Cooper, R.M., McAllan, I., Brandis, C. and Curtis, B. (2016). 'An Atlas of the Birds of NSW and the ACT, Volume 2. Comb-crested Jacana to Striated Pardalote'. (New South Wales Bird Atlassers Inc.: Woolgoolga, NSW.)

Cramp, S. and Simmons, K.E.L. (Eds) (1983). 'Handbook of the Birds of Europe, the Middle East and North Africa. The Birds of the Western Palearctic. Vol. III. Waders to Gulls'. (Oxford University Press: London.)

del Hoyo, J. (2006). Greater Painted-snipe Rostratula benghalensis. https://ebird.org/species/grpsni1, ML 201262701. Accessed 18/07/2020.

del Hoyo, J. (2011a). Greater Painted-snipe Rostratula benghalensis. https://ebird.org/species/grpsni1, ML 201351971. Accessed 18/07/2020.

del Hoyo, J. (2011b). Greater Painted-snipe Rostratula benghalensis. https://ebird.org/species/grpsni1, ML 201351961. Accessed 18/07/2020.

del Hoyo, J. (2014a). Greater Painted-snipe Rostratula benghalensis. https://ebird.org/species/grpsni1, ML 201394961. Accessed 18/07/2020.

del Hoyo, J. (2014b). Greater Painted-snipe Rostratula benghalensis. https://ebird.org/species/grpsni1, ML 201394991. Accessed 18/07/2020.

del Hoyo, J. (2014c). Greater Painted-snipe Rostratula benghalensis. https://ebird.org/species/grpsni1, ML 201394971. Accessed 18/07/2020.

del Hoyo, J., Collar, N. and Kirwan, G.M. (2020). Australian Painted-snipe (*Rostratula australis*). In: del Hoyo, J., Elliott, A., Sargatal, J., Christie, D.A. and de Juana, E. (Eds). 'Handbook of the Birds of the World Alive'. (Lynx Edicions: Barcelona.) https://www.hbw.com/node/467303. Accessed 28/03/2020.

Desai, R. (2022a). Greater Painted-snipe Rostratula benghalensis. https://ebird.org/species/grpsni1, ML 468926961. Accessed 30/07/2022.

Desai, R. (2022b). Greater Painted-snipe Rostratula benghalensis. https://ebird.org/species/grpsni1, ML 468924991. Accessed 28/07/2022.

Desai, R. (2022c). Greater Painted-snipe Rostratula benghalensis. https://ebird.org/species/grpsni1, ML 462620251. Accessed 29/07/2022.

Desai, R. (2022d). Greater Painted-snipe Rostratula benghalensis. https://ebird.org/species/grpsni1, ML 462620251. Accessed 29/07/2022.

Desai, R. (2022e). Greater Painted-snipe Rostratula benghalensis. https://ebird.org/species/grpsni1, ML 468733111. Accessed 30/07/2022.

Desai, R. (2022f). Greater Painted-snipe Rostratula benghalensis. https://ebird.org/species/grpsni1, ML 467488721. Accessed 30/07/2022.

Desai, R. (2022g). Greater Painted-snipe Rostratula benghalensis. https://ebird.org/species/grpsni1, ML 467478701. Accessed 30/07/2022.

Desai, R. (2022h). Greater Painted-snipe Rostratula benghalensis. https://ebird.org/species/grpsni1, ML 463916561. Accessed 30/07/2022.

D'Ombrain, A.F. (1944). Behaviour of the Painted Snipe in Captivity. *Emu* **43**: 248-249.

Estrella, S.M. and Masero, J.A. (2007). The use of distal rhynchokinesis by birds feeding in water. *The Journal of Experimental Biology* **210**: 3757-3762. (Published by The Company of Biologists.)

Fraser, N. (2020). A review of Australian Painted-snipe records from the Hunter Region, 1966-2020. *The Whistler* **14**: 35-43.

Garnett, S.T., Szabo, J.K. and Dutson, G. (2011). 'The Action Plan for Australian Birds 2010'. (CSIRO Publishing: Collingwood, Vic.)

Gottschaldt, K.M. (1985). Structure and function of avian somatosensory receptors. In 'Form and function in birds, Vol. 3'. (Eds A. S. King and J. McLelland). Pp. 375-461. (Academic Press: London.)

Grandry, M. (1869). Recherches sur les corpuscles de Pacini. *Journal of Anatomy and Physiology* **6**: 390-395.

Hamilton, R.B. (1975). 'Comparative behaviour of the American avocet and the Black-necked stilt (Recurvirostridae)'. (Ornithological Monograph No. 17: The American Ornithology Union.)

HelloAoba5541. (2013). Greater Painted-snipe https://www.youtube.com/watch?v=C7PKOSeHqks. Accessed 8/08/2020.

Hilldog. (2020). Greater Painted-snipe Highlight. https://www.youtube.com/watch?v=U1iwjiGMI6Q. Accessed 8/08/2020.

Hindwood, K.A. and Hoskin, E.S. (1954). The waders of Sydney (County of Cumberland), New South Wales. *Emu* **54**: 217-255.

Hosken, B. (2020). Australian Painted-Snipe. https://www.youtube.com/watch?v=K43jNUvQU_4. Accessed 28/03/2020.

Jarvis, M. (2016). Australian Painted-Snipe. https://www.youtube.com/watch?v=En4830_gQxM. Accessed 28/03/2020.

Jimenez, D. (2011a). Greater Painted-snipe Rostratula benghalensis. https://ebird.org/species/grpsni1, ML 201943331. Accessed 18/07/2020.

Jimenez, D. (2011b). Greater Painted-snipe Rostratula benghalensis. https://ebird.org/species/grpsni1, ML 201943321. Accessed 18/07/2020.

Johnsgard, P.A. (1981). 'The Plovers, Sandpipers, and Snipes of the World'. (University of Nebraska Press: Lincoln and London.)

Karingamadathil, M. (2022). Greater Painted-snipe *Rostratula benghalensis*. https://ebird.org/species/grpsni1, ML 402231061. Accessed 30/07/2022.

Kennewell, M. (2004). Greater Painted-snipe Rostratula benghalensis. https://ebird.org/species/grpsni1, ML 201585101. Accessed 29/07/2022.

Kirwan, G.M. (2020). Greater Painted-snipe *Rostratula benghalensis*. In: 'Handbook of the Birds of the World Alive'. (Eds J. del Hoyo, A. Elliott, J. Sargatal, D.A. Christie and E. de Juana (Lynx Edicions: Barcelona.) https://www.hbw.com/node/53745. Accessed 28/03/2020.

Lakshmi, V. (2022). Greater Painted-snipe *Rostratula benghalensis*. https://ebird.org/species/grpsni1, ML 454455771. Accessed 28/07/2022.

Lane, B.A. and Rogers, D.I. (2000). The Australian Painted Snipe *Rostratula (benghalensis) australis*: an endangered species? *Stilt* **36**: 26-34.

Laven, A. (2009). Australian Painted-Snipe. https://ebird.org/species/auspas1, ML 201066961. Accessed 18/07/2020.

Lindsey, A. (2009). Some observations on the behaviour of the Australian Painted Snipe. *The Whistler* **3**: 53-54.

McNeil, R. and Rodriguez, S. Jr. (1996). Nocturnal foraging in shorebirds. *International Wader Studies* **8**: 114-121.

Maher, P. (2011a). Australian Painted-Snipe. https://www.youtube.com/watch?v=lCyOy_aPkgM. Accessed 28/03/2020.

Maher, P. (2011b). Australian Painted-Snipe. https://www.youtube.com/watch?v=QoAxU_kh5yY. Accessed 28/03/2020.

Marchant, S. and Higgins, P.J. (Eds) (1993). 'Handbook of Australian, New Zealand and Antarctic Birds. Volume 2: Raptors to Lapwings'. (Oxford University Press: Melbourne.)

Martin, G.R. and Piersma, T. (2009). Vision and touch in relation to foraging and predator detection: insightful contrasts between a plover and a sandpiper. *Proceedings of Biological Science* **276**: 437-445. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2664340/. Accessed 28/07/2022.

Menkhorst, P., Rogers, D., Clarke, R., Davies, J., Marsack, P. and Franklin, K. (2017). 'The Australian Bird Guide'. (CSIRO Publishing: Clayton South, Victoria.)

Nebel, S., Jackson, D.L. and Elner, R.W. (2005). Functional association of bill morphology and foraging behaviour in calidrid sandpipers. *Animal Biology* **55**: 235-243.

Parashou, L. (2020). Australian Painted-Snipe. https://www.youtube.com/watch?v=nQ2XQT7g6Do&feature=youtu.be. Accessed 28/03/2020.

Piersma, T., van Aelst, R., Kurk, K., Berkhoudt, H. and Maas, L.R.M. (1998). A new pressure sensory mechanism for prey detection in birds: the use of principles of seabed dynamics? *Proceedings of the Royal Society of London* **265**: 1377-1383.

Prince, M. (2020). Greater Painted-snipe Rostratula benghalensis. https://ebird.org/species/grpsni1, ML 246994271. Accessed 18/07/2020.

Puravankara, S. (2021). Greater Painted-snipe Rostratula benghalensis. https://ebird.org/species/grpsni1, ML 374879061. Accessed 29/07/2022.

Rogers, D.I., Hance, I., Paton, S., Tzaros, C., Griffioen, P., Herring, M., Jaensch, R., Oring, L., Silcocks, A. and Weston, M. (2005). The breeding bottleneck: Breeding habitat and population decline in the Australian Painted Snipe. In 'Status and conservation of shorebirds in the East Asian - Australasian Flyway. Proceedings of the Australasian Shorebirds Conference 13-15 December 2003, Canberra, Australia'. (Ed. P. Straw) Pp 15-23. (Wetlands International Global Series 18, International Wader Studies 17: Sydney, NSW.)

Rubega, B.A. and Obst, B.S. (1993). Surface-tension feeding in Phalaropes: Discovery of a novel feeding mechanism. *Auk* **110**: 69.

Sahana, M. (2020a). Greater Painted-snipe Rostratula benghalensis. https://ebird.org/species/grpsni1, ML 214968521. Accessed 18/07/2020.

Sahana, M. (2020b). Greater Painted-snipe Rostratula benghalensis. https://ebird.org/species/grpsni1, ML 240762931. Accessed 18/07/2020.

Sahana, M. (2020c). Greater Painted-snipe Rostratula benghalensis. https://ebird.org/species/grpsni1, ML 240755791. Accessed 18/07/2020.

Sahana, M. (2020d). Greater Painted-snipe Rostratula benghalensis. https://ebird.org/species/grpsni1, ML 24075491. Accessed 29/07/2022.

Sanabria, J. (2007a). Greater Painted-snipe Rostratula benghalensis. https://ebird.org/species/grpsni1, ML 200808961. Accessed 18/07/2020.

Sanabria, J. (2007b). Greater Painted-snipe Rostratula benghalensis. https://ebird.org/species/grpsni1, ML 200808951. Accessed 18/07/2020.

Sanabria, J. (2007c). Greater Painted-snipe Rostratula benghalensis. https://ebird.org/species/grpsni1, ML 200808941. Accessed 18/07/2020.

13seaeagle. (2014). Greater Painted-snipe. https://www.youtube.com/watch?v=dRRZW5P7vZk. Accessed 9/04/2020.

Sharpe, R.B. (1896). Catalogue of the Birds in the British Museum **24**: 521. (London.)

Shenai, R. (2022). Greater Painted-snipe *Rostratula benghalensis*. https://ebird.org/species/grpsni1. ML 459361441. Accessed 29/09/2022.

Siggs, T. (2015). Australian Painted-snipe. https://www.youtube.com/watch?v=r2KuVby7GtE. Accessed 28/03/2020.

Sun Destinations. (2016). Greater Painted-snipe. https://www.youtube.com/watch?v=vZbZEY1ABN4. Accessed 9 April 2020.

Tewari, A. (2017). Greater Painted-snipe *Rostratula benghalensis*. https://ebird.org/species/grpsni1, ML 201974581. Accessed 18/07/2020.

Thillainayagam, A. (2021). Greater Painted-snipe *Rostratula benghalensis*. https://ebird.org/species/grpsni1, ML 330499201. Accessed 29/07/2022.

Thillainayagam, A. (2021). Greater Painted-snipe *Rostratula benghalensis*. https://ebird.org/species/grpsni1, ML 330498171. Accessed 30/07/2022.

Tigers and Birds of India. (2022). https://www.youtube.com/watch?v=UMr3q2H6Jfk. Accessed 30/07/2022.

Toyoshima, K. (1989). Chemoreceptive and Mechanoreceptive Paraneurons in the Tongue. *Archives Histology and Cytology* **52**: 383-388.

Toyoshima, K. (1993). Are Merkel and Grandry cells two varieties of the same cell in birds? *Archives of Histology and Cytology* **56**: 167-175.

Tyrrell L.P. and Fernández-Juricic, E. (2017). Avian binocular vision: It's not just about what birds can see, it's also about what they can't. PLoS ONE 12: e0173235. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0173235. Accessed 22/07/2020.

Van Heezik, Y.M., Gerritsen, A.F.C. and Swennen, C. (1983). The influence of chemoreception on the foraging behaviour of two species of sandpiper, *Calidris alba* and *Calidris alpina*. Netherlands Journal of Sea Research **17**: 47-56.

Wallace, S. (2017b). Australian Painted-Snipe *Rostratula australis*. https://ebird.org/species/auspas1, ML 201635811. Accessed 18/07/2020.

Xeira, A. (2020). Greater Painted-snipe *Rostratula benghalensis*. https://ebird.org/species/grpsni1, ML 253814581. Accessed 30/07/2022.

Azure Kingfisher commensal behaviour

Darren Foster

20 O'Donnell Crescent, Metford NSW 2323, Australia. darrenfoster65@bigpond.com

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This note is about the commensal relationship between the Azure Kingfisher *Ceyx azureus* and people fishing (including my own observations) on several bodies of water within the Hunter Region of NSW, Australia and further west: Glennies Creek Dam, Singleton; Williams River, Clarence Town; Wallis Creek, Buchanan; Woodlands Estate Reserve, Thornton; and Bywondah Fishing Retreat, Ogunbil.

The Azure Kingfisher is one of Australia's two river kingfishers (a group of Afro-Asian birds which specialise on aquatic invertebrates and small fish). The river kingfishers are piscivorous meaning they eat fish (and they also eat aquatic invertebrates). Its foraging behaviour has been described as poorly known (Higgins 1999). However, birds often catch food by plunge-diving from a perch above water (Strahan 1994; Higgins 1999) and sometimes by a sally-hover technique (Forshaw & Cooper 1983). Although Higgins also commented that it did not allow close approach by people, this has not been the case during observations by myself and others when an opportunistic foraging opportunity arose. In all cases, the close contact was initiated by the kingfisher. The above-mentioned sally-hover technique has been documented in Pied Kingfisher *Ceryle rudis* and Common Kingfisher *Alcedo atthis* across Africa and Asia (Douthwaite 1976; Tsang & Jianzhong 2006; Ng 2017).

Over the last 18 years, I have had numerous encounters with Azure Kingfishers while fishing in creeks and rivers around the Hunter Region (and beyond) during both day and night. Usually when I have encountered these quiet, unassuming birds, I have been fishing quietly near a bank and they have become confiding. Some of my observations of their foraging behaviour align with prior reports; other behaviours appear not to have been reported before (at least not within Australia).

Frequently, when I have been lure- or fly-fishing within the territory of an Azure Kingfisher, the bird has come to a perch nearby. When the lure or fly has hit the water, the kingfisher has flown down (plunge-dived) to catch either small fish (Common Jollytail *Galaxias maculatus*, Mountain Galaxias *Galaxias olidus*, Australian Smelt *Retropinna semoni*, Eastern Mosquitofish *Gambusia holbrooki*) or shrimps such as Australian Glass Shrimp *Paratya australiensis* at the surface which had been disturbed by the lure or fly. This behaviour has happened when I have been fishing from a boat and also from a bank.

On one occasion, on the Williams River downstream from Clarence Town, a group of four birds began following me along the shoreline displaying this commensal behaviour and I formed the impression that it was a family group of two adult birds and two young birds, with the young birds being instructed in this technique of gleaning (plunge-diving) and its association with humans on or around their local waters. In this instance, the lure or fly was cast in under the overhanging Weeping Willow *Salix babylonica* tree fronds, disturbing the small baitfish or shrimp taking advantage of the cover.

I also saw the plunge-diving technique when I was fishing from the bank at Lake St Clair (Glennies Creek Dam) at the northern reach of the Carrowbrook arm, where Joshuas Creek flows beneath Carrowbrook Road through a concrete culvert. Adjacent to the culvert is a rock wall for reinforcement of the roadside verge with a moderate tree line providing adequate perches for resting kingfishers. When fishing this type of area, my objective is to cast as close to the shallow edge of the rock wall and work the lure or fly down and out into deeper water. It is usually within the shallow, first 500mm (distance from mean water mark extending out from the bank towards deeper water) that the small baitfish and shrimp make full use of the cover offered by the rocks for protection. However, when the lure or fly hits the water and disturbs them, the kingfisher plunge-dives to take its next meal. Quite often under these circumstances, the kingfisher will stay for as long as the person continues to fish, following the fishing action and only leaving when the fishing action stops. I have seen this plunge-diving behaviour at various locations around the banks of Lake St Clair and at other locations as well: Williams River, Clarence Town; Wallis Creek, Buchanan; Woodlands Estate Reserve, Thornton; and Bywandah, Ogunbil.

At times when I have been night-fishing an Azure Kingfisher has joined me and exhibited the same behaviour, plunging from a perch to catch small fish or shrimp disturbed by the lure or fly. This behaviour during night-time fishing makes perfect sense as under the cover of darkness, small shrimp, crayfish, small fish and at the right time of the year even mudeyes (dragonfly nymphs), damselfly nymphs and mayfly nymphs can be quite prolific, making themselves targets for easy meals by the kingfishers.

During day-time encounters, the kingfisher would often follow as I moved the boat either upstream or downstream along the same stretch of creek or river, usually parallel to the bank. When the boat was paused at-its new location, the kingfisher once again would take up a perch nearby watching for an opportunity to take the plunge for an assisted feed. Similarly, the kingfisher would follow along the river or creek bank when I was walking the banks. At night-time, the kingfisher would silently glide from branch to branch as I walked the bank. It is worth noting here that when fishing at night, the kingfisher was usually spotted either by ambient sky-light or when a head-lamp was turned on after I had caught a fish or was changing tackle or moving to a new location. Another giveaway was the almost-silent splash from the kingfisher hitting the water when chasing a prey item.

At the Wallis Creek location when fishing for Freshwater Mullet *Myxus petardi* using an artificial bread fly, I have used small pieces of bread for burley to attract the mullet which proceed to feed on the bread. The small Gambusia (Mosquitofish) also feed on the bread, on or very close to the surface. The kingfisher is attracted to the disturbance presumably of the mullet splashing on and around the surface when feeding on the bread.

From its perch beside the river, the kingfisher has been observed to fly out over the water (approximately 10-15 m out from the perch) and sally-hover at a height of 2-3 m above the water, watching for an opportunity to dive and catch a prey item before returning to its perch to consume the food (example shown in **Figure 1**). At other times the kingfisher would plunge-dive directly from its perch into the water to catch its prey.

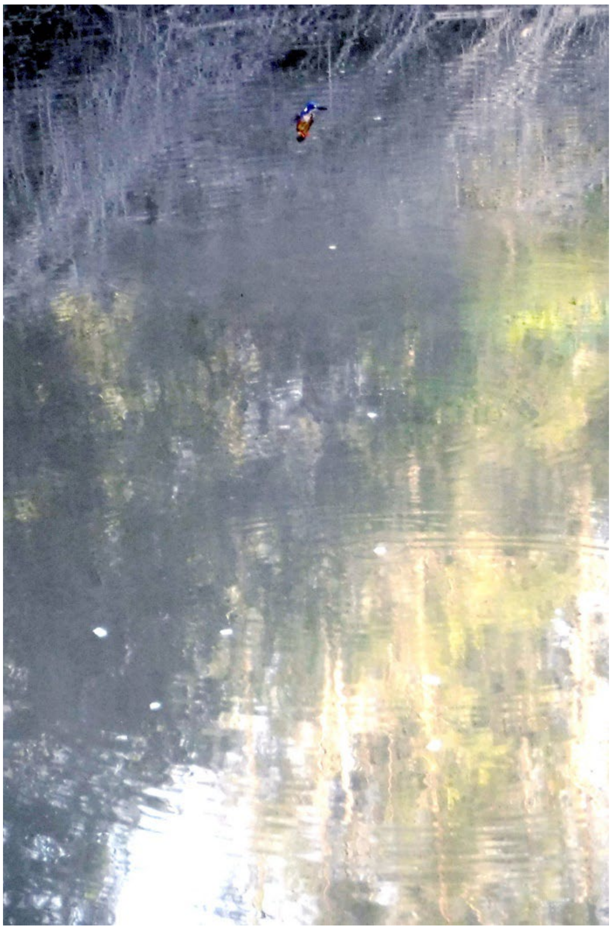

Figure 1. Top image: Azure Kingfisher sally-hovering at 2-3 m above the water surface (at Wallis Creek, Buchanan, 20 January 2018). The white objects on the water are pieces of bread and the ripples are disturbance caused by feeding mullet and Gambusia. Image below: A cropped version of the same photo which indicates the rapidness of the kingfisher's wingbeats.

During the writing of these notes, whilst visiting the inner wetlands area of Four Mile Creek between Metford and Thornton (Woodlands Estate Reserve), I observed an Azure Kingfisher briefly displaying the sally-hover manoeuvre approximately 1–2 metres over shallow water before flying off. I think

I may have inadvertently scared off the kingfisher whilst concentrating on getting a better view of a Black-fronted Dotterel *Elseyornis melanops*.

At no time has a kingfisher been observed to take the lure or fly by mistake or on purpose, they have always been focused on taking prey that has either been disturbed by the lure or fly or attracted by the disturbance.

As also reported in overseas observations (Douthwaite 1976; Tsang & Jianzhong 2006; Ng 2017), these behaviours were always enacted close to shore and never towards the centre of the dam or large expanses of open water which would require excessive flying distances and unnecessary expenditure of energy. The birds I have observed have always been within 5 metres and up to 15 to 20 metres away from my position either on a bank or on a boat.

Other fishermen have reported similar behaviour of the Azure Kingfisher, as per the following quotes:

"*I have watched them dive at my feet to get little fish when standing on the concrete under-road pipes at the northern end of St Clair (Glennies Creek Dam).*" (P. Sewell pers. comm.)

"*I've had them seemingly follow me up a river when wading, but never observed the kind of cooperative hunting you describe.*" (M. Jordan pers. comm.)

"*I have definitely seen this behaviour at Clarence Town.*" "*I have not had the kingfisher follow me along.*" "*Other locations where, after spooking baitfish, the kingfisher gets an easy meal: Darwin Harbour, middle of Cape York, Archer and Jardine Rivers.*" (B. Kershaw pers. comm.)

"*A kingfisher landed on my rod near the first runner. The bird was not disturbed as I slowly drew my rod in 'till we were 10 inches apart and we eyed each other off for a few minutes. I gently moved the rod back to normal hold stance. Under careful watch, I slowly reached down and flicked some mullet into the shallows to draw the attention of the baitfish. In the instant the kingfisher was lining up its prey, the rod doubled over and the kingfisher took for the trees.*" (M. Ewin pers. comm.)

"*I've seen this behaviour before with the kingfishers up the Carrowbrook Arm, St Clair (Glennies Creek Dam).*" (E. Anacki pers. comm.)

REFERENCES

Douthwaite, R. J. (1976). Fishing Techniques and Foods of The Pied Kingfisher on Lake Victoria in Uganda. *Ostrich* **47** (4): 153-160, DOI: 10.1080/00306525.1976.9639555

Forshaw, J.M. and Cooper, W.T. (1983). 'Kingfishers and Related Birds. *Alcedinidae*: Ceryle to Cittura'. (Lansdowne Edns: Melbourne.)

Higgins, P.J. (Ed.) (1999). 'Handbook of Australian, New Zealand and Antarctic Birds Volume 4: Parrots to Dollarbird'. (Oxford University Press: Melbourne.)

Ng, Neo. (2017). Pied Kingfisher and hovering. (Bird Ecology Study Group: Singapore, South-east Asia.)

Strahan, R. (1994). 'Cuckoos, Nightbirds and Kingfishers of Australia. The National Photographic Index of Australian Wildlife'. (Angus and Robertson: Sydney.)

Tsang, K.C. and Jianzhong, L. (2006). Common Kingfisher: Hovering. (Bird Ecology Study Group: Singapore, South-east Asia.)

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The status of the Double-banded Plover in the Hunter Region, New South Wales

Ann Lindsey[1] and Neil Fraser[2]

[1]37 Long Crescent, Shortland NSW 2307, Australia. ann.lindsey@bigpond.com
[2]8 Flannel Flower Fairway, Shoal Bay NSW 2315, Australia. neil8fff@gmail.com

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A proportion of the population of Double-banded Plover *Charadrius bicinctus* migrate to southern and eastern Australia during the non-breeding season, including to the Hunter Region of NSW. This cohort of migrants breed at high altitude on the South Island of New Zealand. Double-banded Plover have been recorded at 13 sites across the Hunter Region over a 55-year period, 1967 to 2021. The majority of records were from six sites – Worimi Conservation Lands, Manning Estuary, Port Stephens, Hunter Estuary, Lake Macquarie and Wallis Lake. Results indicate that there has been a highly significant population decline of 37% in the Hunter Region in the past 14 years. Although a decline is also evident over the entire 55-year period, it could not be measured empirically. The population utilising the Hunter Estuary had declined by the 1980s and the numbers utilizing the Manning Estuary and Worimi Conservation Lands declined after 2014. There was minimal decline in Port Stephens where there was less disturbance at sites used by the birds. Two sites, Manning Estuary and Worimi Conservation Lands are nationally significant for the species as they have often hosted more than 0.1% of the total population.

INTRODUCTION

Double-banded Plover *Charadrius bicinctus* is a small plover which breeds in New Zealand during the austral summer. In New Zealand it is known as the Banded Dotterel. It is described as partly migratory, dispersive and sedentary (Marchant & Higgins 1993). Most birds on the North Island of New Zealand do not migrate and are joined by birds from northern and lowlands areas of the South Island during the non-breeding season. However, most birds found at higher altitudes in the South Island migrate to eastern and southern Australia including Tasmania, Norfolk and Lord Howe Islands. It is also a regular visitor to Fiji and New Caledonia (Pierce 1999; Cooper *et al*. 2014; Wiersma *et al.* 2019). In NSW the majority are present from February until August (Cooper *et al.* 2014). Small numbers are also present in January and September to December. There are two recognized subspecies *bicinctus* and *exilis*. The birds that visit Australia belong to the nominate subspecies *bicinctus*.

In the non-breeding season migrating birds form loose flocks, often displaying high site fidelity from year to year (Marchant & Higgins 1993). Although they have a tendency to roost separately from most other shorebird species, they regularly mix with waders such as Red-necked Stint *Calidris ruficollis* and Red-capped Plover *Charadrius ruficapillus* when roosting and feeding (Stuart 2008; Department of Climate Change, Energy, the Environment and Water 2022; authors' pers. obs.).

Robertson *et al*. (2017) classified the species as Nationally Vulnerable. The 2019 Australian Waterbird Index (Clemens *et al.* 2019) reported a long-term trend (since the 1980s) of decline, a medium-term trend (over 21 years) of increase and a flat short-term trajectory (last 5 years). The Index did not identify any reduction in the Australian wintering population over the past three generations (since 2007). The IUCN has recently raised the status of the species from Least Concern to Near Threatened (IUCN 2021).

The long-term population change cannot be readily determined due to varying population estimates. Lane (1987) estimated the population to be at least 12,450 birds based on simultaneous counts in Australia and New Zealand. In contrast, Bamford *et al*. (2008) and Garnett *et al*. (2011) estimated the population to be 50,000 birds. The most recent estimate is 19,000 birds (Hansen *et al*. 2016). Barrett *et al*. (2007) identified a decline in Reporting Rate (RR) of 25.4% over the 21 years between the 1977-1981 Atlas of Australian Birds and the analogous 1998-2002 Atlas. The Atlas of the Birds of NSW & ACT (Cooper *et al*. 2014) reported that the annual RR declined by around 50% between 1986 and 2006.

The objectives of the present study were to review records of Double-banded Plover from all sites across the Hunter Region and to establish the recent population trend.

METHODS

Records for Double-banded Plover were extracted from the BirdLife Australia Birdata portal (https://birdata.birdlife.org.au/home), the Cornell Lab of Ornithology eBird Australia portal (https://ebird.org/australia/home), the NSW Department of Environment and Heritage BioNet Atlas (http://www.bionet.nsw.gov.au/) and the Eremaea Birdline (http://www.eremaea.com/BirdlineRecentSightings.aspx?Birdline=2). Records were also extracted from Annual Bird Reports for the Hunter Region (https://www.hboc.org.au/publications/annual-bird-report/) for years 1993-2019 and from a spreadsheet of early avian records (1979-1993) for the region (A. Stuart pers. comm). Additional early records from Kooragang Island for 1969-1977 were extracted from *Hunter Natural History* (Kendall & van Gessel 1972; van Gessel & Kendall 1972a and 1972b) and from van Gessel & Kendall (2015). Records for Wallis Lake were provided by Ashley Carlson.

Much of the sourced data were from regular standardised surveys, particularly in the Hunter Estuary, Port Stephens, Manning Estuary, Worimi Conservation Lands, Wallis Lake and Lake Macquarie. Regular standardised monitoring of shorebirds in Lake Macquarie commenced in October 1988 and in the Hunter Estuary in April 1999. A detailed description of the survey protocols for the estuary is available (BirdLife Australia 2021). Prior to 1999, monitoring in the Hunter Estuary was intermittent although parts of Ash Island and Kooragang Island were monitored somewhat more regularly during 1971-99. Regular monitoring of other key sites in the region commenced subsequently: Swan Bay (an important Port Stephens site) in September 2000; the Manning Estuary in February 2008; and the Worimi Conservation Lands section of Stockton Beach north of Newcastle in February 2009. Survey protocols for the Manning Estuary and Worimi Conservation Lands are described by Stuart (2014b) and Lindsey & Newman (2014) respectively.

Sites with regular occurrences were identified and the maximum monthly count was determined for each site. When no birds were recorded, the maximum count was recorded as zero. Mean monthly counts were determined for the period in which the majority of birds were present in sites that had 20 or more records. The maximum monthly counts for sites that were surveyed regularly from 2008/9-2021 were accumulated, mean and standard deviations were calculated, and months in which the majority of birds were present were identified. Sites that were nationally important for the species (i.e. > 0.1% of total population) were identified.

Monthly counts for sites with periods of regular surveys over the study period were charted using MS Excel. The population change (March-August) over selected periods for sites that had been regularly surveyed was tested for significance by conducting Chi Square tests (Pearson 1900) and determining the probability P of the change being significant. The percentage decline over the selected periods was calculated from the ratio of the mean values for each period. It was determined for the region and for the three sites with regular surveys: Manning Estuary; Worimi Conservation Lands; and Port Stephens.

RESULTS

When present in the Hunter Region, Double-banded Plover are widely dispersed in small numbers across beaches, estuaries and near-coastal wetlands.

From 1967-2021, 647 records from 300 months were obtained for 13 sites (**Table 1**). The majority of records and the highest monthly maximum counts were from six sites: Worimi Conservation Lands; the Manning Estuary; Port Stephens; Hunter Estuary; Wallis Lake; and Lake Macquarie. The other seven sites had relatively few records over the study period or had not been the subject of regular surveys. The mean counts from regular monthly surveys from March-August were calculated for sites with 20 or more records and are shown in **Table 1**, together with the survey period.

The mean monthly count and standard deviation for five sites surveyed regularly from 2008/9-2021 is shown in **Figure 1**. This shows that the majority of birds are present from March until August.

The monthly counts for the Hunter Region from February 1967 to December 2021 are shown in **Figure 2**. The greater frequency of higher counts 2008-2021 reflects the commencement of monitoring on Worimi Conservation Lands and the Manning Estuary. **Figure 2** also displays clusters of higher counts from the Hunter Estuary 1971-1977 and Port Stephens, Lake Macquarie and Wallis Lake 1981-1989. Due to variation in the distribution of numbers across sites in the region, each site is discussed separately below.

Table 1. Months with records and maximum monthly count for 13 sites in the Hunter Region, 1967-2021. Mean counts are for March to August for six sites with 20 or more records.

Location	Months with records (1967-2021)	Maximum monthly count (1967-2021)	Mean count regular monthly surveys (Mar-Aug)	Regular monthly surveys
Worimi Conservation Lands	75	173	64	2009-2021
Manning Estuary	235	123	39	2008-2021
Port Stephens	101	55	16	2000-2021
Hunter Estuary	131	400+	30	1971-2021
Wallis Lake	43	76	26	1985-2006
Lake Macquarie	29	32	12	1982-1985, 1999-2021
Morpeth Wastewater Treatment Works	6	10	-	-
Broughton Island	9	4	-	-
Smiths Lake	9	5	-	-
Saltwater National Park	4	1	-	-
Mungo Brush Beach	3	1	-	-
Coopernook	1	1	-	-
Irrawang Swamp	1	1	-	-

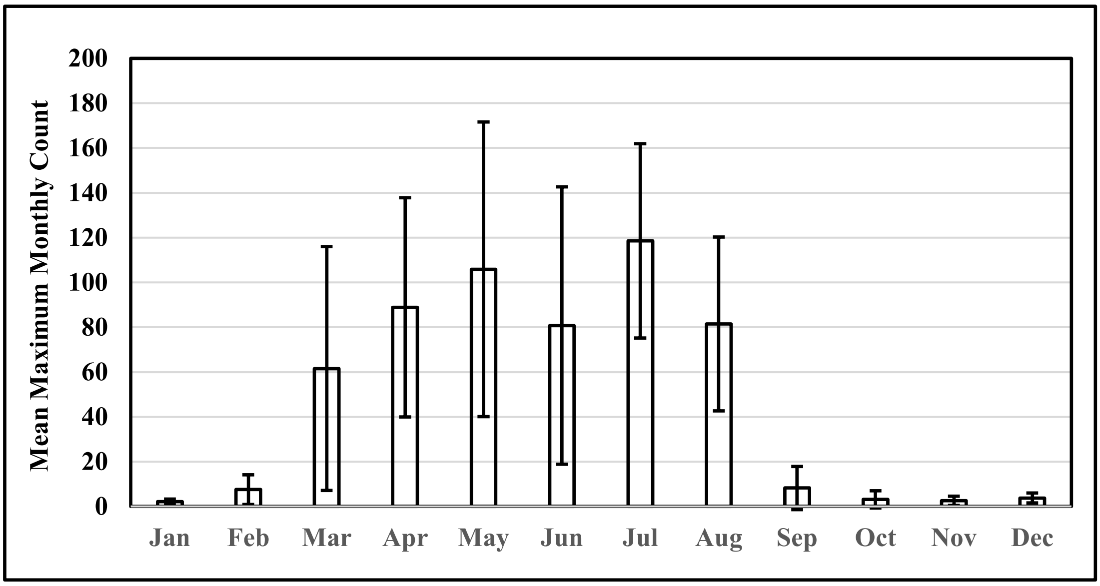

Figure 1. Mean monthly counts for Worimi Conservation Lands, Manning Estuary, Port Stephens, Hunter Estuary and Lake Macquarie 2008/9-2021 (bars), with +/- 1 standard deviation (lines).

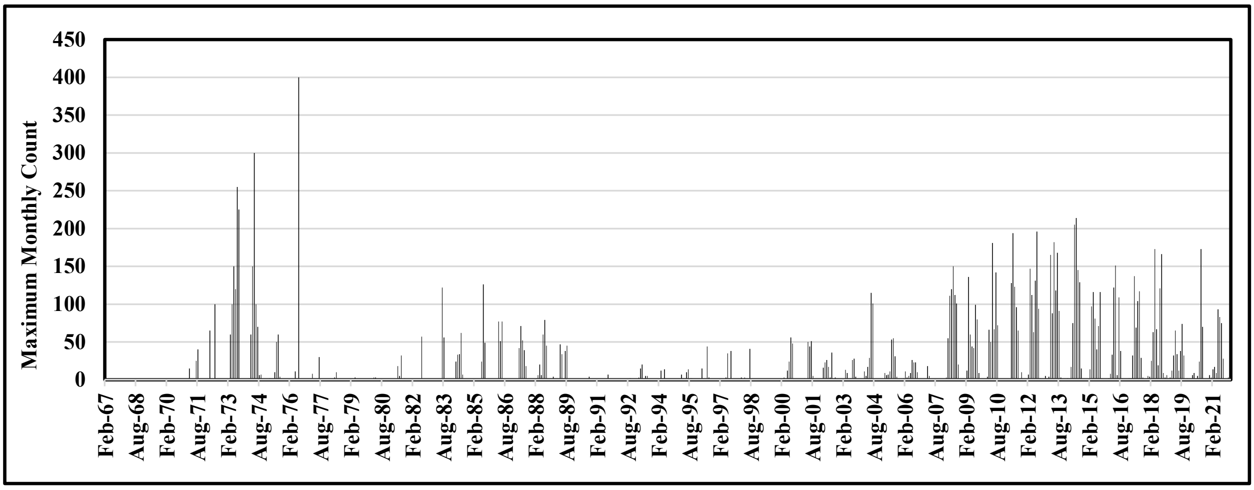

Figure 2. Monthly counts of Double-banded Plover for the Hunter Region 1967-2021

Worimi Conservation Lands

The Worimi Conservation Lands site was divided into three sub-sites for survey purposes. Regular monitoring of shorebirds commenced in 2009 (Lindsey & Newman 2014). Double-banded Plover were recorded regularly on the beach-front at the most southern of the three sites. 173 birds were present in June 2014 and the mean monthly count for March-August over 2009-2021 was 64 birds (**Table 1**). There was a marked decrease in numbers from 2014.

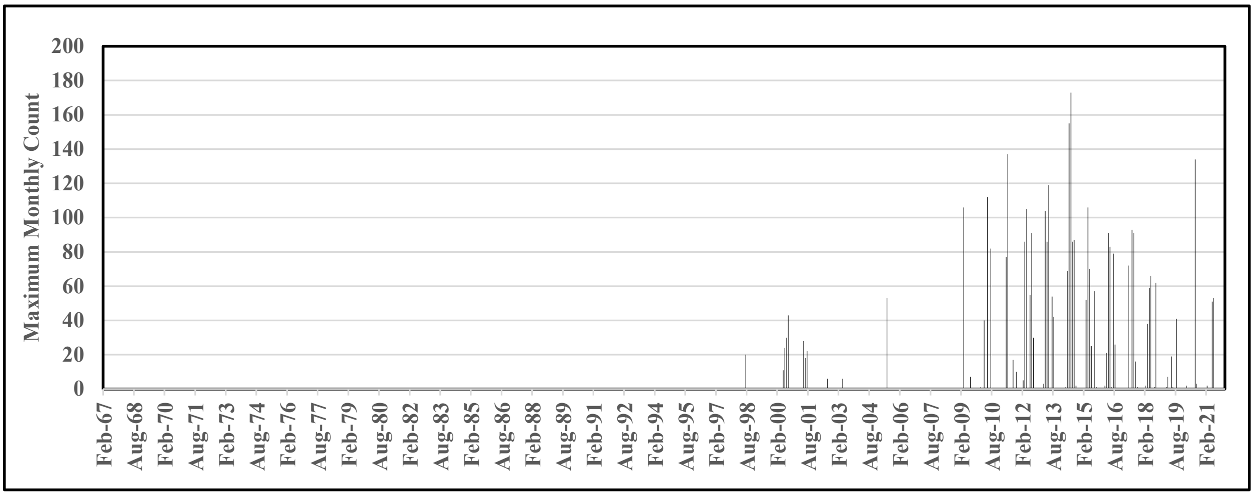

Figure 3. Monthly counts of Double-banded Plover for Worimi Conservation Lands 1967-2021.

Manning Estuary

Regular monitoring of shorebirds on the Manning Estuary commenced in 2008 (Stuart 2008). The Manning River has two entrances. The main channel is at Harrington and a secondary channel is located at Farquhar Inlet, 6km to the south. The majority of birds were present on the ocean shoreline at Farquhar Inlet. The maximum count was 123 birds in June 2011 and the mean monthly count for March-August over 2008-2021 was 39 birds (**Table 1**). There was a marked decrease in numbers after 2014.

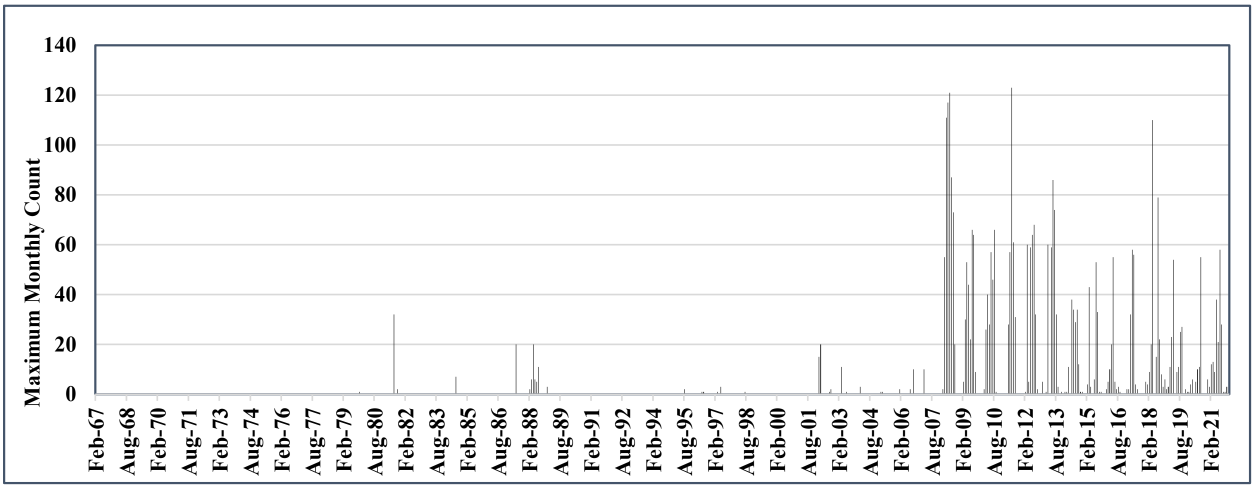

Figure 4. Monthly counts of Double-banded Plover for the Manning Estuary, 1967-2021.

Port Stephens

Records from Port Stephens were from Taylors Beach, Swan Bay/Gir-um-bit National Park, Corrie Island Nature Reserve and Winda Woppa Sandspit. The earliest monitoring was conducted by the Australasian Wader Study Group during 1982-1984. Regular monitoring by the Hunter Bird Observers Club (HBOC) at Swan Bay commenced September 2000. Monitoring of Corrie Island and Winda Woppa by HBOC commenced February 2004. There were 55 birds present in July 2005 and the mean count March-August 2000-2021 was 16 birds (**Table 1**). There was a marked decrease in numbers after 2014. Surveys of Taylors Beach ceased in June 1985. Birds at Corrie Island and Winda Woppa were recorded on sandy beaches while at Swan Bay/Gir-um-bit NP they were present on saltmarsh. Bartrim (1980) reported up to 150 birds were commonly present on saltmarsh areas of Gir-um-bit NP but gave no temporal details.

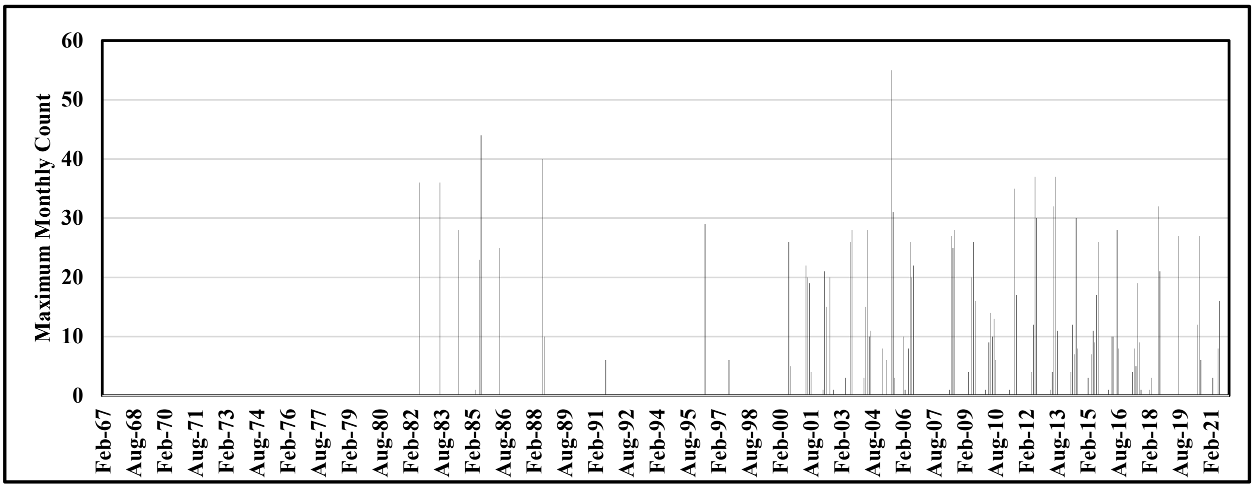

Figure 5. Monthly counts of Double-banded Plover for Port Stephens 1967-2021.

Hunter Estuary

Birds were recorded from multiple sites across the Hunter Estuary including Ash Island, Fullerton Cove, Hexham Swamp, Pambalong Nature Reserve, Stockton Sandspit and Tomago Wetland. There was a discrete cluster of high counts 1971-1976 (**Figure 6**). The maximum count was 400+ birds in July 1976 (van Gessel & Kendall 2015). Subsequent records were intermittent and mostly were of 1-10 birds. There were isolated higher counts of 96 and 90 birds at Fullerton Cove in June and July 2004 and 60 birds at Tomago Wetlands in August 2018 (**Figure 6**). The mean count for March-August over 1971-1976 was 96 birds, but over the entire data period, 1976-2021, it was only 24 birds.

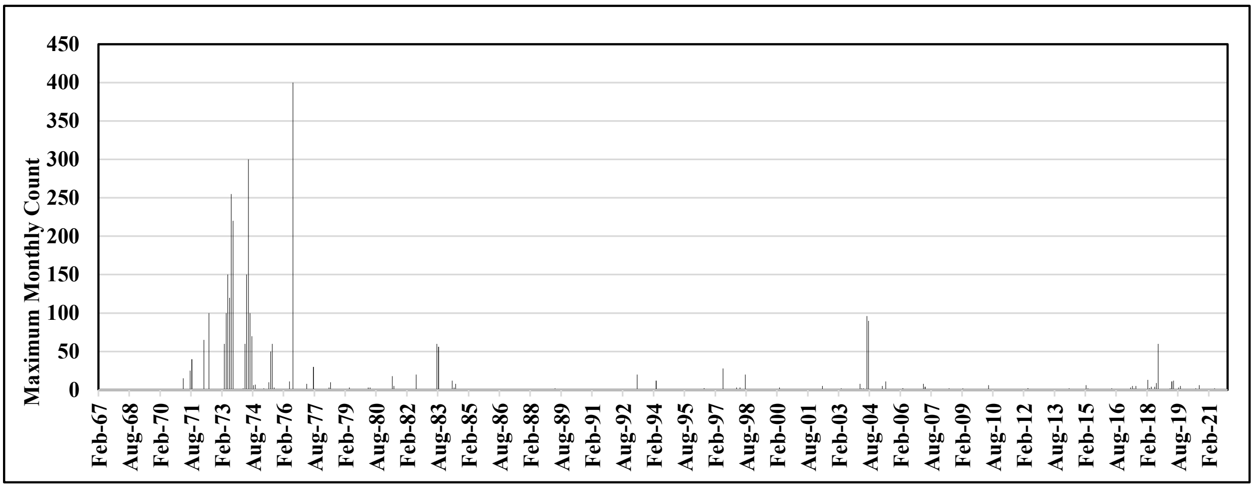

Figure 6. Monthly counts of Double-banded Plover for the Hunter Estuary 1967-2021

Wallis Lake

At Wallis Lake, birds were recorded over 1975-2006, mainly from around Pelican Island, Green Point and Tern Island. A cluster of high counts was recorded 1985-1989 (**Figure 7**). The maximum count was 76 birds in August 1980 and the mean count for March-August over 1985-1989 was 42 birds (**Table 1**). There were a few subsequent records of 1-15 birds.

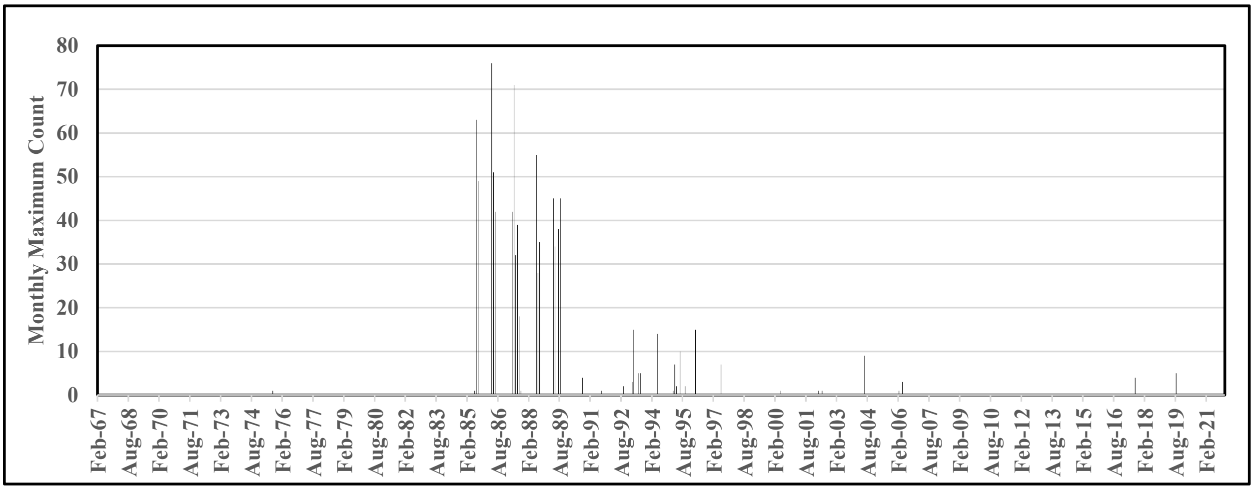

Figure 7. Monthly counts of Double-banded Plover for Wallis Lake 1967-2021.

Lake Macquarie

Sites were clustered around the Swansea Channel at Galgabba Point and Pirrita Island, and at Swansea Heads and Moon Island. Birds were recorded intermittently from 1973 (**Figure 8**). The maximum count was 32 birds in August 1997 (**Table 1**). There was a small cluster of records over 1983-1986 with a maximum count of 31 birds in May 1984. The mean count for March-August from 1982-2021 was 12 birds.

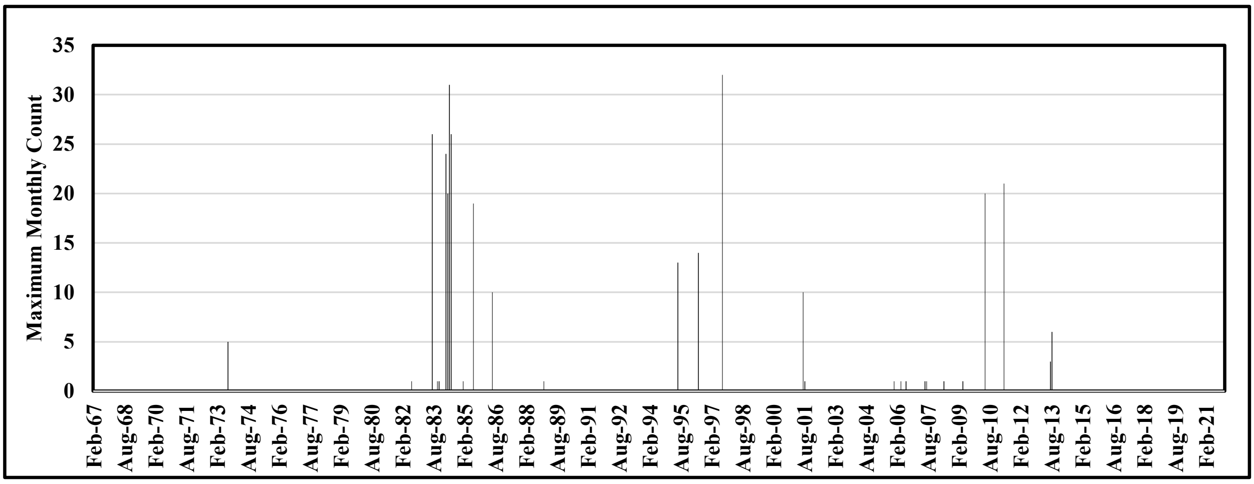

Figure 8. Monthly counts of Double-banded Plover for Lake Macquarie 1967-2021

Other sites

Seven additional sites had 1-9 records and the maximum count was 10 birds at Morpeth Wastewater Treatment Works in June 2002 (**Table 1**). The other sites were Broughton Island, Smiths Lake, Saltwater NP, Mungo Brush Beach, Coopernook and Irrawang Swamp, all with maximum counts of 1-5 birds (**Table 1**).

Population decline

The monthly population counts for the Hunter Region are shown in **Figure 2**. Accurate determination of the long-term population decline was not possible due to the intermittent nature of surveys conducted from 1967 to 2007. Additionally, not all known sites were surveyed every year. During the period 1967-2007 counts of 260 birds in July 1973, 300 birds in May 1974 and 400+ birds in July 1976 were recorded in the Hunter Estuary. These are the highest counts for the region over the study period. The maximum count recorded between 2008 and 2021, when most of the important sites were surveyed regularly, was 214 birds in June 2014.

The regular surveys from 2008-2021 indicated a pronounced population decline from 2014 (**Figure 2**). To test the significance of the decline, mean monthly counts for the Hunter Region, Manning Estuary, Worimi Conservation Lands and Port Stephens were calculated for two time periods: prior to 2015 and 2015-2021. For each of those sites, Chi Square tests were applied to the two time periods to determine the probability (P) of the change being significant, assuming unequal variances. P values <0.05 were classified as significant and values < 0.01 as highly significant. The results, shown in **Table 2**, indicate there has been a statistically highly significant population decline in the Hunter Region over the period analysed. The decline is dominantly in the Manning Estuary and Worimi Conservation Lands. The change in the population utilizing Port Stephens was not statistically significant. There were insufficient data to conduct statistical tests for the other sites.

For the Manning Estuary, the changes over time at the two monitored sites, Farquhar Inlet and Harrington, were compared (**Table 3**). The reduction in numbers at Farquhar Inlet was statistically highly significant while the change at Harrington was not significant.

Table 2. Calculated Chi square values, probability and percentage decline for population change of Double-banded Plover for the Hunter Region, Manning Estuary, Worimi Conservation Lands and Port Stephens.

Location	**Mean Maximum Survey Counts (March-August)**			**χ2 Value**	**P**	**Decline**
Hunter Region		2008-2014	2015-2021	8.94	< 0.01	37%
	Surveys	42	42			
	Mean	110	69			
Manning Estuary		2008-2014	2015-2021	8.72	< 0.01	52%
	Surveys	38	37			
	Mean	56	27			
Worimi Conservation Lands		2009-2014	2015-2021	11.38	< 0.01	36%
	Surveys	24	28			
	Mean	80	51			
Port Stephens		2008-2014	2015-2021	0.00	-	13%
	Surveys	30	24			
	Mean	16	14			

Table 3. Mean counts and Chi-square values for population comparisons for Double-banded Plover at Harrington and Farquhar Inlet, Manning Estuary.

Location	**Mean Maximum Survey Counts (March-August)**			**χ2 Value**	**P**
Farquhar Inlet		2008-2014	2015-2021	4.04	< 0.01
	Surveys	37	26		
	Mean	46	18		
Harrington		2008-2014	2015-2021	0.02	-
	Surveys	22	23		
	Mean	16	17		

DISCUSSION

Although Double-banded Plover have been observed from North Queensland to Tasmania, and west to Perth, the largest numbers spend the winter in Victoria and Tasmania. In the Hunter Region, the known main population sites are currently Worimi Conservation Lands, Manning Estuary and Port Stephens. Previously, regular populations were recorded in the Hunter Estuary, Lake Macquarie and Wallis Lake.

Nationally Important Sites

Initial monitoring of the Worimi Conservation Lands (Lindsey & Newman 2014) and the Manning Estuary (Stuart 2008; 2014) established that these were the most important sites for Double-banded Plover in the Hunter Region and that they were of national importance.

Under the Wildlife Conservation Plan for Migratory Shorebirds (Department of Environment 2015), shorebird habitat is considered nationally important if it regularly supports 0.1% or more of an East

Asian-Australasian Flyway population of any migratory shorebird species (Department of Climate Energy, the Environment and Water 2022). As the most recent population estimate for Double-banded Plover is 19,000 birds (Hansen *et al.* 2016), a site regularly supporting 19 or more is nationally significant. Worimi Conservation Lands and the Manning Estuary have mean counts of 64 and 39 birds respectively, for the period March - August. The Hunter Estuary and Wallis Lake previously supported regular populations for periods of 4-6 years that would have made them nationally significant, but they no longer do so.

Population decline

In assessing the status of Double-banded Plover, the IUCN measured decline over a period of 15 years (i.e. three generations of five years) for the application of their Criterion A, near threatened (IUCN 2021). Robertson *et al.* (2017) classified the species as nationally vulnerable. This was based on the IUCN criteria of a moderate to large population (5,000-20,000 mature individuals) and moderate to high ongoing or predictable decline (30-70%).

Consistent with that assessment, the population in the Hunter Region declined by 37% over 14 years to 2021, while the decline at individual sites varied from ~0 to 52%. The general decline evident in the regional population from 1967 to 2021 (**Figure 2**) correlates with the long-term trend identified by Clemens *et al*. (2019). However, the medium- and short-term trends identified by these authors were not evident.

Cooper *et al*. (2014) suggested that the decline in numbers in some areas of New South Wales was likely a reflection of the level of disturbance at those sites. They noted that most NSW sites used by the species were now affected by coastal development resulting in habitat loss and disturbance from humans and their activities. In the Hunter Region, the most important sites for Double-banded Plover, Worimi Conservation Lands and Manning Estuary, have seen an increase in the number of people and vehicles using the sites for recreational purposes.

In December 2015 the Worimi Conservation Lands Board of Management released their ten-year Plan of Management to guide, amongst other things, conservation of the site. Even so, more than 1000 vehicle movements have been recorded during peak holiday periods (NSW Office of Environment and Heritage 2015). There are always vehicles on the beach-front even during non-peak periods (authors' pers. obs.). This level of usage must impact on Double-banded Plover and other species that use the beach-front for foraging and roosting, and is likely to have been a factor in the decrease in population which was manifest after 2014 (**Figure 3**).

A factor for reduction in population at Farquhar Inlet, Manning Estuary, was probably regular disturbance due to vehicle activity and/or walkers, sometimes with dogs, along Mudbishops Point (Stuart 2008). A decrease in numbers is evident from 2014 (**Figure 4**). In Port Stephens, where numbers have declined only marginally, birds were present at Gir-um-bit National Park, Corrie Island Nature Reserve and the Winda Woppa Sandspit, all of which are relatively isolated from the general public and were not vehicle accessible.

At Farquhar Inlet, Manning Estuary, during high-tide surveys, birds were observed roosting along the beach-front, often in tyre tracks (A. Stuart pers. comm.). In Worimi Conservation Lands birds were mostly observed at the southern end of the site, also roosting on the beach-front and often in tyre tracks (pers. obs. the authors). This makes them particularly vulnerable to vehicular disturbance.

The decrease in numbers in the Hunter Estuary after 1977 may be due to a number of factors. Kendall & van Gessel regularly surveyed a number of sites in the estuary from 1969 to 1977 but after 1977 their regular surveys ceased (van Gessel & Kendall 2015). This would account for the lack of records until the 1980s when counts showed that Double-banded Plover numbers were already decreasing. There are no known records over 1986-1994, but small numbers were recorded over 1995-98 (Stuart 2014a). The majority of observations in the 1970s came from the open sandy areas on Stockton Sandspit and Curlew Point on Kooragang Island (T. Kendall pers. comm.). By the 1990s, mangroves had enclosed both sites and the open sandy areas had become overgrown with exotic vegetation such as Bitou Bush *Chrysanthemoides monilifera* and Spiny Rush *Juncus acutus* (Streever 1998). As a result, the sites became unsuitable for shorebirds which favour sites with good visibility in order to reduce predation risk while roosting (Jackson & Straw 2021).

Surveys at Wallis Lake were conducted from 1985 to 2006. Good numbers were present 1985-1989 when the mean count March-August was 42 birds. Subsequently, numbers decreased and records were intermittent. The cause of the decline is not evident.

The lack of regular records from the seven additional sites may indicate that the birds use these as temporary staging sites when transiting between preferred sites or it may simply be a result of irregular surveying.

Rehabilitated wetlands

Four major rehabilitation projects have been established in the Hunter Estuary focussed on the reintroduction of tidal flushing and/or vegetation management. These are at Ash Island, Hexham Swamp, Tomago Wetland and Stockton Sandspit (Svoboda 2017; Reid 2019; Lindsey 2021; Stuart & Lindsey 2021). As a result, a mosaic of saltmarsh and mudflats was created attracting several species of shorebirds including small numbers of Double-banded Plover. An unusually high number (60 birds) was recorded at Tomago Wetland in August 2018 (Lindsey 2021). At the rehabilitated Fish Fry Flats site on Ash Island, small numbers have been recorded since 2016/17 following restoration of tidal flushing (Reid 2019). In 1995, Kooragang Wetland Rehabilitation Project recontoured the Stockton Sandspit and removed invasive weeds and in 2002 National Parks and Wildlife Service removed half a hectare of mangroves from in front of the beach (Svoboda 2017). Despite the return of open, sandy substrate and improved visibility, Double-banded Plover numbers did not recover and the birds are now seldom seen in this section of the estuary. In response to the disappearance of suitable habitat at the Sandspit and Curlew Point, it is possible that the species relocated to the beach on Worimi Conservation Lands. However, that is speculative as no regular surveys of the beach took place prior to 2009.

Site fidelity

It is known that many species of birds and mammals are faithful to their natal and breeding site or group (Greenwood 1980). Double-banded Plover are reported to show high site-fidelity on wintering grounds (Marchant & Higgins 1993). Barton & Minton (1987) reported that birds showed high fidelity to their wintering site based on banding studies between 1976 and 1986 by the Victorian Wader Study Group. During that time, 1,993 birds were captured of which 1,732 were new birds and 261 were re-traps. Of 241 re-traps investigated, only six birds were found to have moved from the original banding site. In addition, re-sightings of colour-banded and/or dyed birds 1980-1986 revealed only five movements. From 1973-1989 van Gessel banded 150 birds at Stockton Sandspit and Curlew Point, Kooragang Island and of these 33 were re-trapped, from one to four years after initial capture (van Gessel pers. comm.). In the Manning Estuary and at Worimi Conservation Lands, Double-banded Plover exhibited an apparent degree of site fidelity with most observations, though not all, on the same areas of the local beaches. However, without banding studies, it is not possible to be certain that the same individuals are present.

The relatively high previous short-term counts at Hunter Estuary (1971-1976), Lake Macquarie (1983-1986) and Wallis Lake (1985-1989), may however indicate that birds choose a foraging/roosting location for a period and then subsequently choose a different location for unknown reasons. The reduced number of birds present in June (**Figure 1**) compared to preceding and subsequent months, may indicate birds moving from the Hunter Region in June and then returning in July and August. This may indicate that part of the Hunter Region population uses the area only temporarily when over-wintering. Data from this study indicate the overwhelming majority of birds are present in the Hunter Region from March until August. Data compiled by Cooper *et al.* (2014) for the whole of NSW and ACT (1986-2006) indicate that the majority are present from February to August. This difference may reflect varying patterns of temporal movement through different parts of NSW.

While Double-banded Plover exhibit some degree of site fidelity, it is also apparent that they will exploit newly-established, suitable habitat if available, such as Tomago Wetlands and Fish Fry Flats, Ash Island. This may be partly driven by the loss of habitat in other areas through development or change in vegetation, and/or through increased disturbance. The variation in the spatial and temporal data from the Hunter Region suggests that site fidelity is an oversimplification of Double-banded Plover behaviour when wintering in the region and that its movements are more complex.

CONCLUSIONS

Double-banded Plover have been recorded at 13 sites across the Hunter Region over a 55-year period. However, only five sites have supported large numbers on a regular basis and currently only three sites, Worimi Conservation Lands, Manning Estuary and Port Stephens support regular winter populations. Previously, populations were regularly recorded in the Hunter Estuary, Lake Macquarie and Wallis Lake. The size of the populations at Worimi Conservation Lands and the Manning Estuary make these sites nationally significant.

A decline of 37% was determined across the Hunter Region in the last 14 years (2008-2021). This decline is highly significant. The medium- and short-term national trends (reported by Clemens *et al*. (2019) were not evident. The degree of population change varied across sites with the greatest decline occurring in the Manning Estuary and no significant decline in Port Stephens. Although a general decline was evident over the entire 55-year period, an empirical measurement could not be determined due to intermittent surveying during the first 30 years.

The decline on Worimi Conservation Lands and the Manning Estuary (mainly the Farquhar Inlet) is postulated to be the result of increased human disturbance, particularly from vehicles. There is very little human disturbance of sites in Port Stephens where decline is minimal.

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REFERENCES

Bamford M., Watkins, D., Bancroft, W., Tischler, G. & Wahl, J. (2008). Migratory Shorebirds of the East Asian - Australasian Flyway: Population estimates and internationally important sites. Wetlands International. https://www.wetlands.org/publications/migratory-shorebirds-of-the-east-asian-australasian-flyway-population-estimates-and-internationally-important-sites/. Accessed 18/12/2021.

Barrett, G., Silcocks, A., Cunningham, R., Oliver, D., Weston, D. and Baker, J. (2007). Comparison of atlas data to determine the conservation status of bird species in New South Wales, with an emphasis on woodland-dependent species. *Australian Zoologist* **34** (1): 37–77.

Barter, M. and Minton, C. (1987). Biometrics, moult and migration of Double-banded Plovers *Charadrius bicinctus bicinctus* spending the non-breeding season in Victoria. *Stilt* **10**: 9-14.

Bartrim, G. (1980). The Proposed Pipeclay Creek Nature Reserve - A Resource Survey, for NSW National Parks & Wildlife Service. (NSW National Parks and Wildlife Service.)

BirdLife Australia (2021). Hunter Estuary Waterbird Survey Protocols. (Unpublished report for Hunter Local Land Services.)

Clemens, R., Driessen, J. and Ehmke, G. (2019). Australian Bird Index Phase 2 - Developing Waterbird Indices for National Reporting. (Unpublished report for the Department of the Environment prepared by BirdLife Australia, Melbourne.)

Cooper, R.M., McAllan, I. and Curtis, B. (2014). 'An atlas of the birds of NSW & the ACT, Volume 1. Emu to Plains-wanderer'. (NSW Bird Atlassers Inc.: Woolgoolga, NSW.)

Department of Environment (2015). Wildlife Conservation Plan for Migratory Shorebirds. https://www.awe.gov.au/sites/default/files/documents/widlife-conservation-plan-migratory-shorebirds.pdf. Accessed 9 /01/2022.

Department of Climate Change, Energy, the Environment and Water (2022). Species Profile and Threats Database, *Charadrius bicinctus* - Double-banded Plover. http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=895. Accessed 13/07/2022.

Garnett, S., Szabo, J. and Dutson, G. (2011). 'Action Plan for Australian Birds 2010'. (CSIRO Publishing: Melbourne.)

Greenwood, P. (1980). Mating systems, philopatry and dispersal in birds and mammals. *Animal Behaviour* **28** (4): 1140-1162.

Hansen, B.D., Fuller, R.A., Watkins, D., Rogers, D.I., Clemens, R.S., Newman, M., Woehler, E.J. and Weller, D.R. (2016). Revision of the East Asian-Australasian Flyway Population Estimates for 37 listed Migratory Shorebird Species. (Unpublished report for the Department of the Environment by BirdLife Australia, Melbourne.)

IUCN, (2021). The IUCN Red List of Threatened Species. Version 2021-3. Double-banded Plover, *Charadrius bicinctus*. https://www.iucnredlist.org/species/22693845/180230226. Accessed 18/12/2021

Jackson, M.V. and Straw, P. (Eds) (2021). Coastal hightide shorebird habitat management guidelines. figshare. Online resource. doi: 10.6084/m9.figshare.16628560.v1. Accessed 30/08/2022.

Kendall, T. and Van Gessel, F. (1972). The Birds of Kooragang Island. Preliminary Report. *Hunter Natural History* May: 79-94.

Lane, B.A. (1987). 'Shorebirds in Australia'. (Thomas Nelson Australia: Melbourne.)

Lindsey, A. (2021). The birds of Tomago Wetland after reinstatement of tidal flushing. *The Whistler* **15**: 6-26.

Lindsey, A. and Newman, M. (2014). Worimi Conservation Lands bird surveys (2009-2013). *The Whistler* **8**: 23-32.

Marchant, S. and. Higgins, P.J. (Eds) (1993). 'Handbook of Australian, New Zealand and Antarctic Birds. Volume 2 - Raptors to Lapwings'. (Oxford University Press: Melbourne, Victoria.)

NSW Office of Environment and Heritage (2015). Worimi Conservation Lands Plan of Management. https://worimiconservationlands.com/plan-of-management/. Accessed 15/07/2022.

Pearson, K. (1900). On the criterion that a given system of deviations from the probable in the case of a correlated system of variables is such that it can be reasonably supposed to have arisen from random sampling. *The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science* **50** (302): 157–175. https://www.tandfonline.com/doi/abs/10.1080/14786440009463897. Accessed 13/09/2022.

Pierce, R. (1999). Regional patterns of migration in the Banded Dotterel (*Charadrius bicinctus bicinctus*). *Notornis* **46**:101-122.

Reid, P. (2019). Changes in wetland use by shorebirds following mangrove removal, Area E. Ash Island, New South Wales. *The Whistler* **13**: 62-68.

Robertson, H.A., Baird, K., Dowding, J.E., Elliott, G.P., Hitchmough, R.A., Miskelly, C.M., McArthur, N., O'Donnell, C.F.J., Sagar, P.M., Scofield, R.P. and Taylor, G.A. (2017). Conservation status of New Zealand birds, 2016. New Zealand Threat Classification Series 19. (NZ Department of Conservation: Wellington.)

Streever, W.J. (1998). Kooragang Wetland Rehabilitation Project: opportunities and constraints in an urban wetland rehabilitation project. *Urban Ecosystems* **2**: 205-218

Stuart, A. (2008). A preliminary assessment of the importance of the Manning River for shorebirds and other waterbirds. *The Whistler* **2**: 13-19.

Stuart, A.D. (2014a). Early Hunter Region avian records, Part 3. A review of historical data about shorebirds in the Hunter Estuary. *The Whistler* **8**:10-22.

Stuart, A.D. (2014b). Manning Estuary population counts 2008-2013. *Stilt* **65**: 38-40.

Stuart, A. and Lindsey, A. (2021). Shorebird surveys in the Hunter Estuary of New South Wales. *Stilt* **76**:47-63.

Svoboda, P. (2017). Kooragang Wetlands: Retrospective of an integrated ecological restoration project in the Hunter River Estuary. (26th NSW Coastal Conference: Port Stephens.)

Van Gessel, F. and Kendall, T. (1972a). A Checklist of the Birds of Kooragang Island. *Hunter Natural History* August: 194-215.

Van Gessel, F. and Kendall, T. (1972b). A Checklist of the Birds of Kooragang Island, Supplement 1. *Hunter Natural History* November: 256-261.

Van Gessel, F. and Kendall, T. (2015). Kooragang Island Bird Counts 1969 -1977. *HBOC Special Report No. 7.* (Hunter Bird Observers Club Inc.: New Lambton, NSW.)

Wiersma, P., Kirwan, G.M. and Boesman, P. (2019). Double-banded Plover (*Charadrius bicinctus*). In 'Handbook of the Birds of the World Alive'. (Eds J. del Hoyo, A. Elliott, J. Sargatal, D.A. Christie and E. de Juana). (Lynx Edicions: Barcelona.) https://www.hbw.com/node/53844. Accessed 18/12/2021.

A short-term radiotelemetry study of movements by a Lewin's Honeyeater

Greg Little

11 Thurston Street, Boolaroo NSW, 2284 Australia greg@gff.com.au

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The Lewin's Honeyeater *Meliphaga lewinii* is a common bird of eastern Australia, thought to be sedentary although possibly making some local movements in autumn-winter (Higgins *et al*. 2001). It has not been the subject of many studies, and various aspects of its social organisation are unknown. There appears to be no information available about the size of its territory or its home range.

On 15 January 2021, as part of a bird study project at Blue Gum Hills Regional Park (Little 2021), I fitted a radio transmitter to an adult Lewin's Honeyeater. I attached the transmitter by glueing it to the bird's back feathers. The bird's sex is unknown (males and females are identical in plumage: Australian Bird Study Association 2020). The transmitter was an ATS Australia A1055 1.0g backpack transmitter, operating at 40ppm pulse rate at a frequency of 151.301 MHz. The expected battery life for a new A1055 transmitter is 55 days, however the unit I attached was about two years old (although previously unused) when I applied it to the bird.

Over the ensuing 31 days, I visited the park 28 times (on 22 different days) and located the bird's position (each time, by triangulation using an ATS R410 receiver and a 3-element folding Yagi antenna.). The final reading was obtained on 15 February 2021. After that date there was no longer any signal from the transmitter; presumably the transmitter battery had depleted. Using QGIS software (https://www.qgis.org/en/site/) I plotted the locations of the Lewin's Honeyeater onto a map of the Regional Park and some of its immediate surrounds (see **Figure 1**). The bird was often in the park but several times it had moved to locations of up to 50-100 m outside of the park boundary. All of those external locations were in bushland that was contiguous with bushland in the park. Note that there are 29 positions plotted on the map because I have included the location where I caught the bird.

Using a function available within the QGIS software, I estimated the Lewin's Honeyeater had ranged over an area of about 8 ha. The honeyeater's range at 95% confidence interval was subsequently estimated to be 10-11 ha, by fitting bivariate normal 95% probability ellipses to the data after calculating the determinant of the X, Y covariance matrix (A. Stuart pers. comm.).

Because of the limited duration of the study, it would be premature to make any conclusions about the size of the bird's territory or home range. It may have been that certain food resources were available in that particular area at that time and that, at other times of the year, the Lewin's Honeyeater would use other parts of a larger territory. Also, Blue Gum Hills Regional Park mostly comprises heavily-disturbed habitat, much of it being recovering native vegetation plus introduced species (Little 2021); in more natural environments a Lewin's Honeyeater might be able to have a smaller territory. Nevertheless, these findings provide a new insight about the Lewin's Honeyeater and they also demonstrate the potential of radio-tracking for learning about bird movements and the sizes of bird territories and home ranges.

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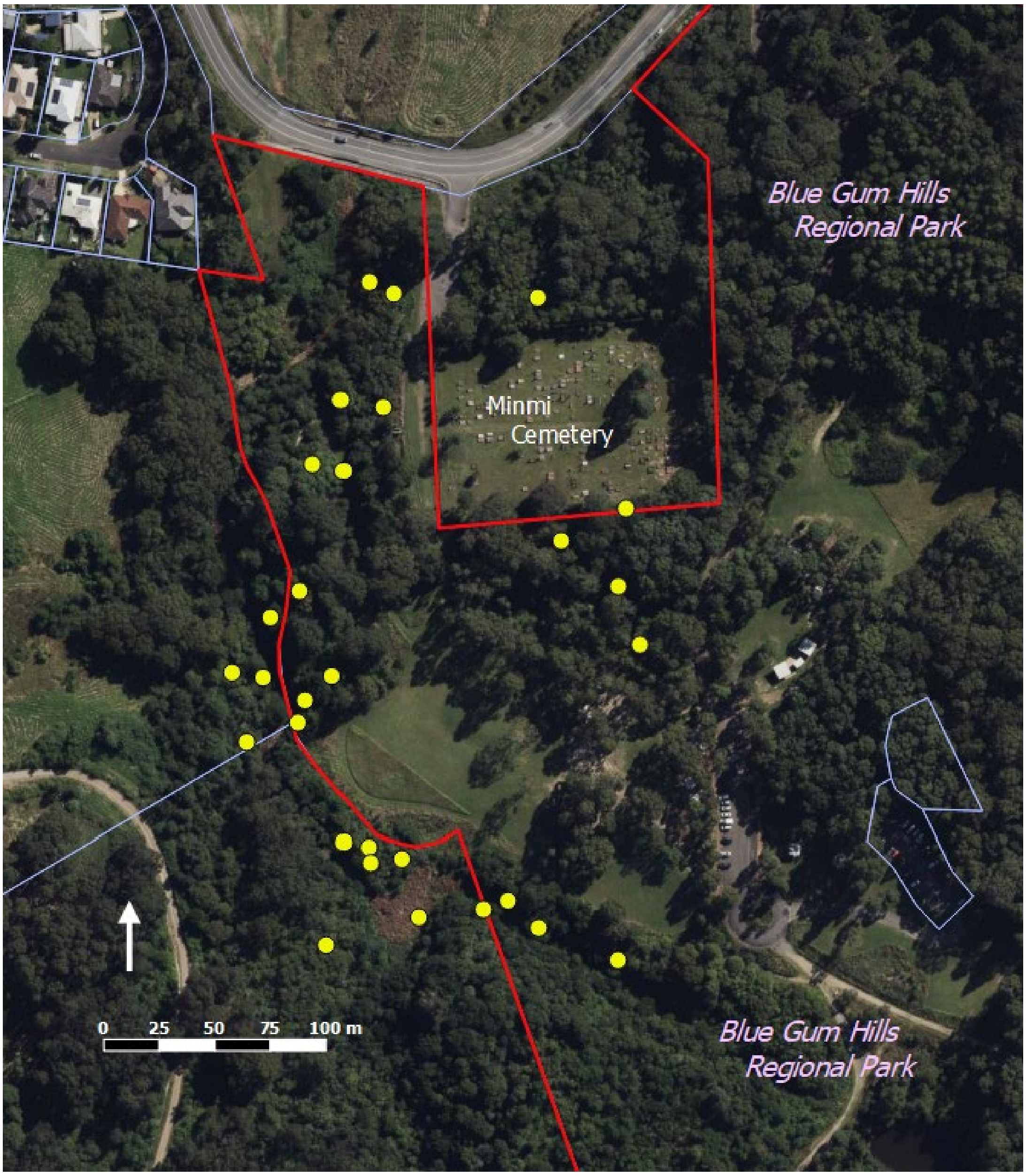

Figure 1. Locations for the radio-tagged Lewin's Honeyeater in and around Blue Gum Hills Regional Park between 15 January and 15 February 2021.

REFERENCES

Australian Bird Study Association (2020). Bird in the Hand (Second Edition) www.absa.asn.au

Higgins, P.J., Peter, J.M. and Steele, W.K. (Eds) (2001). 'Handbook of Australian, New Zealand and Antarctic Birds Volume 5: Tyrant-flycatchers to Chats'. (Oxford University Press: Melbourne.).

Little, G. (2021). Bird surveys of Blue Gum Hills Regional Park 2012-2016. *The Whistler* **15:** 39-45.

Effects of human disturbance during residential developments on the productivity of White-bellied Sea-Eagle in the Hunter Region, New South Wales

Kimberley Jane Pryor

PO Box 3168, Thornton, NSW 2322, Australia Email: kimberleypryor@gmail.com

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Two pairs of White-bellied Sea-Eagle *Haliaeetus leucogaster* attempting to nest <400 m from residential developments in the Hunter Region, New South Wales were monitored during the 2016 breeding season and productivity outcomes recorded. The Chisholm sea-eagles flushed from the nest when construction vehicles were driven past and their nest was unsuccessful. The Fletcher sea-eagles did not respond to human disturbance and their nest was successful (one young fledged). However, the Fletcher nest was later removed for road construction. These results reinforce the need for site-specific management actions to mitigate White-bellied Sea-Eagle population decline in the Hunter Region.

INTRODUCTION

Breeding of the White-bellied Sea-Eagle *Haliaeetus leucogaster* is from June to December in southern Australia and eggs are laid from June to September (Marchant & Higgins 1993). Paired sea-eagles build a large nest of sticks lined with leaves, grass or seaweed, 3-40 m above the ground in a tall, live eucalypt *Eucalyptus* sp. (on the mainland), usually within 1 km of a major water body (Emison & Bilney 1982; Marchant & Higgins 1993; Debus 2008; Corbet & Hertog 2011; O'Donnell & Debus 2012). They often reuse and add to the same nest in consecutive years and may have more than one nest in their territory (Marchant & Higgins 1993). Sea-eagles lay 1-3 eggs (usually 2). The incubation period is 40-42 days, the nestling period is 81-84 days and the post-fledging period of dependence is 2-3 months (Debus 2019).

Breeding success of sea-eagles is subject to fluctuations due to natural (Corbet & Hertog 2011) and human threats (Emison & Bilney 1982; O'Brien & Lacey 2016). Human threats include land clearing, coastal development, loss of foraging resources, recreational activities, entanglement in fishing gear, non-target poisoning and deliberate persecution (NSW Government 2021a). They have adversely affected sea-eagles in Queensland (O'Donnell & Debus 2012; Debus *et al*. 2014), New South Wales (NSW) (Spencer & Lynch 2005; Debus 2008; O'Donnell & Debus 2012; Debus *et al*. 2014), Victoria (Emison & Bilney 1982; Bilney & Emison 1983; Clunie 2003; O'Brien & Lacey 2016), Tasmania (Thurstans 2009), South Australia (Dennis & Lashmar 1996; Dennis 2004; Dennis & Baxter 2006; Dennis *et al*. 2011a; Dennis & Detmar 2018) and the Northern Territory (Corbet & Hertog 2011).

Human disturbance may lead to White-bellied Sea-Eagle population decline (Dennis & Detmar 2018). It adversely affects the productivity of sea-eagles (Emison & Bilney 1982; Clunie 2003; Shephard *et al*. 2005; Debus *et al*. 2014; Dennis & Detmar 2018), especially during courtship and nest building and repair; egg-laying and early incubation; and incubation and the early nestling period (Dennis *et al*. 2012). Furthermore, the level of human disturbance adversely affects production of eggs, success of active nests, frequency with which occupied territories successfully fledge young in a season and proportion of territories in which two young fledge in a year (Dennis *et al*. 2011b).

When human disturbance of established nests has been unavoidable (e.g. during road construction), mitigation measures have sometimes been attempted. However, these mitigation measures, which include relocation of a nest to an artificial platform, removal of nests to encourage rebuilding and establishment of buffer zones, have not been successful in the long term (Debus *et al*. 2014).

In Australia, the White-bellied Sea-Eagle is protected as a marine species under the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act). In NSW, the

White-bellied Sea-Eagle was listed as Vulnerable under the Threatened Species Conservation Act 1995 (TSC Act) in 2016. It is now listed as Vulnerable under the Biodiversity Conservation Act 2016 (BC Act), which replaced the TSC Act in 2017 (NSW Government 2021a). It has been assigned to the landscape species management stream under the Saving our Species (SoS) program because it "is distributed across relatively large areas and is subject to threatening processes that generally act at the landscape scale (e.g. habitat loss or degradation), however, requires management at a site level with a focus of conserving key nesting sites" (NSW Government 2021b). The SoS program aims to ensure that the White-bellied Sea-Eagle is secure in the wild in NSW, that its NSW geographic range is extended or maintained and that its conservation status under the BC Act is maintained (NSW Government 2021b). The Biodiversity Offsets Scheme (BOS) and the Biodiversity Assessment Method 2020 (BAM) were established under the BC Act. The BOS is the framework for offsetting unavoidable impacts on biodiversity from development (NSW Government 2022a) and the BAM is used to assess impacts on threatened species and their habitats (NSW Government 2022b).

The White-bellied Sea-Eagle is a usual resident of the Hunter Region, NSW. The population is thought to be stable (Williams 2021), although the exact number of breeding pairs and suitable territories is not known. However, human disturbance during residential developments has adversely affected the breeding success of sea-eagles in other parts of NSW (Debus *et al.* 2014). Therefore, the aim of this study was to determine whether residential construction activities would negatively affect the breeding success of sea-eagles in the Hunter Region. The objectives were to 1) record whether the nests were successful or unsuccessful, and 2) document the response of sea-eagles to residential construction activities <400 m from their nests. This paper presents observations of two pairs of White-bellied Sea-Eagle in one breeding season (2016) at Chisholm and Fletcher in the Hunter Region.

METHODS

On 13 June 2016, a White-bellied Sea-Eagle nest was discovered at Chisholm (32º45'S, 151º38'E) near Newcastle, NSW (**Figure 1**). The habitat was open farmland with scattered eucalypts. Excellent foraging habitat containing waterfowl and shorebirds was available at Morpeth Wastewater Treatment Works (MWTW) and its surrounding ephemeral flood plain (~1.5 km from the nest) (Newman & Lindsey 2016). The nest was in the fork of a eucalypt with dead branches 20+ m in height (**Figure 2**). The nest tree was on private land but only ~45 m from a boundary fence separating the private land from a new residential development. At the beginning of this study, the nearest construction activities were ~320 m from the nest tree. Residential lot markers were on the grassed slope between Twister Street and the nest tree, however, construction of Percher, Rockmaster and Wiretail Streets (~238, ~138 and ~114 m respectively from the nest tree) had not begun (**Figure 1**).

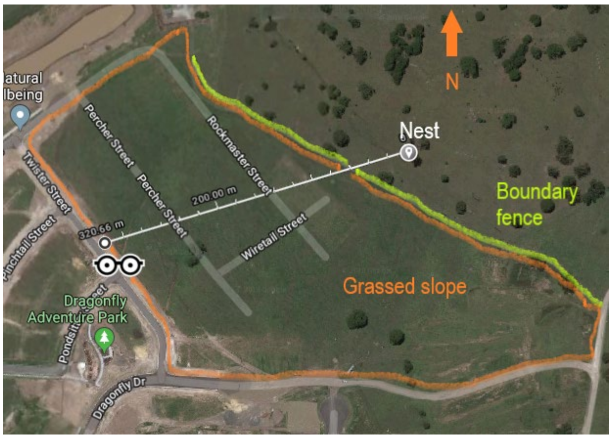

Figure 1. A White-bellied Sea-Eagle nest at Chisholm (0 end of ruler) was ~320 m from the nearest human disturbance (residential construction activities) in June 2016. My observation point in my car is shown (glasses sticker) (Google, 2016a).

Figure 2. A pair of adult White-bellied Sea-Eagles was observed on a nest at Chisholm on 13 June 2016.

On 5 July 2016, a White-bellied Sea-Eagle nest was discovered at Fletcher (32º52'S, 151º38'E) in Newcastle, NSW (**Figure 3**). The habitat was a cleared infrastructure corridor (power lines) ~500 m wide between strips of remnant bushland and new residential developments. Good foraging habitat containing waterfowl was available at Pambalong Nature Reserve and Hunter Wetlands National Park (both ~2.6 km from the nest). The nest was in the fork of a living eucalypt 20+ m in height (**Figure 4**). At the beginning of this study, the nearest construction activities were in The Outlook Estate ~365 m from the nest tree (**Figures 3**, **5**).

Figure 3. A White-bellied Sea-Eagle nest at Fletcher (0 end of ruler) was ~365 m from the nearest human disturbance (residential construction activities) in July 2016. My observation point in dense bushes is shown (glasses sticker) (Google, 2016b).

Figure 4. A juvenile White-bellied Sea-Eagle with an adult was observed on a nest at Fletcher on 21 November 2016.

Field observations were made opportunistically from concealed locations ~320 m from the Chisholm nest (glasses sticker, **Figure 1**) and >200 m from the Fletcher nest (glasses sticker, **Figure 3**). They were made 3-11 times per month in the breeding season, June to November (**Table 1**) using binoculars (Barska 10-30 x 50 mm Gladiator Zoom). From August, field observations of the Chisholm nest were mostly made on the weekends because the continual construction activities on weekdays made access to the site difficult. Field observations of the Fletcher nest were mostly made on weekdays from ~1600 h. Total time observed was 37.5 h (Chisholm) and 30.4 h (Fletcher) (**Table 1**).

Figure 5. Construction activities were taking place ~365 m from a White-bellied Sea-Eagle nest at Fletcher on 1 August 2016.

Table 1. Number of visits to, and combined observation time for, two active White-bellied Sea-Eagle *Haliaeetus leucogaster* nests in the Hunter Region, NSW. (No. = number; h = hours)

Month	Chisholm nest		Fletcher nest	
	Visits (No.)	Time observed (h)	Visits (No.)	Time observed (h)
June	4	4.7	0	0
July	5	6.0	3	4.8
August	5	6.8	3	3.0
September	6	5.3	6	9.6
October	11	13.6	5	4.8
November	3	1.1	9	8.2
Total	**34**	**37.5**	**26**	**30.4**

Photographs were taken with a Canon 7D with an EF 100-400 mm F/4.5-5.6L IS lens. The construction vehicles shown in **Figures 5** and **6** were de-identified because I assumed that the company had all relevant approvals to work near the nests during the breeding season.

Figure 6. Two excavators were being driven <100 m from an active White-bellied Sea-Eagle nest (see **Figure 2**) at Chisholm on 18 August 2016.

In this study, a nest was considered active if an adult sea-eagle appeared to be in an incubating posture on it (a nesting attempt was made) (Bilney & Emison 1983). Further signs that a nest was active included the presence of both adults in the nest, and delivery of food or leaves (fresh nesting material) to the nest (**Table 2**). A nest was considered successful if at least one young fledged and unsuccessful if no young fledged (Bilney & Emison 1983). Both nest sites were assigned to the high disturbance category used in other studies because there were people, roads, tracks and dwellings within 200-500 m of the nest during the breeding season (Dennis 2004).

RESULTS

Chisholm

On 13 June 2016, two adult sea-eagles were observed calling in duet on a guard-roost (vantage point in the territory), copulating and visiting a large nest (**Figure 2**). Subsequent visits by me confirmed that the nest was active until at least 17 September (**Table 2**). From 25 September, the adults were not observed in the nest but they were still in the territory. Juveniles were not observed in the nest or territory.

Table 2. Observation days on which there were signs that two White-bellied Sea-Eagle *Haliaeetus leucogaster* nests in the Hunter Region, NSW were active. (Sign: T = one or both adults in territory but not in nest; D = call in duet; C = copulate; ON = one adult in nest; BN = both adults in nest; F = food delivery (Chisholm, fish; Fletcher, waterbirds); L = leaves delivery (fresh nesting material); JN = juvenile in nest; JT = juvenile in tree)

Month	Chisholm nest		Fletcher nest	
	Day of month	Sign	Day of month	Sign
June	13	D; C; BN		
	25	T; D		
July	9	T; D	5	T
	18	ON	19	T
	23	ON	26	T
August	18	BN	1	ON
	20	BN	15	T
	21	BN; L	29	ON
	27	BN		
	28	D; BN		
Septem-ber	4	D; BN; F	1	T
	10	BN	5	ON
	11	ON	15	T
	17	D; BN	19	T; F
	25	D; T	26	BN; F
			30	T; F
October	1	T	5	T
	2	T; L	6	ON
	3	T	11	ON; F
	9	T	18	T
	29	T	20	T
Novem-ber	12	T	2	ON
			11	T; F; JN
			15	JN
			17	T; JN
			21	ON; JN
			24	JT
			25	T; JT
			28	JT

On 13 July 2016, the first evidence of construction activities (soil pile, materials, construction vehicle) on the grassed slope was observed. Subsequent visits revealed that drainage, road and then house construction was proceeding between ~0800and 1700 h on weekdays. Early in the breeding period, disturbance was mainly from movements and sounds made by construction vehicles and workers. The sea-eagles flushed from the nest whenever construction vehicles were driven past (**Figure 6**) and sometimes returned to the nest within 15 minutes after construction vehicles were turned off for the day (**Table 3**). Late in the breeding period, disturbance was mainly from movements and sounds made by tradespeople, power tools, cars and walkers.

Fletcher

On 5 July 2016, a White-bellied Sea-Eagle was observed flying over a territory containing a large nest. Subsequent visits revealed that the nest was active (**Table 2**) and on 11 November, a juvenile was observed in the nest (**Figure 4**). On 24 November, the juvenile perched in the nest tree and on 28 November, it perched in a different tree and then flew into denser bushland.

During observations, the continual sounds made by construction vehicles in The Outlook Estate (**Figure 5**) were not sudden or excessively loud. The sea-eagles were not observed responding to construction activities. People movements in the infrastructure corridor were rare and transient.

Table 3. Human disturbance and response characteristics at a White-bellied Sea-Eagle *Haliaeetus leucogaster* nest at Chisholm, NSW.

Date (2016)	Human disturbance	Distance of disturbance from nest (metres)	Duration of observed disturbance (minutes)	Response of White-bellied Sea-Eagle
18 July	Construction vehicles	60	75	One adult flushed repeatedly from the nest
30 July	Construction vehicle	200	75	Neither adult seen
18 August	Construction vehicles	60	30	Both adults returned to the nest after construction vehicles turned off at ~5:00 pm
28 September	Construction vehicles Power tools People	60-150	26	Neither adult seen

DISCUSSION

This study found that two active White-bellied Sea-Eagle nests situated <400 m from residential construction activities had different outcomes: the more highly- and frequently-disturbed Chisholm nest was unsuccessful and the Fletcher nest was successful. As seen at Chisholm, a nest will probably be unsuccessful if sea-eagles are subjected to sudden new disturbance (e.g. new, closer construction activities). However, as seen at Fletcher, a nest may be successful if sea-eagles are habituated to routine disturbance (e.g. construction activities that commenced before the breeding season) (Debus *et al.* 2014).

The distance from the disturbance to the nest and the intensity and duration of the disturbance near the nest are likely to have played a major role in breeding outcomes. The finding that the Chisholm sea-eagles only responded to disturbance that was <320 from the nest supports the recommendation that a minimum buffer zone of 250 m should be maintained when a nest is close to existing developments (NSW Government 2021b). The proximity of chronic disturbance to the Chisholm nest (sometimes <100 m) from July onwards is likely to have contributed to the unsuccessful nesting attempt (Debus *et al.* 2014). Conversely, the farther distance of similar chronic disturbance from the Fletcher nest (>365 m) and the apparent decrease in loudness is likely to have contributed to the successful nesting attempt.

The nest site characteristics may have played a role in breeding success. The unsuccessful Chisholm nest in a tree with dead branches located in farmland with scattered trees was level with, and in clear view of, construction activities (**Figures 1**, **2**). The successful Fletcher nest in a living tree in remnant bushland (**Figures 3**, **4**) was on higher land than the construction activities, and partly visually screened from them. Nest sites with little or no visual screening are particularly vulnerable to disturbance from human activity and approach (Dennis & Detmar 2018). The outcomes of these two nesting attempts support Bilney & Emison (1983), who found that sea-eagles nesting in pastures with scattered large trees fledged only 0.2 young per occupied territory and sea-eagles nesting in remnant stands of secluded, dense, tall open forest fledged 1.2 young per occupied territory.

Access to suitable foraging habitat is not thought to have played a role in breeding success. Both pairs had access to excellent foraging habitat. Interestingly, the Chisholm sea-eagles were observed with one fish prey item while the Fletcher pair was observed with four waterbird prey items (family Rallidae). This may be because of differences in the type, abundance or accessibility of prey in each foraging habitat. It may also be because the Chisholm nest was located closer to the nearest major water body. The finding that the Fletcher nest was successful is consistent with Bilney & Emison (1983), who found little difference in the productivity of territories that were less than 1 km and territories that were 2-20 km away from coastal lakes.

Since 2016, both pairs may have had only a limited number of years to breed successfully in their territories because of ongoing large-scale land clearing for residential developments. Prior to 2016, the Chisholm pair was suspected to have bred in a previous (first) nest in the ephemeral wetlands near MWTW (Newman & Lindsey 2016) and since 2016, were known to have bred in a third nest (Ann Lindsey pers. comm.). However, land clearing and house construction are currently occurring near the second and third nests. In 2017, the Fletcher infrastructure corridor was cleared for residential development. By September 2018, the active Fletcher nest, nest tree and surrounding trees had been removed for the construction of Wonnai Street. Extensive land clearing is currently occurring between Fletcher and Minmi. The human disturbance during these residential developments is likely to have displaced both pairs of sea-eagles to sub-optimal habitats (Emison & Bilney 1982; Dennis & Detmar 2018).

Why construction activities were undertaken less than 100 m from an active nest during the breeding season at Chisholm and why an active nest was removed at Fletcher are questions that remain to be answered. Sadly, these White-bellied Sea-Eagle pairs just missed out on protections afforded by the TSC Act, BC Act, SoS program, the BOS and the BAM (Luke Foster pers. comm.). The NSW Scientific Committee made a Final Determination to list the White-bellied Sea-Eagle as a Vulnerable species in NSW under the TSC Act and gazetted this conservation status on 16 December 2016. The BOS and BAM 2017 (NSW Government 2022c) came into force under the BC Act, which commenced on 25 August 2017 (NSW Government 2022d). The results of human disturbance on the two active nests described here highlight the importance of legislation for land management and biodiversity conservation, especially in urban areas in heavily populated coastal south-eastern Australia.

The main limitation of this study is that only two breeding pairs of White-bellied Sea-Eagle were observed, so there is insufficient comparative data from which to draw extensive conclusions. However, the observation that an active nest was unsuccessful after being subjected to continual residential construction activities during the breeding season supports previous findings in larger studies (Debus *et al*. 2014; Dennis & Detmar 2018). Possible future studies in the Hunter Region include estimating the number of breeding pairs, identifying and protecting nest sites and maintaining and improving suitable habitat (Clunie 2003).

CONCLUSIONS

Human disturbance during residential developments can lead to sea-eagles abandoning active nests. It is critically important that breeding sites in the Hunter Region are identified and assessed in accordance with the BAM so that buffer zones can be applied to minimise disturbance and prevent clearing. Otherwise, the White-bellied Sea-Eagle population in the Hunter Region may decline.

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REFERENCES

Bilney, R. and Emison, W. (1983). Breeding of the White-bellied Sea-Eagle in the Gippsland Lakes Region of Victoria, Australia. *Australian Bird Watcher* **10**: 61-68.

Clunie, P. (2003). Flora & Fauna Guarantee Action Statement #60. White-bellied Sea-eagle *Haliaeetus leucogaster*. https://www.environment.vic.gov.au/__data/assets/pdf_file/0024/32892/White-bellied_Sea-Eagle_Haliaeetus_leucogaster.pdf Accessed 11 November 2021.

Corbett, L. and Hertog, T. (2011). Diet and breeding of White-bellied Sea-Eagles *Haliaeetus leucogaster* in subtropical river habitats in the Northern Territory, Australia. *Corella* **35**: 41-48.

Debus, S. (2008). Biology and diet of the White-bellied Sea-Eagle *Haliaeetus leucogaster* breeding in northern inland New South Wales. *Australian Field Ornithology* **25**: 165-193.

Debus, S. (2019). 'Birds of prey of Australia: a field guide'. (3rd Edition) (CSIRO Publishing: Melbourne.)

Debus, S., Baker, G., Owner, D. and Nottidge, B. (2014). Response of White-bellied Sea-Eagles *Haliaeetus leucogaster* to encroaching human activities at nest sites. *Corella* **38**: 53-62.

Dennis, T. (2004). Conservation status of the White-bellied Sea-Eagle, Osprey and Peregrine Falcon on western Eyre Peninsula and adjacent offshore islands in South Australia. *South Australian Ornithologist* **34**: 222-228.

Dennis, T. and Baxter, C. (2006). The status of the White-bellied Sea-Eagle and Osprey on Kangaroo Island in 2005. *South Australian Ornithologist* **35**: 47-51.

Dennis, T. and Lashmar, A. (1996). Distribution and abundance of White-bellied Sea-Eagles in South Australia. *Corella* **20**: 93-102.

Dennis, T., Detmar, S., Brooks, A. and Dennis, H. (2011a). Distribution and status of White-bellied Sea-Eagle, *Haliaeetus leucogaster*, and Eastern Osprey, *Pandion cristatus*, populations in South Australia. *South Australian Ornithologist* **37**: 1-16.

Dennis, T., McIntosh, R. and Shaughnessy, P. (2011b). Effects of human disturbance on productivity of White-bellied Sea-Eagles (*Haliaeetus leucogaster*). *Emu* **111**: 179-185. doi: 10.1071/mu10044

Dennis, T., Fitzpatrick, G. and Brittain, R. (2012). Phases and duration of the White-bellied Sea-Eagle *Haliaeetus leucogaster* breeding season in South Australia and the implications for habitat management. *Corella* **36**: 63-68.

Dennis, T. E. and Detmar, S. A. (2018). A review of White-bellied Sea-Eagle distribution and population stability over time in South Australia. *South Australian Ornithologist* **43**: 55-72. (available at: https://birdssa.asn.au/wp-content/uploads/2018V43P1-2.pdf?mc_cid=5701bdec6e&mc_eid=89573389f9

Emison, W. and Bilney, R. (1982). Nesting habitat and nest site characteristics of the White-bellied Sea-Eagle in the Gippsland Lakes region of Victoria, Australia. *Raptor Research* **16**: 54-58.

Google. (2016a). [Google Maps location of Chisholm, NSW]. Available at https://www.google.com/maps/@-32.750786,151.6321292,1605m/data=!3m1!1e3 Accessed 9 November 2016.

Google. (2016b). [Google Maps location of Fletcher, NSW]. Available at https://www.google.com/maps/@-32.8710163,151.6370159,3212m/data=!3m1!1e3 Accessed 13 December 2016.

Marchant, S. and Higgins, P. (Eds.) (1993). 'Handbook of Australian, New Zealand and Antarctic Birds. Volume 2 - Raptors to Lapwings'. (Oxford University Press: Melbourne).

Newman, M. and Lindsey, A. (2016). Raptor observations at Morpeth Wastewater Treatment Works (2001-2015). *The Whistler* **10**: 3-12.

NSW Government (2021a). White-bellied Sea-Eagle - profile.

https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=20322 Accessed 9 November 2021.

NSW Government (2021b). White-bellied Sea-Eagle *Haliaeetus leucogaster*. https://www.environment.nsw.gov.au/savingourspeciesapp/project.aspx?ProfileID=20322 Accessed 29 September 2022.

NSW Government (2022a). About the Biodiversity Offsets Scheme. https://www.environment.nsw.gov.au/topics/animals-and-plants/biodiversity-offsets-scheme/about-the-biodiversity-offsets-scheme Accessed 29 September 2022.

NSW Government (2022b). The Biodiversity Assessment Method 2020. https://www.environment.nsw.gov.au/topics/animals-and-plants/biodiversity-offsets-scheme/accredited-assessors/biodiversity-assessment-method-2020 Accessed 29 September 2022. Accessed 29 September 2022.

NSW Government (2022c). Biodiversity Assessment Method 2017. https://www.environment.nsw.gov.au/topics/animals-and-plants/biodiversity-offsets-scheme/accredited-assessors/biodiversity-assessment-method-2020/biodiversity-assessment-method-2017 Accessed 29 September 2022.

NSW Government (2022d). About the Biodiversity Conservation Act 2016. https://www.environment.nsw.gov.au/topics/animals-and-plants/biodiversity/overview-of-biodiversity-reform Accessed 29 September 2022.

O'Brien, M. and Lacey, G. (2016). White-bellied Sea-Eagle breeding in the Western Port area, Victoria. *Australian Field Ornithology* **33**: 46-56.

O'Donnell, W. and Debus, S. (2012). Nest-sites and foraging of the White-bellied Sea-Eagle '*Haliaeetus leucogaster*' on the subtropical eastern coast of Australia. *Australian Field Ornithology* **29**: 149-159.

Shephard, J., Catterall, C. and Hughes, J. (2005). Long-term variation in the distribution of the White-bellied Sea-Eagle *Haliaeetus leucogaster* across Australia. *Austral Ecology* **30**: 131–145.

Spencer, J. and Lynch, T. (2005). Patterns in the distribution of White-bellied Sea-Eagles (*Haliaeetus leucogaster*) in Jervis Bay, south-eastern Australia. *Emu* **105**: 211–216.

Thurstans, S. (2009). A survey of White-bellied Sea-Eagle *Haliaeetus leucogaster* nests in Tasmania in 2003. *Corella* **33**: 66-70.

Williams, D. (Ed.) (2021). Hunter Region Annual Bird Report Number **27** (2019). (Hunter Bird Observers Club Inc.: New Lambton, NSW.)

Banding studies on Broughton Island: overview of 2017-2022 results

Greg Little[1] and Alan Stuart[2]

[1]11 Thurston Street, Boolaroo NSW 2284, Australia. greg@gff.com.au
[2]133 Barrenjoey Road, Ettalong Beach NSW 2257, Australia. alanstuart400@gmail.com

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Banding studies on Broughton Island commenced in June 2017 and have involved visits at approximately quarterly intervals ever since. In the first five years, 854 birds representing twenty species were banded. The majority of individuals (~84%) were Silvereye *Zosterops lateralis*, which is now a common species on the island. Tawny Grassbird *Cincloramphus timoriensis*, Yellow-faced Honeyeater *Caligavis chrysops* and Bar-shouldered Dove *Geopelia humeralis* were the next three most-captured species (comprising ~12% of the total captures).

There is evidence of a permanent or regularly-visiting population of subspecies *cornwalli* Silvereye on Broughton Island, supplemented by seasonal influxes of additional Silvereye including birds of two migratory subspecies *westernensis* and *lateralis*. Some Yellow-faced Honeyeater may also be resident on the island but many others appear to be occasional visitors. Tawny Grassbird adults remain around their territories all year and the recapture rates for some individuals have been high. However, towards the end of their first year, young grassbirds disperse from their natal territory to unknown destinations. The residential status of the Bar-shouldered Dove is uncertain, since only one bird has been recaptured to date.

Immature Osprey *Pandion haliaetus* remained around their nest site for up to one year after fledging. Some birds might have stayed for longer than that, as there were two sight records of five or more birds all within ~1 km from the nest site.

INTRODUCTION

Broughton Island (32º 36' 58"S, 152º 18' 58"E) lies ~15 km north-east of the entrance to Port Stephens in New South Wales and forms part of the Myall Lakes National Park. At its closest point, the island is less than three km from mainland parts of the National Park. In 2009 the NSW National Parks and Wildlife Service (NPWS) removed feral rabbits and rats from the island (Priddel *et al.* 2011). It was expected that there would be changes to the island's vegetation as a result of removal of feral animals, which might lead to changes in the terrestrial bird populations. Consequently, in 2012 NPWS and members of the Hunter Bird Observers Club (HBOC) began a study of terrestrial birds on Broughton Island. All non-seabirds are included in the study i.e. bush birds, shorebirds, waterbirds, birds of prey. A 5-year baseline program identified the resident species and showed that some changes were already underway (Stuart *et al*. 2017).

One of the recommendations from the baseline program was to start a bird trapping and banding project on the island. It was expected that the banding project would help to quantify population changes and perhaps also lead to behavioural insights. In this report we summarise results from the first five years of the banding project. Subsequent articles will provide more detailed analyses for some of the individual species. Preliminary results for Silvereye *Zosterops lateralis* have been reported previously (Little *et al*. 2020; Stuart 2020; Stuart 2021).

METHODS

In 2017 we obtained approval from the Australian Bird and Bat Banding Scheme (ABBBS) for a project to capture and band terrestrial birds on Broughton Island (ABBBS Authority No. 2899). In 2021 the ABBBS also approved that coloured bands could be applied to certain species. Banding and colour banding of Osprey *Pandion haliaetus* on the island was carried out under a permit held by Dr Greg Clancy (ABBBS Authority No. 536).

The first visit for banding activities was in June 2017. The results reported here are for the period from then until May 2022. Field trips were at intervals of approximately three months, with their timing and duration governed by weather conditions and personnel availability, and by restrictions intermittently in place associated with the COVID-19 pandemic. Most field trips involved a stay of two nights on Broughton Island, with mist-netting occurring at one set of sites in the afternoon of Day 1 and morning of Day 2, and at a second set of sites in the afternoon of Day 2 and morning of Day 3. In June 2018 weather conditions limited us to a single night on the island, and so that trip involved just two half-days of banding activities. We did not record the specific number of hours of banding activities in each field trip.

Although several methods were used to trap or attempt to trap terrestrial birds, most were caught using mist nets deployed at various locations around the central-western parts of the island. Various types of walk-in traps were trialled. The locations for mist nets or traps were chosen because of observed higher levels of bird activity in a reconnaissance carried out at the start of each field trip. All locations for nets and traps (across all field trips) were within an approximate 500 m radius of one another. However, Osprey chicks were banded at their nest which was located towards the south-western side of Broughton Island, about 2 km from where the main banding activities took place.

A numbered metal band was applied to one leg of all captured birds and their biometric data, brood patch status and moult status were recorded. The following biometric data were recorded for each bird: weight, wing-length, head-bill length and tail length, with the data being obtained using conventional bird banders' equipment. From mid-2021, coloured bands were applied to birds of species covered in the ABBBS Authority.

An important aspect of the banding project was to obtain details about re-trapped birds, as these were considered more likely to be resident on the island or to visit it regularly. A re-trap is defined as being either:

- a bird caught again in a net or trap, allowing its metal band number to be read while the bird subsequently is in hand; or
- a sight record ("visual re-trap") in which the individual bird was able to be unambiguously identified (e.g. from a photograph showing its metal band number clearly, or from seeing its unique pattern of coloured bands).

RESULTS

Twenty species were banded on Broughton Island during 2017-2022, comprising 854 individual birds. The most commonly caught species was the Silvereye; 716 individuals were banded (~84% of the total of all birds caught) and there were 166 re-traps. The number for re-traps includes some individuals that were re-trapped more than once. The second-most common species to be caught and banded was the Tawny Grassbird *Cincloramphus timoriensis*. In five years, 49 individuals were caught and banded, with 27 re-traps (including individuals re-trapped more than once). **Table 1** summarises the banding and re-trapping results for all species.

Table 1. Numbers for all species banded on Broughton Island 2017-2022 and the number of re-traps of each species. Species are listed by order of the number of individual birds banded.

Species	Individuals banded	Re-traps
Silvereye *Zosterops lateralis*	716	166
Tawny Grassbird *Cincloramphus timoriensis*	49	27
Yellow-faced Honeyeater *Caligavis chrysops*	36	17
Bar-shouldered Dove *Geopelia humeralis*	19	2
Welcome Swallow *Hirundo neoxena*	9	0
Brown Quail *Synoicus ypsilophorus*	7	0
Osprey *Pandion haliaetus*	3	5
Grey Fantail *Rhipidura fuliginosa*	5	4
Brown Goshawk *Accipiter fasciatus*	3	0
Shining Bronze-cuckoo *Chalcites lucidus*	2	0
Golden Whistler *Pachycephala pectoralis*	2	0
Red-browed Finch *Neochmia temporalis*	2	0
Buff-banded Rail *Hypotaenidia philippensis*	1	0
Fan-tailed Cuckoo *Cacomantis flabelliformis*	1	0
Sacred Kingfisher *Todiramphus sanctus*	1	0
Little Wattlebird *Anthochaera chrysoptera*	1	0
Willie Wagtail *Rhipidura leucophrys*	1	3
Olive-backed Oriole *Oriolus sagittatus*	1	0
Eastern Yellow Robin *Eopsaltria australis*	1	0
Golden-headed Cisticola *Cisticola exilis*	1	0

Silvereye

An early finding from the banding project was about Silvereye subspecies. Three subspecies, *cornwalli*, *westernensis* and *lateralis*, visited regularly, with seasonal changes in abundance of each species (Little *et al*. 2020; Stuart 2021). Birds of subspecies *westernensis* and *lateralis*, which breed in southern Australia and Tasmania respectively, mainly were present in autumn and winter but *westernensis* birds sometimes persisted into early spring.

About 75% of the Silvereye caught on Broughton Island were *cornwalli* birds (**Table 2** summarises the Silvereye banding data). That subspecies also dominated the Silvereye re-trap results. Only *cornwalli* birds were re-trapped during a different year to the one in which they initially were caught and banded. Of the six *westernensis* birds that were re-trapped; four of those events were during the same field visit when they were banded, and the two others in a winter visit after the birds had been banded on Broughton Island in autumn of that same year. No *lateralis* subspecies birds were re-trapped.

Table 2. Silvereye banding data June 2017 to May 2022.

Silvereye subspecies	Individuals caught	Individuals re-trapped	Total re-traps	Longest re-trap interval	Oldest known bird
cornwalli	545	116	166	4 years 4 months	5+ years
westernensis	122	6	6	3 months	1+ years
lateralis	49	0	0	–	1+ years

Of the 116 re-trapped *cornwalli* birds, 37 individuals were re-trapped more than once. That included ten birds which were re-trapped three times, and a bird which was re-trapped nine times (it being more than five years old at the most recent capture). All of the *cornwalli* birds were re-captured in mist nets – there were no re-traps based on field sightings. Most of the re-traps occurred within two years of when the bird was banded originally; however, there were 43 instances of longer intervals between banding and re-trapping. The longest interval was four years and four months, which involved two different birds, both of which were first banded in October 2017 and re-trapped in February 2022. A third bird was banded in June 2017 and re-trapped in July 2021 – four years and one month later. All three birds were recorded as adults when first captured i.e., they were at least one year old (Australian Bird Study Association 2020). Thus, they were at least five years old at the time of their most recent re-capture.

All of the *westernensis* and *lateralis* birds were identified as being adults based upon plumage (Australian Bird Study Association 2020). Thus they all were more than one year old; however, that was their minimum age and some birds might have been older.

Tawny Grassbird

Of the 49 individuals caught in mist nets, 26 were identified as juvenile or immature birds i.e., as being one year old at most (Australian Bird Study Association 2020). Four of those 26 birds were recaptured during the five-year study – once on the following day, while two birds were recaptured after four months (one bird banded in October 2019 was recaptured in February 2020; the other bird was banded in June 2017 and recaptured in October 2017). The fourth bird was banded in January 2020 and re-captured in August that year i.e., about seven months later. All four juvenile/immature birds were recaptured within 30-50 m of the original site of their capture.

Twenty-three older grassbirds were caught and banded, many of them several times (see **Table 3** for details). The majority of those birds could not be sexed unambiguously when first captured, because there is an overlap of biometrics for males and females (Australian Bird Study Association 2020). However, after recapture three of the initially-unsexed birds were later identified as males, and one bird as a female.

Prior to the start of the colour-banding program, there were two confirmed resightings of a banded Tawny Grassbird. It was the same bird on both occasions. In photographs taken in October 2019 and November 2020, the band number was legible, for a bird banded in November 2018. Two colour-banded grassbirds have been resighted. A bird colour-banded in February 2022 was resighted two days later, while a bird colour-banded in mid-May 2022 was resighted twice on the following day, and three times in a return visit to the island two weeks later. All re-sightings were from within 50 m of the original capture site.

Table 3. Tawny Grassbird banding data June 2017 to May 2022.

Sex	Individuals caught	Individuals re-trapped	Total re-traps	Longest re-trap interval	Oldest known bird
Male	5	4	16	4 years 4 months	6+ years
Female	3	1	1	1 year 9 months	2+ years
Indeterminate	15	8	11	2 years 4 months	3+ years
Juvenile or immature	26	4	4	7 months	1 year

Yellow-faced Honeyeater

Ten male and 16 female Yellow-faced Honeyeater *Caligavis chrysops* were banded, and also ten birds which could not be sexed (see **Table 4** for details). The unsexed birds were either sub-adults or they had biometric data that fell within the area of overlap for males and females.

Seventeen birds were re-trapped in the 5-year study. Two birds were re-trapped twice; a bird banded in October 2017 was re-trapped in July 2019 and May 2021, when it was 5+ years old; and a bird banded in November 2018 was re-trapped in February 2020 and July 2021, by then it was 4+ years old. Initially that bird was not able to be sexed unambiguously – the re-trap biometrics indicated it was a female.

Table 4. Yellow-faced Honeyeater banding data June 2017 to May 2022.

Sex	Individuals caught	Individuals re-trapped	Total re-traps	Longest re-trap interval	Oldest known bird
Male	10	5	6	3 years 7 months	5+ years
Female	16	7	9	2 years 8 months	4+ years
Indeterminate	10	2	2	2 months	2+ years

Bar-shouldered Dove

The majority of captured Bar-shouldered Dove *Geopelia humeralis* have been males, although four of the 19 birds could not be sexed unambiguously. Only males have been re-trapped. Since May 2021 eleven birds have been colour-banded but as yet there have been no field re-sightings. However, one of those birds was re-captured three months after banding – at the same location where it had been caught originally.

Table 5. Bar-shouldered Dove banding data June 2017 to May 2022.

Sex	Individuals caught	Individuals re-trapped	Total re-traps	Longest re-trap interval	Oldest known bird
Male	11	2	2	3 months	1+ years
Female	4	0	0	–	1+ years
Indeterminate	4	0	0	–	1+ years

Welcome Swallow

Six adult Welcome Swallow *Hirundo neoxena* have been captured – all were identified as males. The other three birds caught were assessed as being juvenile or immature birds based on plumage (in particular, their tail dimensions).

Brown Quail

Five adult Brown Quail *Synoicus ypsilophorus* have been banded, and two juveniles. One adult was caught using a walk-in trap; the other six birds were caught in mist nets after having been flushed by an approaching person. There have been no re-sightings. As yet only one bird has been colour-banded.

Osprey

Three young Osprey *Pandion haliaetus* were banded and colour-banded; all of them were young birds at a nest located towards the south-western part of the island. The banding was done shortly before the chicks were expected to fledge – in all cases the banding occurred in December. In one breeding season, there were two chicks at the nest, and a single chick the other time. One colour-banded youngster was re-sighted four times, the latest occasion being 11 months after it had been banded. The one other re-sighting of a colour-banded Osprey was of a bird seven months after it had been banded. Both of the re-sighted young birds were within 1 km of the nest site and adult birds were in the general vicinity.

Other species

Most other species have insufficient data at this stage of the project to warrant closer analysis. An exception perhaps is the Grey Fantail *Rhipidura fuliginosa*. Five individuals have been banded and colour-banded. One bird, banded in May 2021, was re-sighted twice the following day and twice in the July 2021 field trip, and appeared to be remaining within a territory. However, it was not seen at that territory in any of the subsequent field trips.

DISCUSSION

The frequent re-trapping of Silvereye subspecies *cornwalli* suggests they may be resident on the island, or at least that they visit it frequently. The regular influxes of *westernensis* and *lateralis* birds in autumn and winter, and of *cornwalli* birds in spring (Little *et al*. 2020) shows that movements of Silvereye between the mainland and Broughton Island are common. Because no *westernensis* or *lateralis* birds were re-trapped in a different year to the one in which they were caught and banded, it seems unlikely that individuals from these two migratory species return to Broughton Island. Their arrivals on the island in any year seem to be random occurrences. Also, it seems that they might not spend long periods on the island, because the autumn/winter re-trap ratio has been low (~5% for of *westernensis* birds, and 0% for *lateralis* birds).

The frequent re-trapping of young Tawny Grassbird at locations close to where they first were banded suggests that they remained in or near their natal territories in the initial post-fledging period. However, because all the re-traps of young birds occurred within seven months of initial banding, it seems likely that the birds dispersed elsewhere, at ages of 6-12 months. It is not known if they remained on Broughton Island. However, metal bands are difficult for an observer to see, and thus it is possible that some banded young birds established territories elsewhere on the island. In future, the new colour-banding program might clarify the fate of a young Tawny Grassbird, because it will become easier for observers to notice the bands and be able to identify individuals.

In contrast, many adult Tawny Grassbird stayed close to the site where they were caught initially, and were re-trapped several times. Presumably the mist net lane was within their territory. Some birds recently colour-banded have already had re-sightings; again the locations have been near the site where they were first caught. The exact locations for those re-sightings are being recorded, which may in time generate information about territory sizes.

The frequent re-trapping of Yellow-faced Honeyeater individuals may be evidence that some birds are resident on Broughton Island or at least visit it regularly. However, most birds were only re-trapped once, and about half of the banded Yellow-faced Honeyeater were never re-trapped. This is evidence for the existence of a transient population. Further evidence for that comes from population estimates. In most visits to the island, HBOC surveyors have estimated the populations of each species present (Stuart 2021). Typical estimates for Yellow-faced Honeyeater have been 5-10 birds present during the three-day visit, and the highest estimate has been twelve birds. Since a total 36 birds were banded during 2017-2022, most of those individuals cannot have been present at the same time. The Yellow-faced Honeyeater is a known long-distance migrant (Higgins *et al*. 2001) and it should be easy for individuals to fly across from the mainland for short stays.

Osprey in New South Wales have been reported to lay eggs in the period July to September, and then the chicks to fledge between October and December (Marchant & Higgins 1993). The Broughton Island birds have been late breeders, with the chicks fledging in December each year. The fledged young birds have remained in their natal area for almost a year. There were no sightings of colour-banded birds at any later interval; however, it is uncertain whether or not young birds disperse from the island. For example, five Osprey were recorded within ~1 km of the nest in May 2022 – most were too far away for any bands to be visible (AS pers. obs.). Similarly, in February 2019 (prior to the commencement of any colour-banding activities) there were three young birds at the nest and another five birds within ~1 km of the nest (AS pers. obs.). These records probably did not involve additional breeding pairs – in Australia most Osprey nests are at least 1 km apart and usually they are separated by greater distances than that (Marchant & Higgins 1993).

The 19 banded Bar-shouldered Dove represents a considerable percentage of the island's estimated total population of 40-50 birds. The infrequency of re-traps (including of the eleven colour-banded birds) might mean that the population is much larger than has been estimated, or that birds move readily between the mainland and the island. In time, this matter may be able to be resolved. We note that the only instance of a recapture occurred just three months after the bird had been banded. In that instance, the bird may have established temporary residence.

The recapture rate for other species is low and there are not yet enough data for any detailed analysis. In future years, as the database of banding and re-traps grows, it should become possible to develop inferences for some of those species, particularly those for which colour-banding permits have been obtained. The permits apply to most terrestrial species found on the island, excepting Silvereye and Yellow-faced Honeyeater which are migratory species and thus excluded (because of the existence of colour-banding projects for them in other parts of Australia).

CONCLUSIONS

Banding studies on Broughton Island are yielding information about some of the species occurring on the island. Most of the individuals caught and banded have been subspecies of Silvereye, in particular the *cornwalli* subspecies. Some of those birds might be resident on the island; at the very least they seem to visit it regularly. Some Yellow-faced Honeyeater may also be resident on the island. A colour-banding component to the project has recently been started – this is expected to accelerate future data collection, through an increased number of visual re-traps.

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REFERENCES

Australian Bird Study Association (2020). Bird in the Hand – Second Edition (www.absa.asn.au accessed 28 July 2022).

Higgins, P.J., Peter, J.M. and Steele, W.K. (Eds) (2001). 'Handbook of Australian, New Zealand and Antarctic Birds Volume 5: Tyrant-flycatchers to Chats'. (Oxford University Press: Melbourne.)

Little, G., Little, J., Kyte, R. and Stuart, A. (2020). Silvereye subspecies on Broughton Island New South Wales. *Corella* **44**: 38-43.

Marchant, S. and Higgins, P.J. (Eds) (1993). 'Handbook of Australian, New Zealand and Antarctic Birds Volume 2: Raptors to Lapwings'. (Oxford University Press: Melbourne.)

Priddel, D., Carlile, N., Wilkinson, I. and Wheeler, R. (2011). Eradication of exotic mammals from offshore islands in New South Wales, Australia. In: *Island Invasives: Eradication and Management*. (Eds. Veitch, C. R., Clout, M. N. and Towns, D. R.). International Union for Conservation of Nature, Gland, Switzerland.

Stuart, A., Clarke, T., van Gessel, F., Little, G., Fraser, N. and Richardson, A. (2017). Results from surveys for terrestrial birds on Broughton Island, 2012-2016. *The Whistler* **11**: 46-53.

Stuart, A. (2020). Bird studies on Broughton Island 2017-2020. Hunter Bird Observers Club Special Report #9. (New Lambton NSW.)

Stuart, A. (2021). Passerines on Broughton Island. *The Whistler* **15**: 46-52.

Grey Plover in Port Stephens

Neil Fraser

8 Flannel Flower Fairway, Shoal Bay NSW 2315, Australia neil8fff@gmail.com

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Corrie Island in Port Stephens is a known site for migratory shorebirds in the Hunter Region (Stuart 2004a). In recent years Grey Plover *Pluvialis squatarola* has been recorded on the island's tidal flats and nearby sandy beaches. Corrie Island (32º 40' 42"S, 152º 08' 16"E) is a low-lying, partly tidal landmass of sand and gravel at the mouth of the Myall River. Much of it is covered by mangrove forest. However, sandy beaches, tidal flats and sandspits on the southern side of the island provide foraging and roosting habitat for many species of shorebirds (Stuart 2004a). Corrie Island is part of the Myall Lakes Ramsar site (Office of Environment and Heritage 2014).

Records of Grey Plover in Port Stephens are shown in **Table 1**. The earliest record located was of a single bird at Taylors Beach in November 1980 (Stuart 2004a). There are six records of single birds at Corrie Island and the adjacent Winda Woppa sandspit from 2003-2022 (https://birdata.birdlife.org.au/home) and a record of three birds in January 2003 (Stuart 2004b). Single birds were at Soldiers Point in 2010 and Swan Bay in 2013.

Table 1. Grey Plover records from Port Stephens 1980-2022.

Date	Location	Number of birds
1/11/1980	Taylors Beach	1
6/01/2003	Myall river mouth	3
26/02/2006	Corrie Island	1
6/01/2010	Soldiers Point	1
15/11/2013	Swan Bay	1
16/12/2019	Winda Woppa sandspit	1
10/01/2020	Corrie Island south	1
19/01/2020	Corrie Island south	1
20/11/2021	Corrie Island east	1
20/09/2022	Corrie Island south	1

In the Hunter Region, the Grey Plover was considered to be accidental but more recently it has been reclassified as a rare summer migrant (Stuart 2004b; Williams 2020). It has been occasionally recorded as one or two birds in the Manning Estuary with 51 records spanning 1999-2021, and the Hunter Estuary with 35 records spanning 2001-2021. Most reports for the region have been from the period November to January (https://birdata.birdlife.org.au/home). Its conservation status in New South Wales is secure and it is listed globally by the International Union for the Conservation of Nature as least concern (BirdLife International 2022). However, its numbers are declining; the Action Plan for Australian Birds 2020 lists it as vulnerable (Garnett & Baker 2021).

Grey Plover migrate to Australia along the East Asian-Australasian Flyway from their breeding grounds in eastern Siberia and Alaska (Minton & Serra 2001). It is a coastal species and forages on intertidal sand and mudflats. At high tide it usually roosts on beaches (Smith 1991). Birds arrive in Australia from mid-September through to December and depart March to mid-April. It is present around the entire Australian coastline but is least abundant on the east coast. Its numbers are concentrated at 17 northern, western and southern sites that hold over 90% of the estimated Australian population of 12,000 birds (Marchant & Higgins 1993; Minton & Serra 2001). There are no important sites in New South Wales. Grey Plover forage singly or in small flocks, but form large flocks at communal roosts, often with other waders such as Pacific Golden Plover *Pluvialis fulva*, Pied Stilt *Himantopus leucocephalus*, knots and godwits (Marchant & Higgins 1993). Banding studies indicate the species is faithful to non-breeding areas from year to year (Marchant & Higgins 1993).

Figure 1. Grey Plover in breeding plumage (left) and the same bird exhibiting black underwing axillaries (right), Corrie Island 20/09/2022. (Photos by Sharon Taylor).

The reasons for the relative scarcity of the species along the NSW coast, and the Hunter Region in particular, are not known. There are extensive areas of seemingly suitable habitat available. The extent of development along the east coast and associated human disturbance along beaches may be a factor. The bird's ecology, however, is not well understood. Why, for example, are almost all of the birds that share Australia's coastlines each year, female (Australian Wader Study Group 2016). In Port Stephens birds have been present for four consecutive years from 2019-2022 (**Table 1**). The reports span from September to February which suggests that birds are present over several months and are not on passage to southern sites. Grey Plover in non-breeding plumage looks similar to Pacific Golden Plover *P. fulva,* which have also been recorded in the area, and it is possible that birds may have been overlooked sometimes. The bird recorded in September 2022 was still in breeding plumage and was easily identified. See **Figure 1**.

Corrie Island is a relatively undisturbed location in Port Stephens with limited access and extensive areas of suitable shorebird habitat. Recent surveys of the southern part of the island have shown three threatened species breeding there successfully: Beach Stone-curlew *Esacus magnirostris*; Australian Pied Oystercatcher *Haematopus longirostris*; and Little Tern *Sternula albifrons* (Fraser & Stuart 2018). Most recently, Bush Stone-curlew *Burhinus grallarius* was recorded on the island (Katherine Howard pers. comm.). The likely regular presence of Grey Plover over summer, further highlights the importance of Corrie Island and Port Stephens for the conservation of migratory and endemic shorebirds.

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REFERENCES

Australian Wader Study Group (2016). Grey Plover Satellite Tracking Project. https://awsg.org.au/grey-plover-satellite-tracking-project/. Accessed 20/10/2022.

BirdLife International (2022). Species factsheet: *Pluvialis squatarola* http://www.birdlife.org, http://datazone.birdlife.org/species/factsheet/22693749. Accessed 21/10/2022.

Fraser, N. and Stuart, A. (2018). Some recent breeding observations of threatened shorebird species in Port Stephens. *The Whistler* **12:** 61-62.

Garnett, S.T. and Baker, G.B. (Eds) (2021). 'The Action Plan for Australia Birds'. (CSIRO Publishing: Melbourne.)

Marchant, S. and Higgins, P.J. (Eds) (1994). 'Handbook of Australian, New Zealand and Antarctic Birds, Volume 2'. (Oxford University Press: Melbourne.)

Minton, C.D.T. and Serra, L. (2001). Biometrics and moult of Grey Plovers, *Pluvialis squatarola*, in Australia. *Emu - Austral Ornithology*, **101**(1): 13-18.

Office of Environment and Heritage (2014). Statement of Management Intent. Bushy Island, Corrie Island, One Tree Island and Snapper Island nature reserves. (Office of Environment and Heritage: Sydney, NSW.)

Smith, P. (1991). 'The Biology and Management of Waders (Suborder Charadrii) in NSW'. (NSW National Parks and Wildlife Service Species Management Report Number **9**.) (NSW National Parks & Wildlife Service: Hurstville, NSW.)

Stuart, A.D. (2004a). The shorebirds of Port Stephens, recent and historical perspectives. Hunter Bird Observers Club, Special Report No. **2**. (Hunter Bird Observers Club Inc.: New Lambton, NSW.)

Stuart, A. (Ed.) (2004b). Hunter Region Annual Bird Report Number 25 (2003). (Hunter Bird Observers Club Inc.: New Lambton, NSW.)

Williams, D. (Ed) (2020). Hunter Region Annual Bird Report Number **27** (2019). (Hunter Bird Observers Club Inc.: New Lambton, NSW.)

Yaraandoo - How many birds on my patch?

Mike Newman[1] and Glenn Ehmke[2]

[1]72 Axiom Way, Acton Park, Tasmania 7180, Australia omgnewman@bigpond.com
[2] 2 Rainbow Court, Rye, Victoria 3941, Australia glennehmke76@gmail.com

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Birds were monitored regularly at Yaraandoo, a lightly grazed property near Paterson in the Hunter Valley of NSW, over a three-year period from 2011 to 2014. The property, located in a high rainfall area, was bounded on two sides by intact forest with dense understorey vegetation. The property had approximately 20% vegetation cover and an irrigated olive grove.

Surveys, typically of 3.5 hours, were replicated by the same observer at monthly intervals using a constant survey route. Approximately 18 ha was searched during the surveys, which is almost one fifth of the property size. Count data were used to identify seasonal and between-year variations in bird abundance.

The results demonstrated the presence of a diverse and abundant bird population with 104 species recorded and an estimated mean population of 1330 individual birds. Of these, 27 species were regularly present, each being recorded on more than 80% of surveys. The Yellow-faced Honeyeater *Caligavis chrysops* was the most abundant species with a mean count of 21.1 birds/survey. Two species, Speckled Warbler *Pyrrholaemus sagittatus* and Varied Sittella *Daphoenositta chrysoptera,* both classified as Vulnerable in NSW, were recorded intermittently.

Count data (numbers of individual birds) were a more sensitive indicator than presence data (frequency of species occurrence) of seasonal and annual population differences. For example, Jacky Winter *Microeca fascinans*, although regularly present throughout the year, were significantly more numerous in winter when they formed flocks in open areas.

Population densities, estimated from count data, were consistent with the ranges found in other studies. There were no Hunter Region estimates for comparison.

Densities are essential for estimating the size of regional and national bird populations. This paper demonstrates how counting birds in regularly repeated standardised surveys can provide new information on bird populations to the benefit of the national conservation effort. It also highlights the existence of neglected data sets at other locations in the Hunter Region, and potentially elsewhere in Australia, that can quantify the extent to which bird populations have declined during the last 25 years.

INTRODUCTION

The initial focus of terrestrial bird monitoring in Australia involved mapping bird distributions (Blakers *et al*. 1984). Subsequent objectives were broader, including documenting changes in distribution and trends in the abundance of bird populations (Barrett *et al*. 2003). However, there are few reliable estimates of global, or even regional populations of Australian birds, other than for threatened species (Garnett & Baker 2021).

The two Australian Bird Atlases (Blakers *et al.* 1984; Barrett *et al*. 2003) focused on the presence of birds and their abundance was implied by changes in the frequency at which they were recorded (Reporting Rate - RR). The Australian Bird Atlases were inspired by the British Trust for Ornithology's atlases of the UK (Gibbons *et al.* 1993) but fell short of the UK's goal of estimating the population sizes of every breeding species. This ambitious objective requires a link between bird distributions and the numbers of birds. This requires counting birds and relating regional RRs to their population density.

The second Australian Bird Atlas and its subsequent bird monitoring phase Birdata, provided the option for counting birds, but its promotion and use of count data received little focus, particularly for woodland birds. Despite this, some participants counted the numbers of woodland birds.

The protection of birds under Australia's environmental laws requires knowledge of the size and the rates at which populations change. In the recent Action Plan for Australia's Birds 2020 (Garnett & Baker 2021), Birdata was used to establish population estimates using a combination of species distributions and population density estimates, primarily drawing on data involving BirdLife Australia's standardised Birdata 2-ha 20-minute survey protocol. In this paper we explore an alternative approach to estimating species' population densities using standardised Birdata 5-km area search surveys. Our analysis utilised field work conducted between 2011 and 2014 at Yaraandoo (32.63º S, 151.66º E), a rural property lightly grazed by cattle near Paterson in the Hunter Valley, NSW.

We assess the credibility of the species-specific density estimates in this study by comparison with those found in other studies. Finally, we reflect on the importance of rural properties, such as Yaraandoo, in sustaining local bird populations.

METHODS

Twenty-nine 5-km area search surveys (https://birdata.birdlife.org.au/) were conducted between June 2011 and February 2014. Each survey followed the same 3 km route, taking approximately 3.5 h to complete. Surveys were conducted by the same observer (MN) in the morning, typically commencing about 1 h after sunrise. All birds seen and heard were counted. Three standard 2-ha 20-minute surveys (https://birdata.birdlife.org.au/) were conducted as part of the 5-km area search and contributed to the total survey data.

In order to calculate the density of each species, we assumed that an area 30 m either side of the route was sampled; a total area of 0.18 km². A correction was made for species that were not recorded on every survey by decreasing the computed densities in proportion to the fraction of surveys during which they were recorded.

Analysis of results

Survey statistics were summarised as mean count numbers and standard deviations for all species. The total population size for Yaraandoo was estimated from the mean number of individuals/survey assuming that the 0.18 km² area surveyed was representative of the entire 1 km² property. The minimum and maximum population estimates were based on the upper and lower bounds of the mean count indicated by the standard deviation. All population estimates were rounded to the nearest integer.

A comparison of the fit of the count data with normal and log-normal distributions suggested that a normal distribution was the preferred option for assessment of the count data. Results were analysed as mean count numbers and standard errors. Differences in the sub-sets of survey counts by season or year were assessed using Analysis of Variance (when testing across >2 groups) or Student's *t* test (when testing across 2 groups). Variations in occurrence were analysed using RRs (the percentage of surveys that a species was present).

Seasonal variations were assessed based on three arbitrarily defined periods: breeding (Aug to Dec) 14 surveys, post-breeding (Jan to Apr) eight surveys, and winter (May to Jul) seven surveys. Inter-annual comparisons were based on July to June years.

Habitat

Yaraandoo, area *c* 1 km², was split into two properties shortly before these surveys commenced. The survey route sampled habitat in both of the subdivided sections. Surveys commenced from the entrance to the house at the north-western corner of the cleared area (**Figure 1**).

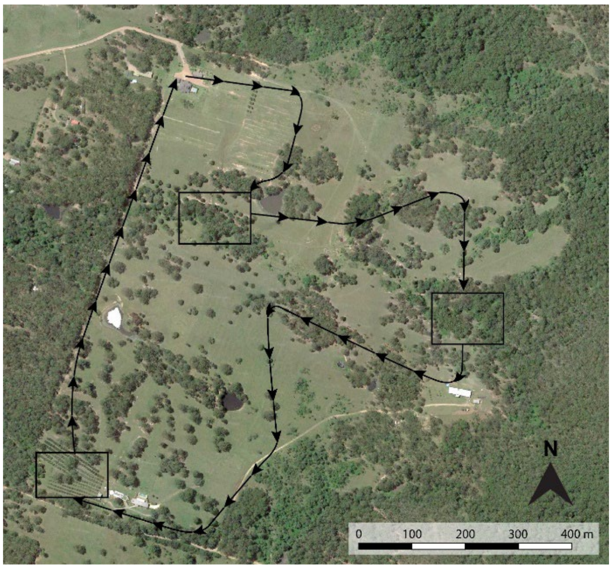

Figure 1. The route used for the 5-km area surveys at Yaraandoo and the locations of the 2-ha 20-minute survey sites.

The route then descended through a recently-cleared olive grove to a small dam above an area of riparian vegetation surrounding a creek, where a 2-ha 20-minute survey was conducted. From there the route ascended to the eastern edge of the cleared area, sampling several copses of retained vegetation. It then descended along a fence line, beyond which there was dense forest, to a creek within a small amphitheatre of grassland surrounded by rainforest vegetation. A 2-ha 20-minute survey was conducted there. The route then descended along a fence line to an area of lightly-timbered pasture, before turning left past a dam and onto the road leading to the property in the south-western corner. A third 2-ha 20-minute survey was conducted in the olive grove adjacent to the house. Finally, the route returned to the starting point, sampling the area adjacent to the fence line and passing another large dam.

RESULTS

One hundred and four species were recorded; a complete list of them is in the on-line **Appendix** (available at https://www.hboc.org.au/the-whistler/the-whistler-volume-16/). From 42-55 species were recorded per survey, with an average of 46 species. Many species were recorded regularly, with 27 species (26% of the total) having RRs of more than 80% of the surveys. In contrast, 34 species (33%) had RRs below 20% (**Figure 2**).

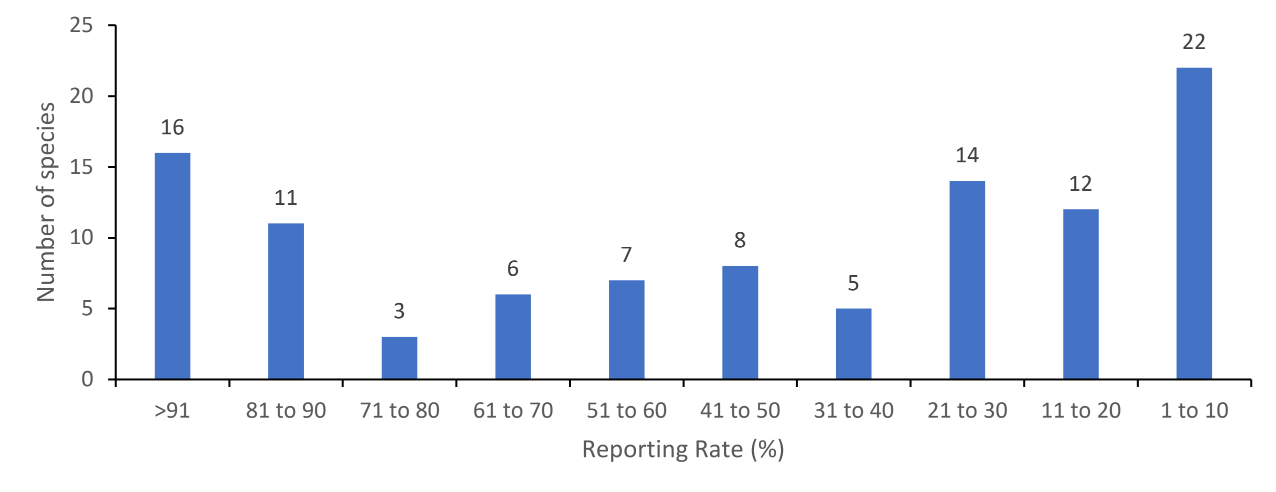

Figure 2. Histogram quantifying the frequency at which species were recorded during surveys at Yaraandoo near Paterson between 2011 and 2014.

Population size

The mean number of birds recorded/survey was 240 (**Table 1**). There were no statistically significant differences between seasons despite seasonal variations for some species (e.g., breeding summer visitors).

Table 1. Statistics for the total number of birds recorded.

Mean number of birds/survey	240
Standard Deviation	56
Mean density (birds/km²)	1330
Maximum density (birds/km²)	1650
Minimum density (birds/km²)	1020

Count statistics and density estimates

Count statistics and density estimates for the 27 most frequently recorded species (those with RR >80%) are shown in **Table 2**. The most abundant species (Yellow-faced Honeyeater *Caligavis chrysops*: 21.1 birds/survey) was recorded 11 times more frequently than the least abundant (Pied Butcherbird *Cracticus nigrogularis*: 1.9 birds/survey). The 27 most regularly recorded species contribute on average 166 birds/survey or 67% of the mean number of birds counted.

Seasonal differences

Six species were found to have statistically significant differences between seasons in the mean number of species per survey (**Table 3** and **Figure 3**). Four species were most abundant in winter - Noisy Friarbird *Philemon corniculatus*, Black-faced Cuckoo-shrike *Coracina novaehollandiae*, Jacky Winter *Microeca fascinans* and Red-browed Finch *Neochmia temporalis*. The increased spread of winter count magnitudes was consistent with the formation of variable sized flocks, as opposed to the presence of territorial pairs in the breeding season (**Figure 3**). In contrast, Rufous Whistler *Pachycephala rufiventris* and Golden Whistler *P. pectoralis* were most numerous in the breeding season.

Table 2. Summary of count statistics and density estimates for the 27 most frequently recorded species ranked in order of decreasing abundance for 5-km area search surveys at Yaraandoo between 2011 and 2014.

Common Name	**Scientific Name**	**Reporting Rate (%)**	**Mean No. of birds**	**Standard deviation**	**Estimated density (birds/km²)**
Yellow-faced Honeyeater	*Caligavis chrysops*	96.6	21.1	19.2	114
Superb Fairy-wren	*Malurus cyaneus*	100	15.6	6.8	87
Red-browed Finch	*Neochmia temporalis*	89.7	11.3	15.1	55
Grey Fantail	*Rhipidura albiscapa*	100	11.1	6.8	62
Lewin's Honeyeater	*Meliphaga lewinii*	100	8.2	2.9	46
Jacky Winter	*Microeca fascinans*	96.6	7.9	6.3	43
Australian Magpie	*Gymnorhina tibicen*	100	6.1	2.3	34
Eastern Whipbird	*Psophodes olivaceus*	100	5.6	2.0	31
Yellow Thornbill	*Acanthiza nana*	86.2	6.6	5.6	32
Striated Thornbill	*Acanthiza lineata*	86.2	6.5	4.4	31
Brown Gerygone	*Gerygone mouki*	89.7	6.0	3.6	30
Noisy Miner	*Manorina melanocephala*	96.6	5.3	2.6	28
Golden Whistler	*Pachycephala pectoralis*	96.6	5.3	2.4	28
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	82.8	5.2	5.0	24
Australian Raven	*Corvus coronoides*	89.7	5.0	4.2	25
Eastern Rosella	*Platycercus eximius*	93.1	4.8	2.7	25
Eastern Yellow Robin	*Eopsaltria australis*	93.1	4.8	2.7	25
Brown Thornbill	*Acanthiza pusilla*	100	4.2	2.4	23
Bar-shouldered Dove	*Geopelia humeralis*	89.7	3.4	1.4	17
Willie Wagtail	*Rhipidura leucophrys*	89.7	3.7	1.6	19
Eastern Spinebill	*Acanthorhynchus tenuirostris*	82.8	3.6	2.3	16
Laughing Kookaburra	*Dacelo novaeguineae*	93.1	3.1	1.5	16
Grey Shrike-thrush	*Colluricincla harmonica*	89.7	3.0	1.8	15
Magpie-lark	*Grallina cyanoleuca*	93.1	2.5	1.5	13
Wonga Pigeon	*Leucosarcia melanoleuca*	89.7	2.4	1.6	12
Grey Butcherbird	*Cracticus torquatus*	93.1	2.3	1.0	12
Pied Butcherbird	*Cracticus nigrogularis*	93.1	1.9	0.8	10

Table 3. Mean numbers and standard errors (SE) for species with statistically significant seasonal differences ($p<0.05$) in the number of individual birds recorded at Yaraandoo between 2011 and 2014.

	RR (%)	**Breeding season means (and SE)**	**Post-breeding means (and SE)**	**Winter means (and SE)**	**Probability (*p*)**
Noisy Friarbird	65.5	3.2 (0.9)	3.4 (0.9)	11.0 (0.6)	0.007
Black-faced Cuckoo-shrike	82.8	3.5 (0.5)	3.8 (1.6)	10.0 (3.2)	0.017
Rufous Whistler	48.3	7.2 (0.8)	1.8 (0.4)	0	0.001
Golden Whistler	96.6	6.3 (0.5)	3.8 (0.6)	5.0 (1.2)	0.047
Jacky Winter	96.6	7.6 (0.8)	5.8 (1.1)	11.0 (1.5)	0.012
Red-browed Finch	89.7	16.8 (2.9)	6.8 (1.4)	25.9 (9.0)	0.044

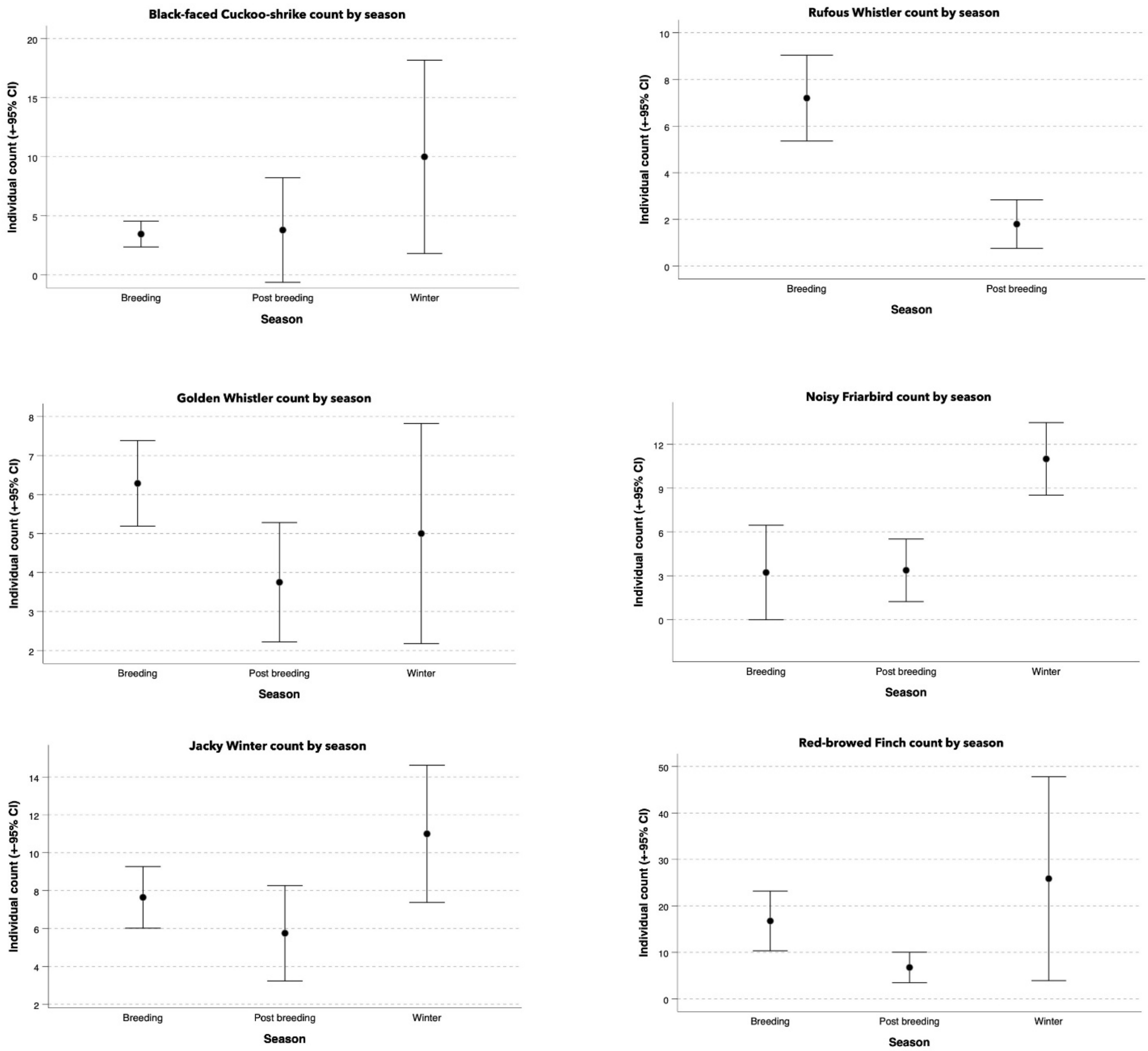

Figure 3. Species with statistically significant differences in seasonal abundance for 5-km area search surveys conducted at Yaraandoo between 2011 and 2014.

Inter-year differences

The number of birds recorded across years was statistically homogeneous except for three species – Yellow Thornbill *Acanthiza nana*, Australian Magpie *Gymnorhina tibicen* and Pied Currawong *Strepera graculina*; their differences are elucidated in **Table 4** and **Figure 4**.

Table 4. Mean numbers and standard errors (SE) for species with statistically significant differences (p<0.05) in the number of individual birds recorded year-on-year at Yaraandoo between 2011 and 2014.

Species	**RR (%)**	**2011/2012 means (and SE)**	**2012/2013 means (and SE)**	**2013/2014 means (and SE)**	**Probability (*p*)**
Yellow Thornbill	86.2	3.2 (1.1)	12.1 (2.4)	4.5 (0.8)	0.001
Australian Magpie	100	8.7 (1.1)	5.7 (0.7)	5.3 (0.4)	0.005
Pied Currawong	65.5	13.5 (3.0)	2.8 (0.6)	1.4 (0.2)	<0.001

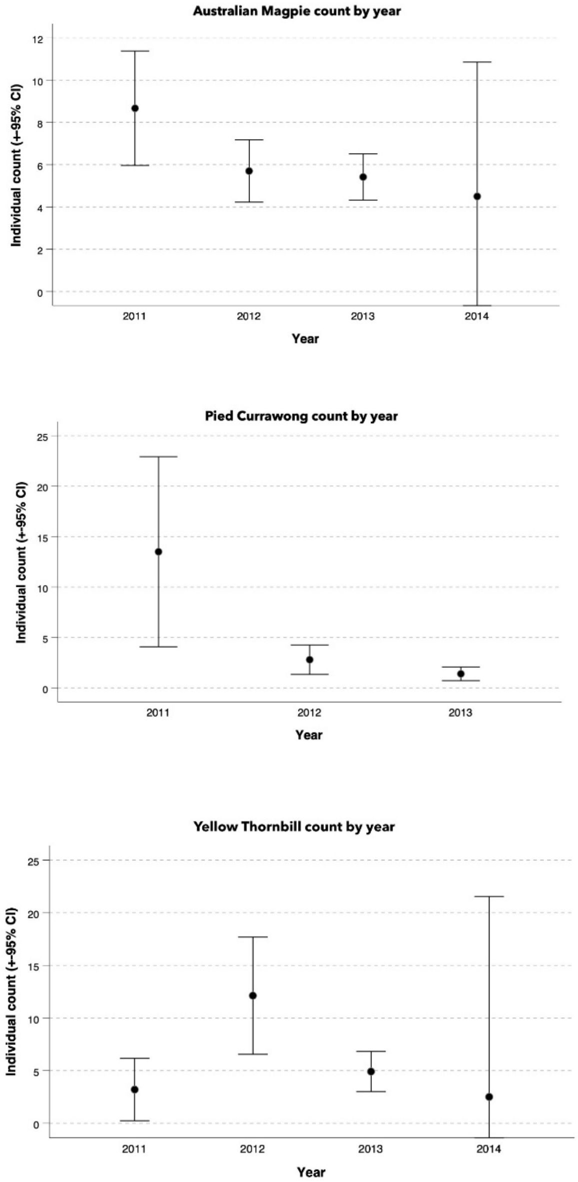

Figure 4. Species with statistically significant inter-year differences in surveys at Yaraandoo 2011-2014.

Threatened Species

Two woodland species listed as threatened in NSW (Roderick & Stuart 2016) were recorded at Yaraandoo. The Varied Sittella *Daphoenositta chrysoptera,* classified as Vulnerable, was recorded on six surveys (RR 20.7%) with a mean count of 4.17 birds/survey and an estimated density of 5 birds/km^2. The Speckled Warbler *Pyrrholaemus sagittatus* occurred on almost half the surveys (RR 48.3%) with a mean count of 2.13 birds/survey and an estimated density of 6 birds/km^2. The attraction of Speckled Warbler to the artificial habitat provided by an irrigated olive grove may have affected these statistics (Newman 2012a).

DISCUSSION

Yaraandoo supported a diverse and abundant bird community with 104 species recorded at the time of these surveys, plus another ten species recorded during surveys not used in this analysis (see the **Appendix**). The total population for the 100 ha (1 km^2) property was estimated to be 1330 birds. To put the magnitude of this estimate into perspective, Loyn (1985) observed populations of 2850, 1450 and 664 birds/km^2 in rainforest gullies, foothill gullies and foothill ridges of forest in Victoria, a rare example of quantified magnitudes of local bird populations.

Twenty-seven regularly occurring species (RR > 80%) contributed two thirds of the total number of birds, suggesting that Yaraandoo provides important habitat (e.g., food availability and in some instances breeding opportunities) for these species. This conclusion also applies to a small number of seasonal visitors such as the Rufous Whistler. Yaraandoo also provides regional connectivity between patches of remnant woodland for many other species that were intermittently recorded.

Abundance

The computed densities are conservative estimates because not all species or individual birds were detected, with small species foraging in the canopy and skulking species being examples. The detectability of species will be variable. For instance, large and highly vocal species (e.g., Australian Magpie) will be more efficiently detected and minimum density based on a 100 m wide sampling zone may provide superior estimates to that based on a 60 m wide sample zone. Conversely, for small skulking species like the White-browed Scrub-wren, the maximum density estimates based on a 40 m wide sampling zone may be more realistic. These estimates of the size of the sampling zone take into account the open nature of the habitat as described below.

The densities estimated in this study, based on whole-of-year survey data, were compared with published values summarized in the Handbook of Australian New Zealand and Antarctic Birds (HANZAB) (e.g., volume 5 for the honeyeater species; Higgins *et al*. 2001) to benchmark the Yaraandoo estimates. HANZAB also provided information on habitat preferences that were used to assess the suitability of Yaraandoo to each species.

The density comparisons in **Table 5** were limited to species that occurred regularly at Yaraandoo, or were of special interest (e.g., threatened species). Species were selected to provide a range of contrasting life-style traits (e.g., ground and canopy feeding specialist species, highly territorial and locally nomadic species etc.). For many species the densities listed in HANZAB were extremely variable. This reflects differences in survey methodology and studies in modified habitat. For example, involving small area (3 ha) survey sites to investigate bird populations in forest communities (Loyn 1985). The ranges shown in **Table 5** excluded apparently anomalous values.

Table 5. Comparison of estimated densities at Yaraandoo with ranges typically recorded in other studies (species listed in order discussed).

	Yaraandoo (birds/km^2)	Other studies (birds/km^2)
Yellow-faced Honeyeater	113	1-100
Lewin's Honeyeater	46	1-20
Noisy Miner	28	80-100
Red-browed Finch	62	10-20
Eastern Rosella	25	5-61
Eastern Whipbird	31	3-45
Superb Fairy-wren	76	20-900
Grey Fantail	62	2-104
Striated Thornbill	31	100-200
Yellow Thornbill	32	10-200
Australian Magpie	34	10-100
Eastern Yellow Robin	25	20 -80
Rufous Whistler	40 [1]	20-200
Golden Whistler	28	20-100
Grey Shrike-thrush	15	10-100
Jacky Winter	43	20-50
Willie Wagtail	19	10-100
Speckled Warbler	6	10-60
Varied Sittella	5	10-60

[1] The breeding season (Aug-Dec) population density at Yaraandoo.

The three most frequently recorded honeyeater species have very different life styles. The Yellow-faced Honeyeater, the most abundant species, predominantly forages in the canopy and is a partial migrant to the Hunter Region. Hence, Yaraandoo supports a combination of locally nomadic birds seeking food resources and passage migrants. Its population probably predominantly involves a constant flux of birds moving through the area, as opposed to resident territorial birds. The estimated density is within the very broad range of densities found in other studies.

In contrast, Lewin's Honeyeater *Meliphaga lewinii* is considered to be a sedentary species with little evidence of local movement throughout its range. Its higher density at Yaraandoo compared to other studies is attributed to the near-coastal location in a high-rainfall locality where forest and riparian vegetation have dense understorey, providing ideal habitat. This proposition is supported by the regular presence of Lewin's Honeyeater at the 2-ha sites in the creekside vegetation and the uncleared forest at the perimeters of the property, whereas it was infrequently recorded at the more open 2-ha site in the olive grove.

The third honeyeater, the Noisy Miner *Manorina melanocephala*, is a despotic species that displaces most other species from its colonies. The Yaraandoo estimate is at the lower end of the range of published densities, which were as high as 80 to 100 birds/km^2 in areas dominated by miners. At Yaraandoo, although they were regularly encountered, it was mainly in habitat that they were unable to dominate because of understorey vegetation. As the survey route did not pass through any breeding colonies of Noisy Miner, the estimated density primarily involved birds foraging away from adjacent miner-dominated colonies.

Red-browed Finch are often found in modified habitats, especially where disturbance creates grassy habitat within or bordering the edges of forest or woodland. Not surprisingly, it was abundant at Yaraandoo with an estimated density of 62 birds/km^2, which is above that recorded in other studies in NSW.

The Eastern Rosella *Platycercus eximius* inhabits open woodland and lightly wooded grassland, including partly-cleared farmland, where they often cohabit with Noisy Miner (Newman 2013). They were a regular feature of Yaraandoo's bird population with an estimated density of 25 birds/km^2 which corresponds to the range of densities (17 – 61 birds/km^2) recorded in studies near Armidale in NSW (Ford 1985).

The Eastern Whipbird *Psophodes olivaceus* is another sedentary species, which like Lewin's Honeyeater, has a preference for dense understorey vegetation. Although having a skulking nature, it is regularly vocal, and hence easily recorded. The estimated density of 31 birds/km^2 compares well with densities ranging from 3 to 45 birds/km^2 found in other studies.

Superb Fairy-wren *Malurus cyaneus*, a widespread and numerous territorial species, had an estimated density of 76 birds/km^2. This is typical of the magnitude of many published values, but well below some (e.g., 900 birds/km^2). The area surveyed contained open areas that were unsuitable for Superb Fairy-wren, which predominantly forage near shrub-layer vegetation that provides shelter.

Grey Fantail *Rhipidura albiscapa*, a common species at Yaraandoo, is a partial migrant in the Hunter Region (Newman 2012c). Hence, the presence of passage birds in spring and autumn, although less obvious than in the case of migrating Yellow-faced Honeyeater, may temporarily increase the overall numbers. Its estimated density of 62 birds/km^2 was central to the broad range of published densities, ranging from 2 to 104 birds/km^2.

Striated Thornbill *Acanthiza lineata* mainly inhabits eucalypt forests and woodland with a well-developed shrub layer, including wet and dry forests and riparian associations. At Yaraandoo its estimated density was 31 birds/km^2. This is towards the lower end of the range of published values with a number of studies involving densities in the range 100 to 200 birds/km^2 and some higher. Yellow Thornbill, which has similar habitat requirements, was slightly less numerous with an estimated density of 32 birds/km^2, typical of the values found in other studies.

The Australian Magpie prefers open country and Yaraandoo provides ideal habitat, with an estimated density of 34 birds/km^2 which is towards the upper end of the published values.

The Eastern Yellow Robin *Eopsaltria australis*, a ground-foraging species, was usually encountered in small numbers at the edges of forests with understorey vegetation. Its estimated density was 25 birds/km^2, lower than many published records, which ranged from 20 to 80 birds/km^2. This difference reflects the lack of suitable habitat at Yaraandoo, other than at the edges of the property where it abuts uncleared forest.

During the breeding season Rufous and Golden Whistlers co-existed at Yaraandoo at similar densities (40 and 28 birds/km^2 respectively). The Rufous Whistler was a spring-summer visitor, while the Golden Whistler, a species that frequents a variety of timbered habitats including rainforests, was present throughout the year at a mean density of 28 birds/km^2, at the lower end of the range of published range of 20-100 birds/km^2. Seasonal variations in the occurrence of these species are discussed further in the next section. Grey Shrike-thrush *Colluricincla harmonica*, another vocal species with similar habitat preferences to the whistler species, was less numerous (15 birds/km^2). This is a relatively low density for this species, further emphasising the limited amount of timbered habitat in the area surveyed.

In contrast, the density of 43 birds/km^2 for the Jacky Winter was at the upper end of that found in other studies. As discussed in the next section, this was associated with the presence of winter flocks in grazed areas at Yaraandoo (Newman 2012b). Willie Wagtail, another species of lightly timbered and open habitats, although regularly recorded, had a density of 19 birds/km^2, at the lower end of the published range.

The two threatened species, Speckled Warbler and Varied Sittella, were present at densities lower than those found in other studies. Their status is discussed in a later section.

The above examples suggest that when birds are counted the 5-km-area survey methodology provides credible density estimates. With hindsight, the methodology could be improved by assessing the typical distance from the nominal survey route at which species were detected, allowing species-specific estimates.

Seasonal Differences

Jacky Winter was more abundant in winter, forming small flocks that foraged in cleared areas (Newman 2012b). The winter density of 61 birds/km^2 was statistically significantly higher than the breeding and post-breeding season densities of 42 and 32 birds/km^2 respectively.

Similarly, there were statistically significant increases in the abundance of the Noisy Friarbird, Black-faced Cuckoo-shrike and Red-browed Finch in winter. These increases may reflect the local movements of flocks formed after the breeding season, but also movements of some populations from higher altitudes towards the coast in the case of the Noisy Friarbird (Higgins *et al.* 2001).

Golden Whistler was another species in which seasonal differences were apparent. In this case the breeding season density of 35 birds/km^2 was statistically significantly higher than in the post-breeding season, 21 birds/km^2, with the winter density at an intermediate level of 28 birds/km^2.

These differences may reflect a seasonal difference in detectability as opposed to an actual decrease in numbers during the post-breeding season. The Golden Whistler is highly vocal in the breeding season when advertising its territories, and this results in a high detection rate. Rufous Whistler, an equally vocal summer visitor, was slightly more abundant, 40 birds/km^2, than the Golden Whistler in the breeding season. Its post-breeding season was significantly lower at 10 birds/km^2, probably reflecting a combination of decreased detectability and the departure of migrating birds. There were no winter records.

The deafening noise of cicadas in timbered areas adversely impacted on the aural detection of all bird species, especially at the beginning of the post-breeding season in January and February.

Inter-year differences

The ability to detect statistically significant inter-year differences in the abundance of three species further emphasises the advantage of count data over presence data in evaluating the dynamics of bird populations. The reasons for the differences are unknown.

Threatened species

The intermittent presence of Speckled Warbler and Varied Sittella demonstrates the importance that rural properties like Yaraandoo have in sustaining them within fragmented landscapes. In the case of the Speckled Warbler, artificial habitat provided by an irrigated olive grove was exploited opportunistically (Newman 2012a).

The case for density estimation options

In the Action Plan for Australian Birds 2020 (Garnett & Baker 2021), 2-ha 20-minute surveys were used to estimate the densities and population sizes of threatened species. An advantage of this approach which uses small area survey data for population estimation is that the survey sites can be related to specific habitat types. As the densities of many species are strongly dependent on habitat type, this knowledge is important when estimating the populations of species at the landscape scale. Hence, the selection of survey sites in uniform habitat is encouraged in many investigations. However, as indicated earlier the 2-ha 20-minute survey approach is data-intensive and for many species data deficiency necessitated the use of inexact expert elicitation methods to estimate densities. A further issue is the preference of many bird species for habitat ecotones, the interface between habitat types.

In this study we took the alternative approach of surveying an area approximately ten times larger than the standard 2-ha survey, in a fragmented landscape involving a variety of habitat types in which ecotones were dominant. In studies of this type, the habitat matrix sampled may be unique, which limits its applicability to the estimation of regional population size. Nevertheless, such studies have an important role as an adjunct to other approaches to landscape scale population estimation. As discussed above, estimation methodologies based on 2-ha surveys have limitations, particularly for sparse species. Studies like Yaraandoo provide a method of testing the credibility of the predictions of more fundamental approaches. The Yaraandoo approach has other benefits, such as the consistency of results when long-term monitoring is conducted using a single observer or observer team.

In this study, significant differences in seasonal and year-on-year population densities were identified using count data, which was a superior indicator of change than was presence data (RRs). Counting woodland birds is difficult because the results are subject to observer bias (sources of bias include the observer's knowledge of calls and their hearing range) and the familiarity of the observer with a survey site. These are valid limitations with respect to the analysis of citizen science data sets involving multiple observers and to comparing studies involving different observers. However, when a single observer is involved, as in this study, the 'observer' becomes a variable that is a systematic as opposed to a random source of error. This increases the reliability of relative measures such as seasonal differences in abundance.

The Yaraandoo survey design was based on the Royal Australasian Ornithologists Union (now BirdLife Australia) Birds on Farms project, which was initiated in 1996. Hence, there is potentially a wealth of historical data that could provide valuable insights into the extent that bird abundance has changed over the last 25 years. For example, MN conducted similar surveys to those at Yaraandoo at other locations near Paterson, including monthly surveys at Green Wattle Creek from mid-1996 to early 2014 (Newman 2009).

CONCLUSIONS

During the period 2011-2014, Yaraandoo, a property lightly grazed by cattle, supported a diverse and abundant bird community. The property was approximately 1 km^2 in size with an estimated 20% remnant vegetation and partially surrounded by uncleared forest.

Count data were used to identify seasonal and year-on-year differences in the abundance of species. Count data were a more sensitive indicator than presence data (i.e. Reporting Rates). The Jacky Winter is an example of a species that, although present throughout the year, was more abundant in winter.

The total species density for the property, and the densities of individual species, were consistent with magnitudes reported in other studies.

There are relatively few estimates of the size of regional bird populations in Australia, or of the species-specific densities that are necessary to estimate the size of bird populations. Consequently, the numbers of a common species such as the Superb Fairy-wren inhabiting either the Hunter Region, NSW or all of Australia, are unknown.

The approach used in this study, involving the same observer regularly searching a relatively large area of diverse habitat types in a systematic manner, has merit as an adjunct to other methods of estimating bird populations using small area habitat-specific surveys (e.g., 2-ha 20-minute). There are similar historical data sets to the Yaraandoo study for other Hunter Region locations, and probably elsewhere, that include count data suitable for this type of analysis. Collectively, such data sets may be capable of providing insights into how the abundance of woodland bird species has changed during the past 25 years. These neglected data sources provide a unique opportunity to inform bird conservation and they require urgent identification and evaluation.

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REFERENCES

Barrett, G., Silcocks, A., Barry, S., Cunningham, R. and Poulter, R. (2003). 'The New Atlas of Australian Birds'. (Royal Australasian Ornithologists Union: Melbourne.)

Blakers, M., Davies, S.J.J.F. and Reilly, P.N. (1984). 'The Atlas of Australian Birds'. (Melbourne University Press: Melbourne.)

Ford, H.A. (1985). The Bird Community in Eucalypt Woodland and Eucalypt Dieback in the Northern Tablelands of New South Wales. In 'Birds of Eucalypt Forests and Woodlands: Ecology, Conservation, Management.' (Eds. A. Keast, H.F. Recher, H. Ford and D.A. Saunders) Pp. 33-46. (Surrey Beatty and Sons in association with the Royal Australian Ornithologists Union: Chipping Norton, NSW.)

Garnett, S. and Baker, B.G. (2021). 'Action Plan for Australian Birds 2020'. (CSIRO Publishing: Melbourne.)

Gibbons, D.W., Reid, J.B. and Chapman, R.A. (1993). 'The New Atlas of Breeding Birds in Britain and Ireland: 1988-1991'. (T. and A.D. Poyser Ltd: London).

Higgins, P.J., Peter, J.M. and Steele, W.K. (2001). 'Handbook of Australian, New Zealand and Antarctic Birds. Volume 5. Tyrant-flycatchers to Chats. (Oxford University Press: Melbourne.)

Loyn, R. (1985). Ecology, Distribution and Density of Birds in Victoria Forests. In 'Birds of Eucalypt Forests and Woodlands: Ecology, Conservation, Management'. (Eds. A. Keast, H.F. Recher, H. Ford and D.A. Saunders) Pp. 333-340. (Surrey Beatty and Sons Pty Limited in association with the Royal Australian Ornithologists Union: Chipping Norton, NSW.)

Newman, M. (2009). Birds of Green Wattle Creek – monthly surveys 1996-2009. *The Whistler* **3**: 14-29.

Newman, M. (2012a). Olive groves – habitat for Speckled Warbler and other birds. *The Whistler* **6**: 49-53.

Newman, M. (2012b). Flocking of Jacky Winter in paddocks in winter. *The Whistler* **6**: 61-62.

Newman, M. (2012c). Fluctuations in numbers of Grey Fantails in the Hunter Region of New South Wales. *Australian Field Ornithology* **29**: 57–76.

Newman, M. (2013). Association between breeding Noisy Miners and Grey Butcherbirds and the adverse impact of understorey. *The Whistler* **7**: 55.

Roderick, M. and Stuart, A. (2016). Threatened bird species of the Hunter Region: 2016 status review. *The Whistler* **10**: 33-49.

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- Should be no more than 4 pages of descriptive or prosaic style.
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