The Whistler

Features

Brahminy Kite
Beach Stone-curlew
Black-necked Stork
Regent Honeyeater
Sharp-tailed Sandpiper
Pallid Cuckoo
Sooty Oystercatcher
Birds of Tahlee, Gloucester Tops, Ash Island

An annual publication of the

Hunter Bird Observers Club
Affiliated with BirdLife Australia

Number 13
2019

The *Whistler* is the scientific journal of the Hunter Bird Observers Club Inc.

ISSN 2208-9845 (electronic copy); ISSN 1835-7385 (hard copy)

All papers are peer-reviewed prior to publication.

The aims of the Hunter Bird Observers Club (HBOC), which is affiliated with BirdLife Australia, are:

- ***To encourage and further the study and conservation of Australian birds and their habitat***
- ***To encourage bird observing as a leisure-time activity***

Printed by NCP Printing, Newcastle

Authors wishing to submit manuscripts for consideration for publication should consult **Instructions for Authors** on page 95 and then submit their manuscripts to the **Editors** at whistler@hboc.org.au

Front cover: Beach Stone-curlew *Esacus magnirostris* - Photo: Trevor Murray

Back cover: Pallid Cuckoo *Heteroscenes pallidus* - Photo: Chris Tzaros

Spine: Sharp-tailed Sandpipers *Calidris acuminata* - Photo: Rob Palazzi

The *Whistler* is proudly supported by

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Editorial

This is the first issue of The Whistler after the joint retirement of long-term editors Harold Tarrant and Mike Newman. As the incoming editors, our aim is to maintain the high standards achieved in previous issues. We think we've done that with this issue, but readers can decide that for themselves.

We have introduced two policy changes, both aimed at increasing the impact of The Whistler. The first of those is on-line publishing of each article when it is finalised. In that way, the information in the article is immediately available for others to use. On-line articles are available at this link: www.hboc.org.au/publications/the-whistler/. The second change, with the support of HBOC's Management Committee, has been to remove the 64-page limit to the size of hard copy issues of the journal. Although printing and postage costs have risen as a result, the change has allowed us to include more articles into this issue, with obvious benefits to authors and to readers. It has also allowed more use of illustrative photographs, for which there previously was very little space. Note though that the policy eschews gratuitous use of images; they must add value to the article.

Two of the papers in this issue report on in-depth studies of the breeding biology of local species. Lois Wooding's study of a pair of Brahminy Kite at their nest at Lemon Tree Passage, spanning two breeding seasons, has added considerably to our knowledge about this species and is an excellent follow-up to her preliminary report published in Volume 11. Similarly, Ann Lindsey's study of a pair of Black-necked Stork across two breeding seasons documents many previously unreported behaviours by adult birds and their chicks. Ann's work is also a case study in Citizen Science; many local birdwatchers assisted with observations or followed with interest her regular updates on Hunterbirding.

Four other full-length papers make important contributions to our knowledge of well-known Hunter Region species. Lois Wooding's review of the status of the Sooty Oystercatcher highlights the importance of offshore islands for their breeding and confirms our region's overall importance for this little-studied species. Mike Newman's review of the Pallid Cuckoo identifies an alarming decline locally, and he contrasts this with the Tasmanian situation where the population appears to be stable. Mike's insightful paper suggests that the Pallid Cuckoo has a large home range and is vulnerable directly (effects on adults) and indirectly (effects on host species) to changes in the status of the local habitat. Alan Stuart demonstrates the importance of the Hunter Estuary in the past decade for the Sharp-tailed Sandpiper. Internationally significant numbers of them have visited every non-breeding season since 2013 and the estuary has become one of the most important Australian sites. Trevor Murray's study of Beach Stone-Curlews has been spread over almost a decade. From his work it is now confirmed that a pair breeds in Port Stephens; he also has made valuable new observations about the transition from immature to adult plumage.

The final single species paper in this issue takes a different approach. Ross Crates challenges the accepted wisdom that the Regent Honeyeater is an accomplished mimic and presents solid evidence that its mimicry is a maladaptive outcome of the drastic population decline for this species. It is also noteworthy that part of Ross's study was supported by a Wilma Barden Memorial Grant from HBOC.

Three papers capture the contemporary status of the birdlife of a particular local area. Stuart Fleming documents his four-year study of the birds at Tahlee on the western side of Port Stephens, showcasing the high species diversity and importance for several threatened or migratory species. Alan Stuart and Mike Newman present a nine-year study of the Gloucester Tops, where six species are high altitude specialists and there is evidence of altitudinal stratification for many other species. Phil Reid documents the changes that have occurred at an area on Ash Island where mangroves have been removed and salt marsh habitat is re-emerging. Several shorebird species have now begun to utilise the area.

In this issue, we also present several short notes, on a variety of topics: Black-necked Stork dispersal; a new Cattle Egret colony; a colonial breeding colony at the Wetlands Centre; Grey Fantail foraging behaviour. We encourage more people to submit articles of this type – they are comparatively easy to write (and to read) and they capture aspects of bird behaviour that otherwise often go unreported. We would like The Whistler to become a forum for short notes about our local species.

We note two unifying themes for the articles in this issue: detailed field observations, and citizen science. Because of careful field work, we are much clearer now about the regional status of the Brahminy Kite, Black-necked Stork and Beach Stone-Curlew. And because of HBOC members ('citizen scientists') carefully analysing their own records or those in Birdata, we have learnt many things about other species at either a local or regional level. In particular, the efforts by Lois Wooding on the Sooty Oystercatcher and Mike Newman on the Pallid Cuckoo stand out as excellent examples of how to use records of multiple types to analyse the occurrence of a species at the local and regional level.

Many people must be acknowledged for helping this issue of The Whistler to see the light of day. Our particular thanks go to all the authors for their efforts; it takes time and commitment to put pen to paper (or fingers to keyboard). Mention must also be made of the referees, whose constructive comments invariably lead to an improved product. Liz Crawford, despite her peripatetic sailor's lifestyle, continues to proof-read each manuscript and turn it into an eye-catching final product. And then once again Rob Kyte has assembled the hard copy product and he also organises its printing and distribution.

Neil Fraser and Alan Stuart
Joint Editors

Brahminy Kite: two consecutive breeding seasons at Port Stephens, NSW, compared

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Received 3 June 2018; accepted 17 January 2019; published on-line 10 March 2019.

The nesting behaviour of a pair of Brahminy Kite *Haliastur indus* at Lemon Tree Passage, NSW, was compared over two consecutive breeding seasons (2016 and 2017), following close observation of the entire cycle from nest-building to juvenile independence in 2017. Incubation took 34-36 days, and the nestling period 50 days. New or supplementary nest building, courtship, parental and juvenile behaviours are described, and a fledged juvenile was followed for 38 days. An attempt was made to study the adult birds when they were away from the nest, and to define their general territory and hunting range throughout the breeding cycle.

INTRODUCTION AND BACKGROUND

A pair of Brahminy Kite *Haliastur indus* has been recorded at Lemon Tree Passage, at the expanding southern limit of the species' breeding distribution in NSW, since 2010 (Stuart 2011-2016; Wooding 2017). Local residents were aware of nesting activity during that time, but confirmation of an active nest was not reported until May 2016 (Wooding 2017). A new nest, constructed in 2017, presented an opportunity to observe nest construction; compare nest sites and nesting behaviour; follow a fledged juvenile, and to try and document the routine of the adult birds when not at the nest. Meanwhile, a population study in northern Australia that covered the egg-laying season, nest sites, breeding density and success and diet (Riddell 2017) complements the behavioural aspects reported by Rourke & Debus (2016) and Wooding (2017). Here I present supplementary information on breeding behaviour and the post-fledging period for the pair breeding at Lemon Tree Passage.

MATERIALS AND METHODS

The same equipment and methodology was used as in the previous study (Wooding 2017). Observations were made with binoculars (Swarovski EL 10x50 SV) and a spotting scope (Swarovski HD 20x60). Photos and videos were taken using a Nikon P900 camera, and a Canon EOS 7D Mark 11 camera equipped with a Canon EF 100-400 f/4.5-5.6 IS USM lens and a 1.4 extender. Distance measurements were taken from Google Earth 2017.

The 2017 study involved a total of 118 observation hours: 66 h at the nest, and 52 h studying off-nest behaviour. Additional time spent tracking the fledged juvenile once it left the nest site was not recorded. The area was visited regularly. The duration of observation periods varied, as did the time of day when they were conducted. Most nest observations were made from a vehicle parked approximately 50 m from the base of the nest tree at a viewing angle of approximately 75˚ to the nest. Off-nest observations were made from six different locations, five of which enabled localised scanning of shorelines, creeks, islands and bays. The elevation of the sixth site provided an overall view of the estuary in the region of Lemon Tree Passage. Field notes were transcribed and, where applicable, logged on an Excel spreadsheet, but a detailed log of parental time budgets was not kept.

It should be noted that distance, weather, and restricted nest views presented constant challenges, which may have influenced the description of individual actions or the sex assigned to the adult birds.

RESULTS

The 2016 nest site

The 2016 nest site was checked regularly between December 2016 and May 2017. No obvious signs of deterioration or damage were noted despite the passage of storms and high winds (**Figure 1**). More frequent nest-site checks began in mid-May 2017. One or both adult birds were found at the nest site several times between 31 May and 6 June, but they did not appear to interact, and the nest was not attended.

On 31 May both adults were found in the 2016 nest-tree, each perched approximately 3 m from the nest but on opposite sides of it, with their backs to each

other and to the nest. They maintained this position for 90 min before the male flew to the estuary. Observation continued for a further 20 min, but the female did not move. On 1 June the female was seen in the same position. The male flew in 38 min later, and perched on the same branch as before. After 4 min, the male circled overhead seven times and flew away. The male returned 12 min later, sat for 8 min, circled again, then flew to the estuary. There was no detectable response from the motionless female.

Between 2 June and 6 June a Brahminy Kite was seen circling over the nest site several times, and on 6 June the female was again observed perching motionless on the same branch for two hours. No Brahminy Kites were seen at the site after 6 June.

The first observation of a Brahminy Kite carrying a stick occurred on 28 May 2017, and although regular stick-carrying continued, no nest renovations were detected. A new nest was suspected and eventually found on 26 June. The disused nest was checked monthly throughout the breeding season; it remained sound, unchanged and unoccupied.

The 2017 nest

On 26 June, an incomplete, well-hidden nest (**Figure 2**) was located in a mature Blackbutt *Eucalyptus pilularis* (identified from Cronin 2002), situated on an urban lot approximately 0.28 km south of the 2016 nest-site and 0.4 km from the estuary. The tree had been severely lopped. The main trunk terminated at a height of approximately 20 m, and the upper canopy was formed by two large lateral branches growing at acute angles to the trunk. The branch on which the nest was constructed leaned over into a strip of urban forest. The treed area, which bordered a small park, was surrounded by a tall chain-link fence. A row of fully-developed urban lots backed onto the site's west side (**Figure 3-**insert). The combination of fence, houses and neighbouring trees prevented access to the base of the nest-tree, and restricted views of the nest. In this urban area human activity was moderate, and the kites seemed unaffected by traffic noise.

Nest preparation and courtship

Between 28 May and 8 July (41 days) stick-carrying was observed daily, more frequently in the morning, until nest completion. On at least three occasions both adults were observed carrying sticks at the same time. The female was rarely seen flying after mid-June, but the male continued to carry sticks.

Figure 1. The 2016 Brahminy Kite nest, Lemon Tree Passage. Photo: Lois Wooding

Figure 2. The 2017 Brahminy Kite nest, Lemon Tree Passage. Photo: Lois Wooding

Nest-building material was mainly sourced from Bulls Island Nature Reserve, a strip of land covered in Grey Mangroves *Avicennia marina* and Swamp Sheoak *Casuarina glauca* (identified from Cronin 2002), which forms the east side of the narrow strait known as Lemon Tree Passage. Stick-carrying was mostly observed from Site 1 (**Figure 3**). The adult male carried sticks in the bill, not the talons, and was frequently mobbed by 40-50 Little Corellas *Cacatua sanguinea*, but no sticks were dropped.

By counting the number of sticks visible on enlarged photographs it was estimated that 250 sticks, 20% of which were ≥3 cm in diameter, and >1 m in length, were required to fill the triangular fork and establish the nest platform. Over 41 days, this number would require gathering and transporting approximately six sticks per day. The shortest distance between Bulls Island and the nest was 0.83 km, which would require the male to fly 5-6 km/day carrying a stick, for a total distance of between 205 and 246 km over the entire nest-building period.

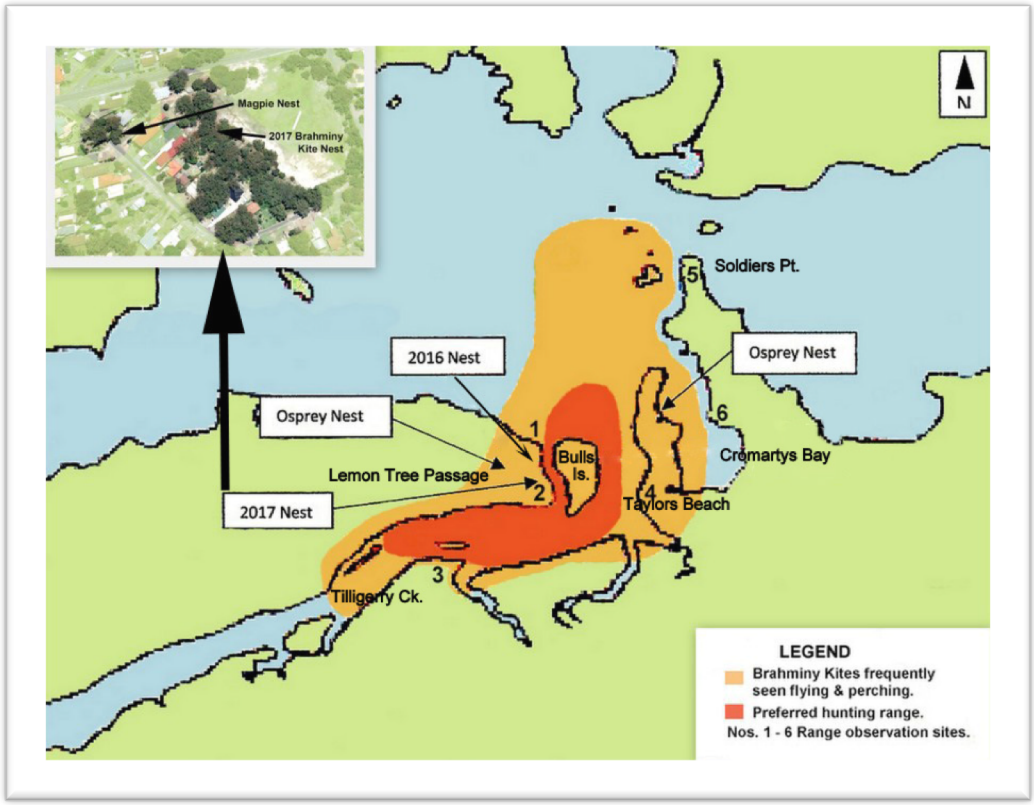

Figure 3. The Lemon Tree Passage region, Port Stephens Estuary, showing nest locations, estuary viewing points, and the suggested territory of a pair of Brahminy Kites during the 2017 breeding cycle.

When the nest was discovered on 26 June, it became obvious that the female was the principal nest-builder, taking considerable time to work the branches, delivered by the male, into the space created by a trisecting, vertical fork along the east-leaning, lateral limb of the nest tree. Nest height was estimated at 25 m. Once the interwoven branches formed a platform that comfortably accommodated the movement of both adults, the female interlaced more branches around the edge of the structure to rim the nest. On 8 July the male made several trips to the nest carrying long strands of grass, which the female arranged in the nest cup. The nest was thought to be complete.

Though not visible in its entirety, nest length was estimated at >1 m, and given that the upper thighs of the standing female were visible when the nest was completed, the depth of the nest cup was thought to be approximately 15-20 cm, based on average tarsus measurements (Marchant & Higgins 1993).

No courtship behaviour was seen prior to 26 June, although between 28 May and 26 June both adults were occasionally seen hunting and feeding together. After 26 June the male was frequently seen circling above the nest location in what was assumed to be a territorial display, and both adults favoured a perch in a neighbouring tree, where they sat close together in the last rays of the afternoon sun. The male was observed bringing fish to the female on 26 June, 3 July and 6 July. The fish was always eaten while perched on a branch near the nest. Copulation was witnessed on 6 and 8 July.

After depositing a stick at the nest, the male frequently circled 10-30 m above the nest site, an exhibition of slip-sliding, aerodynamic control gracefully performed with barely a wing-flap. Circling was often followed by a rapid, spiralling ascent to a height where, reduced to a distant speck, the male flew away. Territorial display was assumed. The female was also seen circling when leaving the nest, but the action was less frequent, less dramatic, and more purposeful, a manoeuvre seemingly more related to gaining the height needed to fly over the town-site to the estuary.

Incubation to hatch

From 8 to16 July, eight days prior to egg-laying, the female was always found on or near the nest, and on two occasions was seen entering the nest at dusk. Overnight nest occupation was not confirmed. On 16 July the female sat low on the nest with only the head and part of the back visible. A nest change-over occurred and the male adopted a similar low position. The presence of an egg was assumed. Incubation was estimated at 34-36 days, with hatch occurring on 21 August.

Nestling to fledging

On 21 August the female began making frequent position adjustments and bill-poking her lower chest area. Hatch was assumed. Feeding behaviour was observed on 22 August, and the juvenile's down-covered head was first seen 12 days post-hatch. At 20 days post-hatch emerging feathers were visible on the neck, wings and body, and the juvenile was seen attempting to feed itself. At 38 days the feather pattern was well defined, and when not sleeping or eating the juvenile was constantly engaged in preening, wing flapping and wing stretching. At 30 days post-hatch, the juvenile began perching backwards on the nest rim in order to defecate over the side of the nest (**Figure 4**). Between 46 days and fledging, play-type behaviour involving leaf-tugging and branch-pulling was occasionally seen. Small sticks, gradually loosened from the nest structure, were sometimes tossed in the air, and a few were dropped over the side of the nest and watched as they fell. Near fledging, the nestling jumped on the nest frequently; while jumping, forward rotation of the wing and shoulder joint was obvious (**Figure 5**).

Figure 4. Nestling Brahminy Kite defecating off nest (30 days old). Photo: Lois Wooding

Figure 5. Nestling Brahminy Kite jumping on nest (40 days old). Photo: Lois Wooding

On 9 October the juvenile was found off the nest and hopping to branches in the nest tree. On 10 October (50 days post-hatch) the juvenile began making short flights to neighbouring trees. The juvenile's first flights above the canopy were strong, but repeated landing attempts on top of the canopy resulted in crashes and tumbles. Landing had improved by the following day, when the juvenile was observed landing on solid, stable branches.

Post-fledging behaviour

The juvenile's first flights, initially short and clumsy (10-20 m), became longer and more controlled within 24 hours. The juvenile was occasionally seen in the nest for 6 days after fledging, but it is not known if the juvenile, or the female, slept in the nest overnight. The juvenile was not seen flying above the canopy until 18 October, eight days after fledging. Delayed open flight may have been a response to attacks by an Australian Magpie *Gymnorhina tibicen*. The juvenile did not leave the nest-site area until 28 October, 18 days after fledging.

An unusual behaviour, possibly related to Magpie attacks, occurred in late afternoon on 11 October, one day after fledging. The juvenile, which had been seen flying around the nest area during the day, could not be located, and the adults appeared agitated. The female flew back and forth approximately 10 m above the canopy, calling, while the male Brahminy Kite circled above the nest tree, dangling a large, headless fish from the talons. Apart from brief rests at the nest tree, both adults continued their search behaviour for 93 min, at which point darkness prevented further observations, although calls could still be heard. At dawn the following morning the juvenile was observed sitting beside the nest; the adult female was perched nearby.

The fledged juvenile was usually alone for 2-3 hours between food drops, although an adult occasionally circled overhead. Both adults shared provisioning responsibilities during this phase, bringing fish at approximately 3-h intervals, and both appeared to encourage the juvenile to take the prey in its talons and hold it while eating perched on a branch. Between fledging (10 October) and vacating of the nest site (28 October) both adults also appeared to encourage the juvenile to take a more active role in handling prey. Apart from breaking open the skin of the fish and offering a first morsel to the juvenile, the adults rarely fed the juvenile bill to bill. The fish was pushed towards the juvenile, which took it slowly, using both beak and talons. Once the transfer was successfully completed, adult and juvenile often

shared the prey. At 20 days post–fledge the adults began flying to a branch some distance from the juvenile, waiting for the juvenile to fly up and collect the prey. If the juvenile was slow to respond, the adult began to eat the fish. The juvenile's reaction was always swift, and the collected prey was taken to a favourite branch where it was consumed. From this stage onward, the adults seldom shared the prey with the juvenile, and usually flew away shortly after the food was transferred.

No Brahminy Kites were seen at the nest site after 28 October. The juvenile was subsequently sighted eight times in the estuary, last seen on 16 November.

Food

The male Brahminy Kite began bringing fish to the female 8 days prior to egg-laying, and continued as principal provider throughout the breeding cycle. The female, seen hunting and feeding when the male was on nest duty, also began bringing fish to the nest site approximately 33 days after the juvenile hatched. Both adults continued to bring fish until the juvenile left the nest site on 28 October. From the late stages of nestling until approximately one week after fledging, the adults often brought larger fish which they shared with the juvenile.

Except for two occasions (18 and 25 October), when the male brought the fledged juvenile what appeared to be a small, headless Common Ringtail Possum *Pseudocheirus peregrinus* (identified from Jones & Parish 2005, based on the prehensile-type feet and long, white-tipped tail), fish was the only prey type identified. Most fish (98%) were headless. Sand Mullet *Myxus elongatus* and Sand Whiting *Sillago ciliate* were thought to be the species most frequently offered (identified from Gomon *et al.* 2008 and Department of Primary Industries 2018).

The juvenile appeared reluctant to eat the possum. On both occasions the juvenile flew to the adult, sampled the prey, and flew away to another branch where it sat with its back to the adult. Each time the adult waited for approximately 3 min then took the prey to the juvenile and persisted in feeding it. The adult's beak constantly followed the beak of the juvenile every time it turned away until the juvenile finally accepted and swallowed portions of the offered flesh. On 25 October, feeding time exceeded 40 min, and when the adult flew away the remains of the "possum" could be seen in the juvenile's left talons. After sitting motionless for approximately 5 min the juvenile let the carcass drop, then spent several minutes cleaning its talons and wiping its bill on the branch.

No scavenging incidents were observed, but live catches over open water were frequently seen. Neither adult kite was seen decapitating prey before transporting it to the nest site, but from a distance dismemberment may have been mistaken for feeding. During October, headless fish bodies estimated at ≥25 cm in length were delivered to the juvenile three to four times a day.

Inter-species interaction and aggression

Between 28 May and 8 July both adult Brahminy Kites were frequently mobbed by 40-50 Little Corellas while perched around the estuary or while transporting nest-building material. No aggressive response was witnessed. The male Brahminy Kite's preferred hunting range overlapped areas where a White-bellied Sea-Eagle *Haliaeetus leucogaster,* a Whistling Kite *Haliastur sphenurus,* and two pairs of Osprey *Pandion haliaetus* also hunted (**Figure 3**). The Sea-Eagle and the Brahminy Kite frequently hunted on parallel transects at the same time, but no aggressive displays were observed, even when they passed within a few metres of each other. The Whistling Kite, seen less frequently, tended to veer away from the path of the Sea-Eagle, but rolled over and flared its talons whenever the Brahminy Kite approached. This display was always ignored and the Brahminy Kite flew steadily on.

The Osprey were not seen hunting at the same time as the Brahminy Kites, but on 10 October, a confrontation between a Brahminy Kite (possibly male) and an Osprey took place above the nest tree. Both birds dived at each other several times with open beaks and flared talons before the Osprey flew away. On 12 October, when no adult Brahminy Kites were present, two Ospreys circled the nest site then flew away. The juvenile Brahminy Kite, which was on the nest during both incidents, responded by flattening down onto the sticks and remaining motionless.

Between 26 September and 21 October, the adult Brahminy Kites were under constant attack from an Australian Magpie, nesting in a neighbouring Blackbutt approximately 55 m from the Brahminy Kite nest tree (**Figure 3**-insert**)**. The Magpie was relentless, attacking whenever the kites approached or departed the nest-site, and often seeking them out when they perched among the foliage. The Magpie was not seen attacking the juvenile while it was still on the nest, but once the juvenile fledged (10 October) it too was targeted. The juvenile appeared frightened and retreated to the centre of the treed area.

The adult Brahminy Kites were never seen initiating aggression towards the Magpie, but retaliation in the form of beak opening, rolling and talon flaring occurred when they were sufficiently provoked. After one particularly vicious Magpie strike, which dislodged a feather from the female kite's back, there was a much stronger response. The female did a complete barrel-roll, the wings went up then arced downwards before folding back along the body, much like the wing action of a falcon. The manoeuvre produced a burst of speed that enabled the kite to overtake the Magpie, which narrowly avoided being caught in the kite's talons.

On one occasion the male Brahminy Kite was seen harassing a Little Pied Cormorant *Phalacrocorax melanoleucos* that had caught a fish. For several minutes the kite swooped, dived and hovered low over the cormorant, the kite's talons almost touching the cormorant's head, and forcing it to dive. The cormorant did not give up the fish, and the kite lost interest, but the kite demonstrated considerable ability to manoeuvre at water level.

Observations away from the nest site

For as long as the juvenile remained at the nest site, off-nest observations of the adults were made from Sites 1, 2 & 3 (**Figure 3**). The adult male was usually found perched on the branch of a dead tree on the north-west shore of Bulls Island, or atop the mast of a yacht, anchored in the bay at the north-west entrance to the "passage". Both perches, approximately 70 m apart, had views of the "passage" and the shallow water of the bay where the male often hunted. The female, seen infrequently and seldom seen perched, had a preference for hunting along Tilligerry Creek (**Figure 3**).

Once the juvenile left the nest site and joined the adults (29 October) observations were made from all six viewing points with limited success. Observation times were not recorded. Although still seen in the vicinity of Bulls Island, all three kites began ranging over a wider area that included Taylors Beach, Cromartys Bay and Soldiers Point. Site 6, to the east of the suggested territory, provided the best overview of the area, but distance and sun position often hampered observations (**Figure 3**).

After leaving the nest site, between 29 October and 6 November, the juvenile was seen accompanying the adults six times: twice flying with an adult, possibly the female, and four times perched near one or both adults. The juvenile was seen again on 7 November and 16 November. On both of these occasions the juvenile was alone (scans of the area failed to locate either adult) and appeared to be hunting independently. Its flight profile suggested hunting, and during the second sighting it was observed swooping down to the water. A splash occurred but a successful catch could not be confirmed. The juvenile was not seen again after 16 November, and sightings of adult kites were sparse; their absence on these occasions may indicate the juvenile's growing independence. The post-fledging period thus lasted at least 38 days before the juvenile apparently ranged more widely or dispersed.

DISCUSSION

Nest sites

The 2016 and 2017 nest sites were comparable in that both nests were constructed on the east side of lopped trees of the same size, species and maturity, and both trees were similarly located on built lots beside strips of urban forest situated approximately 0.4 km from the estuary. The new site was closer to the town's main access road and the Lemon Tree Passage business district. Urban nests of Brahminy Kites have been described previously (Marchant & Higgins 1993; Sivakumar & Jayabalan 2004; Lutter *et al.* 2006; Indrayanto *et al*. 2011; Rourke & Debus 2016; Riddell 2013, 2017).

Residents adjacent to the 2016 nest site had observed Brahminy Kites using the same nest, over several, but not all, breeding seasons (Wooding 2017). Conversations with local residents at the 2017 site elicited similar information, although details pertaining to the year(s) when nesting had occurred, or the tree(s) in which previous nests had been built could not be accurately recalled. No evidence of former nests was found.

Though incomplete and unsubstantiated, these verbal reports were considered to be important. Previously it was thought that the kites had not bred in 2015 due to severe storm damage to the nest tree, and the extensive tree lopping which followed (Wooding 2017). Reports of intermittent nesting at both sites, in a territory with only one known pair of Brahminy Kites, question this assumption and suggest that the focal pair might alternate between nest sites, a possibility that may be related to the behaviour observed at the old nest at the commencement of the 2017 breeding season. The literature contains reports of nest reuse and nest-site faithfulness (Rourke & Debus 2016; Hollands 2003; Marchant & Higgins 1993).

Nest preparation and courtship

Apart from adjustments to sticks *in situ* no nest preparation was observed in 2016 (Wooding 2017). In 2017, 41 days (28 May to 8 July) elapsed between the first observation of stick carrying and nest completion, which includes the period of sometimes lingering at the old nest (28 May to 6 June). Return flight distance was not considered in the estimate of stick-gathering forays, because the male did not always return directly to Bulls Island. Although the basis for this type of calculation may be tenuous, it is indicative of the time, effort, cooperation and cognitive ability required to build a Brahminy Kite nest.

No reference to the normal time-frame for a complete nest construction was found. Indrayanto *et al*. (2011) observed a 10-day nest renovation, whereas Lutter *et al*. (2006) witnessed a 9-day minor nest renovation followed by a 20-day rebuild of an existing nest using newly gathered material. When a pair of Brahminy Kites appropriated a Forest Raven *Corvus tasmanicu*s nest at Port Macquarie NSW, the preliminary refurbishment took 4 weeks, but further nest damage, caused by retaliation from the ravens, took a further 6 weeks to repair. (Rourke & Debus 2016). The tendency for Brahminy Kites to carry more sticks in the morning than the afternoon was noted by Indrayanto *et al*. (2011) and Lutter *et al*. (2006).

The 2017 nest, which looked untidy and insubstantial compared to the settled stability of the 2016 nest, may be comparable to a nest described by Lutter *et al*. (2006) as "flimsy" or to the "rough structure" reported by Cupper & Cupper (1981) (**Figures 1** & **2**). The position of both nests corresponded to a tendency observed by Hollands (2003) for Brahminy Kites to construct nests "further out on more or less horizontal limbs where foliage is denser".

In Mackay, north Queensland, it was observed that old nests disappeared and new nests were built annually. Speculation as to whether the nests were deliberately dismantled by the kites or whether they had succumbed to the elements was not resolved (Hollands 2003). Storms and high winds considerably reduced the volume of the 2017 nest, both during and after occupation, but no evidence of nest dismantling was seen. The 2016 nest remained unchanged.

Prior to incubation in 2016, the adult pair was often seen at the nest site sharing close, mutual perch-time of more than one hour's duration during the main part of the day, and in the late afternoon (Wooding 2017). In 2017 mutual perching was only seen late in the afternoon. The male was not seen carrying fish before the discovery of the 2017 nest, but similar to 2016, the male was seen transferring fish to the female three times during the week prior to incubation.

Incubation to hatch

The only reference found that related to raptor fertility referred to Bald Eagles *Haliaeetus leucocephalus*. The article speculates that successful copulation takes place 5-10 days before the egg is laid (Raptor Research Project 2016). The Lemon Tree Passage nests were not under continuous watch, but the known 2017 copulation dates (6 and 8 July) fall within the suggested fertility window. The female's close proximity to the nest between 8 July and 16 July would seem to concur with the suggestion by Lutter *et al.* (2006) that female Brahminy Kites undergo a pre-incubation phase during which the female prepares, by sitting on, and sleeping in, the nest. In 2016, incubation was thought to have begun on 20 June with hatch occurring 43 days later (2 August) a period which exceeds the generally accepted incubation time of 35 days by 8 days (Wooding 2017). Prior to the publication of the 2016 study, the possibility of a pre-incubation phase was unknown to the author, therefore, the female's behaviour during the first eight days in 2016 may have been mistakenly interpreted as incubation.

Although a detailed record of parental time budgets was not kept for the 2017 study the ratio of male/female "sitting-time" during incubation and nestling appeared similar, as did the regularity of nest provisioning by the male (Wooding 2017).

Nestling to fledging

Juvenile development was also comparable. Feather acquisition, feeding ability, preening, wing-exercise and increased surety of movement about the nest all occurred at similar stages. Additional behaviour at the 2017 nest was observed (i.e. defecation over the nest rim). Jumping on the nest during the week prior to fledging occurred more frequently in 2017. A nestling period of 50 days is similar to 47–52 days recorded by Rourke & Debus (2016), Riddell (2017) and Wooding (2017). There was an impression that the 2017 juvenile was smaller than the 2016 juvenile, leading to speculation that it may have been a male.

Post-fledging behaviour

The 2016 juvenile disappeared five days after fledging, and its fate is unknown. During that time flight was frequent around and above the nest site. On the fourth day the juvenile flew away from the area and was lost from sight, but returned to the nest later in the day. On the fifth day the juvenile flew to the estuary with the adult female and was not seen again (Wooding 2017).

Juveniles in both seasons flew within 24 h of branch-hopping, and both were occasionally seen on the nest after fledging, sometimes at dusk. Overnight nest occupation was not confirmed. The 2017 juvenile appeared to abandon the nest six days after fledging, but seemed reluctant to break from the cover of the trees. Open flight (eight days post-fledge) coincided with a diminished frequency in Magpie attacks.

The final sighting of the juvenile, on 16 November, occurred 38 days after fledging, and is comparable to the six weeks and seven weeks reported by Rourke & Debus (2016). Full juvenile independence is not thought to occur until approximately 60 days after fledging (Marchant & Higgins 1993).

Food

Nest height, distance, and inaccessibility to the base of the nest-tree made detailed fish identification difficult, but a common feature in both seasons was that almost all fish seen were headless when brought to the nest. Delivery of headless fish was also witnessed by Hollands (2003). The amount of food provided seemed excessive, although the adult did sometimes share the catch with the juvenile. "Astounding food consumption" was also noticed by Hollands (2003). The ability of Brahminy Kites to catch and eat small mammals was reported by Marchant & Higgins (1993) and Debus (2012).

Adult Brahminy Kite body-weights are given as 536 g (male) to 588 g (female) and both tarsus and toes are reported to be weak (Marchant & Higgins 1993). This weakness did not appear to inhibit the seemingly effortless ability of the focal pair to catch and transport prey weighing up to 4/5 of their body weight for distances exceeding 500 m (Department of Primary Industries 2018). Large fish, which were often dangled from the talons of one foot, would presumably increase prey-weight by introducing a flight-drag factor, especially in windy conditions. Also, fish transferred to one foot during aerial attacks were never dropped despite acrobatic body rolls and flaring of the unencumbered talons of the other foot.

Inter-species interaction and aggression

No raptors were seen in the vicinity of the nest during the 2016 study, and the activity of the adult birds away from the nest was not monitored. In 2017 there were two active Osprey nests in the area, one on a tower 0.6 km to the north-west of the Brahminy Kite nest, and another in the top of mangroves 2.4 km to the north-east (**Figure 1**). Both nests produced fledged juveniles. The Osprey involved in the 2017 confrontation was thought to come from the closer nest. Osprey occupied the same nest in 2016, but their flight path to the estuary was well south of the 2016 Brahminy Kite nest. However, circling kites gaining altitude before departing for the estuary would have passed over the Osprey nest many times a day, but no conflicts were observed.

Constant harassment from the Australian Magpie provoked many annoyed, defensive responses from the adult Brahminy Kites, but only one serious retaliatory attack was witnessed. There was a sense that the kites tried to avoid confrontation, screening their approach to the nest site by flying below canopy height, and by hiding in thick foliage when perched. The juvenile's tendency to flatten on the nest or hide among the foliage during attacks seemed to indicate fear. Once the Magpie attacks ceased (21 Oct), the juvenile was often seen flying in the open.

Observations away from the nest

Off-nest behaviour was not observed in 2016, and attempts in 2017 to monitor the off-nest activity of the adults, and later the fledged juvenile, met with limited success. A complex shoreline with few access points made it difficult to keep the birds in sight. Observations from a boat may produce better results. What did become apparent was that throughout the breeding cycle the adult kites were generally found within what appeared to be their preferred hunting range (**Figure 3**). The male, seen more frequently, had a distinct preference for particular perches and hunting spots, and the male's reactions to other raptors seemed generally tolerant. Once the juvenile began accompanying the adults, their territory expanded (**Figure 3**). The lack of sightings after mid-November may suggest an even wider off-season dispersal. When last seen, all three birds seemed fit and healthy.

CONCLUSION

The study of two consecutive Brahminy Kite nesting events found that both nesting cycles were similar in that incubation, nestling and post-fledging periods fell within accepted nesting parameters once adjustments were made for misinterpreted behaviour in 2016 (see Marchant & Higgins 1993; Rourke & Debus 2016; Riddell 2017; Wooding 2017). The 7-day decision to relocate to a new nest site, combined with information obtained from residents at both sites, suggests a possible history of alternation between nest sites. Adult roles during nest building were defined, and female pre-incubation behaviour appeared confirmed. New behaviours witnessed at the 2017 nest contribute to the understanding of parental roles, particularly the adult response to a missing juvenile, and the use of food as an inducement to juvenile cognitive development. In 2017, the fledged juvenile was observed until it finally left the nest site. A fear-response to Magpie attacks may have restricted the juvenile's early flight attempts, but no residual inhibitions were seen.

The expanded parameters of the 2017 study revealed off-nest routines not previously recorded for the focal pair. A hunting range with favourite perches seemed well defined. That range was seen to expand when the juvenile joined the adults. A demonstrated tolerance towards other raptors was only breached in circumstances of perceived threats to the nest and incidents of excessive provocation.

Brahminy Kite is still an understudied species, recent studies (cited above) and the present study notwithstanding. This paper, despite its more holistic approach, contributes to a tendency in the literature to focus on nests, particularly nests in urban settings, which are more easily found and studied. Little is known about the nesting incidence of Brahminy Kite in bays and inlets along often inaccessible stretches of coastline, or the bearing that may have on their distribution in south-eastern Australia. Reports of Brahminy Kite south of Port Stephens and the Hunter River are becoming increasingly common (Stuart 1994-2016), and reports of more southerly nest locations would seem inevitable.

ACKNOWLEDGEMENTS

I thank Jordan Skinner, Environment Officer, Port Stephens Council, for park access; Pauline and Martin Eltoft and Pam Hill for their observations. My thanks also to Steve Debus for his much appreciated guidance and referee comments.

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A baseline study of the birds of Tahlee and surrounds (north-western Port Stephens, New South Wales)

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Received 26 June 2017, revised manuscript received 23 November 2018, accepted 18 January 2019, published on-line 10 March 2019.

Surveys for birds in a *c.*100 ha site on the north-western shore of Port Stephens New South Wales during 2014 – 2018 recorded 167 species. The core study area was located at Tahlee although the surveys also included parts of adjacent areas of Port Stephens shoreline and woodlands bordering Karuah Nature Reserve to the west and private property to the north. The study had two main objectives: to establish baseline data about the species occurring in the Tahlee area and to foster interest in citizen science amongst residents and visitors to the property.

Fourteen species classified as threatened under the *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) or the *Biodiversity Conservation Act 2016* (NSW) were recorded in the surveys. Regulars amongst these were Osprey *Pandion haliaetus* and White-bellied Sea-Eagle *Haliaeetus leucogaster* as breeding residents, Beach Stone-curlew *Esacus magnirostris* and Bush Stone-curlew *Burhinus grallarius* the latter of which sometimes roosted on the property, Australian Pied Oystercatcher *Haematopus longirostris* and Glossy Black-Cockatoo *Calyptorhynchus lathami*. Species such as Blue-faced Honeyeater *Entomyzon cyanotis* and White-bellied Cuckoo-shrike *Coracina papuensis* were recorded more frequently in the study area than is the case in other parts of the Hunter Region.

INTRODUCTION

The Tahlee property ("Tahlee") lies on the north-western shore of Port Stephens. Nearby areas include the village of Carrington to the east and Karuah Nature Reserve to the west (see **Figure 1**). Tahlee itself has a noteworthy history. The 75-ha property was first developed in 1826 by the Australian Agricultural Company, as their initial headquarters. Various changes occurred in the first 50-60 years, including substantial clearing along the shoreline to Carrington. The changes culminated in plantings of pine trees and other exotic plants in the 1880s under the direction of Mr Robert (HD) White. Since then, most of the site has been undisturbed. The adjacent woodlands in the Karuah Nature Reserve also are undisturbed now, although formerly it was a State Forest.

The Tahlee owners have recognised the property's conservation values and intend to manage it accordingly. That prompted the present study which had as a main objective the development of baseline information about the species present on the property and some conveniently accessed adjacent areas, comprising a total survey area of *c.* 100 ha. Other objectives were to find opportunities for education through citizen science, and to identify locally significant bird species that could become the basis for future specific studies.

METHODS

The study area

Tahlee and its surrounds have a combination of woodland, grassland and estuarine habitats (Ecological Australia 2015), with some patches of garden around the main settlement. Altitudes range from sea level to 132 m. There is considerable undulation, which creates runoff that forms several gullies with flows into catchment dams and small natural wetlands that provide habitat for waterbirds. There are several walking tracks that allow safe access in most weather conditions.

Much of woodland area of Tahlee, the adjacent private property and Karuah Nature Reserve is sclerophyll forest (Ecological Australia 2015). The predominant species are eucalypts, notably Grey Ironbark *Eucalyptus microcorys*, Swamp Mahogany *Eucalyptus robusta*, Forest Red Gum *Eucalyptus tereticornis,* Tallowwood *Eucalyptus siderophloia* and Spotted Gum *Corymbia maculata*. There also are several species of

Allocasuarina. Introduced species include Lantana *Lantana camara* and African Olive *Olea europaea africana*.

The Tahlee shoreline is part of the Port Stephens – Great Lakes Marine Park. There are large tracts of mangroves. At low tide, exposed mudflats provide foraging habitat for shorebirds many of which roost at nearby Gir-um-bit National Park (Stuart 2004).

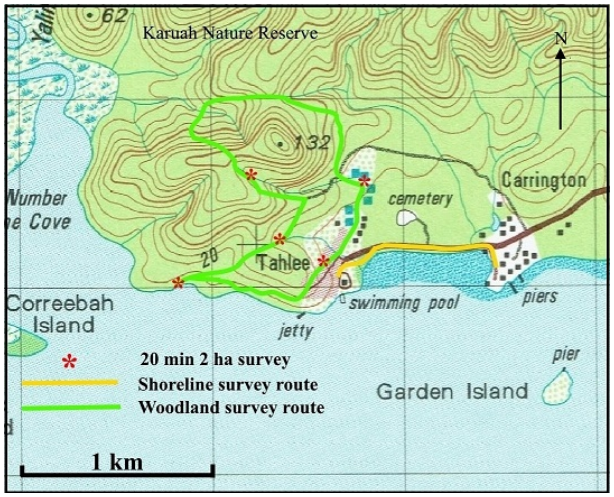

Figure 1. Location of the Tahlee property on the north-west shore of Port Stephens

Survey methods

This baseline study began in July 2014 and spanned a four-year period to June 2018. The main survey effort involved a fixed-route walk along bush tracks in the study area. The route was chosen to be easily repeatable while maximising the area covered. These surveys were carried out by the author or some other experienced surveyor, sometimes accompanied by a small number of other observers. They were conducted once per week, on Wednesday mornings regardless of the weather conditions. They commenced shortly after dawn and required about three hours to complete. All species heard or seen were recorded, and results were entered in the BirdLife Australia National Atlas Birdata as 500-m Area Surveys.

The fixed route incorporates four 2-ha sites, each of which was surveyed separately, in each case recording all species encountered in a 20-minute interval. The 2-ha sites were selected such as to sample a range of habitat types in the overall survey area. For the purposes of this report, results from the four 2-ha surveys have been included into the 500-m area survey.

Additional 500-m radius Area Surveys were sometimes carried out, designed to cover a sub-section of the property for more specific studies, such as the mudflats at low tide for shorebirds, or forest areas when in blossom or fruiting. These surveys were less structured and often had larger participation, involving local community members and visitors. Results from shoreline surveys of the area between Tahlee and Carrington have been included in this report.

RESULTS

In the four-year period July 2014 to June 2018, 263 surveys were conducted, producing records of 167 species. Of those, 128 species were recorded in the sclerophyll forest areas, the rich floral diversity providing good habitat for a range of woodland birds. The neighbouring shoreline with mangrove, mudflat and estuarine/marine habitats supported an additional 39 species. **Table 1** shows the number of surveys conducted in each season and the number of species recorded. Appendix 1 (available at www.hboc.org.au/the-whistler-volume-13/) lists all species recorded and their overall and seasonal Reporting Rates (RR).

Table 1. Surveys in the Tahlee study area July 2014 to June 2018

	Summer	Autumn	Winter	Spring	Overall
No. of surveys	66	64	83	50	263
No. of species	131	140	129	137	167

Thirty species, listed in **Table 2**, had Reporting Rates (RR) of 50% or greater. These may be considered the common birds of Tahlee. However, 92 species had overall RRs above 10%, which is an indication of the high species diversity occurring in the study area. The RR is the ratio of number of records to number of surveys, expressed as a percentage.

The other 76 species included several cryptic species which probably were under-recorded, such as White-throated Nightjar *Eurostopodus mystacalis*, Australian Owlet-nightjar *Aegotheles cristatus* and Powerful Owl *Ninox strenua*.

Threatened species

Fourteen species were recorded that are classified as threatened under the *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) or the *Biodiversity Conservation*

Act 2016 (NSW) (Roderick & Stuart 2016). These are listed in **Table 3**. Four of them had only 1-2 records. The other species appeared to be resident or regular visitors to the study area.

Australian Pied Oystercatcher *Haematopus longirostris* was a regular visitor at low tide. In early 2018 a juvenile was seen several times with parents foraging on the mudflats. A pair of Bush Stone-curlew *Burhinus grallarius* was often recorded although infrequently in summer (**Table 3**). One had a metal band and thus could be identified as having hatched near Bobs Farm in 2009 (A. Morris pers. comm.). The Beach Stone-curlew *Esacus magnirostris* was recorded once in spring surveys, foraging on the mudflats in the study area. Probably it was of one of the pair which regularly breeds on Dowardee Island (T. Murray pers. comm.). Dowardee Island is just 6 km from Tahlee across open water.

The White-bellied Sea-Eagle *Haliaeetus leucogaster* and Osprey *Pandion haliaetus* were breeding residents. A pair of the latter has been breeding at the same nest annually for over a decade. During breeding seasons, it was an amazing sight to see the species interact; most notably the intolerance the Osprey (and the Whistling Kite *Haliastur sphenurus*) had for the Sea-Eagle. Osprey, White-bellied Sea-Eagle and Whistling Kite were the main raptors in the study area. The Osprey was recorded more often in winter/spring than in summer/autumn (**Table 3**).

Migratory shorebirds

Eight migratory shorebird species were recorded in the surveys, as listed in **Table 4**. The most common of these were Eastern Curlew *Numenius madagascariensis* and Bar-tailed Godwit *Limosa lapponica*, recorded in every season, and the Grey-tailed Tattler *Tringa brevipes* which was absent in winter.

Breeding species

During the study period 18 species had one or more confirmed breeding records (nest with eggs or young, or adults were observed feeding recently fledged young). These were: Tawny Frogmouth *Podargus strigoides*, Masked Lapwing *Vanellus miles*, Osprey *Pandion haliaetus*, White-bellied Sea-Eagle *Haliaeetus leucogaster*, Whistling Kite *Haliastur sphenurus*, Dollarbird *Eurystomus orientalis*, Laughing Kookaburra *Dacelo novaeguineae*, Eastern Rosella *Platycercus eximius*, Rainbow Lorikeet *Trichoglossus moluccanus*, Blue-faced Honeyeater *Entomyzon cyanotis*, Noisy Miner *Manorina melanocephala*, Spotted Pardalote *Pardalotus punctatus*, Varied Sittella *Daphoenositta chrysoptera*, Australian Magpie *Gymnorhina tibicen*, Pied Butcherbird *Cracticus nigrogularis*, White-breasted Woodswallow *Artamus leucorynchus*, Eastern Yellow Robin *Eopsaltria australis* and Welcome Swallow *Hirundo neoxena*.

Table 2. Species most often recorded at Tahlee and their overall Reporting Rates (RR)

Species	RR (%)
Noisy Miner *Manorina melanocephala*	92.4
Australian Magpie *Gymnorhina tibicen*	89.7
Laughing Kookaburra *Dacelo novaeguineae*	85.6
Australian Wood Duck *Chenonetta jubata*	84.0
Welcome Swallow *Hirundo neoxena*	82.5
Crested Pigeon *Ocyphaps lophotes*	78.7
Chestnut Teal *Anas castanea*	72.2
Rainbow Lorikeet *Trichoglossus moluccanus*	70.5
Whistling Kite *Haliastur sphenurus*	70.7
Magpie-lark *Grallina cyanoleuca*	70.7
Blue-faced Honeyeater *Entomyzon cyanotis*	70.7
Masked Lapwing *Vanellus miles*	70.1
Pied Butcherbird *Cracticus nigrogularis*	66.2
Lewin's Honeyeater *Meliphaga lewinii*	65.0
Yellow-faced Honeyeater *Caligavis chrysops*	64.3
Osprey *Pandion haliaetus*	62.7
Grey Fantail *Rhipidura fuliginosa*	62.0
Silver Gull *Chroicocephalus novaehollandiae*	62.4
Eastern Rosella *Platycercus eximius*	60.5
Grey Butcherbird *Cracticus torquatus*	58.6
Eastern Spinebill *Acanthorhynchus tenuirostris*	57.8
Spotted Dove *Streptopelia chinensis*	54.4
Eastern Whipbird *Psophodes olivaceus*	54.4
Willie Wagtail *Rhipidura leucophrys*	54.0
Scaly-breasted Lorikeet *Trichoglossus chlorolepidotus*	53.2
Australian King-Parrot *Alisterus scapularis*	52.5
Little Pied Cormorant *Microcarbo melanoleucos*	52.1
Pied Currawong *Strepera graculina*	51.7
Pied Cormorant *Phalacrocorax varius*	51.0
Spotted Pardalote *Pardalotus punctatus*	50.6

Table 3. Threatened species recorded in the study area and their seasonal and overall Reporting Rates

	Reporting Rates (RR %)				
Species	**Summer**	**Autumn**	**Winter**	**Spring**	**Overall**
Bush Stone-curlew *Burhinus grallarius*	1.5	6.3	15.7	16.0	9.9
Beach Stone-curlew *Esacus magnirostris*	0	0	0	2.0	0.4
Australian Pied Oystercatcher *Haematopus longirostris*	43.9	54.7	59.0	62.0	54.8
Sooty Oystercatcher *Haematopus fuliginosus*	7.6	7.8	9.6	12.0	9.1
Eastern Curlew *Numenius madagascariensis*	31.8	3.1	9.6	16.0	14.8
Bar-tailed Godwit *Limosa lapponica*	22.7	17.2	0	22.0	14.1
Black-tailed Godwit *Limosa limosa*	0	0	0	2.0	0.4
Little Tern *Sternula albifrons*	0	0	1.2	0	0.4
Osprey *Pandion haliaetus*	34.8	56.3	81.9	76.0	62.7
White-bellied Sea-Eagle *Haliaeetus leucogaster*	33.3	40.6	47.0	38.0	40.3
Powerful Owl *Ninox strenua*	0	3.1	0	0	0.8
Glossy Black-Cockatoo *Calyptorhynchus lathami*	1.5	6.3	8.4	2.0	4.9
Little Lorikeet *Glossopsitta pusilla*	6.1	34.4	22.9	14.0	19.8
Varied Sittella *Daphoenositta chrysoptera*	13.6	20.3	10.8	20.0	15.6

Table 4. Migratory shorebird species recorded in the study area and their seasonal Reporting Rates

	Reporting Rates (RR %)				
Species	**Summer**	**Autumn**	**Winter**	**Spring**	**Overall**
Whimbrel *Numenius phaeopus*	4.5	9.4	1.2	12.0	6.1
Eastern Curlew *Numenius madagascariensis*	31.8	3.1	9.6	16.0	14.8
Bar-tailed Godwit *Limosa lapponica*	22.7	17.2	0	22.0	14.1
Black-tailed Godwit *Limosa limosa*	0	0	0	2.0	0.4
Latham's Snipe *Gallinago hardwickii*	0	0	0	2.0	0.4
Common Sandpiper *Actitis hypoleucos*	4.5	3.1	0	4.0	2.7
Grey-tailed Tattler *Tringa brevipes*	10.6	23.4	0	22.0	12.5
Common Greenshank *Tringa nebularia*	0	1.6	0	0	0.4

Uncommon birds of the Hunter Region

Several of the species recorded are considered uncommon within the Hunter Region (Stuart 2018). Mostly these had only 1-2 records at Tahlee in the study period (see **Appendix** for details; available at www.hboc.org.au/the-whistler-volume-13/). They included nocturnal species and some threatened species and migratory shorebirds, as noted earlier. Noteworthy others were Painted Button-quail *Turnix varius*, Forest Kingfisher *Todiramphus macleayii*, Spiny-cheeked Honeyeater *Acanthagenys rufogularis*, Forest Raven *Corvus tasmanicus*, and Spectacled Monarch *Symposiarchus trivirgatus*. Both Forest Kingfisher and Spectacled Monarch were near the southern limit of their range (Stuart 2018).

Other observations

The period of several months from late 2017 was very dry which had some impacts, particularly on wetland species. The only records of White-necked Heron *Ardea pacifica* were from that period. Conversely fewer ducks were observed then, compared to previous years.

Several species had noticeably different RRs in different seasons (see **Appendix** for details). Those which I consider worth mentioning are listed below. Note that I did not test the seasonal RR differences to assess if they might be statistically significant.

The Australasian Figbird *Sphecotheres vieilloti* and Olive-backed Oriole *Oriolus sagittatus* had greater RRs in spring compared with other seasons: 76% v 12% (winter) for the Figbird and 53% v 22% (winter) for the Oriole. The Shining Bronze-cuckoo *Chalcites lucidus* had RRs of 18-20% in winter and spring yet was scarcely recorded at all in autumn or summer. Winter was also the preferred time for the Rose Robin *Petroica rosea* and Pied Currawong *Strepera graculina* (with their respective winter v summer observations: 11% vs 0% and 73% vs 20%). Both are known to be

altitudinal migrants, descending from their highland breeding sites to lower altitude areas in winter (Stuart & Williams 2016, Stuart 2018).

DISCUSSION

Species diversity

167 species were recorded in the 100 ha Tahlee area during the four-year baseline study. This compares favourably with similar studies elsewhere – for example, 178 species recorded in the 450 ha Cattai Wetlands in a nine-year study (Carlson 2015), 126 species at the 2,640 ha Curracabundi National Park in a four-year study (Drake-Brockman 2015) and 144 species at the *c.* 100 ha Green Wattle Creek Reserve in a 13-year study (Newman 2009).

On several occasions, large numbers of birds were observed in the water near the main building of Tahlee. Many cormorants (all four local species), gulls, terns, pelicans and raptors were feeding on the schools of fish present in numbers in the channels in Port Stephens. These observations were made in the early to mid-morning and occurred mid-winter (twice in the same month) and spring.

Reviewing the data of the **Appendix**, it is apparent that Tahlee was a place of passage for many species during the study period. There were seasonal fluctuations in the RR of species, indicating that birds were briefly passing through Tahlee or only staying for all or part of one season. Stuart (2018) defines Bird of Passage as 'Species present in a suitable area for a relatively short period and equally likely to be observed in any month of the year.'

Threatened species

Although the Bush Stone-curlew is an uncommon resident in the Hunter Region, Port Stephens is considered its stronghold, with an estimated six pairs present (Roderick & Stuart 2016). In that regional context, Tahlee is an important site for them. One of the Tahlee pair fledged at Bobs Farm in 2009 (A. Morris pers. comm.), which is ~12 km distant. Port Stephens is also a stronghold for Australian Pied Oystercatcher and some pairs now breed there (Roderick & Stuart 2016, Fraser & Stuart 2018). The clean waters of the Karuah estuary and abundant supply of its main food sources, worms, crabs and oysters, presumably were the main reason that it was a regular visitor, especially at low tide.

The differences in RR for the Osprey appear to be associated with their breeding patterns. They begin building their nest in May, chicks are seen/heard from early spring and the birds have left the nest (or it is abandoned) by late spring/summer.

Allocasuarina spp, the main food source for Glossy Black-Cockatoo *Calyptorhynchus lathami* are abundant on the Tahlee property. Possibly this species was under-recorded in the surveys, due to its general shyness. An example occurred when I was leading visitors on a tour of the property. Just as I commented that Glossy Black-Cockatoo feed in the *Allocasuarinas*, and that they can be around without hearing them, several birds were observed eating quietly at the top of one tree. They continued to do so while the tour group moved on. The under-recording is further evidenced by observations of seed pods that had been broken up and left on the ground, indicating birds had recently been there though not seen on surveys.

The RRs for Little Lorikeet *Glossopsitta pusilla* and Varied Sittella *Daphoenositta chrysoptera* were around 15-20% (**Table 3**). Those RRs are considerably higher than for these woodland species across the overall Hunter Region (RRs 4-6%). Although the regional RRs include many areas of unsuitable habitat, the high RRs in Tahlee study area are an indication of the quality of these woodlands. The RR for another woodland species, the White-bellied Cuckoo-shrike, was similarly elevated (21.7% at Tahlee compared with 1.7% for the Hunter Region).

The Little Tern *Sternula albifrons* was recorded once, on 9 August 2017, when two birds were feeding with other terns on an incoming tide. Possibly these were birds on migration passage (A. Stuart pers. comm.).

Migratory shorebirds

Tahlee and the wider Port Stephens region is a key area for migratory shorebirds (Stuart 2004 & 2011). The extensive tidal mudflats between Tahlee and Carrington (**Figure 1**) provide excellent year-round foraging grounds. Species such as Eastern Curlew, Whimbrel *Numenius phaeopus* and Bar-tailed Godwit were commonly seen in the migration season, reflected in the RRs presented in **Table 4**. Eastern Curlew and Whimbrel were recorded all year including throughout winter, indicating that Tahlee provides

suitable habitat for immature (non-breeding) individuals of these species.

The migratory waders at Tahlee are also recorded roosting and foraging in the nearby Gir-um-bit National Park. The littoral habitat at Tahlee therefore might be considered a natural extension of the habitat available in the National Park.

Citizen Science

Two opportunities were identified for engaging local community members and visitors in the study and improving their bird-watching skills. In the 2016 and 2018 breeding seasons for Osprey, Tahlee community members took part in a project to monitor the birds from nest-building through until the eventually successful fledging. The local community and visitors were also encouraged to join the surveys of the Tahlee grounds and adjacent shorelines, and to contribute to preparation of a weekly bird list for the site. Observations from these community projects quickly became part of the routine discussions in the various forums available.

CONCLUSIONS

The Tahlee area is important for several reasons. It is in a largely uninhabited area and is surrounded by two habitats that are protected, ensuring species have a safe and unspoilt corridor in which to live or move through. Its rich diversity comprising woodland and estuarine habitats provides excellent opportunities for foraging species.

The surveys conducted during the four-year study period from 2014 to 2018 have revealed a rich diversity of species, with 167 species recorded in the *c.* 100 ha study area from 263 surveys. This study will serve as a baseline for identifying future changes now that the site is being actively managed for its conservation values by the Tahlee owners.

ACKNOWLEDGEMENTS

My thanks go to Neil Fraser and Alan Stuart for their generous advice and support during the preparation of this paper, and to an anonymous referee whose suggestions led to a much-improved paper. I also thank members of Hunter Bird Observers Club who helped with surveys, Roger Jaensch for his continued encouragement, and John Anderson for his vision.

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Appendix. List of species recorded at Tahlee including overall and seasonal reporting rates

This is available on-line at www.hboc.org.au/the-whistler-volume-13/.

Cattle Egret colony at Cundletown NSW

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Received 11 December 2018; accepted 17 January 2019; published on-line 7 April 2019

This note details a Cattle Egret *Bubulcus ibis* colony at Cundletown near Taree which I have visited 2-3 times each year since November 2013. The colony seems to have established in either 2010-11 or 2011-12.

Location

The colony is in a stand of Broad-leaved Paperbark *Melaleuca quinquenervia* fringing a swamp ("Nulama Ponds") on the outskirts of Cundletown, near Taree. The GPS coordinates are 31.89ºS, 151.50ºE. **Figure 1** shows the general location which is close to the junction of the Manning and Dawson Rivers. Most of the colony is on private property associated with the Nulama Ponds retirement village.

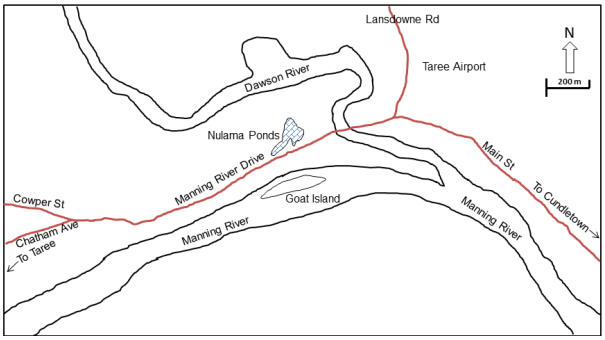

Figure1. Location of Nulama Ponds near Taree NSW

Chronology of the colony's formation

The colony was not mentioned in a 1994 review of egret colonies in New South Wales (Baxter 1994). It was active in 2011-12, because Alan Morris (pers. comm.) reported nests were present in December 2011 although he did not have the opportunity to count them. Members of the Manning Valley – Great Lakes Birdwatchers Club have often visited the area (A. Carlson pers. comm.). In November 2008 they recorded that three pairs of Little Pied Cormorant *Microcarbo melanoleucos* and a pair of Australasian Darter *Anhinga novaehollandiae* had nests. No breeding activity had been noted in visits over the preceding ten years. In January 2010 large numbers of Cattle Egret were present and breeding was suspected to be occurring; however only Little Pied Cormorant, Australasian Darter and Pied Cormorant *Phalacrocorax varius* were confirmed to be nesting (A. Carlson pers. comm.).

This chronology suggests that Cattle Egret began to breed at Nulama Ponds in either the 2010-11 or 2011-12 breeding season.

Breeding activities

Because the colony is on private property I have not been able to obtain accurate counts of the number of nests of the various species breeding there. At least 100 Cattle Egret nests were present in November 2012 (A. Morris pers. comm.). My estimates from visits since November 2013 have been of 300-400 nests each season. Other species which I have confirmed to breed at the colony have been Little Pied Cormorant, Australasian Darter, Pied Cormorant and Great Cormorant *Phalacrocorax carbo*. There have been maximums of 2-3 nests for each of those species.

ACKNOWLEDGEMENTS

I thank Ashley Carlson and Alan Morris for information and assistance.

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Beach Stone-curlew at Soldiers Point, Port Stephens: breeding records and behavioural observations

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Received 4 December 2018; accepted 31 January 2019; published on-line 7 April 2019

A pair of Beach Stone-curlew *Esacus magnirostris* has bred regularly on Dowardee Island in Port Stephens, New South Wales since 2011. I provide details and describe various behavioural and plumage-related observations, made in studies of the adult birds and their chicks.

INTRODUCTION

Since May 2011 a pair of Beach Stone-curlew *Esacus magnirostris* have been resident in Port Stephens. The pair's activity has been centred around Soldiers Point. Soldiers Point is geographically central within the Port Stephens estuary with tidal flats for feeding and nearby undisturbed islands for refuge. During six of the seven summers following their arrival the birds have successfully raised a single chick that has appeared to reach adulthood. The breeding activity has occurred on Dowardee Island to the west of Soldiers Point.

I first saw two birds that I did not recognise, on 20 May 2011 late in the afternoon on the western side of Soldiers Point opposite Dowardee Island. A beachside resident commented to me "they have been around for a couple of days". So this would be very close to their actual arrival date. I photographed them a short while later and established their identity as Beach Stone-curlew. This was the beginning of seven years thus far of observation of these birds during which time they have successfully raised six young. The bird's status as Critically Endangered under the *Biodiversity Conservation Act 2016* (NSW) has seen them feature on local and national television as their presence focused a major conservation effort to protect their habitat.

Marchant & Higgins (1993) is an excellent source of background information on this species, then known as the Beach Thick-knee, although the distribution information for NSW is out of date. In 1993 the range was limited to northern Australia including northern parts of New South Wales. Queensland continues to be a stronghold (Freeman 2003) but the range has expanded southwards (Rohweder 2003; Roderick & Stuart 2016; Mo 2016). The breeding range also has extended southwards (Clancy & Christiansen 1980; Hole *et al.* 2001).

The first confirmed record for the Hunter Region was of a single bird at Manning Point in 1993 (Stuart 1994), with the first confirmed breeding for the Region in 1998 at Harrington (Hole *et al.* 2003). Hunter Bird Observers Club (HBOC) records show that breeding or breeding attempts have continued annually in the Manning River estuary to this date (Stuart 1999-2018). Although records from the Hunter Estuary remain infrequent (single birds present in December 2002 and October-November 2015) there have been many records from around Port Stephens after a single bird was first recorded (on Corrie Island) in February 2006 (Stuart 2007). Since I first saw a pair of Beach Stone-curlew at Soldiers Point in 2011, I and others have recorded them many times in the Soldiers Point area or on Dowardee Island which is situated *c.* 350 m offshore from Soldiers Point. Mo (2016) reported that the pair bred in the area, citing in evidence some articles by me which had appeared in HBOC newsletters. In this article, I present details in relation to breeding by the Soldiers Point / Dowardee Island pair, and I describe some aspects of their behaviour which I have observed during seven years of study.

METHODS

Study Area

Soldiers Point (32.70ºS 152.06ºE) extends northward from the southern shoreline of the Port Stephens estuary. Soldiers Point is extensively developed with

residential, commercial and community facilities. Its shoreline habitat includes sand and mudflats that support populations of invertebrates including Soldier Crab *Mictyris longicarpus.* Dowardee Island (32.70ºS, 152.06ºE) is situated approximately 350 m offshore to the west off Soldiers Point. Referred to as Oakey Island by some local Aboriginal people, the island is now controlled by the Worimi Land Council. The island had a long history associated with the oyster industry and is littered with debris from that era. Its shoreline is a mixture of mangroves (mostly Grey Mangrove *Avicennia marina*), some small sand beaches and rock. Sunset Beach, which I will refer to subsequently, is the beach on the western side of Soldiers Point extending from the Soldiers Point Marina to the southern end of Pearson Park.

Observations

Since 2004 I have been fortunate to reside close to the shoreline of Soldiers Point. I have had the free time and interest to enjoy countless hours of casual observation of the natural life of Soldiers Point. I have also kayaked extensively around the study area. Much of my bird observations have been associated with a strong interest in photography. I trained in the navy as a photographer and have taken many photographs to record the Beach Stone-curlew's presence and behaviour during its time here. When attempting to establish the birds breeding on Dowardee Island I have made visual observations aided by binoculars while on the island and also from my kayak. I have always tried to minimize my impact on the pair, especially when the pair is on Dowardee Island.

RESULTS

Birds' Range within Port Stephens

I will concentrate my comments to the area around Soldiers Point; however, the Beach Stone-curlew has been observed over a wide area of the Port Stephens estuary. Sightings have been made by members of HBOC individually and also during the twice-yearly shorebird survey conducted with the support of NSW Office of Environment and Heritage. The Beach Stone-curlew pair can be observed around Soldiers Point and the wider estuary for much of the year, but from late spring for several months they are not sighted on the 'mainland'.

Breeding

On six of the seven summers since their arrival, the Beach Stone-curlew pair has successfully produced a chick able to make the flight from Dowardee Island to Soldiers Point, feed independently and grow toward maturity. I have photographed adults with a chick in most breeding seasons. **Figure 1** is a collage of such photos taken over this period.

Figure 1 Parents and juvenile Beach Stone-curlew in four breeding seasons. The juvenile is on the right in the 2012, 2014 and 2015 frames which were all taken on Sunset Beach. In the 2018 frame, taken on Dowardee Island, the juvenile is at the rear.

Plumage transition

Clancy (1986) described some of the plumage changes observed when a juvenile bird at Red Rock transitioned to adult plumage. His work is thorough and follows a chick from newly hatched to flying and I would commend this article to the reader wanting to know more. He notes that, "by week 7 the juvenile more closely resembles an adult" and further notes the bird cannot fly at this stage (Clancy 1986).

My observations at Soldiers Point were of birds capable of sufficiently strong flight to have made the journey there. I did not see the juvenile that I photographed on Dowardee Island in 2018 fly; however it looked similar in size and appearance to other juveniles I had seen in February of prior years. There is a gap in the literature regarding the timeframe towards adult plumage. A composite image showing the 2014–15 chick (**Figure 2**) reveals some information. Some areas to note as the bird ages are: more marked definition between the yellow and dark areas of the bill; decreasing size of the white patch on the side of head; decreasing amount of light brown colour and flecking in the feathering; changing presence and definition in the white 'shoulder' wing markings.

Figure 2. Three views, taken at 4-5 week intervals in 2015, showing changes to the 2014–15 chick's plumage.

The illustration of a juvenile Beach Stone-curlew in Marchant & Higgins (1993, Plate 55) shows two distinct white areas on the bird's head – a supercilium and a large white auricular spot, whereas in the illustrations of the adults the two areas of white are joined. The accompanying text noted that only one Australian individual juvenile had been available and that juveniles from the Philippines did not have that characteristic. **Figure 2** clearly shows the 2014–15 Port Stephens juvenile to have a single large area of white. Inspection of available close-up head images of juveniles from the 2011–12, 2013–14, 2015–16 and 2017–18 breeding seasons revealed similar head patterns to the 2014–15 juvenile (**Figure 3**). This suggests that the juvenile illustrated in Marchant & Higgins (1993) may have been aberrant. However, for the 2015–16 and 2017–18 chicks there was narrowing of the white area and the odd darker feather was present.

Figure 3. Head shots from juvenile Beach Stone-curlews from four breeding seasons, showing the varying extent of the white patches on the birds' heads.

Behavioural Observations

I strongly commend Marchant & Higgins (1993) to anyone who wants to garner information on this species. In this section I will occasionally quote from that reference and compare that to some of my local observations.

Feeding

The Beach Stone-curlew in Port Stephens feed predominantly on Soldier Crabs on the exposed tidal flats. I have seen them hunting for other crab species amongst rocks on occasion. The name 'magnirostris' means '*big beak'* in Latin (Marchant & Higgins 1993). The beak, although big in profile, is a relatively narrow wedge when viewed from above. The feeding style varies from simply grabbing Soldier Crabs when they are above the sand, to plunging their beak deep in the sand to catch their prey. Individual birds quickly eat up to six Soldier Crabs and then rest or roost. On the southern end of Sunset Beach, a storm-water drain pipe usually has at least a trickle of fresh water coming from it. If the Beach Stone-curlew pair is on Sunset Beach they usually end up near the drain pipe where I have regularly seen them drink, and if enough water is present they bathe. I believe the birds feed at night; however when I have attempted to observe them they have taken flight even when I used a red light source to view them.

Roosting

Under this heading Marchant & Higgins (1993) record that during one period of study, one group

of 3 birds *"sat, squatted or stood for 67% of the time and that the birds spend 58% of their time in the sun".* My local observations support this. When Soldier Crabs are walking about in large numbers these birds can grab their food very quickly and so have plenty of time to rest. Anyone wishing to view Port Stephens Beach Stone-curlew would be advised to look for locations sheltered from the wind and preferably where there is sunshine. I have observed them squatting in warm dry sand high up on beaches and sheltering from the wind near eroded embankments. They appear to value warmth which probably would help them conserve their energy resources.

Mobility

Although not mentioned in Marchant & Higgins (1993) the Beach Stone-curlew can walk at a very brisk pace and appear to do so easily. I have to walk quickly to keep pace with them. The pair's 'standard' day on Sunset Beach is to fly straight across from Dowardee Island by the shortest route to the beach, then feed and rest alternately during the course of the low tide. During this time they usually walk approximately 450 m south to finish up near the before-mentioned drain. They do not take flight during this transit unless significantly threatened, seemingly preferring to walk.

Response to human activity

Marchant & Higgins (1993) states the birds are *"shy in areas where often disturbed*" and thereafter "*often remarkably confiding and inquisitive in remote areas*". The local pair would have regular exposure to humans in much of the Port Stephens estuary, and particularly so around Soldiers Point. It is not known what exposure to human activity the local birds had prior to their arrival. Two observations merit specific mention. On one occasion when I went to pump for fishing bait (Pink Nippers *Trypaea australiensis*) there were no birds in the area. On my first action with the bait pump (where sand and possibly crustacean are ejected) a single Beach Stone-curlew landed about 5 m from me. On another occasion I observed a Beach Stone-curlew standing unperturbed whilst a family played with a soccer ball nearby.

Some social observations

- I was observing a single bird on Sunset Beach. The bird looked toward Dowardee Island and called a few times fairly quietly (to my ears at least). After a short interval another bird flew across from the island and joined it. If the second bird had responded to the call it apparently had done so from at least 450 m away.
- Recognising some threats is a learned skill. I observed a pair of adult birds with a grown but immature chick, stare upward at a White-bellied Sea-Eagle *Haliaeetus leucogaster* soaring well overhead, while the immature bird showed no interest in the potential threat.
- Immature birds are easily identified by behaviour as well as plumage. They can often have a stooped submissive posture (as shown by the February 2015 chick in **Figure 1**) when near parent birds. Parent birds will run at the chick and strike with their beaks to 'check' the chick's behaviour.
- There seems to be a period after fledging where the parents drive the young, maturing chick away. Later (after a period of possibly some months) the nearly adult-looking bird seems to be accepted and tolerated.
- Head bobbing was noted to be an indication of nervousness /agitation /alarm (Marchant & Higgins 1993). I have observed this behaviour locally also.

DISCUSSION

Breeding

As stated previously the Beach Stone-curlew pair has successfully reared a chick until it was able to make the flight from Dowardee Island to Soldiers Point and feed independently, on six of the seven summers since their arrival. The Beach Stone-curlew pair can be observed around Soldiers Point and the wider estuary for much of the year, but from late spring they are not sighted on the 'mainland'.

The first summer that the pair vanished from mainland Port Stephens I did not pay particular attention. The local yacht club has most of its fleet moored in between Dowardee Island and Sunset Beach. Their newsletter covering that first summer spoke in glowing terms of members witnessing the rearing of a Beach Stone-curlew chick on the beach on the eastern side of Dowardee Island. I was delighted when the pair returned to Soldiers Point with a young bird in early February, and this has been their pattern ever since. They appeared to be unsuccessful over the 2016–17 summer.

Since that first breeding year I have made several careful visits to Dowardee Island with the permission of the Worimi Land Council. I have also observed them from my kayak. The Beach Stone-curlew pair was always present, usually near the southwest corner of the island. The birds were

head-bobbing when I first sighted them from a distance of about 80 m. When not in breeding mode they would tolerate a much closer approach whilst feeding or roosting.

The island, as previously stated, has much debris and relics from the heyday of the oyster industry and much plant undergrowth that provide ideal cover for nesting and also shelter for a young chick. It is not ideal territory to move about in or to spot a nest or a very young chick. Additionally my first priority has been to minimize disturbance to the birds. As such, to this date I have not seen a confirmed nest or chick below fully-fledged development. During some visits, I have noted the parent birds flying off and circling back quickly around the beach on the eastern side. This is a behaviour reported as being associated with breeding (Marchant & Higgins 1993).

On 21 February 2018, as no new chick or the adult pair had returned to the mainland, I kayaked over to Dowardee Island with camera gear. I had only just dragged my kayak up on the southeast corner beach when a single adult Beach Stone-curlew emerged from cover and postured differently to any way I had witnessed previously. Shortly after this the second adult and a fledged chick with immature plumage emerged from the same cover.

I have no doubt from the reports of the Yacht Club members in the first year, and from my observations since, that the resident pair of Beach Stone-curlew has bred on Dowardee Island each year. The pair's presence and breeding success on Dowardee Island was a very significant factor in seeing an attempt by a nearby marina to extend closer to the island blocked by the Land and Environment Court.

In October 2017, there was a breeding attempt by Beach Stone-curlew on the northern side of Port Stephens (Fraser & Stuart 2018). A nest with a single egg was located on a sand dune on the southwest end of Corrie Island (32.68ºS, 152.13ºE). This probably represents another pair attempting to breed at Port Stephens, since the Dowardee Island pair bred again in 2017–2018.

CONCLUSION

It is early summer as I complete this short article. It has been two months since I sighted a lone Beach Stone-curlew on Soldiers Point. Those with the interests of these birds at heart can only hope that there is more successful breeding of this species in Port Stephens this summer.

ACKNOWLEDGEMENTS

I thank an anonymous referee whose comments helped improve the original manuscript. I also wish to thank the joint editors of *The Whistler* for suggesting this article be written and for their assistance in developing it to completion.

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Note added in proof: On 31 January 2019, I saw the Beach Stone-curlew pair and a submissive young bird fly from Dowardee Island and land on Sunset Beach. Thus it appears that the pair has bred again on Dowardee Island in the 2018–19 season.

Colonial nesting birds at the Hunter Wetlands Centre

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Received 16 April 2019; accepted 1 May 2019; published on-line 29 May 2019

This note reports the results of annual counts of colonial nesting birds in the Hunter Wetlands Centre (HWC) from 2010-11 to 2018-19. The HWC in Shortland, Newcastle, has long hosted breeding colonies of four egret species: Cattle Egret *Bubulcus ibis*, Great Egret *Ardea alba*, Intermediate Egret *Ardea intermedia* and Little Egret *Egretta garzetta* (Baxter 1994). Maddock (2008) reported annual counts from there of the nests of all four species for 17 breeding seasons spanning 1987-88 to 2007-2008. At the peak, in the 1988-89 season, there were 2,101 nests. There were more than 1,000 nests every breeding season between 1987-88 and 1989-90, but from the 1995-96 season onwards the counts more typically were of 300-500 egret nests (Maddock 2008).

The Australian White Ibis *Threskiornis moluccus* first bred at HWC in March 1988, a single pair successfully raising two chicks (Maddock 2008). Regular breeding commenced with a single pair in the 2003-04 season and with a steady increase in the number of breeding pairs subsequently. By the 2007-08 season, 117 pairs of Australian White Ibis were breeding at the Wetlands Centre (Maddock 2008).

Max Maddock discontinued his nest counts after the 2007-08 season. In the 2010-11 season he trained me in his methodology and I have continued to do annual counts since then with the help of many volunteers. The surveys are done in December each year when breeding is at its peak, especially for the egret species. The Australian White Ibis starts breeding earlier and the December counts, considered alone, probably under-estimate the total number of pairs breeding at HWC. It is outside the scope of this note to explore that point further.

I present the results from the annual nest counts since 2010-11 in **Table 1**. Usually there have been 200-300 egret nests present, dominated by Cattle Egret. There were 469 nests in the 2011-2012 season including 360 Cattle Egret nests. That season was also a good one for Australian White Ibis with 303 nests present – by far the largest known count for them.

The counts for total egret nests are broadly in line with those obtained by Maddock from 1995-96 onwards. Using the data in Maddock (2008, Figures 1-7) I calculated that the median count in his 13 annual counts from that season onwards was 304 egret nests. This is similar to my median count of 285 egret nests in nine annual counts from 2010-11 (see **Table 2** for details). However, the median counts for the individual egret species have changed, with more Cattle Egret nests recorded in the present study but fewer nests for Great Egret and Intermediate Egret. Closer examination of the Maddock data shows that the declines for both those species date from the 2001-02 season (Maddock 2008, Figures 1 and 2).

Table 1. Annual December counts of the nests of colonial breeding species at Hunter Wetlands Centre, 2010-11 to 2018-19.

	2010-11	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**	**2016-17**	**2017-18**	**2018-19**
Australian White Ibis	159	303	26	48	114	125	47	76	58
Great Egret	44	64	0	13	8	25	8	18	31
Intermediate Egret	1	42	8	10	1	10	0	4	5
Little Egret	0	3	1	5	1	8	1	3	4
Cattle Egret	160	360	300	312	184	192	305	260	216
Total egrets	205	469	309	340	194	235	314	285	236
Total nests	364	772	335	388	308	360	361	361	314

Table 2. Comparison of median nest counts for the periods 1995-96 to 2007-08 (derived from Maddock 2008) and 2010-11 to 2018-19 (this study).

	1995-96 to 2007-08	**2010-11 to 2018-19**
Australian White Ibis	N/A	76
Egrets		
Great Egret	26	18
Intermediate Egret	11	5
Little Egret	3	3
Cattle Egret	221	260
Total Egrets	**304**	**285**

The numbers of nests for all four of the egret species were much higher in the four seasons 1987-88, 1988-89, 1989-90 and 1991-92 (Maddock 2008). The highest counts for each species in those four seasons were: Cattle Egret 1,393 nests; Great Egret 198 nests; Intermediate Egret 453 nests; Little Egret 57 nests. There has been a considerable decrease in the numbers of nests for all four species since that period.

HWC has been an important site for colonially breeding egrets since 1987-88 and for Australian White Ibis since 2006-07 (with regular breeding by them there since 2003-04). Although there are considerably fewer nests than were present in the late 1980s and early 1990s (Maddock 2008), it currently is the largest egret colony in the Hunter Region. There are three other locations in the region where egrets are known to breed. There are sizable colonies at Cundletown (*c.* 300 pairs) and Gloucester (100-200 pairs); both colonies are dominated by Cattle Egret nests (Stuart 2019, Drake-Brockman 2014). There is also a smaller mixed species breeding colony (Cattle Egret, Great Egret, cormorants and Australasian Darter) of 20-50 pairs near Toronto (A. Stuart pers. comm.).

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Movements of an immature Black-necked Stork taken into care and later released

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Received 11 January 2019; accepted 7 May 2019; published on-line 29 May 2019

In 2017 a pair of Black-necked Storks *Ephippiorhynchus asiaticus* nested on wetlands at Tomago, NSW. A single chick which fledged on 7 August was first seen in the nest in May. The fledgling remained in the vicinity of the nest for over a week with its parents feeding it several times a day. This is the first confirmed, successful breeding event south of Bulahdelah, NSW (Lindsey 2019). An immature bird, presumably the fledgling, was subsequently seen with adult(s) foraging on wetlands at Tomago within Hunter Wetlands National Park (HWNP) in September 2017 and January 2018.

On 19 May 2018, N. Fraser, L. Huxtable and I were about to commence the regular, monthly waterbird survey at Tomago in HWNP when we came upon an immature stork just near the site known as Smart Gates. The bird was so ill and emaciated that we were able to catch it easily. We did this by slowly approaching and when close enough, threw a towel over its head and shoulders. It was weak, sitting on its hocks and its plumage was dirty and uncared for. It partially extended its wings but did not put up any real struggle. L. Huxtable nursed it during the fifty-minute drive to Sugarloaf Animal Hospital at West Wallsend.

On arrival at hospital the bird weighed only 2.7 kg, a little more than half of the expected weight of a bird of its size. Examination revealed that it was not injured and subsequent tests found that it was suffering from starvation. After a week in the care of Sugarloaf Animal Hospital it recovered to a point where it could stand alone and would show some aggression when approached.

It was then sent to Native Animal Trust Fund carer, A. Williams, where it remained for the next two months in a large, outdoor aviary. Each day it was eating a kilo of fish and/or prawns and squid thrown into a dish of water from a distance to avoid its perceiving humans as a food source. It was also hunting and catching insects of its own accord. By 4 June it had put on 500 gm and on 22 June it weighed 3.85 kg (A. Williams pers. comm.). I arranged to have the stork banded whilst it was in captivity so that it could be identified post release. This was done on 21 June by Dr Greg Clancy who placed a blue band on its left tibia and a yellow band on its right tibia (see **Figure 1**). On 25 July, weighing 4 kg (A. Williams pers. comm.), it was released on Hexham Swamp, near Newcastle, NSW, where it remained for the rest of that day and all the following day. It did not stay in the open water area, but moved and stood in reed beds where it was less obvious. From time to time it seemed to be pecking at the ground but was not seen to swallow any items of food. There were no reports of it fishing in open water and it was not seen on Hexham Swamp after 28 July.

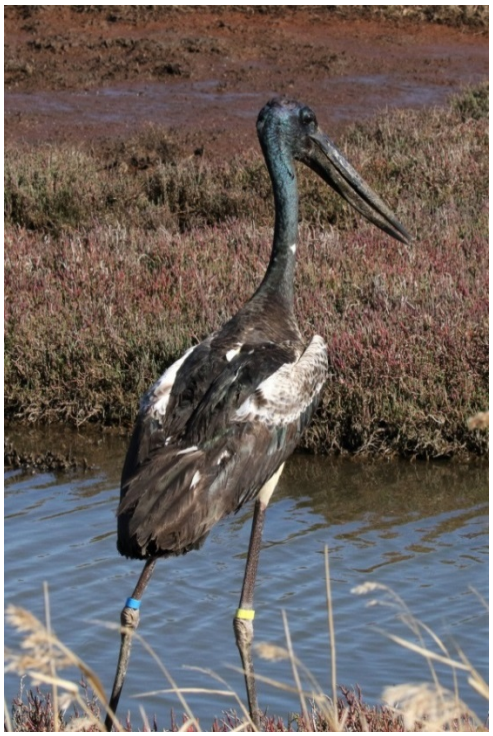

Figure 1. Colour-banded Black-necked Stork.

It is believed that YellowBlue, as this young stork has been named, is a 2017 Tomago fledgling which hatched in May of that year (Lindsey 2019).

YellowBlue was estimated to be around 12 months old when taken into care; its plumage progression was less advanced than that of a known 14-month-old bird from Harwood on the north coast (G. Clancy pers. comm.). This, coupled with its having been found only 2 km from the nest site and 2 km from where the Tomago 2017 fledgling was twice seen foraging with adults in late 2017 and early 2018, suggests that YellowBlue is the same bird.

The first sighting post the Hexham release was on 5 August at 10.40 am when V. Stevens saw it on Horizons Golf Course, Salamander Bay. On the same day, two pictures of an immature stork, one showing it standing on a footpath and the other flying over the roof of a house, were posted on Facebook on the Tea Gardens Hawks Nest Community Noticeboard (TGHNCN). The images are not sharp and the blue band is not visible but the yellow band is present. J. Connors and L. Wooding spent the next few days searching the shores of Port Stephens but failed to find it.

An image posted on 26 August on TGHNCN showed it in a backyard at Myall Quays, just north of Tea Gardens, with the comment that it had been "in the area for over a week before flying to the other side of the river (Myall River) for a few days". Further comment was that "it appeared not to be able to self-feed".

Two images clearly showing the bands were posted on 3 September, the bird having flown into the photographer's backyard. J. Connors continued to search for the stork and found it again at 8.30 am on 13 September at Myall Quays. The area is adjacent to the Myall River. When it was found it was sitting on its hocks and he was able to get as close as 2 m. This lack of fear was probably due to its being hand-fed mince by the resident into whose backyard the bird had flown. John commented that its droppings were extremely runny and he expressed his reservations about its being encouraged to associate humans with food (J. Connors pers. comm.).

On 19 September an image was again posted on TGHNCN with the request not to feed it anything but raw fish and preferably not to feed it at all. The bird looked well with its feathers in place, clean and not skinny. Another person commented that they had been lucky enough to see it "fishing their pond". On 21 September, N. Fraser searched for it around the Tea Gardens area without success.

The next reported sighting was by D. Bertram who photographed it on 19 October again at Myall Quays. A. Stuart and I drove there on 20 October and we saw the bird in the same spot at about 12.30 pm in warm humid conditions. It was sitting on its hocks with bill open. It seemed wary and walked slowly off as we tentatively approached. This behaviour was contrary to earlier reports of its being easily approached and even hand-fed. We watched it for perhaps ten minutes before it flew. As we were leaving at 2.15 pm we found it again a short distance away, sitting on its hocks near a different pond. Local resident, B. Saillard, with an excellent view of the site, told us that she had seen the bird many times and that it often came there to drink from the freshwater pond. Most of the ponds in the area are saltwater.

YellowBlue was seen foraging once in November and twice in December around Myall Quays/Tea Gardens, the last time being on 30 December 2018. Then on 6 January 2019 at 9.00 am, N. McNaughton saw it on Ash Island on Swan Pond where it walked south along the eastern shore before flying off. I rang B. Saillard to tell her that it had flown "home" to the Hunter Estuary. N. McNaughton and I searched Ash Island for over an hour and then I drove over to Hexham Swamp but failed to locate it. We did not find it because, much to our amazement, it had returned to Myall Quays that very same day. B. Saillard rang me at 3.15 pm to say she was watching it at its usual place around the ponds. At the time of writing, April 2019, the bird continues to live and forage in the Tea Gardens/Myall Quays area.

ACKNOWLEDGEMENTS

Grateful thanks to M. Simpson and staff of Sugarloaf Animal Hospital; without their intensive care and treatment, the bird would have died. Thanks to A. Williams of Native Animal Trust for rehabilitating the bird over two months and thanks to HBOC members for financially supporting its food requirements. We are grateful to Dr Greg Clancy for travelling to the Hunter to band the bird. The majority of sightings were reported by local resident, B. Saillard and HBOC member, J. Connors. Their efforts have contributed to overall knowledge of this species. Very little is known about its post-fledging movements. Thanks to other contributors V. Stevens, N. McNaughton, D. Bertram, L. Wooding, N. Fraser and L. Parashou.

REFERENCE

Lindsey, A. (2019). Observations of Black-necked Stork breeding in the Hunter Estuary at Tomago, NSW. Manuscript submitted for publication.

Spring bird surveys in the Gloucester Tops

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Received 14 March 2019; accepted 11 May 2019; published on-line 15 July 2019

Spring surveys between 2010 and 2017 in the Gloucester Tops in New South Wales recorded 92 bird species. The bird assemblages in three altitude zones were characterised and the Reporting Rates for individual species were compared. Five species (Rufous Scrub-bird *Atrichornis rufescens*, Red-browed Treecreeper *Climacteris erythrops*, Crescent Honeyeater *Phylidonyris pyrrhopterus*, Olive Whistler *Pachycephala olivacea* and Flame Robin *Petroica phoenicea*) were more likely to be recorded at high altitude. The Sulphur-crested Cockatoo *Cacatua galerita*, Brown Cuckoo-Dove *Macropygia phasianella* and Wonga Pigeon *Leucosarcia melanoleuca* were less likely to be recorded at high altitude. All these differences were statistically significant.

Two species, Paradise Riflebird *Lophorina paradiseus* and Bell Miner *Manorina melanophrys*, were more likely to be recorded at mid-altitude than at high altitude, and had no low-altitude records. The differences were statistically significant. Many of the 78 species found at low altitude were infrequently or never recorded at higher altitudes and for 18 species, the differences warrant further investigation.

There was only one record of the Regent Bowerbird *Sericulus chrysocephalus* and evidence is provided that this species may have become uncommon in the area. The populations of Green Catbird *Ailuroedus crassirostris*, Australian Logrunner *Orthonyx temminckii* and Pale-yellow Robin *Tregellasia capito* may also have declined.

INTRODUCTION

Watson (2010) noted that although the term "island" is generally used to describe landmasses surrounded by water, a range of other geographic features (e.g. caves, mountain tops, lakes, glacial moraines, rocky massifs) share similar ecological properties. Worldwide these landmasses are characterised by unique flora and fauna assemblages with a high level of endemism including specialised bird species (for example see Robin *et al*. 2015; Forero-Medina *et al*. 2011; Lindenmayer *et al*. 2010; Hernandez-Banos *et al*. 1995; Mayr & Diamond 1976). In Australia, two classes of terrestrial island are of particular importance: lakes and mountain tops (Watson 2010).

Montane "islands" supporting distinctive communities of plants and animals are isolated from other patches by inhospitable habitat. In an era of erratic climate changes and a trend to increasing temperature the extent of these montane islands shrinks and they become increasingly isolated. Any flora or fauna that are unique to the montane island and which cannot survive in the surrounding hostile environment are trapped there and potentially are doomed to extinction. The Rufous Scrub-bird *Atrichornis rufescens*, a skulking species with minimal flight capability, is an avian example of a restricted-range montane island species. It is exclusive to five high-altitude areas in New South Wales and southern Queensland. A predicted consequence of climate change is that all five locations will become unsuitable habitat and that Rufous Scrub-birds will need to be translocated to Tasmania if the species is to survive (Garnett & Franklin 2014; Garnett & Zander 2014).

All five of these isolated areas of montane vegetation in New South Wales and southern Queensland are biodiversity hot spots; each has been designated as a Key Biodiversity Area (KBA) based on the occurrence of avian endemic and restricted-range species (Dutson *et al*. 2009; BirdLife Australia 2017). One of them is the Barrington Tops National Park; it was designated as a KBA on the basis of the presence of seven threatened or range-limited species: Rufous Scrub-bird, Green Catbird *Ailuroedus crassirostris*, Regent Bowerbird *Sericulus chrysocephalus*, Australian Logrunner *Orthonyx temminckii*, Paradise Riflebird *Lophorina paradiseus*, Flame

Robin *Petroica phoenicea* and Pale-yellow Robin *Tregellasia capito* (Dutson *et al.* 2009). The Rufous Scrub-bird was the trigger species for the KBA nomination, with the other six species listed to support the nomination.

The Gloucester Tops, which forms the central eastern part of the Barrington Tops National Park, hosts a substantial population of the southern sub-species of the Rufous Scrub-bird (Stuart & Newman 2018a). The Action Plan for Australian Birds 2010 (Garnett *et al*. 2010) called for ongoing monitoring of the Rufous Scrub-bird; we responded to the challenge by conducting surveys for bird species over the period 2010-2017 in a 5,000 ha area of the Gloucester Tops. Those surveys provided insights into the bird communities present at high altitude (at 1,100−1,300 metres above sea level (masl)) in spring, and suggested that several species may be montane specialists locally (Stuart & Newman 2018b). In contrast, a comparison of montane forest and cool temperate rainforest habitats in Victoria found no significant differences in bird species richness or in the composition of the bird assemblages (Lindenmayer *et al*. 2010).

This paper examines the altitudinal stratification of avian species in the Gloucester Tops based on surveys conducted at three altitude ranges in 2010-2017. There is a dearth of such information in Australia and no previous comparable study for the Barrington Tops National Park.

METHODS

The study area

The boundaries and general location of the Barrington Tops National Park are presented in **Figure 1**, which also shows two zones of the study area, at 1,100−1,300 masl and 350−450 masl respectively. The high-altitude zone was centred at 32°05'S, 151°36'E and the low-altitude zone at 32°04'S, 151°41'E. The third part of the study area was centred on the winding road that connects the high- and low-altitude zones. The Gloucester Tops rise rapidly from ~350 masl to >1,100 masl. **Figure 2** shows altitudes at 1 km intervals by road. The zones indicated in **Figure 2** represent the three altitude zones reported in this study (Zone 1 = 350−450 masl, etc).

A detailed summary of the botanical characteristics of the Gloucester Tops is available elsewhere (Binns 1995). For the purposes of this paper, the habitats in each of the three zones that were studied may be summarised as follows:

Zone 1. 350−450 masl: Principally comprising temperate rainforest, which includes areas of regrowth post-logging. Also within the study area there is a well-grassed picnic area and camping ground. The study area includes the junction of Sharpes Creek and the Gloucester River and it is often referred to colloquially as “the Sharpes Creek site”.

Zone 2. 450−1,100 masl: Principally comprising open eucalypt woodland interspersed with patches of temperate rainforest. In several cases, the woodland areas adjoin open valleys.

Zone 3. 1,100−1,300 masl: Principally a mosaic of open eucalypt woodland and Antarctic Beech *Lophozonia moorei* rainforest.

Bird surveys

Surveys were carried out by volunteers between September and November annually over 2010-2017. The primary aim for the overall study was to monitor Rufous Scrub-birds and the timing coincided with their breeding season, when calling males are most reliably detectable (Ferrier 1984). All surveys were done only when conditions were favourable (low–medium wind, zero–low rainfall).

Transect-based surveys involving 1-3 people (typically 2 people) were conducted in the mid- and high-altitude zones. In both zones, a series of 1-km transects were established along existing roads and tracks. The surveys commenced *c*. 0800 h with surveyors taking several hours to complete all the surveys for a set of 3-5 transects. Typically, *c.* 1 h was spent in each 1-km transect. Surveyors recorded the presence of all bird species seen or heard along each transect, including any birds flying over (although extensive canopy cover in most transects limited the opportunities for the latter). No limit was set for the maximum distance from the track for records; under favourable conditions, a calling Rufous Scrub-bird can be heard 150 m away (Ferrier 1984), but for many other species the sampling width would have been less than that.

Every surveyed transect at high altitude (1,100−1,300 masl, Zone 3 in **Figure 2**) was visited several times each spring, although in some years some of the less-accessible transects were not surveyed (because of logistical constraints).

The mid-altitude zone (450−1,100 masl, Zone 2 in **Figure 2**) was surveyed systematically in 2013 and 2016. In both years, every 1-km mid-altitude transect (nine transects in total) was surveyed on a single morning, all of them being performed as single-pass downhill surveys. Some of the higher-altitude transects within this altitude zone were also surveyed in other years. All surveys took approximately one hour per 1-km transect and the general protocol was the same as for the high-altitude surveys.

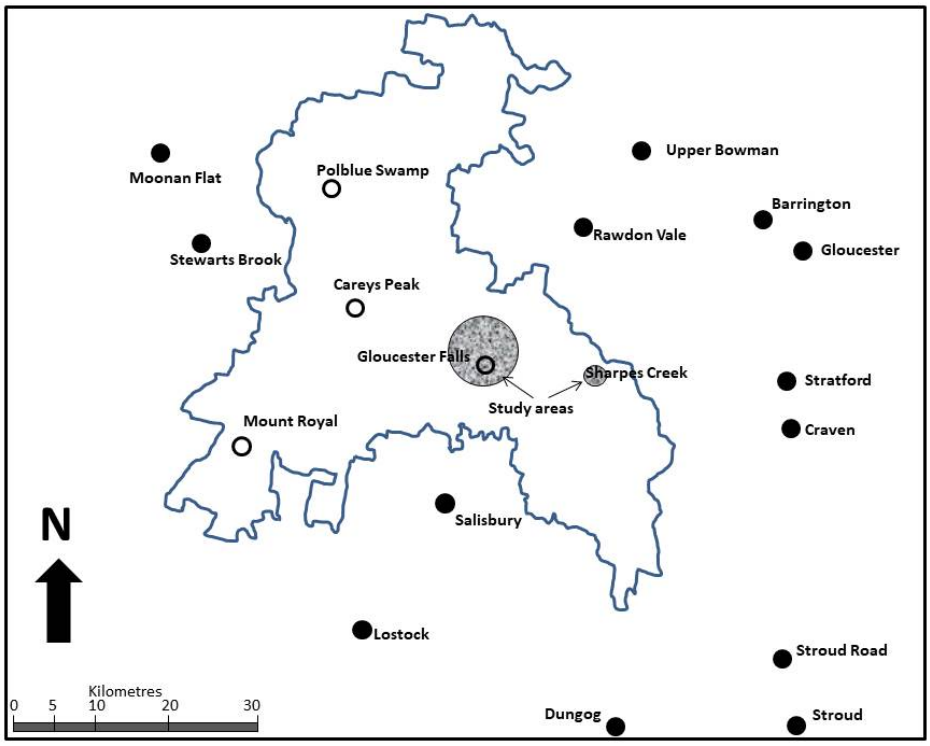

Figure 1. Barrington Tops National Park showing the 350−450 masl (low-altitude Zone 1, centred at Sharpes Creek) and 1,100−1,300 masl (high-altitude Zone 3, centred in the Gloucester Falls area) study areas. Zone 2 was centred on the road which connects Zones 1 and 3.

Figure 2. Altitude profile in the Gloucester Tops study area, commencing from the Sharpes Creek site (the location of the low-altitude study area).

Surveys in the 350−450 masl study area (Zone 1 in **Figure 2**) involved multiple observers (up to 8 observers, more typically 4-6 people) and spanned several hours of elapsed time. The surveys were unstructured and the intensity of effort varied. Surveying in the early morning included birds heard in the dawn chorus or observed in approximately the first hour after dawn (before surveyors relocated to higher altitudes). Additional records were obtained in the final hours of the day (after surveyors had returned to camp). A daily list of all species seen or heard in the low-altitude zone was compiled each evening. Nocturnal birds were included in the daily list for this altitude zone if any were detected, whereas the surveys at higher altitudes were made diurnally and hence unlikely to detect such species.

The BirdLife Australia Atlas (Birdata) was used for storing the records from the surveys and retrieving them later for analysis. All surveys were entered as 500 m-radius area surveys, which are one of Birdata's two main survey options. For each 1-km transect, the mid-

point (i.e. 500 m from each end of the transect) was used as the survey location. This approach is considered valid because a 1-km transect through a 500 m radius area is a fixed route means of surveying that area.

Reporting Rates (RRs) for each species in each altitude zone were calculated. The RR is the number of times the species was recorded divided by the number of surveys conducted (expressed as a percentage). The RR is based on presence/absence; records of multiple birds within the same survey do not affect the RR.

Statistical analysis

The methods used in the high- and mid-altitude zones were identical, involving ~1 h of survey effort within each 1-km transect. Therefore, direct comparison of the results for those two altitude zones is valid. Pearson's Chi-Square (Goodness-of-Fit) test (Fowler & Cohen 1994) was used to assess differences between the observed and expected number of records for a species across the various altitude zones. It is important to note that the Chi-Square test requires the use of raw data (number of surveys, number of records) and not RRs, which are a ratio. Probability *p* values were calculated using the Chi Square test procedure and species with $p < 0.05$ or $p < 0.01$ were identified. Standard statistical nomenclature refers to observed differences as significant (when $p < 0.05$) or highly significant (when $p < 0.01$). Although there were fewer surveys in Zone 2 than in Zone 3 (27 surveys; 306 surveys) the Chi Square test is robust to differences in sample size (i.e., survey effort) between treatments (i.e. altitudinal zones) except when the expected frequencies are less than 5 (Fowler & Cohen 1994).

Comparison of the results from the 350−450 masl zone with those from higher altitudes was thus more problematic and Chi Square tests were used for only some species where expected frequencies were greater than 5. The low-altitude surveys usually involved a less-intensive rate of effort than the surveys done at the higher altitudes but they had longer elapsed times and, in general, more observers participated. Therefore, the probability of detecting any given species was increased. In particular, the low-altitude surveys included birds detected in the dawn chorus, whereas the surveys at higher altitudes took place well after dawn.

Some general conclusions about bird populations in the low-altitude zone were inferred by assuming that those species with many records at low altitude and none or very few records at higher altitudes were candidates for classification as low-altitude specialists.

The possibility of using a list length analysis technique (Szabo *et al*. 2012) to compare the low altitude and higher altitude results was considered and rejected. List length analysis generally is applied to situations where the quantum of survey effort is highly variable and unknown.

RESULTS

Table 1 shows the number of 1-km transect surveys conducted within each altitude zone between 2010 and 2017 and the total number of species recorded for each zone. An additional three nocturnal species were recorded in unstructured surveys of the low- and mid-altitude zones at night; the Greater Sooty Owl *Tyto tenebricosa*, Masked Owl *T. novaehollandiae* and Powerful Owl *Ninox strenua*. Thus, 95 species were confirmed to be present in spring in the Gloucester Tops study area over 2010−2017.

In the **Appendix** (which is available at www.hboc.org.au/the-whistler-volume-13/) we present the number of records and the RR for each of the 92 species in each of the three altitude zones. The more noteworthy examples of apparent or confirmed altitudinal stratification are reported below.

High-altitude (Zone 3)

Five species (Rufous Scrub-bird, Red-browed Treecreeper *Climacteris erythrops*, Crescent Honeyeater *Phylidonyris pyrrhopterus*, Olive Whistler *Pachycephala olivacea* and Flame Robin) were only recorded at >1,100 masl. These differences were highly significant ($p < 0.01$) when compared to the mid-altitude zone and assessed using the Chi Square test. Nine other species were exclusively recorded at high altitude, but there were insufficient records (1-5 for each) for statistically valid conclusions to be drawn. Those species were the Lewin's Rail *Lewinia pectoralis*, Grey Goshawk *Accipiter novaehollandiae*, Collared Sparrowhawk *A. cirrocephalus*, Australian Hobby *Falco longipennis*, Fuscous Honeyeater *Ptilotula fusca*, Varied Sittella *Daphoenositta chrysoptera*, Satin Flycatcher *Myiagra cyanoleuca*, Australian Magpie *Gymnorhina tibicen* and Scarlet Robin *Petroica multicolor*.

Sulphur-crested Cockatoo *Cacatua galerita* and two pigeon species, the Brown Cuckoo-Dove *Macropygia phasianella* and Wonga Pigeon *Leucosarcia melanoleuca*, were recorded infrequently in the 1,100−1,300 masl altitude zone (RRs below 2%) and much more frequently in both lower altitude zones (with RRs ranging from 26.3% to 53.5%). Compared to the high-altitude zone, the differences were highly significant ($p < 0.01$) when assessed using the Chi Square test.

Table 1. Summary of results for the three Gloucester Tops altitude zones, for surveys in 2010-2017

	Zone 1 350-450 masl	**Zone 2 450-1100 masl**	**Zone 3 1100-1300 masl**	**Overall**
No. of surveys	43	27	306	376
No. of species	78	51	71	92

Table 2. Species which are candidates for classification as low-altitude specialists (recorded more frequently in the 350−450 masl zone than in the higher altitude zones) and their Recording Rates in each altitude zone.

Species	**RR (%): Zone 1 350−450 masl**	**RR (%): Zone 2 450−1100 masl**	**RR (%): Zone 3 1100−1300 masl**
Australian Brush-turkey *Alectura lathami*	62.8	0	1.3
Fan-tailed Cuckoo *Cacomantis flabelliformis*	65.1	26.3	24.5
Laughing Kookaburra *Dacelo novaeguineae*	81.4	21.0	11.4
Yellow-tailed Black-Cockatoo *Zanda funereus*	25.6	0	10.1
Australian King-Parrot *Alisterus scapularis*	51.2	0	10.8
Superb Lyrebird *Menura novaehollandiae*	88.4	42.1	28.8
Satin Bowerbird *Ptilonorhynchus violaceus*	69.8	21.0	15.7
Superb Fairy-wren *Malurus cyaneus*	88.4	0	1.3
Eastern Spinebill *Acanthorhynchus tenuirostris*	60.5	31.6	29.4
Yellow-faced Honeyeater *Caligavis chrysops*	53.5	15.8	19.9
Australian Raven *Corvus coronoides*	41.9	0	0.3
Spectacled Monarch *Symposiarchus trivirgatus*	20.9	0	0
Rose Robin *Petroica rosea*	74.4	42.1	40.2
Eastern Yellow Robin *Eopsaltria australis*	88.4	36.8	48.0
Red-browed Finch *Neochmia temporalis*	76.7	5.3	1.3
Welcome Swallow *Hirundo neoxena*	76.7	0	0
Russet-tailed Thrush *Zoothera heinei*	72.1	5.3	0.3

Mid-altitude (Zone 2)

Two species, Bell Miner *Manorina melanophrys* and Paradise Riflebird, were recorded in all three altitude zones, but more frequently at mid-altitude. The RRs for both species at 450−1,100 masl were >40% compared with RRs below or considerably below 10% in both the other altitude zones. Using the Chi Square test, these differences between the mid and high-altitude cases were significant (p <0.05).

Low-altitude (Zone 1)

Fifteen species were only recorded within the 350−450 masl altitude zone (see **Appendix** for details: www.hboc.org.au/the-whistler-volume-13/). However, with the exception of the Spectacled Monarch *Symposiarchus trivirgatus*, discussed later, and three nocturnal species, all had very few records. There were insufficient data to draw any conclusions about altitudinal preference for those 15 species. Also, three of them, Tawny Frogmouth *Podargus strigoides*, Australian Owlet-nightjar *Aegotheles cristatus* and Southern Boobook *Ninox boobook*, were nocturnal birds, which therefore were unlikely to have been detected in the diurnal surveys done at higher altitudes.

A further 17 species were recorded in more than one altitude zone and had RRs which were higher in the 350−450 masl zone than at higher altitudes. These are listed in **Table 2**, with their RRs in each of the three altitude zones.

Key Biodiversity Area nomination species

The overall study was conducted within the Barrington Tops and Gloucester Tops KBA. The trigger species for the KBA listing was the Rufous Scrub-bird, which was recorded frequently, but only at high altitude. Of the other species listed to support the KBA nomination, the Flame Robin and Paradise Riflebird were recorded frequently and the Green Catbird, Australian Logrunner and Pale-yellow Robin less frequently. There was only one record of the Regent Bowerbird from any of the surveys (a male in the 350−450 masl zone in October 2011). The Flame Robin was found to prefer the high-altitude zone (1,100−1,300 masl)

and the Paradise Riflebird to prefer the mid-altitude zone (450−1,100 masl). There were insufficient records for the other three species to draw any conclusions concerning differences in their altitudinal distribution.

Observations in other seasons

All the structured survey effort took place in spring when Rufous Scrub-birds breed (Ferrier 1984). A few insights were developed from unstructured non-spring visits to the study area, especially over 2014-2017. An influx of honeyeaters was noted to occur each autumn in the high-altitude zone; the main species involved being Eastern Spinebill *Acanthorhynchus tenuirostris* and Yellow-faced Honeyeater *Caligavis chrysops*, with lesser numbers of various other honeyeater species. This seemed to be associated with flowering of *Banksia* species. Although the Yellow-faced Honeyeater is a passage migrant through the Hunter Region in autumn (Stuart 2017), high numbers of them persisted in the Gloucester Tops for about two months (April-May) in at least some years and perhaps originated from a nomadic local population rather than migrating birds.

The Bassian Thrush *Zoothera lunulata* became more common in the low-altitude zone in winter, with several birds often observed foraging in the open grassy areas around the campsite. Although birds continued to be recorded at low altitude at all other times of the year, a spring-summer movement to higher altitudes was noted.

DISCUSSION

High-altitude zone specialists

The study identified that five species had a clear preference for the high-altitude parts of the Gloucester Tops. The Rufous Scrub-bird is now only known at high-altitude locations throughout its range in eastern Australia (Higgins *et al*. 2001; Cooper *et al*. 2016). In the past there have been records of it to approximately 1,000 masl in the Gloucester Tops (Ferrier 1984; Ekert 2005). That appears to be no longer the case; the areas where previously they had been recorded below 1,100 masl were badly affected by fires in 2009 and 2016 (Stuart & Newman 2018b).

Across its range, the Crescent Honeyeater is recorded from a wide variety of dense vegetation, from coasts to sub-alpine areas (Higgins *et al.* 2001). Its absence below 1,100 masl in the Gloucester Tops is intriguing, since apparently suitable habitat (e.g. woodland with an under-storey of shrubs) is present particularly in the 450−1,100 masl altitude zone. There are just two records from lower altitude locations anywhere in the Hunter Region of New South Wales. In both cases, the birds were present for only a short time (Raine 2014; Stuart 2015).

The Olive Whistler was recorded in Watagans National Park (near Cooranbong, New South Wales) in 1990 and 2000 (Higgins & Peter 2002), which are the only records in the Hunter Region outside Barrington Tops National Park (Stuart 2017). Northern populations of Olive Whistler mainly occur in cool-temperate rainforest dominated by Antarctic Beech (Higgins & Peter 2002). Although some of the high-altitude Gloucester Tops records were of birds in eucalypt woodlands, Antarctic Beech rainforest was always adjacent. In contrast, the Watagans National Park spans altitudes mainly of 100−500 masl, with highest altitude 621 masl (Wikipedia 2017) and has no Antarctic Beech. The records from Watagans National Park presumably involved vagrant birds.

The Flame Robin is well known to be an altitude migrant, breeding within mountainous areas in south-eastern Australia and Tasmania and spending winters at lower altitudes (Higgins & Peter 2002; NSW Office of Environment and Heritage 2011). That description is applicable for Flame Robins in the high-altitude zone of the Gloucester Tops. Birds were absent in autumn and most of the winter, beginning to return from late August (AS pers. obs.). There were many breeding records for them in the 2010-2017 spring surveys.

Across its range in eastern Australia, the Red-browed Treecreeper occupies a variety of habitats and a range of altitudes, with the highest densities occurring in wet sclerophyll forests in gullies of foothills and dry sclerophyll forests on ridges in hilly and mountainous areas (Higgins *et al.* 2001). The lower-altitude parts of the Gloucester Tops seemingly offer habitat matching the former description. Hence, the reasons for the absence of Red-browed Treecreepers below 1,100 masl in the Gloucester Tops warrants closer investigation.

In a Gloucester Tops context, these five species would seem to be most at risk from the effects of climate change. If the amount of suitable habitat for them above 1,100 masl should decrease, they apparently would not be able to exist as sustained populations at lower altitudes.

Mid-altitude zone specialists

The preference of the Bell Miner for the mid-altitude zone is consistent with its habitat preference for open eucalypt forests and woodlands; it is rarely found in rainforest (Higgins *et al.* 2001). The Paradise Riflebird generally is considered to be a bird of subtropical and temperate rainforests and of sclerophyll forests adjacent to rainforests (Higgins *et al.* 2006). In the present study, it was noted that the Paradise Riflebird was more likely to be recorded in eucalypt woodlands adjoining open valleys and having large dead trees which provided advantageous perching sites. The proximity to rainforest habitat was not noted. In the 2016 surveys of all nine 1-km transects in the 450−1,100 masl zone, Paradise Riflebird was recorded in seven of them and some of those records were of multiple birds.

Low-altitude zone specialists

Seventeen species may be candidates for classification as low-altitude specialists. Three of these 17 species mainly utilised the well-grassed picnic area and camping ground – a habitat that was not available elsewhere in the study area. These species were Superb Fairy-wren *Malurus cyaneus*, Red-browed Finch *Neochmia temporalis* and Welcome Swallow *Hirundo neoxena*. The other 14 species seemed to show a strong preference for the temperate rainforest habitat of the lower altitudes. It is noted that the Spectacled Monarch *Symposiarchus trivirgatus* did not arrive in the Gloucester Tops until mid-October each year (AS pers. obs.) and hence was not recorded in any September surveys. As there were no records of it from higher altitudes in September or October, its preference for the low-altitude rainforest would be more strongly apparent if the September data were excluded from analysis. A similar comment may be made about the Noisy Pitta *Pitta versicolor*, which also arrived in the Gloucester Tops in mid-October each year (AS pers. obs.).

An alternative explanation for the higher RR of these 17 species may be that they are more common in temperate rainforests, making their distribution independent of altitude. A potential direction for future studies would be to examine more closely the altitudinal and habitat distribution of these 17 species using directly comparable survey methods.

Key Biodiversity Area nomination species

There was only one record of the Regent Bowerbird from any of the surveys (a male in the 350−450 masl zone in October 2011). This result initially seemed surprising; however, it is consistent with the information available from the national bird atlas, Birdata (Birdata 2017). In Birdata since 2010, considering all months and all types of survey, including records of incidental sightings, there have only been two records of the Regent Bowerbird in the entire KBA, from a total of 760 surveys (RR 0.3%; see **Table 3**). The other record was from an area of temperate rainforest north-west from Salisbury (see **Figure 1**). In contrast, between 1998 and 2010 there were 15 records of the Regent Bowerbird in the KBA from 333 surveys over all months (RR 4.5%). Eighty percent of those were from the area north-west of Salisbury, with the other three records being from the Gloucester Tops low-altitude zone of the present study. The Regent Bowerbird seems to have become uncommon in the KBA in recent years.

Table 3. Reporting Rates in Birdata for the Key Biodiversity Area nomination species for the periods 1998-2009 and 2010-2017, using data for all survey types.

	1998-2009 (333 surveys)		**2010-2017 (760 surveys)**	
Species	**No. of records**	**RR (%)**	**No. of records**	**RR (%)**
Rufous Scrub-bird	20	6.0	282	37.1
Green Catbird	39	11.7	39	5.1
Regent Bowerbird	15	4.5	2	0.26
Australian Logrunner	19	5.7	18	2.4
Paradise Riflebird	19	5.7	31	4.0
Flame Robin	40	12.0	94	12.4
Pale-yellow Robin	11	3.3	6	0.79

Comparison of Birdata records for all seven KBA nomination species for the pre- and post-2010 periods indicates other changes may have occurred (**Table 3**). The two review periods were chosen to coincide with commencement of the annual spring survey program. The results from all survey types including reports of incidental sightings are presented in **Table 3**. Similar patterns were obtained when a single survey type (either 2 ha / 20-minute survey or 500 m-area survey) was compared across the two review periods.

The RR for the Rufous Scrub-bird increased substantially (**Table 3**), reflecting targeted surveys in its core habitat by experienced observers. RRs for Paradise Riflebird and Flame Robin were similar for both periods. However, the RRs for Regent Bowerbird, Green Catbird, Australian Logrunner and Pale-yellow Robin decreased (**Table 3**). A factor in the observed decline may be that a greater proportion of surveys in the KBA have been in areas of unsuitable habitat for these species (*viz* in the core habitat of the Rufous Scrub-bird). However, when the area of the Scrub-bird study was excluded from the Birdata analysis (removing 306 of 760 surveys), the RRs for all four species remained much lower for the 2010-2017 period. A matter for future investigation will be to confirm the apparent decline and seek reasons for it, including assessing either if there are specific areas within the KBA where species have declined or if the changes are more widespread across the KBA.

CONCLUSIONS

Spring surveys between 2010 and 2017 in the Gloucester Tops in New South Wales recorded 92 bird species, with an additional three species recorded in unstructured night surveys. Five species (Rufous Scrub-bird, Red-browed Treecreeper, Crescent Honeyeater, Olive Whistler and Flame Robin) were found to be highly significantly more likely to be recorded at altitudes above 1,100 masl. In a Gloucester Tops context, these five species would seem to be most at risk from the effects of climate change based on the concept of shrinking islands of montane vegetation (Watson 2010).

The Sulphur-crested Cockatoo, Brown Cuckoo-Dove and Wonga Pigeon were found to be highly significantly more likely to be recorded below 1,100 masl. Paradise Riflebird and Bell Miner were significantly more likely to be recorded in the 450−1,100 masl zone. In the lowest altitude zone, 78 species were recorded, including 17 species which are candidates for classification as low-altitude specialists.

There was only one record of the Regent Bowerbird from the surveys and this species appears to have become uncommon in the KBA. The populations of Green Catbird, Australian Logrunner and Pale-yellow Robin may also have declined.

ACKNOWLEDGEMENTS

We thank staff of the New South Wales Office of Environment and Heritage and the National Parks and Wildlife Service for their support, particularly Peter Beard. More than 40 volunteers helped with the surveys, and their contributions were invaluable. The majority were members of the Hunter Bird Observers Club, which promoted the surveys as part of its annual program of activities. We also thank the anonymous referee whose comments and suggestions considerably improved the original paper.

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Occupancy at two Rufous Scrub-bird territories in the Gloucester Tops

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Received 4 June 2019; accepted 14 June 2019; published on-line 15 July 2019

This note reports the disappearance of two male Rufous Scrub-bird *Atrichornis rufescens* from their long-term occupied territories in the NSW Gloucester Tops and shows that there must not have been any other males waiting at those territories to replace the absent male.

The Rufous Scrub-bird is a cryptic near-flightless species with a restricted range. Locally it occurs in some high-altitude parts of the Barrington Tops National Park, such as the Gloucester Tops. There are four additional isolated populations in northern NSW and southern Queensland (Ferrier 1985; Newman *et al*. 2014). Most of our knowledge about the Rufous Scrub-bird derives from a study undertaken in the 1980s (Ferrier 1984; Ferrier 1985). Many unknowns remain. Often the gaps in knowledge about the Rufous Scrub-bird's behaviour and breeding biology are filled by extrapolating from what is known for the Noisy Scrub-bird *A. clamosus*, a species found in the south-west of Western Australia (e.g. see Garnett *et al*. 2011, p. 281). The Noisy Scrub-bird was thought extinct until a surviving small population was discovered in 1961 (Robinson & Smith 1976). Since then it has been well-studied, as part of an overall recovery plan.

The Noisy Scrub-bird breeds in winter, lays a single egg and the female's territory is located up to a kilometre from the male's territory (S. Comer pers. comm.). In contrast, the Rufous Scrub-bird breeds in spring and early summer, lays two eggs (typically) and the female's territory is on the edge of that of the male (Jackson 1921; Ferrier 1984; Higgins *et al*. 2001). These points suggest it is likely that there will be some other behavioural differences between the two species.

For the Noisy Scrub-bird there is an active translocation program in which males are removed from their original territory and released elsewhere. It has been found that there often are silent subordinate males within the territory of the dominant vocal male, and that a subordinate bird will rapidly assume the dominant singing role when the original dominant male is removed (Berryman 2007). By extrapolation that situation might be expected to happen sometimes with the Rufous Scrub-bird. Obtaining evidence to support or contradict the scenario is not straightforward, because all male Rufous Scrub-birds look very similar and they all sound the same (based on our current knowledge). However, monitoring of the Gloucester Tops population has offered some insights, as outlined below.

A project to monitor Rufous Scrub-birds in a high-altitude area of the Gloucester Tops was initiated in 2010 (Newman *et al.* 2014). The focus has been to identify and monitor Rufous Scrub-bird territories; this is done by walking transects within an area of core habitat for them (at approximately 32.1°S, 151.6°E, see **Figure 1** for the locations of transects). Thirty-seven Rufous Scrub-bird territories were identified during surveys over 2010-2016, these being a mix of territories with short-term occupancy (1-2 years) and long-term (multiple year continuous) occupancy (Stuart & Newman 2018). A similar mix of short-term and long-term territory occupancy was found in the New England Region population (Andren 2016).

At two long-term occupied territories in the Gloucester Tops, the male Rufous Scrub-bird disappeared after several years of continuous presence. One territory (code name GT170R) was located about 2 km beyond the junction of Gloucester Tops Road and Kerripit Road. It was first identified as a territory in the 2010 surveys although anecdotally a scrub-bird had been present for some years prior to that. The territory was occupied throughout the 2010-2016 breeding seasons (i.e. it had long-term occupancy). The scrub-bird usually was within 20-50 m of the road. Because it called reliably, the bird was readily detected whenever a survey team passed by. The Recording Rate (RR) for this scrub-bird from the spring surveys over 2010-2016 was above 90% (i.e. the bird was detected in more than 90% of the

surveys). In 2016 I included the GT170R territory in a study of Rufous Scrub-bird singing behaviour (Stuart & O'Leary 2019) and made several multiple-day recordings there using an automated recording unit (ARU). The bird was singing well in November 2016 (ARU data showed that it had made 1,500-1,800 chipping calls per day). It was still present at the territory when I visited on 14 December 2016. However, the ARU recordings in February, March, August, September and October 2017, each spanning several days, contained no scrub-bird calls. After that I moved the ARU to another territory. Since then I have visited the GT170R site 3-4 times each breeding season and several other times during each year, usually for 20-minute periods. I have never heard any Rufous Scrub-bird calls in those visits. It seems that there was no subordinate male Rufous Scrub-bird waiting at or near the territory. Visual inspection of the habitat at the territory suggests that it is unchanged from its pre-2017 condition.

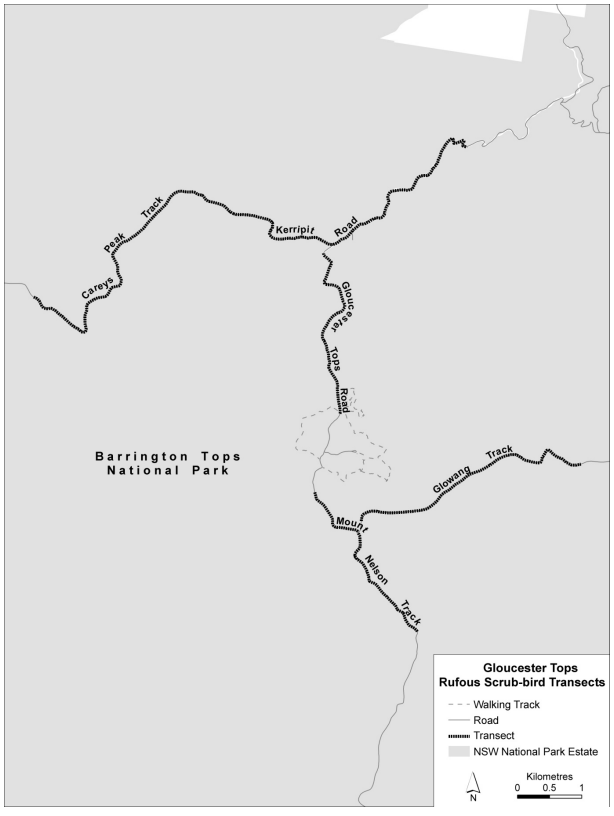

Figure 1. Rufous Scrub-birds survey transects in the Gloucester Tops (taken from Newman *et al*. 2014).

Another territory (code name KP316L) is near the junction of Gloucester Tops Road and Kerripit Road. A Rufous Scrub-bird disappeared from the territory for two breeding seasons. The KP316L territory was occupied throughout the 2010-2013 breeding seasons (i.e. it had long-term occupancy). The scrub-bird usually was within 50 m of the road, and often it was less than 10 m from it. This bird called reliably and was often detected when a survey team passed by. The RR for this scrub-bird from the spring surveys over 2010-2013 was above 80%. However, in the 2014 and 2015 spring surveys, no Rufous Scrub-birds were detected. Surveyors did at least ten transects past the territory in that time. As the location is readily accessible, the transect-based surveys were supplemented by using stationary observers who listened for the bird for periods of 30-60 minutes at a time. In the breeding season it is very unusual for a Rufous Scrub-bird not to have called at least a few times during any hour of the day (Stuart & O'Leary 2019). Many hours (estimated at 8-10 hours) were invested over several days in the 2014 and 2015 breeding seasons waiting in vain to hear the scrub-bird call. I also did not hear the bird in my visits at other times during those years. It seems valid to conclude that the KP 316L territory was not occupied in 2014 and 2015.

In September 2016, I heard a Rufous Scrub-bird calling at that Gloucester Tops Road location and the bird was readily detected in the surveys carried out in October and November 2016. A scrub-bird has been present regularly ever since. The territory was confirmed to be occupied in the 2017 and 2018 breeding seasons. Since 2016, I have made numerous visits to the site outside of the breeding season as part of my study of Gloucester Tops Rufous Scrub-birds and I have seen or heard the bird many times during those visits. The ease of detection of the scrub-bird since 2016 is further evidence that there was no bird present in 2014-2015. There also is evidence which suggests a different scrub-bird now occupies the KP316L territory. The singing area is now centred 50-80 m further away from the road than appeared to be the case in 2010-2013, and also is approximately 50 m closer to the Kerripit Road junction. I have never encountered the post-2016 scrub-bird close to the road and it is sometimes *c.* 100 m from it. Rufous Scrub-bird singing areas are only about 1 ha in size (Stuart 2018) and the change in location of the singing area seems unusual if it was still the original bird.

A plausible scenario is that the original KP316L Rufous Scrub-bird died (or moved away) after the 2013 breeding season and that the territory was unoccupied for two seasons until a new scrub-bird moved in before the start of the 2016 breeding season. This therefore is a time marker that may lead to insights about how many years an individual male Rufous Scrub-bird defends a territory.

Many of the Rufous Scrub-bird territories that we have found in the Gloucester Tops have had short-term occupancy (Stuart & Newman 2018). The eventual disappearance of the scrub-bird from such a territory may be explained in various ways; for example the habitat may have been marginal or had become so, or the scrub-bird either did not succeed in attracting a mate or did not have breeding success. However, long-term occupied territories imply prime habitat and that the bird has had breeding success. Thus, the absence of any evidence for the presence of subordinate scrub-birds at two long-occupied territories in the Gloucester Tops indicates that young adult male Rufous Scrub-birds, at least sometimes, do not remain within the vicinity of a dominant male that is actively advertising his territory. This observation warrants further investigation.

ACKNOWLEDGEMENTS

Mike Newman proposed the methodology that has been used in the Gloucester Tops Rufous Scrub-bird surveys since 2010. More than 40 people, mostly members of Hunter Bird Observers Club, have assisted in them. Collectively they have walked hundreds of kilometres for the cause. I thank Sarah Comer and her team at Albany WA for teaching me a little about Noisy Scrub-birds. I also thank the referee Mick Andren for his helpful comments.

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Observations of Black-necked Stork breeding in the Hunter Estuary at Tomago NSW

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Received 5 May 2019; accepted 4 August 2019; published on-line 9 August 2019

In 2017 and 2018 a pair of Black-necked Stork *Ephippiorhynchus asiaticus* bred successfully near Newcastle NSW thus extending southwards the confirmed breeding range. The pair raised a single chick in both years. Attendance at the nest site, incubation and fledging commenced earlier than in northern NSW. The adults provisioned young at the nestling and post-fledging stages with eel and other species of fish. Young were observed taking food directly from adults' bills as well as eating regurgitated items.

INTRODUCTION

This paper documents consecutive breeding events of the Black-necked Stork *Ephippiorhynchus asiaticus* in the Hunter Estuary in 2017 and 2018 and describes aspects of the behaviour of the young bird and its parents at the nest and post-fledging.

The Black-necked Stork occurs as two sub-species: *asiaticus*, found in India, Pakistan and parts of south-east Asia; *australis*, present in northern Australia and the southern parts of New Guinea (BirdLife International 2016). In NSW it is mainly confined to coastal and sub-coastal areas extending as far south as Sydney, with some records from the west of the state (Clancy 2010a). In 2006 the NSW population was estimated at 200-220 birds including 75 breeding pairs (Clancy & Andren 2010). It is classified as Endangered in NSW under the *Biodiversity Conservation Act 2016.*

A pair of Black-necked Stork breeds regularly near Bulahdelah *c.* 80 km north of Newcastle and is generally considered Australia's southernmost breeding pair (Clancy & Ford 2013). Breeding by the Black-necked Stork in the Hunter Estuary has not previously been confirmed although there have been recent instances of pre-breeding behaviour and of suspected breeding. A pair built a nest at Hexham Swamp in 2014 but there were no indications of them incubating or of the presence of any nestlings. A pair and two juveniles were regularly present at Hexham Swamp in 2015-16 but the nest location was unknown and might not have been within the estuary (Stuart 2016), although the age and behaviour of the juveniles suggested local breeding (G. Clancy pers. comm.).

On 13 March 2017, Tomago residents C. and B. Pascoe contacted Hunter Bird Observers Club Inc. (HBOC) to report that for two weeks they had been watching a pair of Black-necked Storks building a nest opposite their house. They later stated that a pair had also bred in the same area in 2016. I decided to undertake a behavioural study of the 2017 breeding event. The pair bred again in 2018 and I again spent many hours recording aspects of the birds' behaviour.

METHODS

Nest site and study area

The nest was located approximately 270 m south of Tomago Road, on private land. **Figure 1** shows the location of the nest and the main topographic features nearby, and **Figure 2** shows the location of the study area relative to the other parts of the Hunter Estuary that are mentioned in this report.

The nest was built in a Narrow-leaved Paperbark *Melaleuca linariifolia* approximately three metres tall, growing in wetland dominated by Common Reed *Phragmites australis*. The tree had multiple trunks and the crown was broad and flattened at the top. The nest structure was almost invisible from the observation point on Tomago Road because it was obscured by the tree's thick, upper foliage. Its presence was discernible when the adult birds were in attendance. From the observation point (see below) the nest appeared to be *c.*2 m above ground.

There were two Swamp Oaks *Casuarina glauca* to the east of the nest site, *c.* 33 m and 57 m from it. A set of powerlines (five lines, two above and three below) run east/west about 40 m to the north. Tomago Road is another 230 m further to the north. It is a busy two-lane

connecting road which also has powerlines on both sides (with a total of 15 individual strands). The presence of almost continuous traffic and associated noise did not appear to bother the birds but made it almost impossible for me to hear any calls made by them, if indeed they did call.

The northern side of Tomago Road has residences and several factories. Tomago House, an historic homestead surrounded by tall trees giving way to fenced open grassland, was 534 m to the west of the nest. There was a light industrial shed 224 metres to the north-north-east. All distances are derived from Google Earth 30/04/18.

From the nest site towards Tomago Road, the ground rises gently and Common Reed is replaced by exotic grasses. This open area, dubbed "Upland", stretches between the shed to the east and Tomago House to the west. It played a prominent role in the 2017 and 2018 breeding events.

In 2017 after fledging, the young Black-necked Stork remained for a week in a paddock on the northern side of Tomago Road. The paddock was occupied by four horses during the day. On the southern boundary was a horse-riding area fenced by loose white tape and 100 metres further, a residence. The northern and western sides had barbed wire fencing and immediately adjacent, thick woodland. The eastern side had high fencing and light industrial area with trucks coming and going most of the day.

Observing the nest

Permission to access the private land where the nest was located was sought from the landowners but not granted. The observation point was therefore on the side of Tomago Road approximately 270 m directly north of the nest (see **Figure 1**). I used Swarovski 10 x 42 binoculars and Swarovski x 20 telescope to make observations; most events occurring at the nest tree could be clearly seen using the telescope. Photographs were taken with a Canon 7D Mark 2 camera fitted with a 100-400 mm zoom lens (for example, **Figure 3** shows the nest photographed from the observation point). All observations were written in a notebook and later converted into typed notes. I identified the sexes of the adults based on iris colour, the female having a yellow iris and the male, dark brown (Clancy & Ford 2013). I was not able to identify fish species brought to the young and have used the word "fish" to describe species other than eel.

In 2017 I visited the nest on 40 occasions between 13 March, when the nest was first reported, and 7 August when the chick fledged. In that time, I spent 64 hours 40 minutes at the observation point, recording all the behaviours of the adults and chick at the nest or in the study area. The shortest watch period was 25 minutes and the longest 5 hours and 5 minutes. Eleven watch periods were of more than three hours. I chose different times of the day to visit the nest but the majority of visits took place in the morning (27 watch periods).

After the chick left the nest, it stayed in the northern horse paddock (see **Figure 1**) for a week, until 15 August. In that period, I spent another 12 hours and 5 minutes on observations, often going twice per day.

Figure 1. The Black-necked Stork nest site at Tomago, also showing the observation point on Tomago Road and other nearby topographic features.

Figure 2. Location of the Black-necked Stork nest site within the Hunter Estuary.

Figure 3. Nest tree with both adults present, photographed 25 March 2017. Powerlines and the Upland area are in the foreground.

During the 2018 breeding event, I visited the nest on 24 occasions logging a total of 12.9 observation hours. The observation periods generally were shorter than for 2017, with the longest period being 80 minutes and the shortest one 10 minutes.

Although several HBOC members visited the study area in either the 2017 or 2018 breeding events and reported their observations to me, their time spent was not logged. If new or different information on the birds' behaviour was reported, it has been included in this report. L. Parashou made several recordings of various stork behaviours, using a Nikon Coolpix, P 900 video camera. She subsequently prepared an informative video which can be seen on YouTube posted 26 January 2018 https://youtu.be/rtTPQET1oio.

RESULTS

Nest building

From the beginning of March 2017 a pair of Black-necked Storks had been observed carrying branches from large trees around Tomago House to the nest. The pair continued to bring branches until the end of March. During this time smaller, softer vegetation, presumably for nest lining, was also brought in (for example, see **Figure 4**). The pair would spend up to three hours at a time arranging and rearranging the vegetation, picking up sticks and lining and laying them down again and then just standing around. On 26 March they were seen copulating on the nest. After this time, they were observed only once bringing in branches but they continued to carry in soft vegetation. Sometimes both adults were seen sitting on the nest at the same time and on occasions the birds were so hunkered down on the nest that they were barely visible.

Figure 4. Female bringing nest lining from the Upland, photographed 29 April 2017.

In 2018, observation of the nest commenced about three weeks earlier than in 2017. The pair was first observed standing on the nest on 8 February. On thirteen out of fifteen visits until 20 March both adults were observed together on the nest. During that time some large branches were carried in but less often than in 2017. As in 2017, the pair would spend time rearranging vegetation or just standing around. On 5 March and 20 March they were observed copulating on the nest.

Behaviour at the nest and incubation

Because the bottom of the nest was screened from view it was not possible to see how many eggs were laid or if small nestling(s) immediately post-hatching were present. The early stages of the breeding event were therefore interpreted through the actions of the adults when attending the nest.

Several different behaviours indicating incubation were observed including persistent sitting down on the nest for long periods and regurgitation of water onto the nest. Adults had already been observed sitting for brief periods in late March in 2017 but sitting for longer periods began in earnest from 5 April and this continued into May. The sitting bird would sometimes continue to sit even while the other bird flew in and out with nest lining. On 7 April both birds were rearranging nesting material when observations commenced at 1000 h. When the female flew off the male sat down. She returned within five minutes with nest lining which she then organised while the male continued to sit. Again she flew off and returned with nest lining, clapping her bill as she landed. This time the male stood briefly, organised vegetation and quickly sat down again. The female stood preening for approximately ten minutes before flying off while the male continued to sit.

Similar behaviour was observed on 29 April during a three-hour watch from 0900 h to midday. The male sat on the nest while the female flew back and forth collecting soft vegetation – green grass or black rotten vegetation. She did this eight times. The ninth time she brought only a little vegetation but she regurgitated a stream of water onto the nest. At 0956 h the male stood up and flew south, landing in the wetland about 100 m away, whilst the female arranged vegetation on the bottom of the nest before sitting down. He returned twice with vegetation and on the third return, he expelled water onto the nest twelve times in quick succession. The female then flew to the Upland while the male rearranged the interior bottom of the nest before sitting down. The female in the meantime collected a couple of larger sticks from Tomago House area and placed them in the nest

while the male continued to sit. She then flew off and the male stood up, reorganised the nest and sat down.

From 30 April 2017 there was a slight change in behaviour which may indicate that the birds were turning the egg(s). The adult on the nest was more restless, often just standing peering into the nest, or with small movements back and forth with the bill pointed vertically down, doing something in the bottom of the nest or standing up and turning around 180 degrees then shifting weight from leg to leg before gently folding down.

It was difficult to ascertain the length of the incubation period. In 2017, assuming a chick hatched on 9 May (see "Behaviour indicating that hatching had occurred" below) the incubation period would have been 33 days if counted from 5 April when persistent sitting was first observed. The male spent more time sitting than did the female, 71% of the total observation period compared to 29% (see **Table 1**). Note that on 8 April both adults were at the nest and I could not tell which of them was doing the incubating.

Table 1. Summary of incubation periods for male and female 2017.

Date	Period of observation (minutes)	Male incubating (minutes)	Female incubating (minutes)
05/04/2017	10	10	0
06/04/2017	10	0	10
06/04/2017	10	0	10
07/04/2017	35	25	0
08/04/2017	35	35	35
29/04/2017	180	160	0
30/04/2017	115	115	0
02/05/2017	130	0	130
07/05/2017	75	75	0
08/05/2017	35	35	0
Total Time	**635**	**455**	**185**

Insufficient observations were carried out in 2018 to allow speculation as to the incubation period. Some observations of behaviour indicated that incubation was in progress on 30 April as the male was observed sitting tightly although he stood twice very briefly during the 80-minute watch, turned around and sat down again. The female was either foraging or collecting nest lining on the Upland and when she returned to the nest the male did not stir. On 6 May the male was sitting so low and tightly that he was invisible until he stood up on one occasion during that watch. Chick(s) may, however, have been present on 12 May (see "Behaviour Indicating that Hatching had Occurred" below) which means that incubation had commenced well before 30 April. Even though observation time was limited, the male appears to have spent more time incubating, 73%, than the female, 27% of the total observation time.

Table 2. Summary of incubation periods for male and female 2018.

Date	Period of observation (minutes)	Male incubating (minutes)	Female incubating (minutes)
30/04/2018	80	80	0
06/05/2018	85	85	0
12/05/2018	60	0	60
Total Time	**225**	**165**	**60**

It was found from observations of two nests at Tomago that out of a total of 860 observation minutes the male spent 620 minutes incubating, 72% and the female 245 minutes, 28 % (**Table 3**).

Table 3. Summary of total time spent incubating by male and female over two breeding events.

Year	Total observation (minutes)	Male incubating (minutes)	Female incubating (minutes)
2017	635	455	185
2018	225	165	60
Total Time	**860**	**620**	**245**

Behaviour indicating that hatching had occurred

On 9 May 2017 the female was seen swallowing fish stockpiled in the nest. It is known that adults will consume food deposited in the nest for the nestlings if the food remains uneaten (Clancy & Ford 2013). From this behaviour I assumed that a chick was now present.

When I arrived at 0800 h that day, the female was sitting. At 0915 h she stood and made small movements in the bowl of the nest with her bill. She then raised her bill and swallowed a silver item. She was seen to swallow three more items of food. At 0927 h the male flew in from the south and landed in the Upland where he stood and watched the nest. At 0932 h the female swallowed eight items including six small fish, identified by the silver gleam in the sun and ovoid shape. The female then sat down, remaining sitting until the end of the watch. At 0946 h the male flew from the Upland over the powerlines to the nest with a small amount of vegetation in his bill which he dropped into the nest. The female did not stir. At 0950 h he flew south to the wetland landing about 300 metres away but he returned a few minutes later and did

some minor rearranging of vegetation. At 1002 h he sat down beside the female.
On 16 May 2017 a chick was seen in the nest (A. Lindsey & G. Tong pers. obs.) thus confirming a successful breeding attempt. Between 1315 h and 1400 h, the female was observed to eat six eels (two longer than her bill as one hung out the end before she was able to swallow it) and five fish. She also regurgitated an unidentified item and a fish. During this time the chick was bobbing up and down swallowing food items. Subsequent observations confirmed that only one chick was present.

In 2018 the behaviour of the female indicated that a chick may have been present on 12 May. The female was sitting and during the observation period she stood three times and sat down again. While standing, she spent some minutes just peering into the nest and/or making small bill movements as observed the previous year. On 19 May 2018 a nestling was observed in the nest (A. Lindsey, N. Fraser & L Huxtable pers. obs.).

Attending the nest between hatching and fledging

From 16 May 2017, the first date that the chick was seen, to 19 June when the chick was seen alone for the first time, both adults attended the nest for similar amounts of time (**Table 4**). The male spent 49% and female 53% of the total observation period at the nest. Both were present on the nest on three occasions.

Table 4. Summary of time spent on nest by male and female after chick had hatched until seen alone on nest. Data includes three occasions when both birds were present on the nest.

Date	Period of observation	Male attending nest	Female attending nest	Nestling alone on nest
16/05/2017	65	0	65	0
18/05/2017	15	15	15	0
21/05/2017	200	05	200	0
24/05/2017	90	0	90	0
27/05/2017	105	90	15	0
04/06/2017	210	210	0	0
14/06/2017	30	0	30	0
17/06/2017	60	60	0	0
Total Time (min.)	**775**	**380**	**415**	**0**

Table 5. Summary of amount of time male or female spent attending the nest after chick had been left alone for first time and presence of adult(s) on the Upland.

Date	Period of observation	Male attending nest	Female attending nest	Upland
19/06/2017	10	0	0	Male
23/06/2017	20	0	0	0
24/06/2017	40	0	0	Female
01/07/2017	30	0	0	0
03/07/2017	30	0	13	0
05/07/2017	80	80	0	0
20/07/2017	30	0	0	0
21/07/2017	20	0	0	Male
22/07/2017	45	0	0	Male & Female
23/07/2017	80	0	0	0
23/07/2017	30	0	0	0
24/07/2017	20	0	0	0
25/07/2017	60	0	10	Male & Female
28/07/2017	160	46	88	0
29/07/2017	210	02	97	Male & Female
30/07/2017	215	0	33	Female
31/07/2017	180	20	61	Male & Female
02/08/2017	215	03	32	Male & Female
03/08/2017	120	0	0	0
04/08/2017	240	0	0	0
05/08/2017	260	0	219	Female
05/08/2017	50	20	0	Male
07/08/2017	75	0	0	0
Total Time (min.)	**2,220**	**171**	**553**	

However, after 19 June the chick was left alone on the nest for long periods and the adults seemed to attend only when provisioning the chick or refurbishing the nest. They would then fly to the Upland and watch the nest. I did not record the amount of time adults spent on the Upland but I noted whether they were present there or not. The female attended the nest *c.* 3 times more often than the male, approximately 25% and the male 8% of the total observation period (**Table 5**).

The female attended the nest more often than the male in both the hatching and fledging phases; 31% and 19% of total observation time, respectively (**Table 6**).

Table 6. Summary of amount of time spent by male and female attending nest post-hatching.

Date	Period of observation (minutes)	Male attending nest	Female attending nest
16/05 to 7/08/17	2930	546	903

Provisioning the chick

When the chick was very small it was assumed to be eating when either it was bobbing up and down or it was actually seen to swallow an item of food. As the chick grew and became more visible, it was possible to identify food items, which consisted of small fish and eel. No other type of food was seen. The usual method of feeding nestlings is for the adult to regurgitate food into the nest (Clancy & Ford 2013). On nine occasions adults were seen to regurgitate food into the nest, four times by the female and five times by the male. On four of these occasions, food was identified as eels and once, fish. When an adult landed on the nest regurgitation would not necessarily take place immediately even if the chick started begging behaviour. Sometimes both would stand around for several minutes until the chick started begging behaviour again and then feeding would take place. The adults appeared to be efficient hunters. In 2018 on one occasion the female flew in three times within twenty minutes and regurgitated food. On another occasion the female produced a large eel, twice as long as the chick's bill. The chick proceeded to swallow it whole and 13 minutes later the male regurgitated items and the chick swallowed three black, thin items as long as its bill one after another.

A seldom observed method of feeding was recorded on 2 August 2017. The chick, in begging mode, put its bill into the male's bill three times. The fourth time this happened, the adult regurgitated an item of food and the chick took it straight from the bill and swallowed.

Behaviour of the adults on the nest and on the Upland

In the early stages of brooding, either the male or female attended the nest or both. Typically, an adult would stand or sit low in the nest. Sometimes both adults would be standing or both sitting when the watch started. If only one adult was standing on the nest and the other flew in, they would stand or both sit down. The sitting adult would often stand, walk around and sit down again facing a different direction. There did not appear to be any physical display on arrival and departure but on one occasion the male clacked its bill on returning to the sitting female. On another occasion I saw the female clack her bill on arrival. The adults frequently reorganised vegetation by lifting up sticks with the bill and laying them down. Sometimes, but not often, wing stretching and preening took place.

From the very beginning of the nesting event, the Upland played an important role even though it was very close to a busy road and power lines stretched east west 40 metres north of the nest separating it from the nest. The adults would negotiate the power lines several times a day flying over them at a point just west of the nearest power poles. Only on three occasions were the adults seen to fly under them, the female twice and the male once. Both adults roosted on the Upland, alone or together, sometimes standing but also sitting on their hocks, sometimes preening. Although a couple of times, soft vegetation, presumably nest lining, was brought from the Common Reed bed to the south, most was gathered from the Upland. The adult would walk along with head down, picking up pieces of material in the bill until the bill was quite full. The vegetation was sometimes black, perhaps damp and rotten or it appeared dry – pale green to yellowish. The adult then flew directly back to the nest and dropped the vegetation onto the nest. Most often the bird collecting the vegetation then arranged it in the nest even when the other adult was present. During the early incubation period when the male spent more time incubating, the female spent her time collecting nest lining. During one observation period on 29 April the female collected vegetation and returned to the nest with it nine times in three hours. Although the male occasionally collected nest lining, it was more often the female that

refurbished the nest even up to two days before the nestling fledged.

In 2018 the adults exhibited similar patterns of behaviour at the nest and on the Upland as in 2017. The only different behaviour I observed was on 11 July when the 'up-down display' was performed. (**Figure 5**). During the 'up-down display' the birds mirror each other's actions which may involve shaking their wings, stretching their necks and bill clapping. The display may take place for a variety of reasons (Clancy & Ford 2011). The adults were roosting on the Upland, sitting on their hocks and apparently dozing in the warm sun. The chick was similarly on its hocks dozing on the nest. At 1428 h both adults suddenly stood up and faced each other, with wings outstretched quivering and clacked their bills. After a couple of minutes they returned to standing position. They performed this display four times before the male flew off towards the west at 1450 h. It was the only time this behaviour was observed.

Figure 5. Adults performing the up-down display on the Upland, photographed 11 July 2018.

Figure 6. Chick practising flying three days before fledging, photographed 4 August 2017.

Figure 7. The young bird clearing the powerlines on its first flight, photographed 7 August 2017.

Behaviour of the chick at the nest 2017

When the chick was still small it was not possible to see much activity other than the chick's head bobbing around. Sometimes it could be seen to swallow an item of food. By mid-June, although it was still spending most of the time sleeping, it was standing up more often or sitting on its hocks looking around. From 19 June it was observed for 1,496 minutes out of 2,220 alone on the nest (67% of total observation time).

Table 7. Summary of time chick spent alone on nest

Date	Period of Observation	Nestling alone on nest
19/06/2017	10	10
23/06/2017	20	20
24/06/2017	40	40
01/07/2017	30	30
03/07/2017	30	17
05/07/2017	80	0
20/07/2017	30	30
21/07/2017	20	20
22/07/2017	45	45
23/07/2017	80	80
23/07/2017	30	30
24/07/2017	20	20
25/07/2017	60	50
28/07/2017	160	26
29/07/2017	210	111
30/07/2017	215	182
31/07/2017	180	99
02/08/2017	215	180
03/08/2017	120	120
04/08/2017	240	240
05/08/2017	260	41
05/08/2017	50	30
07/08/2017	75	75
Total Time (min)	**2,220**	**1,496**

By 5 July the chick's body was as tall as the top of an adult's legs and it was about half the size of the adult when standing. As the chick grew it began to move around more and spent less time sleeping. Activities included wing-stretching and flying

practice, walking around the nest platform, preening, watching the adults organise vegetation. When an adult returned to the nest with vegetation it would sometimes take part in the arrangement of the material. On 28 July it took a short stick from the bill of the male and placed it in the nest. Similarly, it grasped the loose end of a reed stalk held by the female in her bill and together they placed it in the nest.

Flying practice which commenced during the first week of July ranged from simple wing-stretching and gentle flapping to vigorous flapping and lifting high off the nest, legs dangling, sometimes to a point where it looked like it would miss landing back on the nest again. **Figure 6** shows an example of the chick's flying practice. Apart from one occasion this activity took place when the adults were either absent or watching from the Upland.

Fledging

On 7 August, it was 10 degrees C with a light north-west breeze when observations began at 0710 h. The chick was standing on the nest, left leg sometimes tucked, occasionally preening or stretching a wing, fiddling with the vegetation and giving no indication that it was about to fly. The adults were nowhere to be seen. At 0825 h without preamble, it simply flew straight out of the nest, circled once and flew high over the power lines just north of the nest. Flying strongly, it circled three times above the Upland during which time it dropped a little height. At 0832 h it flew across Tomago Road with its two sets of power lines, over a house and landed behind the house in a paddock with four horses. It stood around until 0930 h when it flew to the northern edge of the paddock. Between then and 1215 h it took five short flights around the paddock. Between flights it walked to and fro picking up sticks and dropping them or resting on its hocks. The horses appeared to ignore it. In the meantime the female was standing on the nest at 0840 h (N. McNaughton pers. obs.). I saw her leave at 0910 h and return at 0938 h. She remained on the nest until 1205 h at which point she flew to the Upland and landed in direct line of sight with the fledgling. Mid-afternoon both adults were observed in the paddock (residents' pers. obs.) but when I arrived at 1705 h only the fledgling was present. The female arrived at 1715 h and, in response to begging behaviour by the young bird, regurgitated food onto the ground. By then it was too dark to see further actions.

The 2018 chick probably fledged on 12 August as it was present on the nest the day before but not the day after. It is likely that this chick remained hidden in long grass in the vicinity of Tomago House as the adults were seen on the Upland on 13 and 14 August. No interaction between it and adults was noted.

On the morning of 5 September a juvenile stork was observed standing in the middle of Tomago Road adjacent to Tomago House (B. Kinsey pers. obs.). As traffic approached it flew off to the north narrowly avoiding being run over. Despite a further search the bird was not located again. It seems likely that this juvenile bird was the 2018 fledgling. This report was followed up immediately and although the male bird was found on the western side of Tomago House no juvenile was observed. On 8, 10 and 11 September, the juvenile was seen with the adult male on the far western side of the Upland but it disappeared after those dates.

Post-fledging period in the horse paddock 2017

The young bird remained in the horse paddock from 7 to 14 August. During that time, between feeding bouts the fledgling would spend the time standing, walking around or resting on its hocks. Because it mostly chose a position against the fence adjacent to the woodland it was well camouflaged. Apart from the first day when the newly-fledged bird made five short flights, it was seen to make only four short flights around the paddock. On occasions, after food had been provided, the adults would remain on site either standing around or sitting on hocks, but not close to the fledgling or each other. They were usually 50 to 100 m apart.

The open aspect of the paddock allowed unobstructed observation of feeding bouts. An adult would fly in and the young bird would assume a begging position, sitting on hocks, flapping half-extended wings, shuffling around to position itself in front of the adult so that it could put its bill into that of the adult (see **Figure 8** for an example). Both adults provided food, mostly eels but on 14 August I saw the female in one regurgitation bout disgorge an eel followed closely by a fish. On one occasion the fledgling took five minutes to swallow the huge eel provided by the male. The eel was very fat in the middle and three times longer than the fledgling's bill. Other eels provided were smaller and more readily despatched. On two occasions, the young bird took

an eel directly from the female's bill. The video by L. Parashou, shows the juvenile taking an eel from the female's bill and flipping it until it could be swallowed head-first.

Figure 8. The female feeding the juvenile in the Horse Paddock; she is about to regurgitate an eel. Photographed 14 August 2017.

Interaction with other animals in the paddock

The fledgling remained in the paddock despite considerable surrounding activity. For instance, the horses were removed from the paddock each evening and returned next morning. Whilst the horses showed no interest in the young bird, they were constantly wandering around grazing. There were minor interactions between the adults and one of the horses. On two occasions a horse showed some aggression to the male by purposefully walking towards it. The male walked off quickly in the other direction. Once the male walked towards the group of horses as the female came in to land nearby. She took up position much further away and sat down. For the next fifteen minutes the male remained in the vicinity of the horses but when they stopped grazing suddenly and approached him at a fast pace, he moved off. A few days later the female was similarly approached and she responded by moving off.

The resident pair of Masked Lapwings *Vanellus miles* ignored the young bird apart from one occasion when it presumably walked too close to their nest.

Dispersal

After fledging there is circumstantial evidence that juveniles remained in the vicinity of Tomago Precinct of Hunter Wetlands National Park (HWNP) for several months.

The 2017 fledgling left the paddock on the afternoon of 14 August and was not seen there again but early on the morning of 15 August, N. McNaughton found a female with a very young bird on Northern Flats in HWNP approximately 2.1 km away, undoubtedly the same family. In September a juvenile bird was seen flying over HWNP Samphire Flats adjacent to Northern Flats and in December 2017, January and April 2018 an immature bird in the company of an adult(s) was observed on Samphire Flats. Then on 19 May an immature bird, later diagnosed as suffering from acute starvation, was captured at the site known as Smart Gates in HWNP, a short distance from Samphire Flats, and taken into care. Proximity to the natal area and plumage suggest that this was the 2017 chick. Its rehabilitation and release are documented (Lindsey 2019).

The 2018 fledgling remained in the vicinity of Tomago House until 11 September. From October 2018 to April 2019 a juvenile bird was seen seven times in the company of an adult male, once with an adult female, and six times alone, on Milhams Pond/Phoenix Flats complex, Ash Island approximately 3.3 km south-west of the nest site. On 18 January 2019 an adult male and a juvenile and on 8 February 2019 a juvenile were seen in the same general area on Little Bittern Pond on Kooragang Island 3.5 km south-east of Milhams Pond and 5 km south of the nest site. It is likely that this juvenile was the Tomago 2018 chick.

Adults continued to visit the nest after fledging had taken place in both 2017 and 2018 and in March 2019 adults were seen frequently on the Upland.

DISCUSSION

According to Clancy (2010a), breeding extended as far south as Bulahdelah in the Upper Hunter although most breeding was in the Northern Rivers and Mid-north Coast Regions. There was one breeding record west of the Dividing Range and unsuccessful nesting events took place in the 1960s and 70s in the Shoalhaven district and at Castlereagh and there is a record of "adults with young" at Wyong in the 1990s (Clancy 2010a) but there is no further detail. Clancy & Andren (2010) state that there was no confirmed breeding south of Bulahdelah during their study. In August 2014, on Hexham Swamp near Newcastle, NSW, an adult stork was observed carrying a large branch to a nest on which another adult was standing. Subsequently, adults were observed standing on the nest on several occasions; however breeding

was not confirmed. A pair, accompanied by two juveniles, was regularly present at Hexham Swamp in 2015-16; there is no evidence that breeding took place within the Hunter Estuary (Stuart 2016), although the age and behaviour of the juveniles suggested local breeding (G. Clancy pers. comm.).

The Tomago breeding events therefore extend the confirmed breeding range of this species by approximately 80 km southwards.

Breeding at Tomago started earlier than in northern NSW in both 2017 and 2018. Nest building was in full swing from the beginning of March in 2017 and from 8 February 2018. Both dates coincide with nest observation period and it may be that attendance at the nest had commenced even earlier. In 1980s in the Richmond River area breeding behaviour commenced in mid-March (Gosper & Holmes 2002), earlier than was otherwise noted in northern NSW where it started from May, but mostly June (Clancy 2008). Fledglings did not appear in the Richmond River district until late September/October (Gosper & Holmes 2002) whereas, at Tomago, fledging took place in the first two weeks of August, 7 August in 2017 and probably 12 August in 2018.

The choice of the nest site at Tomago is largely consistent with other nest sites observed – coastal location, on or adjacent to floodplain, in or less than 100 metres from water and more than 200 metres from a road or house (Clancy & Ford 2011). Although situated in a wetland, the nest site was relatively close to an industrial area. A study of breeding Black-necked Storks in India revealed that nests were often in areas of intense human activity but so long as there was no direct interference storks were able to breed successfully (Sundar 2003). The height of the Tomago nest did not fall within the typical range being only approximately three metres above the ground. Observations on the north coast show that 75.7% of nests were at a height of between 10 and 30 metres (Clancy & Ford 2011) and the height of nests in India ranged between 9 and 16 metres (Sundar 2003). In 2018 nest building did not appear to be as intensive as in 2017. I saw adults carry in large branches occasionally but less often than in 2017. I speculate that they were repairing the nest rather than building it.

Powerlines in the vicinity of the nest were a cause for alarm as they are a major hazard for both adult and immature storks. Collision with powerlines is the principal man-made cause of mortality (Clancy 2010b). While the chick was in the nest the adults negotiated the powerlines several times a day as they flew between the nest and the Upland. After the 2017 chick fledged, they had to clear the additional two sets of powerlines along Tomago Road several times a day if foraging in wetlands to the south.

In accordance with assumptions made by Clancy & Ford (2013), I assumed that, in 2017, incubation started from 5 April when an adult commenced sitting for long periods. From then until the first week of May either the male or female was sitting for long periods on the nest. I further assumed that the birds were still incubating on 29 April when both adults regurgitated water onto the nest which is also known behaviour during incubation. This activity may be a strategy to increase moisture rather than to regulate temperature (Clancy & Ford 2011). On 29 April it was not particularly hot, only 22 degrees Celsius at midday (Time and date.com). Because of the long distance between the observation point and the nest and because the nest platform was screened by foliage, it was difficult to establish with certainty exactly when egg(s) hatched. A chick was almost certainly present on 9 May when the female was seen swallowing fish cached in the nest. It is known that storks eat food that has been deposited in the nest and not eaten by the chicks (Clancy & Ford 2013). If counted from 5 April to 8 May 2017, the incubation period would have been 33 days which corresponds with the accepted incubation range of 32 to 38 days (Clancy & Ford 2011).

I was not able to approximate the incubation period for 2018.

Over the two breeding events in 2017 and 2018 the male appeared to spend more time incubating than the female: male 72% and the female 28% of total observation times. This result differed from observations from 10 nests on the north coast which revealed that the male and female spent similar amounts of time, 43% and 57% respectively, incubating (Clancy & Ford 2013).

The nestling period is not well known but for birds in captivity it ranges from 87 to 100 days (Clancy & Ford 2013). The nestling period for 2017 was 90 days assuming the chick which fledged on 7 August was present on 9 May. In 2018 adult behaviour suggested the presence of a chick on 12 May but the behaviour was not as persuasive as in 2017. However, assuming a chick was present, the nestling period of 92 days would be within known range. If counted from 19 May when a chick was seen, the nestling period would add up to only 85

days. In both nesting events chicks were probably present before assumed hatching dates.

Provisioning was observed only in 2017. The usual method of the transfer of food from adult to chick is for the adult to regurgitate food into the nest and for the chick to then pick it up and eat it. When the chick is small adults may re-swallow the regurgitated food several times so that it breaks up making it easy for the chicks to pick up small pieces (Clancy & Ford 2013). The incidence of young birds taking food directly from an adult's bill has been rarely reported. However in this study, it was observed on several occasions in 2017. On 27 July L. Parashou's video shows the chick taking food from the female's bill and on 2 August the nestling was again seen to take an item of food from the adult's bill and swallow it. This method was seen again on at least three occasions post-fledging. On the video the juvenile can also be seen taking an eel from the female's bill and flipping it until it could be swallowed head-first. It may be that bill-to-bill transfer is more usual when young birds have grown large enough to handle and consume prey whole.

According to observations in India, adults stopped provisioning their young when they reached 3 or 4 months of age and they were never observed to bring food to fledged young (Sundar 2003). However, according to Clancy & Ford (2013) adults regularly returned to feed juveniles left alone on wetlands. The 2017 Tomago chick was still being fed for at least a week post-fledging while in the horse paddock.

As Clancy identified only eels being delivered to nestlings (Clancy & Ford 2013), it is noteworthy that the Tomago female was eating fish deposited in the nest on 9 May and again on 16 May when a chick was definitely present. Fish including eel continued to be delivered to the juvenile post-fledging. A photograph taken on 13 August shows it with both a fish and an eel in its bill at the same time and on 14 August, another photograph shows it with a fish. It would appear that fish species other than eel were an integral part of the diet. Neither the species of fish nor the species of eels could be identified but it is likely that the eels were Long-finned Eel *Anguilla reinhardtii* which prefer estuarine water and are common in NSW (Anon 2010).

According to Sundar (2005) the 'up-down display' is rarely performed. There was no apparent trigger for the display observed in 2018. Such displays may occur at the nest during changeover or to apparently to warn off a third adult or when other birds are in the area (Clancy & Ford 2011). This display has been reported from the Hunter Region only once before when it was photographed in May 2014 on Hexham Swamp; the display was performed in response to a third adult being present (Warnock 2014).

It has been found that fledglings may remain close to nest site (within 300-400 m) during the first month (Clancy & Ford 2013). The post-nesting site on the horse paddock in 2017 was approximately 450 m away and in an area of high activity. One can speculate that this high activity area afforded the young stork a level of safety from predators such as birds of prey or foxes. One might further speculate that, since the adults ostensibly made no attempt to relocate the chick for seven days, the site was deemed suitable. It is assumed that in 2018 the fledgling remained in the paddocks around Tomago House approximately 400 m to the west. The incident on the road outside Tomago House on 5 September 2018, when the juvenile was almost run over, bears witness to the dangers of this breeding area.

CONCLUSIONS

The Tomago breeding events have provided new or little-known insights into the life cycle of the Black-necked Stork. Even though there is circumstantial evidence of previous successful breeding events at Wyong in the 1990s and at Hexham in 2015-16 (adults accompanied by juveniles), the Tomago events are the first instances of nests with young observed as far south as the Hunter Estuary, extending the range south by approximately 80 km. Breeding commenced earlier, February/March, than in northern NSW, where breeding commenced occasionally, mid-March but typically May/June. Fledglings appeared at Tomago a month earlier than further north. The situation of the nest tree was unexceptional but its height was atypical being considerably shorter than other examples. Provisioning the young bird post-fledging was seen on many occasions in 2017. Direct removal of food from adults' bills by a young bird is uncommon behaviour but this method was seen on several occasions in 2017 both in the nest and post-fledging. Provisioning young with fish species other than eels was not seen in previous studies in Australia.

ACKNOWLEDGEMENTS

I would like to thank residents, B. and C. Pascoe, I. Maynard and local business owner, T. Peirson, for providing information about the presence of the storks. I am indebted to L. Parashou for her filming of events both in and out of the nest and confirming some feeding behaviours which were not otherwise clearly established. Thanks to Dr G. Clancy for his advice and support throughout the breeding events and for refereeing the paper. I am grateful to A. Stuart who commented on an early draft and advised me as to how to approach the writing of this paper. N. Fraser provided the maps and R. Palazzi improved my photos. Many HBOC members generously contributed their observations, in particular, P. Svoboda, L. Parashou, N. McNaughton, B. Kinsey, P. Weinstock, L. Huxtable, N. Fraser and R. Stewart.

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Mimicry in Regent Honeyeaters: is it really mimicry after all?

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Received 4 July 2019; accepted 4 August 2019; published on-line 16 August 2019

The Regent Honeyeater *Anthochaera phrygia* is widely understood to mimic other species. To the best of our knowledge, amongst the Meliphagidae mimicry is unique to the Regent Honeyeater. An obvious question, therefore, is why does the Regent Honeyeater appear to be the only honeyeater to mimic other bird species? After spending 5 years monitoring the Regent Honeyeater throughout its range, here I propose that the incorporation of other species' songs into the repertoires of Regent Honeyeater should not be defined as "mimicry". Instead, I suggest that interspecific singing is maladaptive, confers no fitness advantage and is a consequence of the Regent Honeyeater occurring at population densities far below those in which it evolved. Low population density appears to be compromising the ability of some individuals to learn the species-specific song, probably due to a lack of other Regent Honeyeater demonstrators to learn songs from during a critical song-learning period in early life.

INTRODUCTION

Similar to humans, primates and parrots, many components of the vocal repertoire of songbirds (Passerines) are not innate. Instead, songbirds learn their songs, just as babies learn to speak, during a critical period in early life (Beecher & Brenowitz 2005). The ability to learn to sing 'correctly' is of crucial importance, because vocalisations have evolved to play key roles in social life-history. Just as language helps humans communicate, songs help birds to acquire mates and maintain territories (Arcese 1989), recognise relatives (Sharp *et al.* 2005) and defend against predators (Igic *et al.* 2015).

Many bird species have learned to incorporate the songs of other species into their own songs in a process defined as mimicry. Whilst the Superb Lyrebird *Menura novaehollandiae* is the classic example of a mimic (Dalziell & Magrath 2012), many other Australian birds are excellent mimics, including Olive-backed Oriole *Oriolus sagittatus* (Diamond 1982), Brown Thornbill *Acanthiza pusilla* (Igic *et al.* 2015) and Spotted Bowerbird *Chlamydera maculata* (Kelley & Healy 2010). Birds mimic other species because it provides them with a fitness benefit in some way, for example through mate acquisition, foraging efficiency, competitor deception, or nest defence (Igic *et al.* 2015; Dalziell *et al.* 2015).

The fact that mimicry conveys a selective advantage to the mimic is key to determining exactly which vocalisations can, and which cannot, be considered as mimicry. Dalziell *et al.* (2015) define a vocalisation to be mimetic if 'The behaviour of the receiver changes after perceiving the acoustic resemblance between the mimic and the model' (See **Box 1** for definition of key terms) and that 'the behavioural change of the receiver confers a selective advantage on the mimic.'

Box 1. Definition of key terms

- **Mimic** – an individual that sings the song of other species with a high degree of resemblance. In doing so, the mimic obtains a selective advantage by altering the behaviour of the recipient.
- **Recipient** – the individual receiving and interpreting the song from the mimic or the interspecific singer.
- **Model** – the species which the mimic or the interspecific singer has learned to sing like.
- **Interspecific singer** – an individual that has learned the song of another species with a high degree of resemblance, but receives either no, or negative, fitness costs from doing so.
- **Conspecific** – an individual of the same species.
- **Interspecific / Heterospecific** – an individual of a different species.
- **Fitness benefit** – a means by which an individual can enhance their lifetime breeding success or survival.

METHODS

We searched for Regent Honeyeater in the Capertee Valley in 2015 and throughout their contemporary breeding range between 2016 and 2018 (Crates *et al.* 2019). I recorded the songs of a sample of males and noted the location of any males that sang songs of other species. I also included verified public observations of interspecific singing by Regent Honeyeater during this period. I then compiled a database of historic records of interspecific singing by Regent Honeyeater, through a literature search and from personal communication with other Regent Honeyeater researchers.

RESULTS

In **Table 1** I have summarised known examples of interspecific singing by a male Regent Honeyeater. In those cases where the source of the information was not my own study, I have indicated either where the report was published or the name of the field worker who reported the observation to me.

Table. Records of interspecific singing in male Regent Honeyeater.

Species	Location	Year	Observer / reference
Red Wattlebird	Melbourne, VIC	1974	Veerman 1991
Anthochaera carunculata	Bundarra, NSW	1998	S. Debus
	Canberra, ACT	1992	Veerman 1994
	Chiltern, VIC	1988	R. Webster / Veerman 1994
	Capertee Valley, NSW	2008	Powys 2010
Little Wattlebird	Adelaide, SA	1977	H. Crouch / Veerman 1991
Anthochaera chrysoptera	Melbourne, VIC	1984	F. Smith / Veerman 1991
	Wyong, NSW	1991	Morris & Chafer 1991
	Dunbogan, NSW	2019	L. Murphy
	Guerilla Bay, NSW	2019	J. Morgan
	Coffs Harbour, NSW	2017	L. Murphy
	Lake Macquarie, NSW	2014	Roderick 2014*
	St Albans, NSW	2016 & 17	B. Hensen
Pied Currawong	Chiltern, VIC	2015	R. Crates
Strepera graculina	Kurri Kurri, NSW	2018	M. Roderick
New Holland Honeyeater	Chiltern, VIC	2015	R. Crates
Phylidonyris novaehollandiae			
Spiny-cheeked Honeyeater	Capertee Valley, NSW	2015	R. Crates
Acanthagenys rufogularis	Capertee Valley, NSW	2000	D. Geering
	Capertee Valley, NSW	2008	Powys 2010
	Barraba, NSW	2019	S. Debus
Noisy Friarbird	Barraba, NSW	2017	R. Crates
Philemon corniculatus	Capertee Valley, NSW	2018	
	Armidale, NSW	1991	A. Ley / Veerman 1991
	Chiltern, VIC	2018	D. Ingwersen
Little Friarbird	Capertee Valley, NSW	2016	R. Crates
Philemon citreogularis	Deniliquin, NSW	1992	P. Maher / Veerman 1994
Olive-backed Oriole	Capertee Valley, NSW	2015	R. Crates
Oriolus sagittatus			
Eastern Rosella	Emmaville, NSW	2016	R. Crates
Platycercus eximius	Armidale, NSW	1998	S. Debus
Black-faced Cuckoo-shrike	Wollongong, NSW	2018	R. Crates
Coracina novaehollandiae			
Noisy Pitta	Sydney, NSW**	2012	M. Roderick
Pitta versicolor			
Australasian Figbird	Sydney, NSW**	2008	S. Debus
Sphecotheres vieilloti			
Cockatiel	Sydney, NSW**	2008	Powys 2010
Nymphicus hollandicus			
Bush stone-curlew	Sydney, NSW**	2008	Powys 2010
Burhinus grallarius			

* This bird was also heard to include some 'snippets' of typical Regent Honeyeater song in its repertoire. See video at https://www.youtube.com/watch?v=55IQwd_ynH0.

** Denotes captive origin bird

DISCUSSION

Batesian vocal mimicry hypothesis

Given the need for mimicry to change the behaviour of the receiver to the benefit of the mimic, how might a Regent Honeyeater that sings the songs of other species benefit by changing the behaviour of another Regent Honeyeater or other bird species to their advantage? Veerman (1994) and Roderick (2014) suggest that singing like other, larger species such as Red *Anthochaera carunculata* or Little Wattlebird *A. chrysoptera* may reduce interspecific aggression from co-occurring honeyeaters during foraging. This theory, known as 'Batesian vocal mimicry' implies that a Regent Honeyeater singing like a larger, more dominant species can deceive other honeyeaters into thinking that a Regent Honeyeater *is* an individual of that other larger species, thereby reducing the rate at which it is chased off from nectar resources.

The Batesian hypothesis does at first seem plausible, especially given the struggles of Regent Honeyeater to compete for nectar against larger honeyeater species in unnaturally small flocks (Ford *et al.* 1993; Crates *et al.* 2017). Indeed, almost all records of interspecific singing in Regent Honeyeater (i.e. putative mimicry) involve larger model species (**Table 1**), suggesting that there may be a selective advantage to 'sounding bigger than one actually is.'

The Batesian mimicry hypothesis has limitations however (**Table 2**). Firstly, there is no evidence that a Regent Honeyeater singing like a larger species experiences less aggression when foraging than a Regent Honeyeater that sings like a Regent Honeyeater. Second, any selective advantage that a mimic may obtain by sounding like a larger species will immediately be lost at the point the recipient sees the mimic. Considering how active and abundant honeyeaters are during feeding bouts at rich blossom patches (Ford 1979; Ford *et al.* 1993), the length of time that a Regent Honeyeater could 'acoustically conceal' its identity by mimicking a larger honeyeater before being seen must surely be very short. Third, observation data shows that in many honeyeaters, most aggression is directed towards conspecifics (Ford 1979; Ford *et al.* 1993), in which case a Regent Honeyeater would still be subject to high levels of aggression even if it mimicked a different species. If there are advantages to sounding bigger, we might also expect acoustic mimicry to occur in a range of other small, co-occurring honeyeater species yet, to the best of my knowledge, no such evidence exists. Finally, one may suppose that the best way to avoid detection, and hence minimise aggressive displacement when feeding, would be to not sing at all; and this is exactly the strategy that male Regent Honeyeater employ to minimise predation risk when nesting (Ley & Williams 1994; R. Crates, pers. obs.).

Table 2. Evidence for and against the Batesian vocal mimicry and interspecific singing hypotheses for the Regent Honeyeater.

Batesian Vocal mimicry		**Interspecific singing**	
For	Against	For	Against
- Models invariably larger species	- Model species does not always co-occur with interspecific singer. - No records of mimicry in any other Meliphagidae. - Is relatively rare. Should be more common (selected for) if it confers a fitness advantage. - Interspecific singers never heard to sing any 'typical' Regent Honeyeater song. - Any benefits of vocal mimicry immediately lost when competitor sights the mimic.	- More frequent in birds occurring at low population density. - Young captive-bred birds learned to sing like other, co-occurring species. - Appears to be increasing in frequency concurrent with ongoing decline in population size and density. (Very rare in the Capertee Valley in 1990s). - Anecdotal evidence of interspecific singing in other species e.g. starlings (Hindmarsh 1984), Prairie Warbler (Byers *et al.* 2013), Florida Grasshopper Sparrow (Ragheb *et al.* 2015).	?

An alternative potential benefit of interspecific song learning in Regent Honeyeater is to improve chances of mate acquisition. Song appears to be a key component of courtship and territory acquisition for the Regent Honeyeater, as males sing directly 'at' both females and rival males with characteristic head bobbing behaviour (Ley & Williams 1994, Figure 1). In contrast to the observations of Veerman (1994), I can confirm that interspecific singing does occur in the Regent Honeyeater during the breeding season, though mostly only prior to nesting. Despite this new evidence, and despite further evidence that interspecific singers can successfully obtain a partner female and initiate nesting, I consider it unlikely that interspecific song learning improves the breeding success of a male Regent Honeyeater. Unlike mimicking species that increase the complexity of their species-specific song with songs of other species (Hindmarsh 1984), I have never observed an interspecific singing Regent Honeyeater also vocalise songs typical of Regent Honeyeater, despite monitoring some interspecific singers for many weeks during the breeding season. I have sometimes heard Regent Honeyeater-type calls in interspecific singers, but unlike songs, calls are innate rather than learned. In this instance, interspecific singing represents a replacement song rather than an enhancement of a species-specific song. It is hard to imagine a female being impressed by a male singing exclusively like a Black-faced Cuckoo-shrike *Coracina novaehollandiae* or a Pied Currawong *Strepera graculina*! (**Table 1**). In addition, we find that, although interspecific singers can be paired and initiate nesting, more often than random they are located away from the core breeding range, often in isolation (Veerman 1991). It is hard to determine cause and effect in this relationship. In other words, are interspecific singers less likely to find a mate because of their interspecific songs, or is the very reason they have interspecific songs because of a lack of co-occurring male Regent Honeyeater to learn from, and hence a lack of co-occurring females to mate with?

Erroneous interspecific song learning?

If interspecific singing provides a male Regent Honeyeater with no obvious fitness benefit, then why do they do it and why does it appear to be increasing in frequency? As Veerman (1991) suggests, the explanation is likely linked to the decline in population status of the Regent Honeyeater. Like most songbirds (Mennill *et al.* 2018), the Regent Honeyeater almost certainly learns to sing by replicating the songs of other male Regent Honeyeater that they co-occur with between the ages of 2 to 8 months (Vescei 2015). By one year of age, their songs are likely to be fixed for life (Beecher & Brenowitz 2005). Young male Regent Honeyeater are unlikely to learn songs from their fathers because, to avoid attracting predators, male Regent Honeyeater do not sing at all when raising young (R. Crates pers. obs.). Young birds also disperse away from their parents before they enter their song-learning phase, meaning young males must find 'another' singing male to learn their song from.

Given how sparsely distributed Regent Honeyeater nesting activity now is (Crates *et al.* 2019), it is entirely plausible that, after dispersing from the natal area, some young male Regent Honeyeater fail to locate any other males during their song-learning phase. Instead, these males learn the songs of other species they co-occur with during this period, hence the wide range of model species that interspecific singers have learned to sing like (**Table 1**). Long-distance nomadic wanderings of Regent Honeyeater likely explain why interspecific singers don't always co-occur with their model species when sighted (Franklin *et al.* 1998; Powys 2010). Hence, whilst interspecific singers are often found in association with the species they have learned songs from, we also find males in the Capertee Valley and Chiltern singing like Little Friarbird and New Holland Honeyeater *Phylidonyris novaehollandiae*, respectively, despite both model species being rare at these locations.

Due to their rarity and unpredictable post-breeding movements to largely unknown areas (Commonwealth of Australia 2016), our ability to gather monitoring data to test the interspecific song-learning hypothesis will always be limited. Nevertheless, it appears that the proportion of male Regent Honeyeater that are interspecific singers is increasing as the population decreases. I estimate that around 15% of the current wild male population are interspecific singers. Given that interspecific singers are more likely to occur away from the remaining core range and are therefore less likely to be found, 15 % may well be a conservative estimate. David Geering and Stephen Debus (pers. comm.) both report that incidence of interspecific singing in the Capertee Valley and Bundarra-Barraba, respectively, was rare in the 1990s, at which time the Regent Honeyeater

population was around an order of magnitude larger than it is today (Commonwealth of Australia 2016).

There are a small number of published examples of other, isolated wild songbirds learning to sing the wrong songs. Most notably, Ragheb *et al.* (2015) report observing a critically endangered Florida Grasshopper Sparrow *Ammodramus savannarum floridanus* that had learned to sing like a co-occurring Bachmans's Sparrow *Peucaea aestivalis*. Similarly, Byers *et al.* (2013) report a Prairie Warbler *Setophaga discolor* that sang songs of a Field Sparrow *Spizella pusilla.* Perhaps the best available evidence in Regent Honeyeaters comes from the captive population at Taronga Zoo. Young birds housed in crèche aviaries appear to have learned the songs of other species present nearby, including Australasian Figbird *Sphecotheres vieilloti* (S. Debus pers. comm.) and Noisy Pitta *Pitta versicolor* (M. Roderick pers. comm.).

CONCLUSIONS

Interspecific singing in male Regent Honeyeater is a fascinating phenomenon. Similar to loss of languages in indigenous societies, it is sad to think that the severe population decline which the Regent Honeyeater has undergone may now be impacting the ability of the remaining population to maintain their song culture. With the standardised Regent Honeyeater monitoring data we have been gathering over the past 5 years, and with experiments planned to study song learning in captive Regent Honeyeater, we hope to gain a better understanding of this unusual behaviour, as Powys (2010) discusses, in the near future. One intriguing question remains: as Veerman (1991, 1994) noted, the model species that interspecific singing Regent Honeyeater have learned from are almost exclusively larger-bodied species (**Table 1**). Under the interspecific singing hypothesis, I see no reason why the Regent Honeyeater should not learn the songs of smaller species, yet they very rarely appear to do so.

ACKNOWLEDGEMENTS

I thank Hunter Bird Observers Club for funding my research on Regent Honeyeaters through the Wilma Barden Memorial Grant. Phillip Veerman, Mick Roderick, Dean Ingwersen, David Geering, Damon Oliver and Stephen Debus provided insightful discussion on putative mimicry by Regent Honeyeater. I also thank the referee for their helpful suggestions.

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Recent high counts of Sharp-tailed Sandpiper in the Hunter Estuary

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Received 20 February 2019; accepted 8 August 2019; published on-line 27 August 2019

At least 1% of the total population of Sharp-tailed Sandpiper *Calidris acuminata* have visited the Hunter Estuary every austral summer since 2011/12. The peak counts have been 7,000-8,000 birds, which is around 9% of the total population. The birds prefer to use newly established salt marsh in areas where tidal inundation has recently been restored.

INTRODUCTION

The Sharp-tailed Sandpiper *Calidris acuminata* lives within the East Asian – Australasian Flyway. Around 90% of the world's population comes to Australia after their breeding season (Bamford *et al.* 2008; Hansen *et al*. 2016). They often use ephemeral wetlands across inland Australia; hence their distribution varies considerably from year to year depending where inland rain has fallen. Bamford *et al*. (2008), using the then-current Sharp-tailed Sandpiper population estimate of 160,000 birds, identified 39 sites in Australia where more than 1% of the population had been recorded. The Hunter Estuary was not on the list although a record of 1,800 birds at Hexham Swamp in 2002 had been overlooked (Stuart 2003). The Sharp-tailed Sandpiper population estimate was revised to 85,000 birds in 2016 (Hansen *et al*. 2016).

Prior to the 2011/12 austral summer, Sharp-tailed Sandpiper were recorded only intermittently in the Hunter Estuary with occasional short duration reports of 1,000 or more birds (Stuart 2016). Since then, there have been large numbers present every summer. **Figure 1** shows the main sites where Sharp-tailed Sandpiper has been recorded in the Hunter Estuary.

In 2016 I documented the known records and demonstrated that the high numbers of Sharp-tailed Sandpiper were associated with newly rehabilitated wetlands at Tomago and Hexham (Stuart 2016). High numbers of Sharp-tailed Sandpiper have continued to visit the Hunter Estuary. This note places on record the 2015/16, 2016/17, 2017/18 and 2018/19 data and presents an overview of what has happened over eight successive non-breeding seasons since 2011/12.

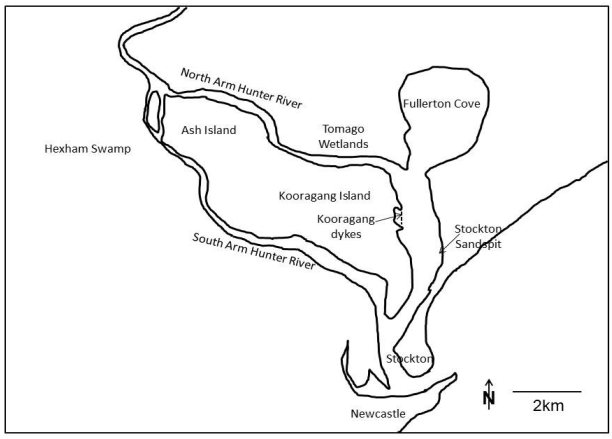

Figure 1. Main locations for Sharp-tailed Sandpiper in the Hunter Estuary

Shorebird habitat rehabilitation projects in the Hunter Estuary

From the 1950s, for several decades there was considerable loss of shorebird habitat within the Hunter Estuary, mainly to create land for actual or proposed industrial developments (Herbert 2007). However, more recently there have been several rehabilitation projects, including:

- Re-opening of creeks on Ash Island to tidal flushing, and at around the same time the re-engineering of Stockton Sandspit to encourage tidal coverage of the area (Streever 1998; Svoboda 2017).
- Installation of smart gates at Tomago Wetlands in 2008 to allow tidal flushing (Lindsey 2012). Tidal flushing did not occur regularly until 2012 for various operational reasons, and was

again disrupted from October 2018 for several months (J. Erskine pers. comm.).

- Re-opening of the floodgates at Hexham Swamp. One floodgate opened in December 2009 but progress with the others was slow and it was not until July 2013 that all eight gates had been re-opened (Hunter Local Land Services 2015).

METHODS

I extracted records from various sources. The main source was the monthly surveys of the Hunter Estuary done by members of Hunter Bird Observers Club (HBOC). Those surveys use a standard procedure involving multiple teams who visit all the known high tide shorebird roost sites (Stuart *et al*. 2013). Additional records were sourced from the Hunter Region Annual Bird Reports (e.g. Stuart 2018) and from the Birdata portal (www.birdata.birdlife.org.au). For my analysis I used the highest daily total count of Sharp-tailed Sandpiper on record for each month. Usually this was the count obtained from the systematic surveys by HBOC members. However, sometimes higher peak counts were obtained by other observers who, for example, saw a large flock in flight. There are considerable practical difficulties in counting Sharp-tailed Sandpiper accurately as they often are widely dispersed when foraging or roosting and the entire flock is rarely on view simultaneously.

Data for Australian inland rainfall in 2014-2016 were sourced from the CHIRPS (Climate Hazards Group InfraRed Precipitation with Station data) dataset (Funk *et al.* 2014; Stuart 2017). Data for 2018 inland rainfall was obtained from the Bureau of Meteorology website (Bureau of Meteorology 2019).

RESULTS

Figure 2 shows the monthly numbers of Sharp-tailed Sandpiper recorded in the Hunter Estuary between January 2011 and June 2019. There had been very few birds in the estuary in the 2010/11 non-breeding season (the maximum count was 40 birds, in December 2010). The period graphed spans eight non-breeding seasons. In the 2013/14 and 2014/15 seasons, there were many estimates of flock sizes of 7,000-8,000 birds in flight (these included some counts made from photographs). These are plotted as 7,500 birds in **Figure 2** and are the greatest counts on record for the estuary. However, more than 1,000 Sharp-tailed Sandpiper were present for at least some part of each of the eight non-breeding seasons. Since the 2013/2014 season, the maximum counts have been of more than 4,000 birds every austral summer.

The Sharp-tailed Sandpiper was recorded at many sites within the Hunter Estuary but there were four main locations – Ash Island, Stockton Sandspit, Tomago Wetlands and Hexham Swamp. The latter two were the most important of the locations, often hosting more than 1,000 Sharp-tailed Sandpiper. **Figures 3** and **4** show the monthly highest records at Tomago and Hexham.

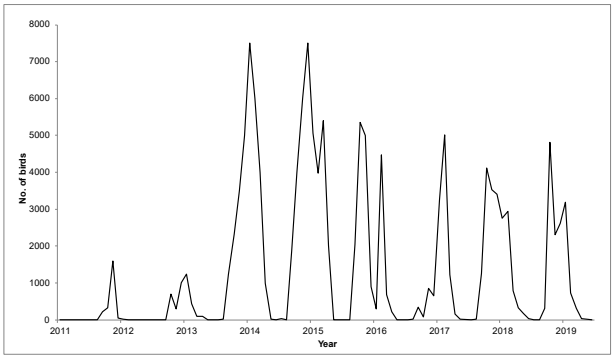

Figure 2. Monthly maximum records for Sharp-tailed Sandpiper in the Hunter Estuary for the period January 2011 to June 2019.

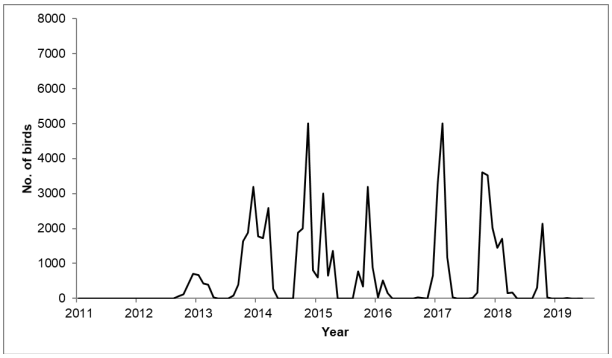

Figure 3. Monthly maximum records for Sharp-tailed Sandpiper at Tomago Wetlands for the period January 2011 to June 2019.

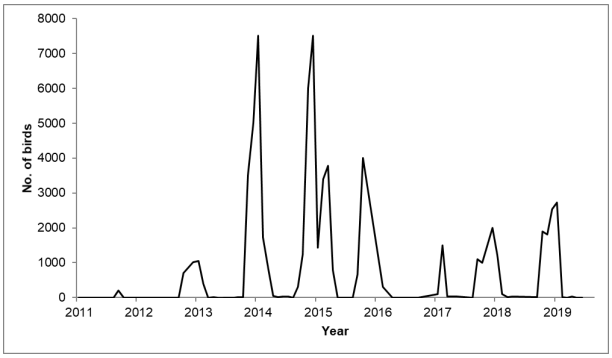

Figure 4. Monthly maximum records for Sharp-tailed Sandpiper at Hexham Swamp for the period January 2011 to June 2019.

DISCUSSION

International significance

Sites that host more than 1% of the population of a shorebird species are considered internationally significant (Department of the Environment, Water, Heritage and Arts 2009; Clemens *et al.* 2010). The estimated world population of Sharp-tailed Sandpiper is 85,000 birds (Hansen *et al.* 2016). Hence, the threshold for international significance is records of 850 or more Sharp-tailed Sandpiper. This threshold count of birds has occurred in the Hunter Estuary every austral summer from 2011/12 to 2018/19. More than 5% of the world population was present every summer from 2013/14 onwards. The peak counts of 7,000-8,000 birds in 2013/14 and 2014/15 were around 9% of the world population.

The importance currently of the Hunter Estuary for Sharp-tailed Sandpiper is very clear. The estuary has hosted internationally significant numbers of them for eight non-breeding seasons in succession since 2011/12. Only ten other sites in Australia have ever hosted more Sharp-tailed Sandpiper than the Hunter Estuary's peak counts of 7,000-8,000 birds (Bamford *et al.* 2008; Shorebirds 2020 database 2019). Those sites are: Lake Cawndilla NSW (37,522 birds February 1996); The Coorong, SA (33,740 birds January 2006, also 17,067 birds February 2002); Eighty Mile Beach, WA (25,000 birds date unknown); Port Hedland Saltworks WA (20,000 birds, date unknown); Tullakool Evaporation Ponds, NSW (10,000 birds, date unknown); Lake Gregory, WA (10,000 birds, date unknown); Lake Buloke, Vic. (12,000 birds, February 1984); Lake Hawdon, SA (16,430 birds January 2019, also 7,860 birds January 2010); Goolwa Barrage, SA (14,222 birds January 2012, also 11,542 birds January 2010) and Penrice SA (9,800 birds, December 1980).

BirdLife Australia's Shorebirds 2020 database has many thousands of records for Sharp-tailed Sandpiper in Australia, including the location and date and the numbers of birds present (D. Weller pers. comm.). Inspection of Shorebirds 2020 records revealed that, outside of the Hunter Estuary, there have been fewer than 20 locations where there have been 850 or more birds present (i.e. 1% or more of the Sharp-tailed Sandpiper total world population) in more than one year. The main sites elsewhere in Australia for >850 birds have been:

Victoria

- Avalon Saltworks (2006-2008)
- Western Treatment Plant (2012-2018)
- Eastern Treatment Plant (2012-2018)
- Lake Connewarre (2007-2010)
- Moolap Saltworks / Reedy Lake (2007-2009)
- Edithvale (2006-2015, some years)
- Hospital Swamp (2006, 2009)
- Lake Linlithgow (2007-2008)

South Australia

- Coorong/Goolwa area (2006-2008)
- Cheetham Saltworks (2008, 2010)
- Morella basin (2006, 2018-2019)
- Lake Hawdon (2009-2010, 2017-2018)

Queensland

- Cape Bowling Green (2011, 2013)
- Bishop Island (2005-2009)
- Ross River (2005-2006)

New South Wales

- Fivebough Swamp (2013, 2015)

Western Australia

- Lake McLarty (2005-2013, some years)
- Peel Inlet (2006, 2009-2010)

Temporary departures from the Hunter Estuary

In some seasons the numbers of Sharp-tailed Sandpiper varied considerably, with a thousand or more birds sometimes disappearing for a period of time (**Figure 2**). The three most notable examples occurred in the 2015/16, 2016/17 and 2018/19 seasons. Those apparently temporary departures of 1,000-2,000 birds may be associated with difficulties in locating and accurately counting Sharp-tailed Sandpiper when they are dispersed in salt marsh habitat. That is, their numbers may have been under-estimated. However, all three instances corresponded with heavy rainfall events occurring inland. I have previously shown a strong relationship between inland rainfall and the numbers of Red-necked Avocet *Recurvirostra novaehollandiae* present in the Hunter Estuary

(Stuart 2017). The Sharp-tailed Sandpiper in the Hunter Estuary probably exhibits the same behaviour, based on examination of the three main instances of reduced numbers.

In February 2015, 3,974 birds were recorded in the Hunter Estuary with estimates in the two adjacent months of 5,000-5,500 birds. That decline of 1,000-1,500 birds corresponds with heavy inland rainfall occurring in the period December 2014 to January 2015 (see Table 1 in Stuart 2017). In October and November 2015, 5,000-5,500 birds were again in the estuary, declining to *c* 900 Sharp-tailed Sandpiper in December 2015 and *c* 300 birds in January 2016. The numbers rose again in February 2016 to a peak count of 4,467 birds late in the month. The 2-3 month absence of Sharp-tailed Sandpiper again corresponded to heavy inland rainfall, which commenced in November 2015 (Stuart 2017). Almost twice as much rain fell inland compared to the December 2014 - January 2015 period, perhaps explaining why almost all the Sharp-tailed Sandpiper departed the Hunter Estuary.

Substantial inland rain fell in South Australia and south-eastern parts of Western Australia over October to December 2018, with large parts of that area recording the highest rainfall on record (Bureau of Meteorology 2019). The numbers of Sharp-tailed Sandpiper in the Hunter Estuary dropped from *c* 4,800 birds present in October 2018 to 2,300-2,600 birds in November and December.

Tomago Wetlands and Hexham Swamp

In every austral summer since Tomago Wetlands and Hexham Swamp began to be significantly affected by tidal flushing, they have each regularly hosted more than 1% of the total population of Sharp-tailed Sandpiper. Often there has been more than 5% of the population present.

A new smart gate system was installed at Tomago Wetlands in 2008 but tidal flushing only occurred intermittently for the next few years because of operational issues followed by a period of heavy rain, and shorebirds were only occasionally recorded (Lindsey 2012). Shorebirds began to visit Tomago Wetlands regularly from September 2012, including increasing numbers of Sharp-tailed Sandpiper which peaked at ~700 birds in December that season. In every subsequent austral summer, more than 2,000 have been present regularly and the peak counts were of ~5,000 birds (**Figure 3**).

The importance of the tidal flushing regime at Tomago Wetlands was clearly demonstrated in 2018/2019. Birds began arriving there in September 2018 and rose to a peak count of 2,132 birds in October (**Figure 3**). However, from late October 2018 the tidal gates were closed because of operability issues (J. Erskine pers. comm.). Sharp-tailed Sandpiper numbers plunged to zero within two weeks of the closure of the gates. Although one of the tidal gates was re-opened in late 2018, the resultant water flows into Tomago Wetlands were minimal and the Sharp-tailed Sandpiper did not ever return to the site in the 2018/2019 season.

The first of eight floodgates at Hexham Swamp was re-opened in December 2009 but progress in opening the others was slow and it was not until July 2013 that all eight gates had been re-opened (Hunter Local Land Services 2015). In October 2012, 700 Sharp-tailed Sandpiper arrived and the peak count for them at Hexham Swamp that summer was 1,057 birds in January 2013. Since then, more than 1,000 birds have been recorded every summer and the peak counts were of 7,000-8,000 birds in 2013/14 and 2014/15 (**Figure 4**).

Salt marsh in transition

Sharp-tailed Sandpiper have foraged and roosted in large numbers each summer in the considerable tracts of salt marsh that formed at Hexham Swamp and Tomago Wetlands after each site became tidally influenced. There also are areas of salt marsh at Ash Island and Stockton Sandspit but Sharp-tailed Sandpiper have used those areas less frequently and/or birds were present in lesser numbers.

There are some records since 2013 of up to 1,000 birds at Stockton Sandspit but primarily these were of birds which were roosting not foraging.

Ash Island has large areas of salt marsh, most of which was formed after tidal flushing was progressively restored there in the early 2000s (AS pers. obs.). The highest counts for Ash Island occurred in 2002-2011 after tidal flushing had recommenced and salt marsh had newly established. The maximum count was 1,600 birds in November 2011 (see **Figure 2**). It is noteworthy that in the period since 2012/13 of regular Sharp-tailed Sandpiper visits to the Hunter Estuary, the birds have shown a decided preference for newly established salt marsh at Hexham and Tomago rather than the longer-established salt marsh

occurring on Ash Island. The peak count of Sharp-tailed Sandpiper on Ash Island since 2013 was 514 birds in October 2018. In the other periods when several thousand birds have been in the Hunter Estuary, the highest counts of them from Ash Island have been of fewer than 100 birds.

The importance of salt marsh in transition might also explain the much greater counts for Sharp-tailed Sandpiper at Hexham Swamp and Tomago Wetlands in the 2014/15 and 2015/16 seasons. However, other explanations may also be possible.

The pattern of visits suggests that foraging opportunities for Sharp-tailed Sandpiper are better when the saltmarsh is first establishing. There seem to have been no studies of what the birds are eating in the new salt marsh habitat and how saltmarsh food productivity changes as the saltmarsh becomes established.

CONCLUSIONS

Since 2011/12, the Hunter Estuary has become a regular site for large numbers of Sharp-tailed Sandpiper. This contrasts with the sporadic nature of records of large numbers of them from elsewhere in Australia. More than 1% of the total world population has been present for at least some part of each austral summer for eight years in a row and often more than 5% of the total. Peak counts have been 7,000-8,000 birds, which is around 9% of the world population. Following brief periods of heavy inland rain, many Sharp-tailed Sandpiper temporarily depart the Hunter Estuary.

The birds prefer to use newly established salt marsh in areas where tidal inundation has recently been restored. A study seems warranted, to understand how saltmarsh food productivity changes as the saltmarsh becomes established.

ACKNOWLEDGEMENTS

My main source of data was the monthly surveys of the Hunter Estuary by multiple teams of observers. In the eight austral summers analysed, more than 40 people have assisted in at least one survey. I thank them all, and particularly the stalwarts who turned up most months. I also thank an anonymous referee, and Dan Weller, Migratory Shorebirds Program Manager with BirdLife Australia, who sent me a spreadsheet with the dates and locations of all records of more than 850 Sharp-tailed Sandpiper in Australia.

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Changes in wetland use by shorebirds following mangrove removal, Area E, Ash Island, New South Wales

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Received 2 May 2019, accepted 26 August 2019, published on-line 3 October 2019

Hydrological controls, such as flood and tidal gates, have been used historically in Australian estuarine environments to make tidal environments more arable. The removal of flood gates such as these from Fish Fry Flats and Wader Creek on Ash Island in the Hunter Estuary in the mid-1990s led to the proliferation of grey mangroves *Avicennia marina* in both wetlands. Subsequently, shorebird usage of the wetlands declined substantially.

As part of work to offset biodiversity impacts of the third coal export terminal in the Port of Newcastle, mangroves were removed from both wetlands to restore migratory shorebird habitat. There was a positive response in shorebird usage of Fish Fry Flats and Wader Creek following the mangrove removal. Shorebird species richness and abundance have increased since 2016, including both migratory and endemic species. Notably, there have been relatively high counts of small sandpiper and plover species, including Sharp-tailed Sandpiper *Calidris acuminata*, Red-capped Plover *Charadrius ruficapillus*, Red-kneed Dotterel *Erythrogonys cinctus* and Red-necked Stint *Calidris ruficollis*. Currently, Fish Fry Flats/Wader Creek appears to be the preferred habitat in the Hunter Estuary for Red-capped Plover.

INTRODUCTION

Fish Fry Flats (32º 52'S, 151º 43'E) is a tidal wetland at the southern extent of Ash Island, in the Hunter Estuary (see **Figure 1**). The wetland is connected to the South Arm of the Hunter River via Fish Fry Creek, opposite the Newcastle suburb of Sandgate. Wader Creek is a tidal creek proximal to Fish Fry Flats, although the two wetlands are not directly connected, with the exception of some high tide and flood events throughout the year (Rodríguez & Sandi Rojas 2014). There is some indirect connection of the waterbodies through Swan Pond. These wetlands constitute a portion of a wetland system, known as 'Area E'. Area E, defined as the wetlands east of the Hunter River South Arm, south of the Jemena gas pipeline and west of the Kooragang Island main rail line, is subject to a complex set of tidal and freshwater influences and includes other water bodies known as Wader Pond and Northwest Pond (Avifauna Research & Services 2016).

Fish Fry Flats has historically been considered important shorebird habitat in the Hunter Estuary (Herbert 2007). Until 1995, Fish Fry Creek was tidally restricted, which resulted in a tidal wetland dominated by saltmarsh species and mudflats with minimal mangrove growth (Hunter-Central Rivers Catchment Management Authority 2011). Following the removal of hydrological controls at Fish Fry Creek, Grey Mangrove *Avicennia marina* were observed to have proliferated over a 20-year period, eventually occupying the majority of Fish Fry Flats (see **Figure 2**). Based on aerial photographs, Wader Creek was also observed to have transformed from a saltmarsh/mudflat wetland to a mangrove-dominated wetland over a similar period. While the causes of this are less understood than at Fish Fry Flats, it is likely these developed through similar processes.

Habitat restoration

As part of work to offset biodiversity impacts of the third coal export terminal in the Port of Newcastle (Newcastle Coal Infrastructure Group (NCIG), Kooragang Island), a decision was made to attempt to restore migratory shorebird habitat at Area E. This was specifically the removal of mangroves from within the Fish Fry compartment (Fish Fry Creek and Fish Fry Flats) and an ongoing commitment to keeping the tidal wetland free from mangrove regrowth. This was intended to facilitate the re-establishment of saltmarsh vegetation communities and, to some extent, open tidal mudflats. The project was approved by the NSW State Government in 2013 (NCIG 2013) and mangroves were progressively removed from May 2016 to September 2016.

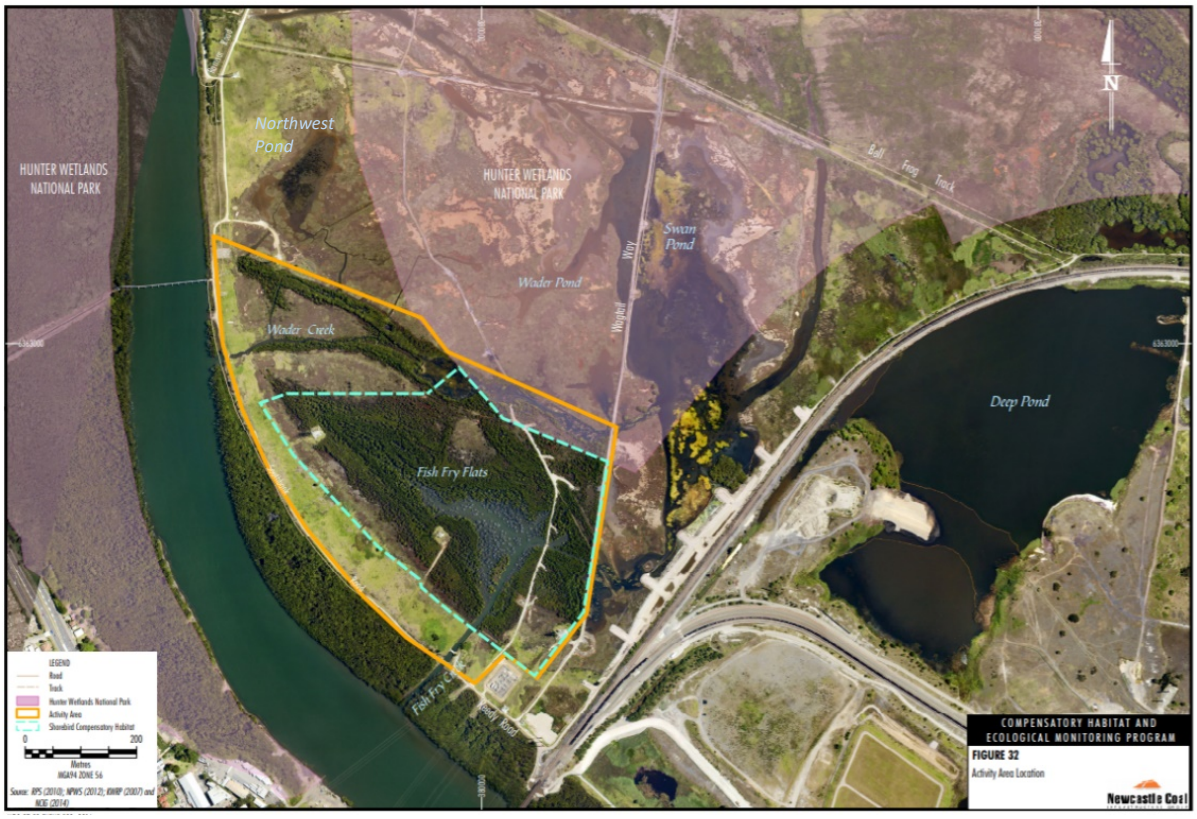

Figure 1 - NCIG Migratory Shorebird Compensatory Habitat Area, Area E, Ash Island (NCIG 2013).
Note: Shorebird Compensatory Habitat outlined by dashed light blue line; Activity Area outlined by solid orange line.

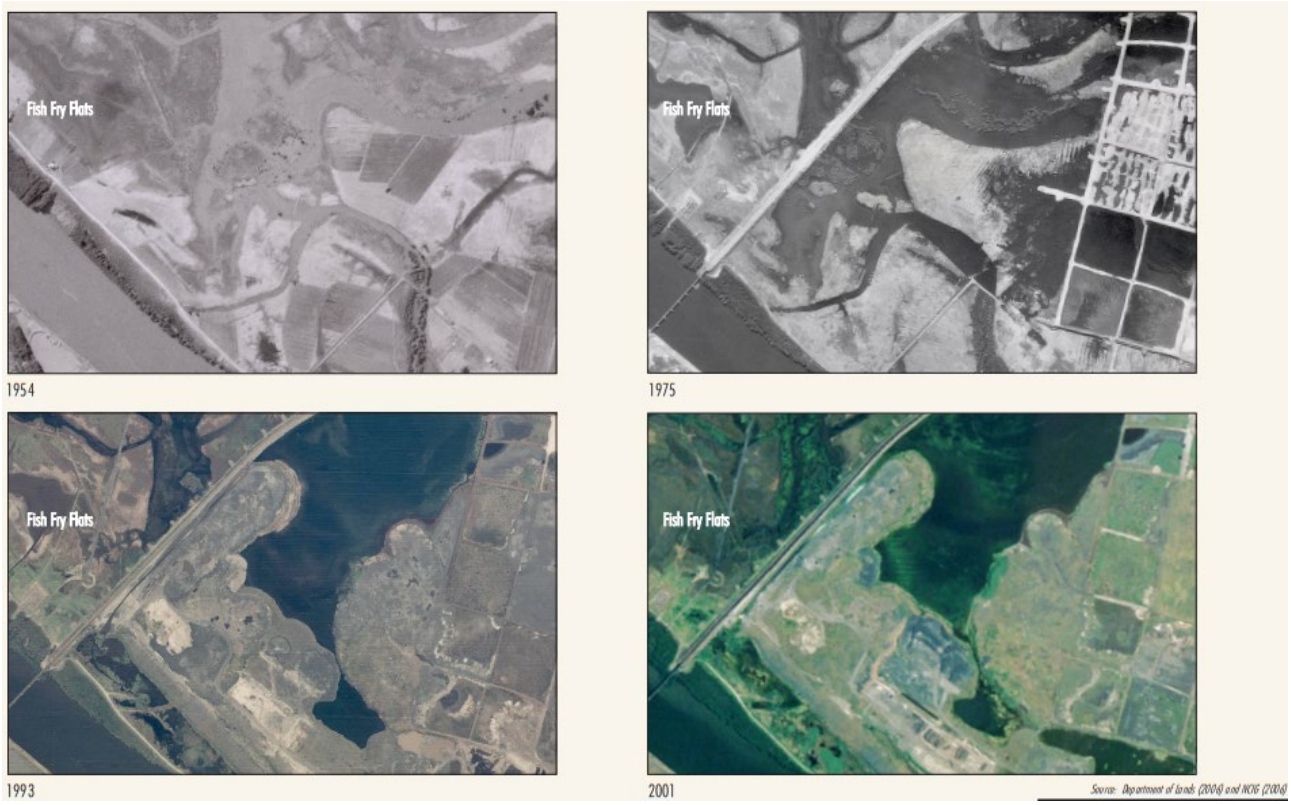

Figure 2 – Historical photographs, Fish Fry Flats and Wader Creek (1954, 1975, 1993, 2001) (NCIG 2013)

As part of the project, the proponent, Newcastle Coal Infrastructure Group, in consultation with Avifauna Consulting and National Parks and Wildlife Service, decided to also remove mangroves from Wader Creek, directly adjacent to Fish Fry Flats. That was because retaining the mature mangroves in that area would be a potential deterrent for shorebirds and would also be an ongoing source of new mangrove progeny in the Area E system, which would lead to extensive and continuous effort to keep the remaining area free of mangrove regrowth. To assist in maintaining ideal hydrological conditions within Fish Fry Flats and to limit the ingress of mangrove propagules from the South Arm of the Hunter River, an automated tidal gate and 20 mm stainless-steel mesh screen were fixed to an existing culvert in Fish Fry Creek. To further mitigate mangrove re-establishment, a finer mesh net was fixed further upstream within Fish Fry Creek and a small 20 mm stainless-steel mesh screen was installed in the existing Wader Creek tidal connection to the river.

In total, 17 hectares of mangroves were removed from Fish Fry Flats and Wader Creek. The area is effectively free of mangrove regrowth, with follow-up removal efforts conducted in December 2017 and November 2018. Removal has mostly been new mangrove progeny from seeds remaining from the original removal effort.

The purpose of this article is to document shorebird and other waterbird species records prior to and after tidal connectivity and mangrove removal and discuss the reasons for the observed changes.

METHODS

Baseline measurement

For the purposes of baseline comparison, the study has considered bird presence/absence data from two temporal periods – historical data (1994-2003) and pre-mangrove removal (Feb 2015-Mar 2016). The historical data has been obtained from three separate data sets, namely a report prepared for NSW National Parks and Wildlife Service (Kingsford 1995), continuous data collected by the Hunter Bird Observers Club (Stuart 1999-2003) and survey data collected by Birds Australia in 2002 (Hutchinson & Morris 2003).

Studying the change

During and following removal of the mangroves (Kleinfelder 2017; General Flora & Fauna 2018), regular bird surveys were conducted at Fish Fry Flats and Wader Creek. Since removal of the mangroves, this has been combined with data collected from Swan Pond (north and south), Wader Pond and North West Pond. This monitoring has been conducted in parallel with monitoring of other biotic and abiotic parameters such as vegetation surveys, benthic fauna surveys (Rankin 2018), surface water/groundwater chemistry, water levels and 6-monthly topographical surveys, which do not form part of the analysis of this report.

The avian data studied included records of migratory and endemic shorebirds and other waterbirds.

Changes have been recorded in vegetation communities since the initial mangrove removal. There has been proliferation of saltmarsh species within the intertidal zone, specifically Seablite *Suaeda australis*, Samphire *Sarcocornia quinqueflora* and Saltwater Couch *Sporobolus virginicus* (Rankin 2018). There have also been apparent changes in benthic fauna assemblages and surface topography (Rankin 2018).

RESULTS

The temporal changes revealed by the study are presented in a number of Excel line and bar charts. Counts of migratory shorebirds from 1995 to 2003 following tidal reconnection are presented in **Figure 3** and counts of endemic shorebirds from the same period are presented in **Figure 4**. Migratory shorebird and endemic shorebird counts prior to, during and following mangrove removal are presented in **Figure 5**, while **Figure 6** presents species richness (shorebirds plus other waterbirds) for the same three periods. The average number of shorebirds and waterbirds recorded on Fish Fry Flats and other wetlands in Area E since mangrove removal in 2016 are presented in **Figure 7** while **Figure 8** presents the total number of shorebirds and waterbirds over the same period. **Figure 9** presents Red-capped Plover *Charadrius ruficapillus* counts for Stockton Sandspit and Fish Fry Flats from 20014 to 2018. Counts of Sharp-tailed Sandpiper *Calidris acuminata* on Fish Fry Flats and Wader Pond since mangrove removal in September 2016 are presented in **Figure 10**.

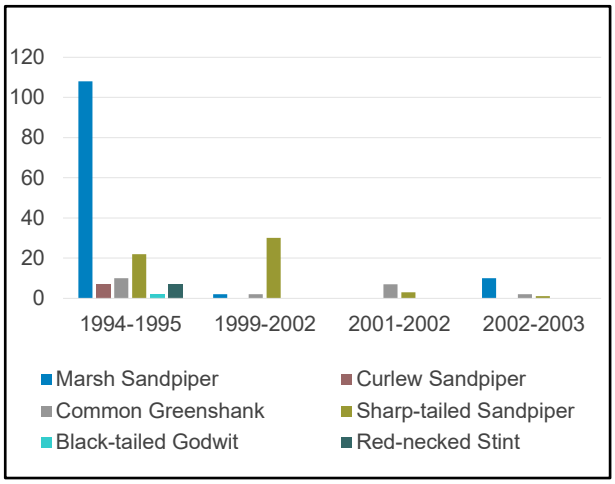

Figure 3 - Maximum migratory shorebird count by species, Fish Fry Flats during the period of mangrove growth following tidal connection in 1995 (based on three separate datasets)

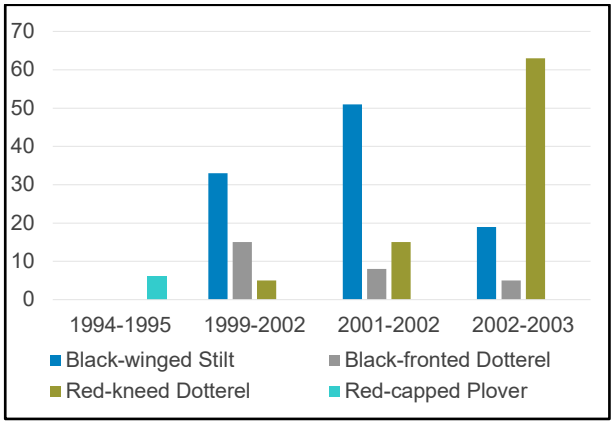

Figure 4 - Maximum endemic shorebird count by species, Fish Fry Flats during the period of mangrove growth (based on three separate datasets)

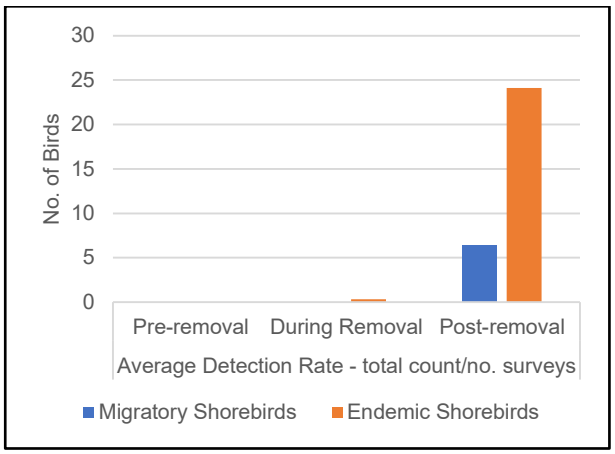

Figure 5 - Average detection rate - Fish Fry Flats/Wader Creek

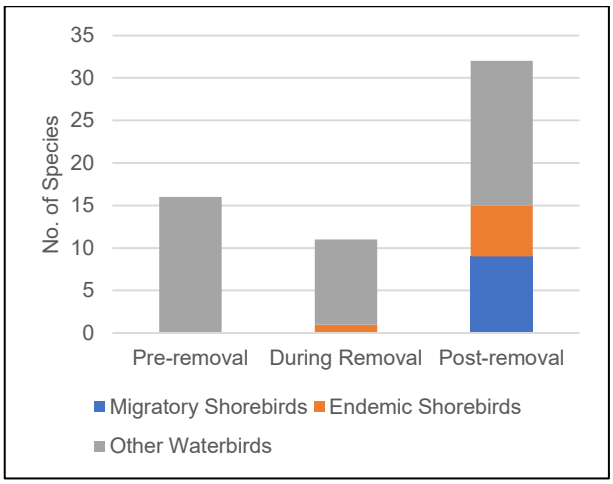

Figure 6 - Species richness - Fish Fry Flats/Wader Creek

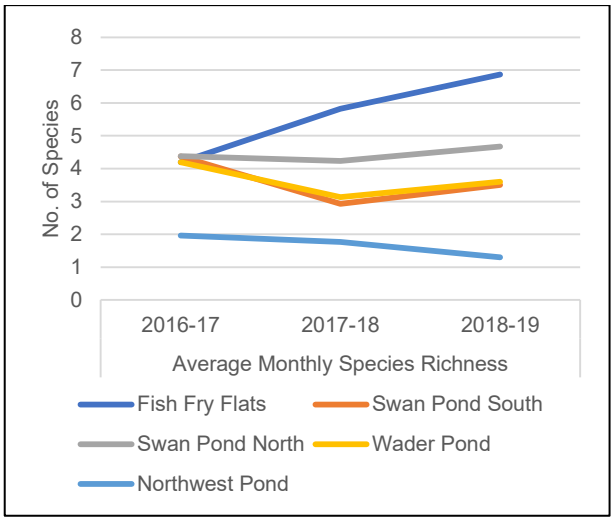

Figure 7 - Average monthly shorebird and other waterbird species richness, Area E, Ash Island

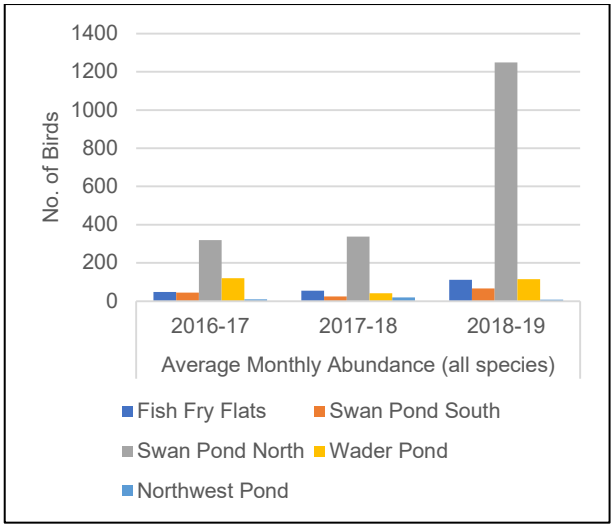

Figure 8 - Average Monthly Shorebird and other Waterbird Abundance, Area E, Ash Island

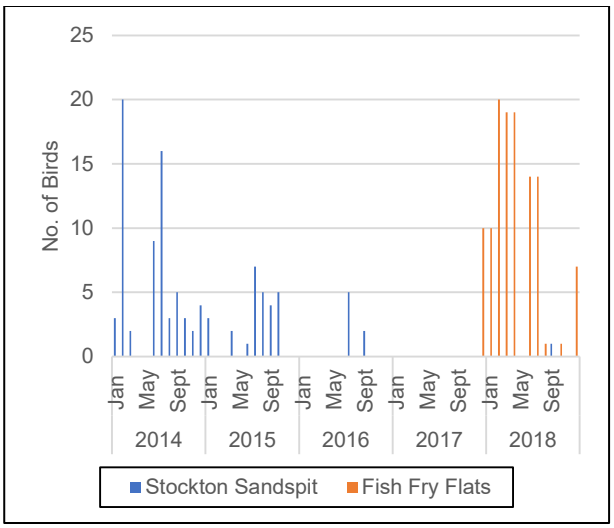

Figure 9 - Monthly Red-capped Plover counts, Fish Fry Flats and Stockton Sandspit

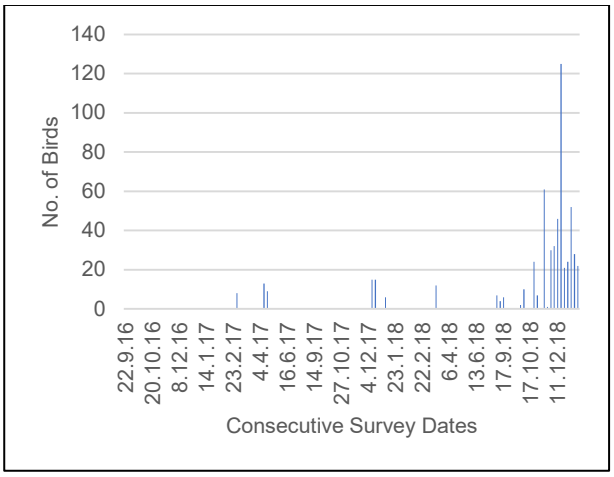

Figure 10 - Sharp-tailed Sandpiper counts, Fish Fry Flats/Wader Creek - consecutive surveys since mangrove removal

DISCUSSION

Changes in shorebird utilisation as mangrove proliferation occurred

The resultant impact of the change in tidal connectivity on wader occupation can be seen in the monitoring records. Between 1995 and 2003, a number of migratory wader species that historically used Fish Fry Flats were either no longer observed or were present in much lower numbers (**Figure 3**). These include Marsh Sandpiper *Tringa stagnatilis*, Curlew Sandpiper *Calidris ferruginea*, Black-tailed Godwit *Limosa limosa* and Red-necked Stint *Calidris ruficollis*, although a general decline in migratory shorebird numbers may also be attributed to overall population declines in the East Asian-Australasian Flyway (Hansen *et al*. 2016). Trends were different amongst endemic shorebird species (**Figure 4**). Red-capped Plover *Charadrius ruficapillus* and Red-necked Avocet *Recurvirostra novaehollandiae* were no longer recorded after 1995 (Note – Red-necked Avocet is not shown in **Figure 4** due to scale. The total observations during the 1994/1995 season were 677 individuals). Species such as Pied Stilt *Himantopus leucocephalus* and Black-fronted Dotterel *Elseyornis melanops* were relatively unchanged across the period, while Red-kneed Dotterel *Erythrogonys cinctus* increased between 1994 and 2003.

Figures 3 and **4** were developed from three data sets: Kingsford (1995); Hunter Bird Observers Club (1999-2003); and Hutchinson & Morris (2003). The data from the Hunter Bird Observers Club have been presented across two separate time periods (1999-2002 and 2002-2003).

This general downward trend in shorebird usage was confirmed through additional monitoring conducted more recently by Avifauna Consulting from 2015 to 2016, with no migratory shorebird or endemic shorebird species recorded in Fish Fry Flats (Avifauna Research & Services 2016). Consistent usage by other waterbirds was observed across all datasets with Australian White Ibis *Threskiornis moluccus*, White-faced Heron *Egretta novaehollandiae* and Chestnut Teal *Anas castanea* recording the highest maximum counts of birds which were observed in all datasets (Avifauna Research & Services 2016).

Shorebirds present during and after mangrove removal

Figures 6-8 summarise the changes that occurred during and after removal of the mangroves. The overall species richness (**Figure 6**) declined slightly while mangroves were actively being removed but increased subsequently, to more than double the pre-removal levels. That result is reflected in the monthly average species richness levels from the surveys (**Figure 7**). There was little or no change in species richness at the adjoining water bodies (Swan Pond, Wader Pond, Northwest Pond) but at Fish Fry Flats / Wader Creek the average number of species per survey increased from 4.2 species per survey to 6.9 species per survey.

There has been a distinct change in bird usage observed in the Fish Fry / Wader Creek

compartment. Since removal of the mangroves, there has been an immediate response in shorebird usage of the habitat. This can be seen in **Figure 5**, with the average number of shorebirds per routine survey count at Fish Fry Flats/Wader Creek changing from zero prior to mangrove removal to an average of 6.4 birds following mangrove removal. The average number of endemic shorebirds changed from 0.32 to 24.1 after mangrove removal. The species with the highest counts were Masked Lapwing *Vanellus miles*, Sharp-tailed Sandpiper *Calidris acuminata*, Red-kneed Dotterel, Red-capped Plover, Pied Stilt and Red-necked Stint. Across all waterbird species, there was also a distinct increase in species richness observed at Fish Fry Creek after mangrove removal (**Figure 6**).

To date, there have been nine different species of migratory shorebirds recorded at Fish Fry Flats/Wader Creek. Some species, such as Whimbrel *Numenius phaeopus*, Bar-tailed Godwit *Limosa lapponica*, Common Greenshank *Tringa nebularia* and Curlew Sandpiper, were present only fleetingly after the initial mangrove removal (Kleinfelder 2017; General Flora & Fauna 2018). Other species have been recorded more consistently since the 2016/17 season, including Eastern Curlew *Numenius madagascariensis*, Double-banded Plover *Charadrius bicinctus*, Pacific Golden Plover *Pluvialis fulva*, Sharp-tailed Sandpiper and Red-necked Stint (General Flora & Fauna 2018).

In comparison to neighbouring wetlands in Area E, such as Swan Pond, Wader Pond and Northwest Pond, Fish Fry Flats/Wader Creek has experienced a steady increase in average species richness (total number of shorebird and waterbird species observed) since removal of the mangroves (see **Figure 7**). Despite this high species richness, Swan Pond North remains the most important wetland in Area E for shorebirds and waterbirds with an average monthly count far greater than all other wetlands (**Figure 8**). During the 2018/19 season there was an increase in average monthly counts across all wetlands with the exception of Northwest Pond. The cause of this is unknown although it may have been a result of wetting/drying cycles or broader shorebird and waterbird trends in the estuary and elsewhere across the Australian eastern seaboard.

Changing Red-capped Plover usage patterns

While the purpose of restoring saltmarsh and mudflat habitat to Fish Fry Flats and Wader Creek was intended to provide habitat for all shorebird species, particularly migratory shorebirds, there has been a trend of increases in the number of small sandpiper and plover species using the water bodies. Red-capped Plover have been recorded during monthly Hunter Bird Observers Club (HBOC) surveys with counts of up to 20 birds, while NCIG-commissioned surveys recorded up to 22 individuals (General Flora & Fauna 2018). **Figure 9** represents the two most consistent locations in the estuary for Red-capped Plover observations over the past 5 years – Stockton Sandspit and Fish Fry Flats. Traditionally these birds have been observed predominantly at Stockton Sandspit. More recently the predominant location in the estuary[1] for this species is Fish Fry Flats/Wader Creek. Note – there was one significantly high count of Red-capped Plover at Tomago Wetlands, Samphire Flats in August 2018 (155 individuals) (A. Stuart pers. comm.).

Red-capped Plover have also been recorded as breeding at Fish Fry Flats. Chicks were observed twice during HBOC monthly wader surveys in the 2017/18 season, while a chick and a nest containing two eggs were recorded in the 2018/19 season (A. Stuart pers. comm.).

Sharp-tailed Sandpiper increase

Sharp-tailed Sandpiper have also been observed in increasingly large numbers at Fish Fry Flats/Wader Creek. Since post-mangrove-removal monitoring commenced in September 2016, regular surveys have been conducted by the ecological consultancy General Flora and Fauna Consulting. The surveys were conducted fortnightly in the period from September to April and monthly in the period from May to August. Fortnightly monitoring has involved low- and high-tide surveys, as well as nocturnal surveys, while monthly monitoring has involved low- and high-tide surveys only. **Figure 10** shows occasional usage of Fish Fry Flats and Wader Creek by Sharp-tailed Sandpiper in the 2016/17 and 2017/18 seasons with a substantial increase in the numbers present since October 2018.

[1] The Hunter Estuary, for the purpose of this article, excludes Worimi Conservation Lands

While it is unclear as to the reason for the increase in Sharp-tailed Sandpiper numbers, there does not appear to be a correlation between total summer records at Fish Fry Flats and total summer records in the broader estuary (2016/17 season - 3173 birds recorded; 2017/18 season - 15,956 birds recorded; 2018/19 season (to Dec 2018) – 9002 birds recorded) (Stuart 2014-2018). It is also noted that the majority of Sharp-tailed Sandpiper using Fish Fry Flats and Wader Creek were foraging rather than roosting.

CONCLUSION

The removal of mangroves at Fish Fry Flats and Wader Creek on Ash Island has promoted the presence of shorebird species utilising the habitat. Species abundance and richness have both increased for migratory and endemic shorebirds. Since the removal of mangroves, average shorebird and other waterbird species richness has steadily increased at Fish Fry Flats/Wader Creek in comparison to neighbouring wetlands. However, overall abundance remains highest at neighbouring Swan Pond (north).

The restored habitat at Fish Fry Flats and Wader Creek has become the preferred habitat for Red-capped Plover in the Hunter Estuary, while Sharp-tailed Sandpiper are increasingly using the habitat for feeding. More work is required to better understand the value of Fish Fry Flats and Wader Creek to wader species, particularly as feeding habitat. This should include analysis of bird usage patterns, vegetation coverage and benthic infauna assemblages, as well as further analysis of biotic and abiotic factors.

ACKNOWLEDGEMENTS

I would like to thank the efforts of the ecologists, consultants and volunteers in collating the important data that supports this work, including Phil Straw (Avifauna Research & Services), Greg Little (General Flora and Fauna), Dan O'Brien (Kleinfelder) and Alan Stuart (Hunter Bird Observers Club). Ann Lindsey has been very helpful in generating estuary-wide data for comparison with specific data from the project site. I would also like to thank all club members and volunteers from the Hunter Bird Observers Club who have been involved in the NCIG Biodiversity Offset to date, as well as researchers from the University of New South Wales and University of Newcastle who are conducting research on the project site more broadly. Finally, a thank you to my colleagues, Nathan Juchau and Hayley Ardagh, as well as NCIG management for committing the substantial time and resources to the habitat restoration project.

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Why is the Pallid Cuckoo declining in the Hunter Region, but relatively stable in Tasmania?

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Received 13 July 2019; accepted 14 August 2019; published on-line 2 September 2019

A comparison of the status of the Pallid Cuckoo *Heteroscenes pallidus* in the Hunter Region and Tasmania using records from the BirdLife Australia database (Birdata) confirmed the species to be more abundant in Tasmania. In the Hunter Region a sustained decline in status was apparent over the last 20 years at both the regional scale and at individual locations. Over the corresponding period in Tasmania the evidence is ambiguous; increases apparent at the regional scale conflict with evidence of local declines.

In both regions the Pallid Cuckoo is a breeding visitor with more than 95% of records occurring between September and January.

Interpretation was based on the assumption that the Pallid Cuckoo has a very large home range supporting a large number of pairs of its brood host.

Pallid Cuckoo prefer dry open woodland, especially woodland edges. Excessive removal of tree cover and increases in the extent of dense moist understorey vegetation are detrimental. Recent changes in land use in the central Hunter Region near Paterson may have contributed to local decreases. The decreased presence of cuckoos may reflect issues with the status of its host species.

INTRODUCTION

The Pallid Cuckoo *Heteroscenes pallidus* occurs throughout Australia (Blakers *et al*. 1984; Barrett *et al*. 2003) but is primarily a breeding summer visitor in the southern part of its range, including the Hunter Region of NSW.

In the Hunter, where it is more frequently recorded in the west of the region, the Pallid Cuckoo is never numerous and there is evidence that its population status may be decreasing (Stuart 2018). On returning to south-east Tasmania in 2014 after 21 years in the Hunter Region, the contrast between the abundance of Pallid Cuckoo in the two areas was obvious. This paper compares the population status of the Pallid Cuckoo in the two regions, attempting to understand why there are fewer Pallid Cuckoo in the Hunter.

Examination of the literature on the Pallid Cuckoo highlights the complexity surrounding the apparently simple objectives outlined above. For instance, the HANZAB account of the Pallid Cuckoo (Higgins 1999: 665) summarises the movements as follows: "Migratory or partly migratory, but patterns of movement poorly understood, even though much information in the literature. Also described as nomadic or possibly resident". A further complication in evaluating the populations of cuckoos is the possibility that their status may be linked to that of their brood host. Again, the literature is vague with 55 host species being listed for the Pallid Cuckoo in HANZAB (Higgins 1999) and at least 80 host species mentioned in the First Atlas of Australian Birds (First Atlas) (Blakers *et al*. 1984). In the Hunter there is little information on host species with only one breeding record in the Annual Bird Report series (Stuart 1993 - 2018). That record involved a Yellow-faced Honeyeater *Caligavis chrysops* as host. In Tasmania the endemic Black-headed Honeyeater *Melithreptus affinis* and Strong-billed Honeyeater *M. validirostris* are both named as hosts (Higgins 1999).

A related species, the Common Cuckoo *Cuculus canorus* has a widespread breeding distribution in the northern hemisphere and has been well studied (Davies 2015). Findings from those studies provide insights into aspects of cuckoo behaviour important to the interpretation of local data. Again, ambiguity prevails; on the one hand cuckoos, particularly females, are secretive, seeking to avoid the attention of their brood hosts. On the other hand, they are highly vocal, since males and

females need to remain in contact as they seek hosts. It has been estimated that female Common Cuckoo may lay up to 25 eggs at two-day intervals and hence seek a similar number of hosts, usually of one species (Davies 2015). Consequently, they have large territories. For instance, in the UK the population density has been estimated to be four pairs in 100 km^2 (Gibbons *et al*. 1993), which could include pairs parasitising different host species. However, a number of males and females may be sharing the same home range and parasitising the same host species, as there is evidence that both males and females may have two or three different partners in one breeding season (Davies 2015). Recent satellite tracking studies in Scandinavia have indicated a breeding season home range of 130 km^2 (Williams *et al*. 2016*)*. A further complication is that the diets of the cuckoo and the host species may be different and the home range must provision both species. The Common Cuckoo (Davies 2015) and the Pallid Cuckoo (Higgins 1999) both predominantly feed on hairy caterpillars.

Seasonal distributions reported in the New Atlas of Australian Birds (New Atlas) (a 1999 – 2002 study) (Barrett *et al*. 2003) suggest that there is a population shift from south-east Australia in the breeding season, to north-west Australia in winter. Griffioen & Clarke (2002) provide support for this conclusion, suggesting that the Pallid Cuckoo is one of five species that migrate inland in an anti-clockwise circular pattern.

The Pallid Cuckoo favours open habitats with sparse understorey, inhabiting a range of lightly timbered country including open woodlands, shrublands, wooded grasslands and farmland (Higgins 1999). Insights into the habitat preferences in the Hunter Region are provided by studies in the forests of the Upper Hastings Valley north of the region where the Pallid Cuckoo was only found in dry open forest, preferring areas with dry understorey (Shields *et al.* 1985). Dry woodlands and open areas are also preferred in Tasmania (Ridpath & Moreau 1965). The importance of forest edges has been emphasised (Higgins 1999).

METHODS

Data source

The evaluation in this paper is based on the presence of Pallid Cuckoo in surveys submitted to Birdlife Australia's (BLA) Birdata archive between 1998 and 2019. Records for the Hunter Region and Tasmania for 1998-2019 were extracted in June 2019. Most Pallid Cuckoo records were submitted as one of three types of surveys:

2-ha surveys. This is BLA's preferred survey type and involves compiling species lists at 2-ha survey sites in a 20-minute period. This standardised procedure removes bias associated with variations in survey effort (i.e. time and area surveyed are fixed provided that observers exclude calls made outside the boundaries of their 2-ha survey site). Unfortunately, when a species is scarce, as in the case of the Pallid Cuckoo in the Hunter Region, this survey method may not provide sufficient records for meaningful population trends to be established.

500-m surveys involve recording the presence of species within an area of 500-m radius (*c.* 78.6 ha). The duration of the survey is variable. Most surveys are completed on the same day but some involve accumulating species lists over a period of one month. The increase in the area searched and the duration of these surveys usually leads to higher RRs, thus ameliorating the issue of insufficient records. However, the results may be subject to sampling bias associated with variations in the size of the area sampled (i.e. the actual area surveyed often is much smaller than the nominal 78.6 ha) and the duration of the survey. However, within 500-m survey data there are sub-sets of data where repeat surveys have been conducted at the same site in an identical manner by the same observer. These surveys were used to generate bias-free local trends for comparison with regional trends.

5-km surveys allow data collection over even larger areas (5-km radius) and the issues associated with potential survey effort bias in terms of variation in the area sampled and the duration of the surveys are further exacerbated. Again, there are sub-sets of data involving long-term repeat surveys that provide bias-free trends at a limited number of survey sites.

In the following analysis 500-m surveys were used as the default source of data for analysis because in the case of the Pallid Cuckoo it was deemed least compromised by issues such as data deficiency and bias. However, information from other survey types was used for confirmatory purposes and when it was considered more reliable.

Selection of sites for analysis

The Hunter Region and Tasmanian bird data records were searched to find survey sites monitored by the same person for at least five years that had sufficient Pallid Cuckoo records for temporal analysis. Most of the suitable sets involved either 5-km or 500-m surveys, where the duration of the survey was of the order of 3 hours. For short duration 500-m and 2-ha 20-minute surveys there were insufficient records and it was necessary to pool the results from local clusters of sites located in similar habitat in order to achieve sufficient statistical power.

Hunter Region

Three suitable long-term data sets in the central Hunter Region were identified (see details immediately below). Unfortunately, there were not any similar long-term data sets at sites in the western part of the Hunter Region where the Pallid Cuckoo is indicated to be more numerous (see maps in Stuart 2018) which could be used for comparative purposes. However, the area around Medhurst Bridge has been frequently visited since 1998 by a number of observers and their pooled data involving a combination of survey types was used.

Green Wattle Creek - Birdata Site ID 767161: 32.661°S 151.649°E; 500-m surveys of typically 200-min duration by M. Newman. Dry woodland with understorey recovering after cattle grazing ceased (Newman 2009; Newman & Cunningham 2018).

Black Rock – Birdata Site ID 97476: 32.568°S 151.649°E; 61 breeding season 5-km surveys of typically 150-min duration made by M. Newman in a lightly wooded area grazed by cattle (Newman 2014).

Balickera – Birdata Site ID 275801: 32.656°S 151.789°E; 500-m surveys conducted throughout the month by Jenny Musicka, survey duration unknown but typically longer than at other sites. There were no surveys in 2002/2003.

Medhurst Bridge – 32.514°S, 150.698°E – All Birdata for 2-ha 20-min, 500-m and 5-km surveys conducted within 20 km of Medhurst Bridge were pooled and evaluated as seven three-year data sets. Trends generated by this approach in which survey effort is variable, and many different observers contribute, is expected to be less reliable than the other data sets used for trend analysis. The habitat surrounding Medhurst Bridge was highly fragmented with extensive clearing of the valley floor for agricultural purposes. Remnant scrub and woodland were mainly restricted to creek lines and ridges.

Tasmania

Seven suitable data sets were identified in Tasmania, located in three regions of the state. At two sites, where 5-km surveys were used, there were sufficient records at the individual sites. At the other sites where 500-m and 2-ha 20-min surveys were used it was necessary to pool data across several sites.

Lake Llewellyn and Cuprona Road – Birdata Site IDs 449937 and 327214: 40.933°S, 145.567°E and 41.100°S, 145.983°E respectively. Two sites in north-west Tasmania approximately 30 km apart which were surveyed regularly for 21 years by Richard Ashby using 5-km surveys of approximately 240 minutes duration. There were no changes to the habitat at either site, other than those occurring naturally.

Woodsong – Birdata site IDs 22480, 405217, 640557 and 640708: 41.300°S, 148.117°E. A cluster of four 500-m survey sites in north-east Tasmania located in dry sclerophyll woodland with wet gullies. Breeding season surveys were made by Albert Nichols between 2009 and 2019. There were extensive fires in the surrounding area towards the end of this period, but no fires at the survey sites.

South Arm – 2-ha 20-minute and 500-m survey data for sites within a 5-km radius of Sandville (Birdata site ID 492918: 43.000°S 147.485°E) were pooled independently to provide separate trends for 2-ha 20-minute (12) and 500-m (3) sites. The 2-ha 20-minute sites were in dry sclerophyll woodland, fragmented by low-density residential development. Newman (2018) provides additional information on the habitat surrounding the Sandville survey sites. The 2-ha survey sets include both ridge and valley survey sites. The 500-m sites were located in an adjacent more lightly wooded area with large paddocks in the valleys.

Meehan Range – Birdata Site IDs 290076-77, 2960089 and 2960091-93: 42.840°S 147.397°E. Surveys were conducted at six 2-ha 20-minute survey sites located along a 4 km creekline transect in a gully through dry sclerophyll woodland (Newman 2018) at a location approximately 20 km north of the South Arm peninsula. Surveys were conducted most months between September 2014 and January 2019. The area was burnt in a wildfire in October 2006, eight years before the surveys commenced.

Analysis of data

Reporting Rates (RR), the ratio of the number of surveys in which the Pallid Cuckoo was recorded to the total number of surveys, expressed as a percentage, were used to compare the presence of Pallid Cuckoo in the two regions. The assumption that RRs are a measure of abundance is central to the interpretation of survey results reported in the following sections. The Chi Square test (χ^2) was used to test statistical differences in RRs (Fowler & Cohen 1994).

In both the Hunter Region and Tasmania >95% of Pallid Cuckoo records occurred between September and January, the nominal breeding season when Pallid Cuckoos are vocal (see Results section). Surveys outside of the nominal September to January breeding season were excluded in order to eliminate bias associated with annual variations in the proportion of surveys conducted in the breeding season. It is possible that birds were under-recorded outside the breeding season because they were less vocal.

Unless stated, no attempt was made to correct for the location bias caused by repeat surveys at the same location when determining regional scale trends. Similarly, no corrections were made for variations in the proportion of surveys conducted in areas outside the Pallid Cuckoo's core range (i.e. in unsuitable habitat).

RESULTS

Seasonal variation

Seasonal variations in the occurrence of the Pallid Cuckoo in the Hunter Region and Tasmania are compared in **Figure 1**. In both areas most of the records were in the period September to January (96.1% in the Hunter and 95.2% in Tasmania). Consequently, in temporal evaluations only surveys for these five months were used as discussed previously.

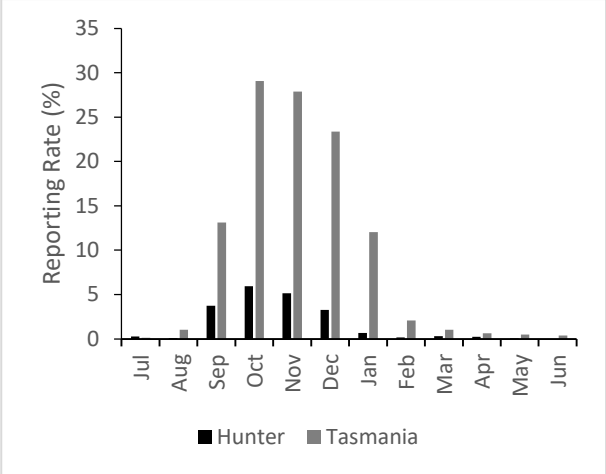

Figure 1. Monthly variations of the Reporting Rates of the Pallid Cuckoo in the Hunter Region and Tasmania for the 21 years between 1998/1999 and 2018/2019 (Birdata 500-m surveys: Hunter n = 15,926 surveys; Tasmania n = 12,790 surveys).

Regional trends

The annual RRs for the Pallid Cuckoo in the Hunter Region and Tasmania are compared in **Figure 2**. Throughout the 21-year period the Pallid Cuckoo was more frequently recorded in Tasmania than in the Hunter Region. In the Hunter, the RR decreased by 87%, or by 0.31%/annum assuming a linear trend, compared with an increase of 77% in Tasmania at a linear rate of 0.6%/annum. The increase in RR in Tasmania from 12.7% in 2008/2009 to 31.6% in 2009/2010 is partly, but not completely, explained by the commencement of an intensive 500-m survey campaign at one survey site, which contributed 21% of the Tasmania 500-m surveys during the second decade of the study period (unpublished results).

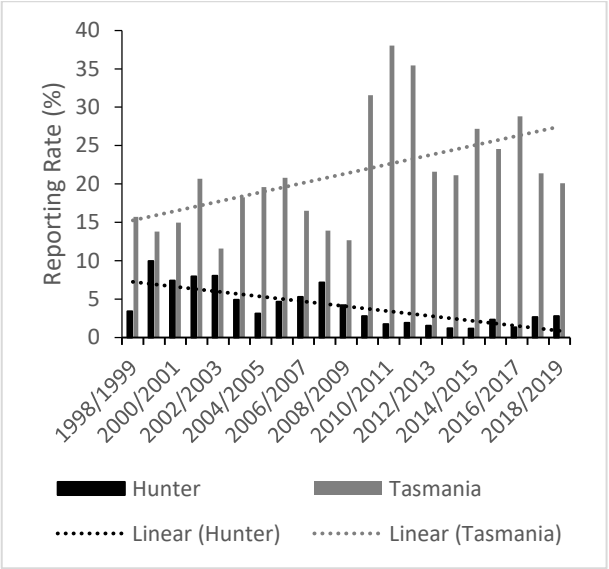

Figure 2. Comparison of temporal variations in the breeding season Reporting Rates of the Pallid Cuckoo in the Hunter Region and Tasmania (Birdata 500-m surveys).

Because the difference in the trajectories of the RR trends in the two regions was unexpected, confirmation was sought by comparing the RRs for the four-year periods at the start and end of the 20-year study of the study period (**Table 1**). The initial period, from 1998/1999 to 2001/2002 was during the data collection phase of the New Atlas of Australian Birds (Barrett *et al*. 2003). The second period 2015/2016 to 2018/2019 involved an increase in survey effort following promotion of Birdata in both regions. During both these periods the number of 2-ha and 500-m surveys was considerably higher than in the intervening years.

This analysis (**Table 1**) confirmed the finding that the RRs for the Pallid Cuckoo had decreased in the Hunter Region but had increased in Tasmania. Furthermore, this result was common to data generated by all three survey methods. In five of the six data sets the differences were highly significant statistically ($p < 0.01$) based on χ^2 tests.

In all six comparisons in **Table 1** the RRs for Tasmania were higher than for the Hunter Region. For example, in the period 1998/1999 to 2001/2002 the Tasmanian RR was 2.1 times that for the Hunter, but by the period 2015/2016 to 2018/2019 this difference had increased to 8.7 times (2-ha surveys). The differences for the other survey types were similar. All of the differences were highly significant $\chi^2 > 8$ for 1 df: $p < 0.01$.

Table 1. Comparison of the breeding season Reporting Rates of Pallid Cuckoo in the Hunter Region and Tasmania for two four-year periods using three types of Birdata survey method.

Survey type	**2-ha**	**2-ha**	**500-m**	**500-m**	**5-km**	**5-km**
Region	Hunter	Tasmania	Hunter	Tasmania	Hunter	Tasmania
1998/99 – 2001/02 RR (%)	3.8	6.8	7.5	14.6	11.0	35.1
2015/16 – 2018/19 RR (%)	1.2	10.6	2.2	19.7	3.7	41.9
Change in RR (%)	-61.5	56.0	-70.7	34.9	-66.5	19.3
$\chi 2$	8.5	8.9	59.6	15.2	14.6	3.7
Probability *p*	0.0035	0.0028	<0.0001	<0.0001	0.0001	0.0736
1999 – 2002 records	21	53	78	295	110	316
2015 – 2019 records	18	229	67	423	13	178
1999 – 2002 surveys	662	783	1040	2021	1003	900
2015 – 2019 surveys	1475	2164	3059	2164	354	425

As expected, RRs increased with the survey effort, being lowest in the 2-ha surveys and highest for the larger area longer duration surveys (e.g. in the Hunter Region for the period 1998/1999 to 2001/2002 the RR for 5-km area searches (11.0%) was 3.5 times higher than for 2-ha surveys (3.2%) (**Table 1**).

I also examined the results for individual sites to determine whether the trend apparent at the regional scale was replicated locally in unbiased data sets (i.e. surveys conducted in a consistent manner by the same observer).

Hunter sites

At Green Wattle Creek (**Figure 3**) the overall RR during the breeding season was 28.9% based on surveys at monthly intervals over an 18-year period commencing 1996/1997. Although the RR was higher in the first seven years (RR 42.9%), than in the subsequent 11 years (RR 20.0%) the difference was not statistically significant (χ^2 = 3.11 for 1 df: p = 0.077). The surveys, lasting approximately 200 min, were made in the morning and included four embedded 2-ha 20-min surveys. No Pallid Cuckoo were recorded at the 2-ha sites.

The Balickera surveys (**Figure 3**) involved observations accumulated throughout the month, and hence, are not directly comparable to those at Green Wattle Creek (200-min survey duration) because the observations were collected over a longer period and in a less consistent manner.

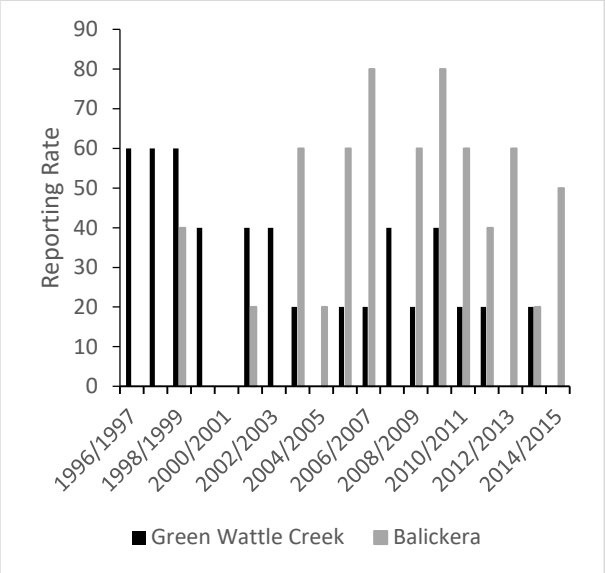

Figure 3. Variation in the breeding season Reporting Rates for Pallid Cuckoo at Green Wattle Creek and Balickera in the central Hunter Region (500-m surveys; zero bars reflect the absence of Pallid Cuckoo except for Balickera in 2002/2003 when there were no surveys). Balickera surveys by Jenny Musicka.

Surveys which I conducted at Black Rock Road near Martins Creek (**Figure 4**) between 1998 and 2014 (Newman 2014) provide another long-term data set, although annual survey effort was less consistent than at Green Wattle Creek. The overall RR was 23.3%, but as shown in **Figure 4**, the Pallid Cuckoo occurred more frequently in the three-year period 1999/2000 to 2001/2002 (RR 40.7%) than in the subsequent 12 seasons (RR 8.8%). This difference was statistically significant (χ^2 5.36 for 1 df: p 0.025).

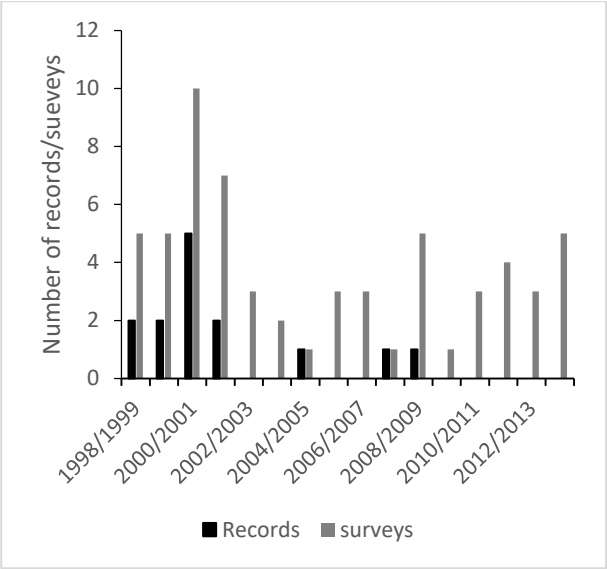

Figure 4. Pallid Cuckoo records from Birdata 5-km surveys conducted at Black Rock Road, Martins Creek in the central Hunter Region between 1998/1999 and 2013/2014.

The results for surveys conducted within 20 km of Medhurst Bridge in the west of the Hunter Region (**Figure 5**) suggest that with the exception of 2010-2013, when the number of surveys was low, the Pallid Cuckoo was less common post the 2003/2004 breeding season. However, an increase in the final three-year period is apparent.

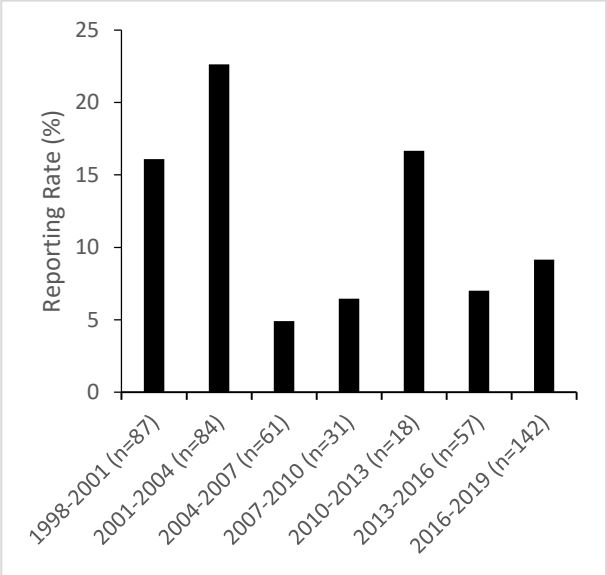

Figure 5. Variations in the breeding season Reporting Rates of Pallid Cuckoos for surveys conducted within a 20-km radius of Medhurst Bridge in the south-west of the Hunter Region. (Birdata 2-ha, 500-m and 5-km surveys pooled over three-year periods; n = the number of surveys).

Tasmania sites

The trends for two sites in north-west Tasmania are shown in **Figure 6**.

At Lake Llewellyn the overall RR rate was 59.7%. The linear trend line indicated a decrease of 13.5% in RR over the 20-year period, but the change was not statistically significant (p 0.59). At Cuprona Road the overall RR (58.8%) was similar, but in this instance the linear trend line, which indicated a 53.9% decrease from 81.2% to 37.4%, was statistically significant (p *0.011)*. There was a statistically significant correlation between the Lake Llewellyn and Cuprona Road data sets (p 0.031).

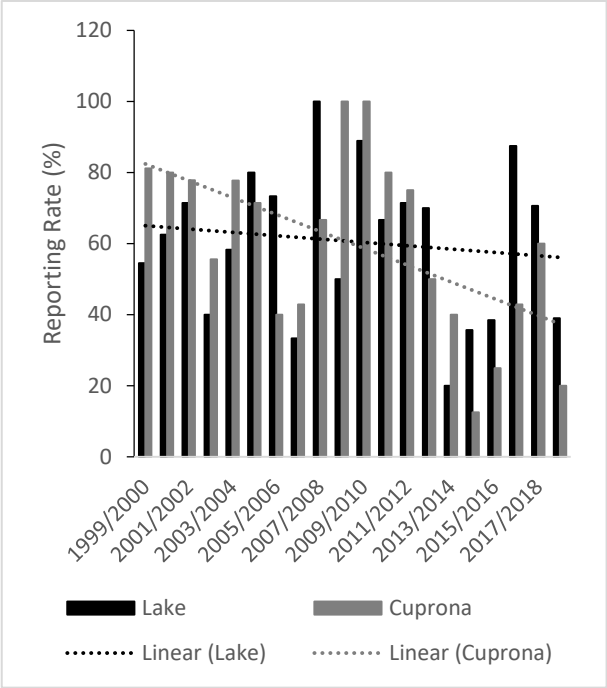

Figure 6. Variation in breeding season Reporting Rates of Pallid Cuckoos at two locations in north-west Tasmania (Birdata 5-km surveys of typically 240-min duration made by Richard Ashby: 232 and 136 surveys at Lake Llewellyn and Cuprona Road respectively).

At Woodsong there was compelling evidence of a decrease in the status of the Pallid Cuckoo for the decade commencing 2009/2010. The overall RR was 44.2% and the linear trend line indicated a statistically significant decrease (p 0.014) of 50.9% from a RR of 63.2% to 40.6%.

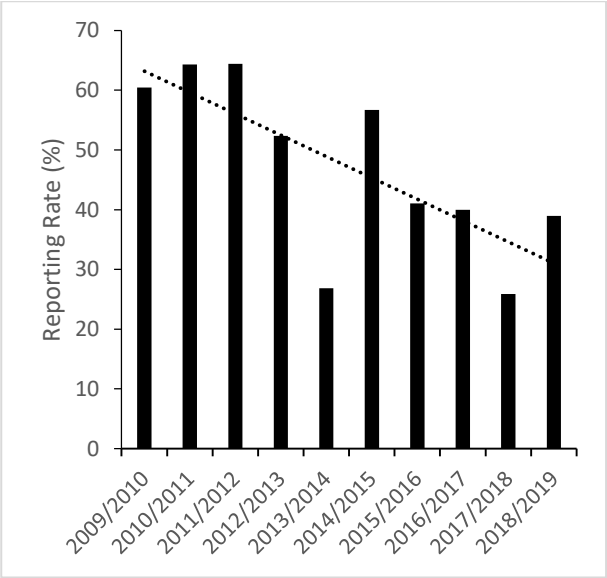

Figure 7. Variations in the breeding season Reporting Rates of the Pallid Cuckoos at Woodsong in north-east Tasmania (Birdata 500-m surveys of approximately 30 minutes duration conducted by Albert Nichols between September and January; 615 surveys).

The final data sets involve a five-year study on the South Arm peninsula near Hobart in south-east Tasmania (**Figure 8**). The overall RRs for the 2-ha and 500-m surveys were 32.0% and 54.1% respectively. Although the linear trends indicate the possibility of short-term decrease, they were not statistically significant.

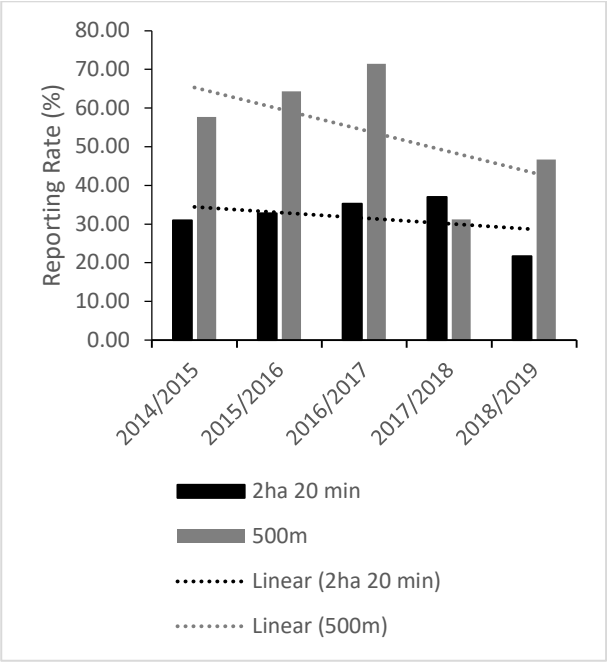

Figure 8. Breeding season Reporting Rates for the Pallid Cuckoo on the South Arm peninsula near Hobart in south-east Tasmania for monthly Birdata 2-ha 20-min (n = 317) and 500-m 45-min (n = 85) surveys made over a five-year period.

In contrast, in the Meehan Range, 20 km north of the South Arm peninsula, the overall RR for Pallid Cuckoos in a comparable set of 2-ha surveys over the same five-year period was 6.1%.

DISCUSSION

Effective use of Birdata records to establish comparative measures of bird populations and their trajectories requires a knowledge of both the behaviour of the target species and the manner in which the data were generated. In evaluating 20-year sets of citizen science data there is an inherent risk that changes in bird populations inferred from RR trends may in part relate to changes to the manner in which the data were collected. Data biases and measures taken to decrease them have been described earlier.

Timing of breeding season

The Pallid Cuckoo is a breeding season visitor to both the Hunter Region and Tasmania (Barrett *et al*. 2003) with most records in both regions occurring between September and January (**Figure 1**). The shape of the seasonal distributions suggests that the breeding season in the Hunter Region (32°S) is slightly earlier than in Tasmania (42°S), as would be expected given the latter region's more southerly latitude.

The seasonal variation of the RRs in **Figure 1** suggests that Pallid Cuckoo only spend about one third of their year in their southern breeding range. Most adults are thought to depart before the juveniles (Higgins 1999), but some remain and may assist the host to feed juveniles (Kikkawa & Dwyer 1962), in order to facilitate the transition from the food supplied by the host to the diet of independent Pallid Cuckoo (e.g. hairy caterpillars).

Reporting Rates are higher in Tasmania

During the breeding season RRs were higher in Tasmania than in the Hunter Region (**Figure 1**). This conclusion was found for all three survey types throughout the 21-year period of this study (**Table 1**) and these differences were highly significant statistically (p <0.01). Indeed, breeding season RRs in Tasmania are the highest in Australia (Barrett *et al*. 2003). The obvious conclusion is that the Pallid Cuckoo breeds more successfully at more southerly latitudes which may reflect on the quality of habitat for both the cuckoos and their hosts.

Regional trends

The statistically significant decline at the regional scale in the Hunter Region (**Figure 2** and **Table 1**) is supported by declines found in long-term studies at Green Wattle Creek (**Figure 3**) and Black Rock Road (**Figure 4**). Balickera, the third long-term data source in the central Hunter Region (**Figure 3**) provides evidence for the ongoing presence of Pallid Cuckoo at high RRs post-2002/2003 when the species had declined at the other sites. However, because the Balickera records were accumulated throughout the month they are not directly comparable with the other two data sets which involved surveys conducted during one day with duration of up to 240 minutes. When records are conducted over protracted periods, as at Balickera, the RRs of sparse species increase and it is not possible to detect changes in their status. Indeed, the RR levels do not even provide evidence that the Pallid Cuckoo was more common at Balickera than at the other two locations. Collectively, the records at these three survey sites, which are within a 10-km radius of each other in the central Hunter Region, indicate the persistent presence of Pallid Cuckoo at low RR levels, making it difficult to determine statistically reliable population trends. At Green Wattle Creek changes in the habitat to less-open woodland after cattle grazing ceased may have contributed to the observed decrease in RR (Newman & Cunningham 2018).

In contrast, the Tasmanian regional data (**Figure 2** and **Table 1**) indicates a statistically significant increase in the RR of the Pallid Cuckoo. However, long-term trends at individual survey sites (**Figures 6** and **7**) suggest that the Pallid Cuckoo population was either stable (Lake Llewellyn) or had declined (Cuprona Road and Woodsong). As there was no evidence of increases in RR at individual sites, it is concluded that the apparent increases at the regional scale probably were anomalous, a consequence of uncorrected survey bias. For instance, the period 1998 to 2002 involved data acquisition for the New Atlas with an emphasis on achieving widespread regional coverage (i.e. conducting surveys throughout the state). During the subsequent monitoring phase there was more emphasis on repeat surveys at a smaller number of sites (i.e. spatial coverage decreased). Woodsong (500-m surveys) and South Arm (2-ha and 500-m surveys) are examples of large subsets of data in the second decade of the study, conducted in habitat supporting Pallid Cuckoo at high RR levels. No correction was made for the increased proportion of Pallid Cuckoo records from these survey sites.

Similar biases almost certainly exist in the Hunter Region. As both the regional and individual site trends suggest a declining population trajectory, this provides a degree of confidence in the conclusion that the Pallid Cuckoo is declining in that region. Support for this conclusion is provided by the decreasing trend for NSW found by Cooper *et al*. (2016).

A comparison between the First Atlas and the New Atlas data suggested that a redistribution of Pallid Cuckoos had occurred between bioregions (Barrett *et al*. 2003). The statistically significant correlation between the increase in RR in Tasmania and the decrease in the Hunter Region is consistent with a population shift to more southerly latitudes. However, this evidence must be treated with caution in view of the issues with uncorrected bias in the Tasmanian regional trends. Nevertheless, Pallid Cuckoo populations have clearly been more resilient in Tasmania than in the Hunter Region during the last 20 years.

Local changes in Reporting Rates

Local changes in RR, either at individual survey sites (e.g. Green Wattle Creek in the Hunter Region; Lake Llewellyn in Tasmania), or locations (e.g. South Arm peninsula), might appear to provide our most reliable insights into changes in the status of the Pallid Cuckoo, but even these indicators need cautious interpretation.

If the breeding season home ranges of the Pallid Cuckoo are similar to the mean magnitude of 130 km^2 recently established for the Common Cuckoo in Scandinavia (Williams *et al*. 2016) they will be of similar magnitude or exceed the size of the Birdata 5-km survey method. However, during 5-km surveys the area actually sampled usually is relatively small (e.g. in the range 2.5 km^2 to 5 km^2 with a duration of approximately 240 minutes at the north-west Tasmanian survey sites). During surveys the probability of an observer encountering a Pallid Cuckoo moving around its home range, particularly males which call frequently, is increased by the duration of the survey and the area of habitat sampled. Hence, as demonstrated in **Table 1**, RRs are expected to be higher in 5-km surveys. The following discussion contrasts the results of long-term data sets involving similar types of surveys in the two regions.

The long-term Birdata 5-km surveys at Black Rock Road in the Hunter Region (**Figure 4**), and Lake Llewellyn and Cuprona Road in Tasmania (**Figure**

6) were conducted in a similar manner. Other than some clearing of roadside trees at Black Rock Road there was little habitat modification or change in land use at any of the sites. Thus, the differences in the magnitudes and trends of RRs at those sites reflect local differences in the occurrence of Pallid Cuckoo as opposed to survey methodology.

At Black Rock Road the RR for the Pallid Cuckoo was 40.7% for the period 1998/1999 to 2001/2002 when it was most regularly recorded (**Figure 4**). This was lower than at the sites in north-west Tasmania discussed above (**Figure 6**). This suggests that the home ranges of the Pallid Cuckoo were larger in the Hunter than in Tasmania and that habitat was less suitable, either in terms of providing sufficient brood hosts, or food for the adult cuckoos. The area surveyed at Black Rock Road involved land cleared for cattle grazing resulting in a landscape with highly fragmented remnant woodland. After 2001/2002 Pallid Cuckoo was seldom recorded. During this period the area was slowly developed for low-density residential dwellings and ongoing clearing of roadside trees and woodland occurred. This may have been detrimental as Pallid Cuckoos favour woodland edges in heterogeneous landscapes. Williams *et al*. (2016) suggest that the home range of the Common Cuckoo increases as woodland cover decreases. Although there was some evidence of a long-term decrease at one of the two north-west Tasmanian sites, overall the status of the Pallid Cuckoo was remarkably similar at the two sites with RRs of 59.7% and 58.8%. These were approximately 2.5 times higher than that at Black Rock Road. Short-term fluctuations in annual RRs at Lake Llewellyn and Cuprona Road were synchronous. The observed annual variations are consistent with the hypothesis that the Pallid Cuckoo has a home range larger than the areas surveyed at those locations. For instance, it is known that cuckoos avoid continual exploitation of hosts at the same location every year in order to prevent hosts from developing tactics which decrease the cuckoo's breeding success (Davies 2015). Hence, these short-term fluctuations in annual RRs may reflect changes in the Pallid Cuckoo's movements within its home range rather than an increase in the size of the home range and a decrease in abundance at the regional scale.

At Green Wattle Creek, which is approximately 10 km from Black Rock Road, the area surveyed (0.5 km^2) was smaller and the duration slightly longer (200 minutes). Initially RRs (42.9%) were similar to Black Rock Road, subsequently decreasing, but to a lesser extent (RR 20%) than at Black Rock Road (RR 9%, for the period post 2001/2002). At Green Wattle Creek the area surveyed was within lightly grazed continuous woodland with little understorey other than along creek lines. The Pallid Cuckoo records were exclusively outside the four embedded 2-ha survey sites which were located in areas of denser vegetation. The absence of the Pallid Cuckoo from the 2-ha survey sites is consistent with the species' preference for open woodland and forest edges (Shields *et al*. 1985). The area surrounding the Green Wattle Creek Reserve is a combination of land cleared for cattle grazing which was being progressively developed for acreage residential dwelling. The removal of cattle from the Green Wattle Creek woodland resulted in an increase in understorey vegetation, which is less suitable for Pallid Cuckoo (Shields *et al*. 1985). In addition, the continual removal of tree cover and increasing fragmentation of the landscape surrounding the Green Wattle Creek woodland would be expected to increase the home range of any Pallid Cuckoo frequenting the area.

Before European settlement the central Hunter Region landscape was probably dominated by forest with wet understorey and hence largely unsuitable for the Pallid Cuckoo. Forest clearing for agriculture provided a mosaic of open spaces favouring Pallid Cuckoo, which further benefitted when cattle grazed within woodland and removed understorey. However, during the past 20 years changes in the management of the landscape, including ongoing clearing of remnant woodland and removing cattle from State Forest and reserves, have contributed to regional scale changes in the vegetation structure which are unfavourable to the Pallid Cuckoo. Indeed, in NSW a passive parks management style, involving a philosophy of reversion to wilderness, may be detrimental to the status of some species, including the Pallid Cuckoo (see Newman & Cunningham 2018). Other factors such as drought may have contributed to the Pallid Cuckoo becoming less common, both directly, and indirectly through declines in their brood host populations. In the area surrounding Paterson in the central Hunter Region the Pallid Cuckoo is regularly present as evidenced by the records at Balickera (**Figure 3**). Collectively, records at these central Hunter sites are consistent with a scenario in which the breeding season home ranges of the Pallid Cuckoo have increased as conditions and habitat became less favourable. Consequently, Pallid Cuckoo now move more widely within their extended home range seeking brood hosts, food and places to roost. Hence, it is encountered less frequently by bird watchers.

The relatively high RR levels for the area around Medhurst Bridge for data involving a combination of survey types (**Figure 5**) provide tentative support for the view that the Pallid Cuckoo is more common in the western areas of the Hunter Region, particularly in the last decade. Unfortunately, there are no long-term data sets involving standardised data collection. While contemporary RRs may be higher than at survey sites in the central Hunter Region, they are well below those in Tasmania at sites where survey duration was similar (e.g. Woodsong - **Figure 7**, and South Arm - **Figure 8**). The increases apparent for the period 2016/2019 in **Figure 5** and noted elsewhere in the Hunter Region correspond to a period of drought in inland NSW. This suggests that the Hunter Region may act as a drought refuge for the Pallid Cuckoo. Evidence for periodic shifts in the distribution of the Pallid Cuckoo was identified in the comparison of the two national Atlases (Barrett *et al*. 2003). How displaced birds will be accommodated when moving to a region where resources already appear sub-optimal is an intriguing question. In addition, a cuckoo displaced from an inland to a coastal bioregion may have difficulty finding suitable brood hosts, because it is adapted to exploiting species which are either absent or scarce in the region to which it has moved.

The RRs for surveys of generally similar duration at Woodsong and South Arm in Tasmania were much higher than in the Medhurst Bridge area of the Hunter Region. At both Medhurst Bridge and Woodsong there were long-term decreases in RR. The statistically significant decade-long decrease at Woodsong commencing 2009/2010 (**Figure 7**) included an abnormally low RR of 26.9% in the 2013/2014 breeding season which was 44% lower than the linear trend line value and outside the 95% confidence interval. Various explanations are possible for this anomalous decrease including the previously mentioned strategy of cuckoos periodically using hosts from a different part of their home range in order to prevent their hosts becoming habituated to their presence (Davies 2015). Fires in the area surrounding Woodsong may have resulted in a loss of resources and caused the home range to increase, thus contributing to the long-term decrease in RR (i.e. as the home range increases cuckoos are recorded less frequently on a pro rata basis). For the above reasons the observed trends may be local and not necessarily representative of the regional situation.

The timing of the decrease at Medhurst Bridge (**Figure 5**) may be related to periods of drought in 2002 and 2006 that resulted in the decline of a number of bird species in that area (Tarrant 2008). In addition to decreasing the food available to adult Pallid Cuckoo, host species may have struggled to fulfil the voracious appetites of young cuckoos causing poor breeding success. Over a five-year period commencing 2014/2015 Pallid Cuckoo RRs were 32.0% and 58.3% for 2-ha (12 sites) and 500-m (3 sites) surveys conducted on the South Arm peninsula at monthly intervals during the breeding season. This corresponded to recording a Pallid Cuckoo on average at least once every 61 minutes in 2-ha surveys and every 77 minutes in 500-m surveys. These rates of occurrence were similar to Woodsong where a Pallid Cuckoo was recorded on average at least once every 68 minutes in 500-m surveys of similar duration. As very large data sets were involved the results provide a benchmark against which populations at other locations can be compared.

It is important to understand the features of these woodland areas in eastern Tasmania which provide suitable, perhaps optimal habitat for the Pallid Cuckoo. At South Arm the sites were in remnant woodland with a very open structure, particularly along ridge lines where there is minimal understorey. Small dams collecting run-off have increased water availability and this may have benefitted host species. Several instances of successful breeding were noted, involving Black-headed Honeyeater hosts feeding fledged young. The overall conclusion is that the home ranges of Pallid Cuckoo in the open dry woodland in eastern Tasmania are smaller than in the Hunter Region. Arguably this may be the bench-mark habitat for the species. Unfortunately, there are no comparable historical data that can be used to determine whether the contemporary South Arm population has increased recently; for instance, as a consequence of an influx of Pallid Cuckoo from the Australian mainland to Tasmania.

Selecting survey methods

In the above analysis it was advantageous to be able to draw on data from a range of survey types as outlined below.

The standardised 2-ha surveys provide the most reliable data provided that the cuckoos were frequently recorded as exemplified by the survey sets at South Arm and the Meehan Range in Tasmania. However, in the Hunter Region where the cuckoos were less common, 2-ha data sets contained insufficient observations for statistically meaningful conclusions to be drawn.

Birdata 500-m and 5-km surveys sample larger areas for extended periods of time and not surprisingly the Pallid Cuckoo was encountered more often in these surveys resulting in more records and higher RRs (**Table 1**). These surveys proved invaluable for the analyses in the Hunter Region during periods when the Pallid Cuckoo was scarce. The problem with these surveys in regional-scale assessments is that they involve variable survey effort (i.e. the duration of the survey and the area sampled within the nominal search area change between survey sites). However, repeat surveys under replicated conditions by the same observer involve constant survey effort and provide reliable trend data at individual locations. For detecting the Pallid Cuckoo, variation in survey duration appears more important than the size of the area searched and potentially provides a method of comparing surveys involving different survey effort. This possibility may be unique to the evaluation of species such as the Pallid Cuckoo where home ranges are much larger than the area surveyed.

When the Pallid Cuckoo is regularly present, long-duration surveys become insensitive to changes in status (e.g. Lake Llewellyn in NW Tasmania and Balickera). Variations in annual RR may be a consequence of local factors as opposed to changes in the status of the species at the landscape scale. When the Pallid Cuckoo is very uncommon, extremely long duration surveys, such as lists accumulated throughout the month at Balickera, provide evidence of the ongoing presence of the species in the area.

Intensive survey campaigns at single locations (e.g. South Arm and Woodsong) can skew the results of regional trends, for instance, by over-representing the dry open woodland habitat preferred by Pallid Cuckoo. This may have contributed to or even caused the apparent increase in the population status of the Pallid Cuckoo at regional scale in Tasmania (**Figure 1** and **Table 1**).

Breeding

As juvenile Pallid Cuckoos are very noisy when begging food from their brood host (the author's unpublished observations), it is surprising that there are so few breeding records in the Hunter Region (Stuart 1993–2018). This lack of breeding records is consistent with Pallid Cuckoo being a sparse species with large home ranges in the breeding season.

In dry woodland on the South Arm peninsula in Tasmania the RR for the Pallid Cuckoo was double that of its known host at that location, the Black-headed Honeyeater. In adjacent more open habitat, the RR for the Pallid Cuckoo was four times that of the Black-headed Honeyeater (M. Newman unpublished results). These results are consistent with the theory that the breeding season home range needs to include the habitat preferences of both the host (dry woodland) and the cuckoo (more open lightly timbered country). Although considerably less numerous, the extremely vocal and mobile Pallid Cuckoo has a higher detectability and hence a higher RR than its host.

CONCLUSIONS

The Pallid Cuckoo is a summer breeding visitor to both the Hunter Region of NSW and Tasmania. Most records are between September and January, when it is more vocal and easily detected.

Reporting Rates derived from survey records in the BirdLife Australia database (Birdata) suggest that the Pallid Cuckoo is more numerous in Tasmania than in the Hunter Region.

Evidence that the Pallid Cuckoo has declined in the Hunter Region during the last twenty years was found to be statistically significant. This conclusion at the regional scale is supported by local trends where surveys were conducted in a consistent manner by the same observer. The correspondence between the local and regional trends alleviated concerns that the regional trends might reflect changes in the style of data collection, rather than the status of the Pallid Cuckoo.

In Tasmania the regional-scale trends suggested that the Pallid Cuckoo has become more common. However, some local trends indicated that its RR was decreasing, although remaining at levels well in excess of those in the Hunter Region. The regional scale increases in Tasmania, although statistically significant, were, at least in part, a consequence of increases in the proportion of surveys conducted in the dry woodland habitat preferred by Pallid Cuckoo during the second decade of this study. Consequently, the conclusion that the species has increased regionally in Tasmania may be unsound and needs to be confirmed by more sophisticated analysis involving corrections for biases in survey effort across habitat types.

It is probable that during the breeding season the Pallid Cuckoo has large home ranges in which it seeks brood hosts as well as food and roost sites. Decreases in Pallid Cuckoo reporting rates may

reflect changes in the status of their brood-host species. There are few records of Pallid Cuckoo breeding in the Hunter Region, which is consistent with large home ranges and low RRs.

Pallid Cuckoo favour fragmented landscapes with high levels of open woodland cover, but without moist understorey vegetation. In the Paterson area of the central Hunter Region, ongoing clearing of remnant woodland and destocking of previously grazed woodland may have contributed to the Pallid Cuckoo's decline. Peak RRs in Tasmania were found in open dry sclerophyll where extensive tree cover had been retained in a fragmented landscape, supporting the above conclusion that the moister forest of the Hunter Region may provide less suitable habitat for the Pallid Cuckoo.

No conclusions were reached concerning the extent to which hotter drier breeding season conditions contribute to the differences in the abundance of Pallid Cuckoo between the two regions or to the decline in the Pallid Cuckoo's status in the Hunter Region.

The analysis presented in this paper benefitted from the availability of data generated by a range of survey methods. Long-term repeat surveys at individual locations provided valuable insights into the reliability of regional-scale trends as well as the habitat preferences and breeding season lifestyle of the cuckoos. However, local trends may not be representative of changes in status at the landscape scale.

ACKNOWLEDGEMENTS

Many people in the Hunter Region and Tasmania contributed their time to collecting Birdata. All are thanked, but especially Richard Ashby (Figure 6), Albert Nichols (Figure 7) and Jenny Musicka (Figure 3) whose long-term data provide valuable insights into the interpretation of regional trends. My estimate suggests that Richard Ashby walked 8000 km at his sites in north-west Tasmania. I have just found that Albert Nichols used to live in East Maitland, a connection made through writing this paper. Eric Woehler is thanked for providing regression analyses. Alan Stuart encouraged me to write this paper and is thanked for a stimulating and rewarding challenge. At the outset it seemed a simple assignment, but nothing is ever straight forward with cuckoos! An anonymous referee is thanked for a number of helpful comments.

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Foraging behaviour by Grey Fantail at the Sugarloaf State Conservation Area, NSW

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Received 12 August 2019; accepted 30 August 2019; published on-line 2 September 2019

Over the past several years I have regularly visited a study site in the Sugarloaf State Conservation Area, near Wakefield, NSW. On three of my visits I have observed a foraging interaction involving a Grey Fantail *Rhipidura fuliginosa* and a White-throated Treecreeper *Cormobates leucophaea*. The behaviour of each bird was quite similar on each occasion, suggesting that the interaction of the two species was not unusual.

The habitat at the site where the interactions have occurred is dry sclerophyll forest containing Smooth-barked Apple *Angophora costata*, Black She-oak *Allocasuarina littoralis*, Red Bloodwood *Corymbia gummifera*, Ironbark *Eucalyptus sideroxylon* and Sydney Peppermint *Eucalyptus piperita*, with understorey vegetation that includes Sandpaper Fig *Ficus coronata*, Lantana *Lantana camara* and various grasses.

The dates of my observations were 15 March 2015, 20 March 2016 and 19 January 2019. My notes from the first observed interaction are reported below. The behaviours of both species were very similar on the two other occasions. Early morning on 15 March 2015 a White-throated Treecreeper flitted past at close quarters to me and landed low on the trunk of a nearby mature Ironbark. The treecreeper was followed by a Grey Fantail which landed in a Sandpaper Fig next to the Ironbark. The treecreeper proceeded to climb the trunk of the Ironbark, foraging and pulling off pieces of bark. The fantail left its perch and flew over to the treecreeper and began to follow it, often within a few centimetres of the bird as it climbed the tree searching for morsels. This behaviour continued for at least a minute until the treecreeper reached a height of approximately 6 m when it then flew on to the next tree. The Grey Fantail closely followed and again proceeded to track the treecreeper's movement up the tree before becoming lost from my sight.

The Grey Fantail was gathering small winged insects that had escaped the attention of the treecreeper as it foraged. The treecreeper did not appear to be bothered in any way. On all three occasions when I have observed this behaviour, the White-throated Treecreeper seemed completely at ease with the Grey Fantail's presence.

There was a clear benefit for the Grey Fantail from this foraging behaviour but there seems no apparent benefit for the White-throated Treecreeper. This form of one-way benefit feeding association is known as commensalism (Campbell & Lack 1985). It may in fact be a characteristic behaviour by the Grey Fantail. For example, in a study in the Maclean River valley in northern NSW, a fantail followed either a treecreeper or a Brown Gerygone *Gerygone mouki* on five occasions, staying within 1 m and catching insects flushed by the lead bird (Cameron 1975). Similarly, a Grey Fantail in Tasmania was observed to shadow a foraging Scrubtit *Acanthornis magna* in the same manner as described above (M. Newman pers. comm.). The Grey Fantail is also well known to forage around farm animals (such as horses and cattle) and people, catching insects flushed by them (Higgins *et al*. 2006).

Commensalism, although uncommon, is practised by some other avian species. For example, the Pilotbird *Pycnoptilus floccosus* is known to track the movements of the Superb Lyrebird *Menura novaehollandiae*, collecting food displaced during the lyrebird's scratching. The Yellow-throated Scrubwren *Sericornis citreogularis* has been observed following both Superb Lyrebird and Australian Logrunner *Orthonyx temminckii* (Higgins & Peter 2002). Hoary-headed Grebe *Poliocephalus poliocephalus* has been recorded following Hardhead *Aythya australis* when the latter was diving for aquatic plants and animals (Roderick & Newman 2013).

The Grey Fantail often joins mixed-species feeding flocks, usually of other small insectivorous passerines. The way that these mixed flocks interact is not well studied. Higgins *et al*. (2006) list more than 30 species which the Grey Fantail sometimes associates with in mixed flocks, including the White-throated Treecreeper and more than 20 other Australian species as well as several in New Zealand (where the nominate race of Grey Fantail occurs). Association with other species in mixed-species feeding flocks is recorded more often in the non-breeding season (Higgins *et al*. 2006). It is notable that my observations of commensalism by Grey Fantail have occurred in January and March, presumably still within the breeding season although probably closer towards the end of it (especially with the March observations). This suggests that commensalism may be a common behaviour by the Grey Fantail, and may occur when it forages with other species in mixed feeding flocks.

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Note added in proof: At 1410 on Saturday 31 August 2019 at the same location within the Sugarloaf State Conservation Area, I and a colleague witnessed two additional instances of commensalism by a Grey Fantail with a White-throated Treecreeper. Both instances happened within a mixed-species feeding flock of approximately 30 birds containing Grey Fantail, thornbills, Golden Whistler *Pachycephala pectoralis*, Spotted Pardalote *Pardalotus punctatus* and White-throated Treecreeper. As the flock moved slowly through the lower canopy, two different fantails could clearly be seen to be following 'their own' White-throated Treecreeper while it foraged.

A review of the Sooty Oystercatcher on the Hunter Region coastline of New South Wales, Australia

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Received 2 June 2019; accepted 6 September 2019; published on-line 29 September 2019

Data compiled from annual bird reports by the Hunter Bird Observers Club, and from surveys archived in the BirdLife Australia national database, Birdata, were used to review the history and current status of the Sooty Oystercatcher *Haematopus fuliginosus* along the Hunter Region coastline of New South Wales. The Hunter population is stable and comprises approximately 150 birds. Small, scattered groups of birds were found to occur along many rocky sections of the region's coastline. Two major mainland concentrations were identified; one was based at the Newcastle Rock Platforms (with peak counts 48-52 birds in recent years) and the other in Port Stephens (with peak counts 31-52 birds in recent years). Another population of 20-30 birds is based offshore, on Broughton Island.

A timeline of offshore sightings and breeding records was assembled in order to quantify local nesting activity by Sooty Oystercatcher. There are several breeding records from Cabbage Tree Island and occasional reports of breeding from within the Broughton Island Group and elsewhere.

Findings from the Hunter Region data were compared with studies conducted on southern (Wollongong to the Victorian border) and northern (South Ballina Beach to Sawtell) sections of the NSW coast. Similarities relating to population growth, habitat selection, breeding behaviour and social behaviour were found and are discussed.

INTRODUCTION

The Sooty Oystercatcher *Haematopus fuliginosus*, a species endemic to Australia, occurs in widespread, low-density populations along rocky mainland coasts and offshore islands all around Australia (Marchant & Higgins 1993; Geering *et al.* 2007). There are two phenotypically similar sub-species, *H. f. opthalmicus* and *H f. fuliginosus*. While not listed as threatened nationally the nominate subspecies *H. f. fuliginosus*, which predominates south of the Tropic of Capricorn, is listed as Rare in Queensland and South Australia, Near Threatened in Victoria and Vulnerable in NSW, where a low population is distributed within a limited ecological habitat (NSW Scientific Committee 2008; Harrison 2009; NPWS 2018).

Compared to its international counterparts the Sooty Oystercatcher is one of the least studied oystercatchers in the world (Harrison 2009). Inconsistent survey efforts have produced a largely uninformative database, making long-term population trends difficult to predict (Harrison 2009; Hansen *et al.* 2014). Their dependence upon rugged habitat along the coastal mainland, and breeding territory on rocky offshore islands, makes finding and monitoring nests difficult and hazardous. As a result, nests are seldom found and rarely studied, and data related to nest behaviour and chick survival remain elusive (Marchant & Higgins 1993; Ens & Underhill 2014; Hansen *et al.* 2014). Oystercatchers generally, are a long-lived species (possibly 40 years) with a suggested adult survival rate of 90%, but their longevity is offset by low clutch size, high chick mortality, slow transition to adulthood (estimates range from 3.6 to 6.9 years) and limited breeding habitat (Newman 1992; Harrison 2009; Ens & Underhill 2014).

Maturing birds must relocate to non-territorial areas that provide conditions required for young birds to achieve breeding status (Ens & Underhill 2014; Hansen *et al.* 2014). How and where young birds manage to find safe areas in which to spend their adolescent years is not well understood, some locations may be far removed from natal breeding territories (Ens & Underhill 2014; Hansen *et al.* 2014). Estuarine habitats, which provide shelter and nutritional diversity, may play an important role in the early development of oystercatchers (Hansen *et al.* 2014).

National distribution and population trends

National survey data indicate that population density is more concentrated in northern Tasmania, the Bass Strait islands and southern Victoria (Close 2008; Hansen *et al.* 2014). An estimated total population of 4,000 birds, which was proposed in 1993, was unchanged in 2018 (Watkins 1993; Delany & Scott 2006; Wetlands International 2018).

Small groups of Sooty Oystercatcher occur along the entire NSW coastline, particularly in locations where offshore islands occur in close proximity to rocky coastal headlands (Marchant & Higgins 1993; NSW Scientific Committee 2008; Cooper *et al.* 2014; Hansen *et al.* 2014). Based on previous population estimates (Watkins 1993; Delany & Scott 2006), the NSW Scientific Committee estimated that the state's population in 2008 was 600-800 birds, of which 400 birds were thought to be mature, and with the breeding population estimated to be less than 200 birds (NSW Scientific Committee 2008).

There are indications that the NSW population of Sooty Oystercatcher is increasing. Monitoring by the South Coast Shorebird Recovery Programme found an increased presence of Sooty Oystercatcher along southern sections of the NSW coast, and also identified areas where breeding occurred on associated offshore islands (Dunn & Harris 2009; Jarman 2010). In a PhD thesis focussed on the northern NSW coastline population, Harrison (2009) suggested the possibility that the northern population was expanding. A study of threatened species in the Hunter Region concluded that the local Sooty Oystercatcher population was stable and perhaps increasing (Roderick & Stuart 2016). Also, data from both the NSW and Australian Atlas show an increase in Reporting Rates, which supports an assumption of population stability and perhaps population increase in NSW (Cooper *et al*. 2014; BirdLife Australia: accessed 20 August 2018).

Objectives of the present study

Early records for Sooty Oystercatchers along the Hunter coast were sparse and therefore were unlikely to have had any major impact on the national and state population estimates established in 1991 and reassessed in 2008 (Watkins 1993; NSW Scientific Committee 2008). However, in the past 10-15 years, a more regular survey effort has suggested the existence of a significant, and stable or increasing, Hunter Region population (Stuart 1994-2017; Roderick & Stuart 2016). The aim for the present study was to assess more carefully the status of Sooty Oystercatcher in the Hunter Region. By locating and collating current and archival data, the study aims to: describe the known history of the Sooty Oystercatcher in the Hunter Region; assess population trends and seasonal movements; detail the known local breeding areas; document observed behavioural characteristics. Finally, by comparing the study's findings with research conducted in other coastal regions, the study aims to enhance overall understandings about the status of the Sooty Oystercatcher along coastal NSW.

METHODS

Study area

The study area comprises approximately 200 km of coastline lying from just north of the Manning River, near Harrington (31º52'35"S; 152º42'09"E), and Bird Island (32º21'45"S; 151º30'13"E), near The Entrance. Bird Island lies slightly south of the boundary for the Hunter Region. The coastal geography consists of long sandy beaches interspersed by rocky headlands, rocky outcrops and rock platforms, and three large estuaries (on the lower Manning and lower Hunter Rivers, and in Port Stephens).

Port Stephens, the largest tide-dominated estuary in NSW, has proved to be an important mainland site for Sooty Oystercatcher. It lies approximately equidistant from the northern and southern study boundaries. The Port Stephens estuary is divided into two distinct basins: a western fluvial basin and an eastern marine basin. It is a very popular tourist destination, and hence the disturbance potential is high.

Another important mainland roost site is the Newcastle Rock Platforms. These are located south of the mouth of the Hunter River, adjacent to the major city of Newcastle, with a population of approximately 600,000 people (World Population Review: accessed 22 February 2019). The Rock Platforms are a year-round recreation area; again, the disturbance potential there is high.

The study area also includes offshore islands, from the Broughton Island group (located at 32º36'17"S; 152º18'24"E) south to Bird Island. The islands have areas ranging between 0.9 ha and 132 ha, and elevations ranging from 10 m to 123 m. Most are extensively vegetated, and all lie within 4 km of the mainland. Details about the offshore islands are presented in **Table 1**.

Data sources and data management

All known Hunter records were tabulated and the comments of survey participants were considered in an effort to establish the extent of the current Hunter population, their movement patterns, and their behavioural characteristics. Data for the Hunter Region polygon were retrieved from Birdata (https://birdata.birdlife.org.au) and exported to an Excel spreadsheet. The spreadsheet then was supplemented with data for Sooty Oystercatcher published in the Hunter Region Annual Bird Report series (Stuart 1994-2017) and by my own observations. A general literature search was conducted to assemble specific species information. Studies conducted to the north and south of the Hunter study area were examined for similarities related to population size, habitat, nesting, and behavioural characteristics.

Data from the "Seabird Island" series published in the journal *Corella* (see specific references in later sections, including in **Table 3**) together with comments from visiting birdwatchers were used to develop an historical timeline for Sooty Oystercatcher on offshore islands. The primary focus of these island visits always was the study of nesting seabirds, but references to Sooty Oystercatcher were found in some report addendums listing "Other Birds".
Geographical and topographical details relating to offshore islands were sourced from the "Seabird Island" series and National Parks & Wildlife Service websites. Latitudes, longitudes and distances were calculated using Google Earth.

Table 1. Details of islands located off the Hunter Region coastline and the estimated flying distances to mainland destinations*.

Island Name	Area (ha)	Altitude (m)	Vegetation (ha)	Distance# (km)				References
				Mainland	Port Stephens	Hunter Estuary	Newcastle Rock Pl	
Broughton Is Group:				3.8	25.4	59.9	60.7	
Broughton	132	91	117					Carlile *et al.* 2012
Little Broughton	27.4	98	19					Carlile *et al.* 2013c
Looking Glass	4	69	~1					Carlile *et al.* 2013a
Gandja-Baa	1.4	31	0.4					Carlile *et al.* 2013e
North Rock	2.4	23	1					Carlile *et al.* 2013d
Inner Rock	0.9	10	0.3					Carlile *et al.* 2013b
Cabbage Tree	26.3	123	veg.	1.6	15.3	49.1	49.7	Priddel & Carlile 2004b
Boondelbah	9.3	55	veg.	2.1	15.6	48.1	49.5	Priddel & Carlile 2004a
Little	4	Unknown	veg.	3.2	16.8	47.4	49.1	NSW Dept.Primary Ind 2018
Moon	2.25	10	0.36	0.7	56.7	22.4	20.0	NSW NPWS 2005
Bird (Central Coast)	7.3	20	veg.	1.5	74.4	40.5	37.7	Lane 1973

* Flying distance from Broughton Island and other islands within the archipelago was measured from the centre of Broughton Island. Soldiers Point was selected as the approx. mid-estuary destination point for the Port Stephens Estuary. (Google Earth: accessed 15 December 2018)
# Flying distance measured from the centre of each island to the nearest mainland point, and to the three major mainland groups of Sooty Oystercatcher.

RESULTS

Early Hunter Region records were found to be scarce. The Sooty Oystercatcher was not mentioned in an extensive bird list compiled during a visit to Port Stephens in November 1928, when the entire length of the Myall River, the Port Stephens Estuary and Cabbage Tree Island were surveyed (Chisholm & Cayley 1929). However, the 1928 expedition did not visit Broughton Island where a sighting of one bird was later reported in January 1931 (Horden & Horden 1931). In 1987, when Lane identified the top twenty Sooty Oystercatcher sites in Australia, ranked on the presence of 20+ birds, no site on the Hunter coast was mentioned, and Hunter Region reports remained sporadic until 2008 (Lane 1987; Stuart 1994-2017).

The Hunter Bird Observers Club began shorebird surveys in the Hunter Estuary in 1999. By 2008 the survey programme had expanded to include the Port Stephens and Manning estuaries to the north, and the Lake Macquarie coastline to the south (Stuart 1994-2017; Stuart *et al.* 2013). In **Table 2** I

Table 2. Annual highest counts for Sooty Oystercatcher at regularly monitored locations on the Hunter Region coastline (2004-2017)*.

Year	North Coast	South Coast	Tomaree Head to Birubi	Port Stephens Estuary	Hunter Estuary	Newcastle Rock Platforms	Offshore Islands	Total	% of Total Aust. Est. Pop. (4,000)	% of Total NSW Est. Pop. (800)
2004	6	N/A	N/A	18	5	N/A	N/A	29	0.58	2.88
2005	5	5	N/A	5	8	N/A	8	31	0.33	1.63
2006	20	N/A	N/A	9	10	N/A	N/A	39	0.48	2.38
2007	N/A	9	N/A	11	11	N/A	6	37	0.55	2.75
2008	2	3	16	14	22	23	2	82	1.88	9.38
2009	4	1	12	13	21	36	7	94	2.18	10.88
2010	8	N/A	10	24	22	39	13	116	2.53	12.63
2011	8	N/A	16	19	12	38	14	107	2.38	11.88
2012	6	2	13	28	12	42	34	137	2.58	12.88
2013	4	N/A	9	42	7	48	20	130	2.70	13.50
2014	8	6	8	37	18	49	10	136	3.00	15.00
2015	5	2	8	52	18	49	24	158	3.23	16.13
2016	12	N/A	9	42	9	52	30	154	2.80	14.00
2017	1	N/A	9	31	14	49	20	124	2.63	12.88

*Main data are based on HBOC Annual Bird Reports 2004-2017 (Stuart 2005-2018). Highest counts for Port Stephens are based upon land and water-based surveys plus counts carried out by the author. N/A: no data available

have compiled data from the Annual Bird Reports for the main Hunter Region sites monitored from 2004 until 2017, the date of the most recent available Bird Report. Although it was rare that all sites were monitored in any given year, the data indicate a regional population of approximately 150 birds. That figure is equivalent to ~3% of the estimated total Australian population of 4,000 birds and more than 15% of the estimated NSW population of 800 birds. (Watkins 1993; Delany & Scott 2006; Wetlands International 2018).

Table 2 indicates that the population of Sooty Oystercatcher in the Hunter Region is increasing. Numbers have risen from occasional sightings, usually of 1-10 birds, to regular counts of larger numbers. There have been two major and regular mainland concentrations of birds – at the Newcastle Rock Platforms and in Port Stephens.

The largest aggregation of Sooty Oystercatcher has been at the Newcastle Rock Platforms where the highest monthly counts each year are now of 48-52 birds (**Table 2**). The group is mainly comprised of adult birds, but the size and composition of the flock varies in conjunction with the breeding season (Herbert 2007; R. Nicholas pers. comm.). **Figure 1**, which presents the recorded highest count for each month at the site, shows how the population of Sooty Oystercatcher at the Newcastle Rock Platforms varies during the year.

Numbers within the Port Stephens estuary have increased to more than 30 birds, making them the second largest group in the region (**Table 2**). Sooty Oystercatcher numbers generally were higher in the quieter, inner (western) fluvial basin, where they occur in small groups. Birds in the estuary's outer (eastern) marine basin were usually found in pairs (**Figures 2** and **3**)

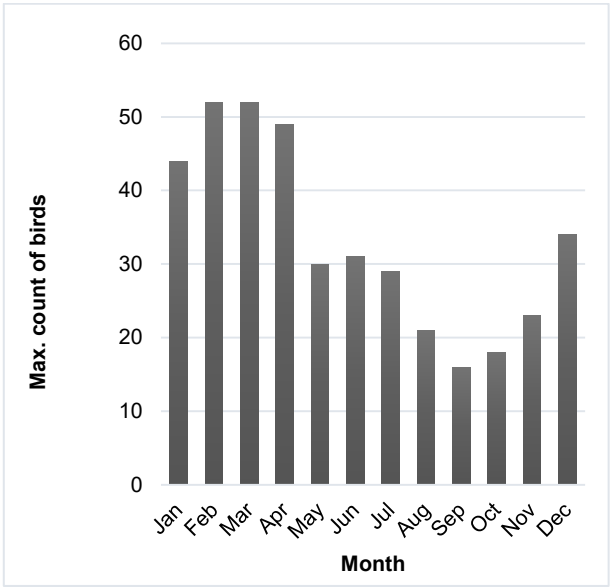

Figure 1. Maximum monthly counts for Sooty Oystercatcher at the Newcastle Rock Platforms, 1993-2017 (Source: Hunter Region Annual Bird Report series (Stuart 1994-2017)).

Although some sections of coastline with difficult access still remain unchecked, small scattered groups of Sooty Oystercatchers were regularly encountered along many of the rocky sections of the region's coastline. The importance of offshore islands should be noted, in particular Broughton Island where twice-yearly surveys from 2012 (Stuart *et al.* 2017) recorded increasing numbers of birds (**Table 2**).

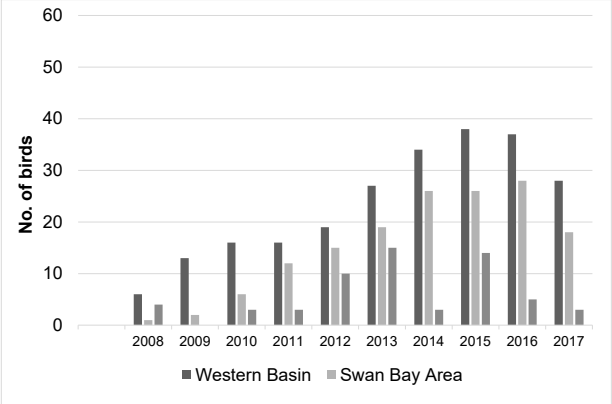

Figure 2. Population distribution of Sooty Oystercatcher in the Port Stephens estuary in summer (Sources: Hunter Bird Observers Club unpublished data and the author's personal records).

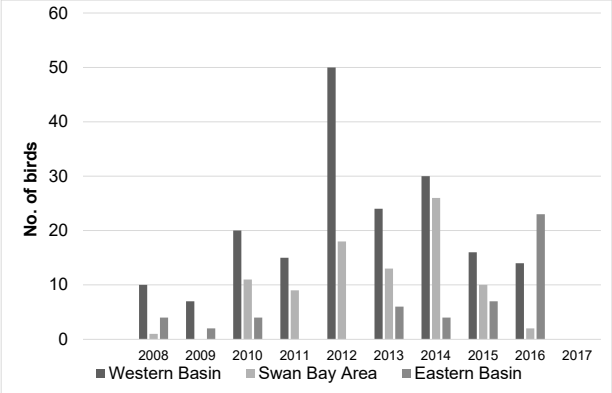

Figure 3. Population distribution of Sooty Oystercatcher in the Port Stephens estuary in winter (Sources: Hunter Bird Observers Club unpublished data and the author's personal records).

A timeline of records from offshore islands is presented in **Table 3**, along with details of any reports about birds breeding. Birds appear to have bred often on Cabbage Tree Island, with occasional reports of breeding within the Broughton Island Group and elsewhere.

DISCUSSION

Lane (1987) provides a reference point from which to anchor three decades (1987-2017) of Sooty Oystercatcher records in the Hunter Region, and to examine the resulting data against the backdrop of an ever expanding human population attracted to the Hunter coast by opportunities for commerce, tourism and retirement. During those thirty years the Sooty Oystercatcher population has risen from occasional sightings of 1 to 10 birds to regular counts of approximately 150 birds (**Table 2**).

Distribution of Sooty Oystercatcher in the Hunter Region

Sooty Oystercatcher is found along much of the mainland coast within the study area as well as in estuaries and on offshore islands. The main sites are detailed below.

Newcastle Rock Platforms

The largest concentration of Sooty Oystercatcher in the region has been at the Newcastle Rock Platforms. Intermittent monitoring revealed that their numbers increased steadily over 1987-2006, from 1-8 birds in 1987 to 11-26 birds in 2006 (Herbert 2007). Regular monitoring since 2008 has revealed a further population increase, and consistently high counts at the site now suggest a population in the non-breeding season of ~50 birds (**Table 2**). The group is mainly comprised of adult birds, but the size and composition of the flock varies in conjunction with the breeding season (Herbert 2007; R. Nicholas pers. comm.).

Sooty Oystercatchers are the main foraging shorebirds on the Newcastle Rock Platforms and their year-round persistence may indicate that, to date, the location's roosting and foraging opportunities offset the effects of human disturbance (Herbert 2007). While this adaptive behaviour may be seen as conducive to long-term survival, it should also be noted that shorebird roosting and foraging is dictated by the tide-cycle at a specific habitat. The cumulative stress from frequent disturbance, particularly when that disturbance disrupts and restricts foraging time, may be detrimental (Herbert 2007; Harrison 2009).

Port Stephens estuary

Early records of 1-3 birds in the estuary prior to 1994, and the highest counts of 10+ birds between 1994 and 2000, may not be a reliable reflection of the Sooty Oystercatcher population during that time,

Table 3. A timeline of sightings and breeding records for Sooty Oystercatcher on islands off the Hunter Region coastline.

Year	Date	Location	Breeding	Number of birds seen	Reported by	Where Published
1931	Jan	Broughton Is.		1	Horden & Horden	*The Emu* **31**: 21-26
1958-1970		Moon Is.	Nesting annually	1 pair	Gray & Gwynne	*Aust. Bird Bander* **12**: 36-37
1959	Dec 18-20	Broughton Is.		# unknown	Hindwood & D'Ombrain	*The Emu* **60**:3
1973	Apr 7-9	Broughton Is.		# unknown	S.G. Lane	*Aust. Bird Bander* **14**: 10-13
	Dec 10	North Rock		2 birds	S.G. Lane	*Aust. Bird Bander* **14**: 16-17
	Dec 8-11	Broughton Is.		# unknown	S.G. Lane	*Aust. Bird Bander* **14**: 10-13
1995	Dec 4-8	Cabbage Tree Is.		1-5 birds	Alan Morris	HBOC: *Ann. Bird Rept* No. **3**
1996	Dec 13-16	Cabbage Tree Is.		# unknown	Anon.	HBOC: *Ann. Bird Rept* No. **4**
1997	Dec 11-14	Cabbage Tree Is.		6+ birds	Graeme O'Connor	HBOC: *Ann. Bird Rept* No. **5**
	Dec 7	Moon Is.		1-5 birds	Jim Perry	HBOC: *Ann. Bird Rept* No. **5**
1998	Jan	Broughton Is.	Nest	7 birds w. dep. young	Chris Herbert & Liz Crawford	HBOC: *Ann. Bird Rept* No. **6** **1st confirmed breeding record**
1999	Jan	Broughton Is.	Nest	6 birds w. dep. young	Chris Herbert & Liz Crawford	HBOC: *Ann. Bird Rept* No. **7**
	Dec 10	Cabbage Tree Is.		1-2 birds	Cumberland Bird Observers	HBOC: *Ann. Bird Rept* No. **7**
	Dec 10	MLNP[1] (Broughton Is.?)		1-2 birds	Cumberland Bird Observers	HBOC: *Ann. Bird Rept* No. **7**
	Dec 22	MLNP[1] (Broughton Is.?)		1-2 birds	Michael Kearns	HBOC: *Ann. Bird Rept* No. **7**
2000	Feb 17	Broughton Is.		1-2 birds	Keith Laverick	HBOC: *Ann. Bird Rept* No. **8**
	Mar 23	Boondelbah Is.	Nesting	# unknown	Birds Australia Atlas Survey	HBOC: *Ann. Bird Rept* No. **8**
2002	Oct 10-12	Boondelbah Is.		# unknown	Priddel & Carlile	*Corella* **28**(4): 104-106
	Nov 22-23	Boondelbah Is.		# unknown	Priddel & Carlile	*Corella* **28**(4): 104-106
	Dec 16-17	Boondelbah Is.		# unknown (Presumed recorded on all visits)	Priddel & Carlile	*Corella* **28**(4): 104-106
	Nov 21-24	Cabbage Tree Is.	Reg. nesting	1-2 pairs	Priddel & Carlile	*Corella* **28**(4): 107-109
	Dec 2-6	Cabbage Tree Is.	Reg. nesting	1-2 pairs	Priddel & Carlile	*Corella* **28**(4): 107-109
	Dec 13-15	Cabbage Tree Is.	Reg. nesting	1-2 pairs (Presumed recorded on all visits)	Priddel & Carlile	*Corella* **28**(4): 107-109
2003	Feb 27	Boondelbah Is.		# unknown	Priddel & Carlile	*Corella* **28**(4): 104-106
	Feb 27	Cabbage Tree Is.	Reg. nesting	1-2 pairs	Priddel & Carlile	*Corella* **28**(4): 107-109
2005	Jan 9-10	Broughton Is.	Nesting	6-8 birds	Chris Herbert & Liz Crawford	HBOC: *Ann. Bird Rept* No. **13**
2007	Feb 24	Moon Is.		1-5 birds	Cumberland Bird Observers	HBOC: *Ann. Bird Rept* No. **15**
	Oct 24-26	Broughton Is.		6+ birds	Tom Clarke	HBOC: *Ann. Bird Rept* No. **15**
2008	Nov	Cabbage Tree Is.	Nest w. egg	1 breeding pair	Leone, John Storm	HBOC: *Ann. Bird Rept* No. **16**
	Dec 17	Moon Is.		1-2 birds	Chris Herbert	*The Whistler* **2**: 49-51
2008-09	Jan 2008 or Oct/Dec 2009	Broughton Is.	Nest w. eggs	1 breeding pair	S. Callaghan pers. comm., reported by A. Stuart	*The Whistler* **11**: 46-53
2009	Apr 7-9	Broughton Is.		7 birds	Tom Clarke	HBOC: *Ann. Bird Rept* No. **17**
	Oct 17-19	Broughton Is.		# unknown	Carlile *et al.*	*Corella* **36**(4): 97-100
	Nov 21-23	Broughton Is.		# unknown	Carlile *et al.*	*Corella* **36**(4): 97-100
	Dec 3	Broughton Is.		3 pairs	Ray McLean	HBOC: *Ann. Bird Rept* No. **17**
2010	Sep 14-16	Broughton Is.		13 birds	Chris Herbert & Liz Crawford	HBOC: *Ann. Bird Rept* No. **18**
	Oct 23	Moon Is.		1-2 birds	Allan Richardson	HBOC: *Ann. Bird Rept* No. **18**
	Oct 1-2	Little Broughton Is.		# unknown	Carlile *et al.*	*Corella* **37**(2): 41-43
	Dec 20-21	Little Broughton Is.		# unknown	Carlile *et al.*	*Corella* **37**(2): 41-43
	Oct 1-2	North Rock		# unknown	Carlile *et al.*	*Corella* **37**(2): 44-46
	Dec 20-21	North Rock		# unknown	Carlile *et al.*	*Corella* **37**(2): 44-46

[1]MLNP – Myall Lakes National Park

Continued overleaf

Table 3. A timeline of sightings and breeding records for Sooty Oystercatcher on islands off the Hunter Region coastline (continued)

Year	Date	Location	Breeding	Number of birds seen	Reported by	Where Published
2011	Sep 13-15	Broughton Is.		14 birds	Tom Clarke *et al.*	HBOC: *Ann. Bird Rept* No. **19**
	Nov 8-10	Broughton Is.		6+ birds	Tom Clarke *et al.*	HBOC: *Ann. Bird Rept* No. **19**
	Nov 3	One Tree Is.	Nest	# unknown	Geoff James	HBOC: *Ann. Bird Rept* No. **19**
	Dec 16	Gandja-Baa	Nest	1 breeding pair with nestling	Carlile *et al.*	*Corella* **37**(3): 69-70
2012	May 7-9	Broughton Is.		10 birds	Craig Anderson	HBOC: *Ann. Bird Rept* No. **20**
	Jul 13-24	Broughton Is.		34 birds	Tom Clarke	HBOC: *Ann. Bird Rept* No. **20**
	Aug 31	Broughton Is.		17-20+ birds	Alan Stuart *et al.*	HBOC: *Ann. Bird Rept* No. **20**
	Sep 18-20	Broughton Is.		17-20+ birds (some immat.)	Alan Stuart *et al.*	HBOC: *Ann. Bird Rept* No. **20**
					Alan Stuart *et al.*	*The Whistler* **11**: 46-53
	Dec 17-20	Cabbage Tree Is.		1-2 birds	Tom Clarke	HBOC: *Ann. Bird Rept* No. **20**
2013	Apr 7-8	Broughton Is.		9-15 birds	Alan Stuart *et al.*	HBOC: *Ann. Bird Rept* No. **21**
	Sep 23-25	Broughton Is.		20+ birds	Alan Stuart *et al.*	HBOC: *Ann. Bird Rept* No. **21**
	Dec 29	Broughton Is.		9-15 birds	Chris Herbert & Liz Crawford	HBOC: *Ann. Bird Rept* No. **21**
2014	Jan 13	Broughton Is.	Poss. nest	1 pair – defence behaviour	Chris Herbert & Liz Crawford	HBOC: *Ann. Bird Rept* No. **22**
	Mar 24-26	Broughton Is.		10 birds	Alan Stuart *et al.*	HBOC: *Ann. Bird Rept* No. **22**
	Sep 24	Broughton Is.		10 birds	Chris Herbert & Liz Crawford	HBOC: *Ann. Bird Rept* No. **22**
	Dec 8-10	Cabbage Tree Is.		1-2 birds	Adam Fawcett	HBOC: *Ann. Bird Rept* No. **22**
2015	Mar 31	Broughton Is.		10 birds	HBOC Camp	HBOC: *Ann. Bird Rept* No. **23**
	Aug 20	Broughton Is.		24 birds	Chris Herbert & Liz Crawford	HBOC: *Ann. Bird Rept* No. **23**
2016	Apr 18-20	Broughton Is.		25-30 birds incl. juvs	Alan Stuart *et al.*	HBOC: *Ann. Bird Rept* No. **24**
	Oct 10-12	Broughton Is.		15 birds	Alan Stuart *et al.*	HBOC: *Ann. Bird Rept* No. **24**
2017	Jun 22-24	Broughton Is.		20+ birds	Alan Stuart *et al.*	HBOC: *Ann. Bird Rept* No. **25**

given the absence of regular organised surveys prior to 1999 (Stuart 1994-2017). Monthly surveys at Swan Bay, which commenced in 2002 (S. Hamonet pers. comm.) were augmented by regular summer and winter water-based surveys commencing a few years later (summer surveys from 2004, winter surveys from 2008). These surveys enabled better coverage of the entire estuary, and hence the counts for Sooty Oystercatcher became more representative of the local status. The data revealed Port Stephens had the second largest group of Sooty Oystercatcher in the Hunter, including many birds considered to be non-breeding (Stuart 2005; Stuart 1994-2017).

Hunter River estuary

Sooty Oystercatcher also occur in the Hunter River estuary (**Table 2**), where they roost mostly on the Kooragang Dykes and forage on oyster banks along the north arm of the Hunter River, west of the Stockton Bridge (Herbert 2007). While only six sightings of 1-3 birds were recorded in this area between 1970 and 1977 (Gosper 1981), data from regular surveys conducted between 2008 and 2017 indicated a monthly average of 15.5 birds.

The population demographic within the Hunter River estuary is uncertain. Movement of birds between the Newcastle Rock Platforms and the estuary has often been observed, especially when the Rock Platforms have become inundated by high spring tides or heavy wave action during inclement weather (Herbert 2007; R. Nicholas pers. comm.). To date, numbers in the estuary have not exceeded 22 birds. However, between 2004 and 2017 the monthly, non-weather-related, high-count average was of 14 birds (**Table 2**). That suggests the presence of a discrete, resident, estuarine population, which may contain immature birds.

Mainland Coast

Small, mixed groups of 1-8 mature and immature birds also used rocky coastal areas from Newcastle north to the mouth of the Manning River, and from Newcastle southwards to around The Entrance (**Table 2**). There are only occasional reports of the southern birds. More frequent monitoring of the northern coastline in recent years has produced an increase in the number of sightings; however, the total number of birds remains much the same.

Offshore Islands

Sea conditions, difficulty of access, and logistical problems relating to the coordination of boats and

observers are factors which militate against the establishment of a regular regime of offshore island surveys. However, since 2012, Hunter Bird Observers Club in conjunction with NSW National Parks and Wildlife Service, has conducted systematic autumn and spring surveys of the terrestrial birds on Broughton Island, the largest island (132 ha) in an archipelago of smaller islets and rocky crags (Stuart *et al.* 2017). Between 2012 and 2017, Sooty Oystercatcher numbers seemed to be increasing (from 13 to 20+ birds) and they were the most common shorebird on the island (Stuart *et al.* 2017).

Breeding

The Sooty Oystercatcher typically breeds on offshore islands occurring in close proximity to the mainland (Marchant & Higgins 1993; Hansen *et al.* 2014). Sooty Oystercatcher counts in the Hunter Region have been found to peak in February. Their numbers gradually decreased through March, April and May, with winter counts falling to approximately 50% of the February count before rebuilding again through the summer months (**Figure 1**). It is assumed that the annual fluctuation in numbers reflects the movement of breeding birds to offshore island breeding territories, followed by their return in early summer, accompanied by newly fledged young (Herbert 2007; Roderick & Stuart 2010; R. Nicholas pers. comm.).

The indication of breeding success reflected by the mainland count data is not supported by the number of confirmed nesting attempts (**Table 3**). However, as previously stated, visits to offshore islands are infrequent; hence most nests would be unlikely to be discovered. Currently therefore, breeding success by Sooty Oystercatcher is best assessed by monitoring the steady increase in population size indicated by the overall count data, supplemented by regular observations of juvenile and immature birds throughout the known population. However, recruitment of immature birds from breeding territories beyond the Hunter Region may also occur (Stuart 2011).

Access to suitable breeding territory may be restricted by offshore island topography and the fact that resident breeding pairs can occupy the same breeding territory for up to 20 years (Lane 1987). A lack of available nest sites may have led some first-time breeders to attempt nesting on the mainland (Harrison 2009; Ens & Underhill 2014). In the past decade at least three mainland nests have been reported on the far south coast of NSW, and a possible fourth nest was destroyed before it could be confirmed (Dunn & Harris 2009; Jarman 2010). In 2011, a nest, possibly built by an inexperienced pair that was unable to find an offshore site, was found on One Tree Island, in the Port Stephens estuary (Stuart 2011). Technically this nest qualifies as an island nest, but the island is located *c*. 13 km inland from the coast (Google Earth, accessed 30 April 2019). It is unclear whether mainland nests are an anomaly or a response by first-time breeders to a scarcity of traditional breeding territory.

Habitat preference

Sooty Oystercatcher is a marine coastal species typically found in small groups along rocky sections of the shoreline. It is more numerous where offshore islands lie in close proximity to the mainland (Lane 1987; Marchant & Higgins 1993). The rocky topography along the Hunter Region coastline matches this description, particularly in the vicinity of Port Stephens and Newcastle, where the largest congregations of birds occur (**Table 2**). Sessile prey (algae and invertebrates) a major component of the Sooty Oystercatcher diet, tends to attach to rock surfaces; also, many of the coastal rocks, which are dark in colour due to their volcanic origin, provide background camouflage for roosting and foraging birds (Creese *et al.* 2009; Gilmore 2014).

Sooty Oystercatchers are also found in estuaries, inlets, mud flats, sandy shores and reefs (Lane 1987; Marchant & Higgins 1993). There are three main estuaries within the study area. While surveys in the Manning Estuary have been semi-regular, survey efforts in the Hunter and Port Stephens estuaries have been consistent over the past decade, during which time increasing numbers of Sooty Oystercatcher have been recorded.

The largest estuary, located within the Port Stephens-Great Lakes Marine Park, has extensive (~1000 ha) seagrass beds, and much of the relatively undeveloped shoreline has tracts of mangrove-lined, muddy substrate. These are factors which are prerequisites for the reliable production of the marine biota needed to underpin the shorebird prey-base (Creese *et al.* 2009; Port Stephens Council 2016). Benthic sampling carried out during 2012-2014 indicated that the biodiversity of organisms in the substrate was relatively unaffected by shoreline development, marine enterprise or recreational activity (Stuart & Wooding unpublished).

In 2007, the demolition of an oyster processing facility at Swan Bay, in the western basin, exposed a ~110 m^2 cement slab (B. Clulow pers. comm.) which has since become an important roost for a variety of shorebirds, waterbirds, gulls, terns and oystercatchers (Wooding 2016). Prior to the demolition, 1-2 Sooty Oystercatcher routinely roosted on the breakwater at the rear of the site. Since the demolition, the numbers of roosting Sooty Oystercatcher at this site have increased, to 30-40 birds now (**Table 2**). The incoming and outgoing flight direction of the Sooty Oystercatcher using the roost usually has been to the north or south, which suggests that these birds forage around the estuary's western mud flats. The birds at this location were mostly immature (LW pers. obs.). It is thought that estuarine habitat may be of particular importance for the survival of maturing birds (Stuart 2005).

The rugged nature of the Hunter's offshore islands has been a natural deterrent to human visitation, and, as protected Nature Reserves, most islands have remained relatively pristine (NSW National Parks and Wildlife Service 2002; Stuart *et al.* 2017). The Hunter Region offshore islands are not dissimilar to islands where successful breeding activity was recorded in regional studies to both the north and south of the Hunter (Dunn & Harris 2009; Harrison 2009; Jarman 2010). Sooty Oystercatchers have been sighted on eight of the eleven offshore islands of the Hunter Region, and nests have been found on six of them (**Table 3**). There are no records for Little Island, Looking Glass Island or Inner Rock, but it should be noted that only brief visits (1 to 2 h) have been made to these islands to check for seabirds; therefore, the presence of Sooty Oystercatcher may have been overlooked (Lane 1976; Carlile *et al.* 2013a, 2013b).

Diet

Sooty Oystercatcher prey base is largely sessile and only available during low tide. However, Chafer (1994) is of the opinion that optimal dietary choice in predators with foraging time constraints is more catholic than might be expected. The Sooty Oystercatcher is known to use prey-specific foraging techniques to select prey from eleven morphologically different intertidal taxa, and while molluscs may be preferred, their consumption of crustaceans, echinoderms, polychaetes, ascidians and insects is well documented (Chafer 1994; Harrison 2009; Ens & Underhill 2014; Hansen *et al.* 2014). No dietary studies have been undertaken in the Hunter Region, but population stability suggests an adequate prey base. Benthic collections conducted throughout 2012-2014 at eight sites within the Port Stephens estuary found that the distribution of benthic species was both varied and abundant (Stuart & Wooding unpublished).

Behaviour

Sooty Oystercatcher tend to be rock specialists, but they are known to co-exist with sand-foraging Australian Pied Oystercatcher *H. longirostris* in areas where their individually preferred habitats overlap (Schultz 1995; Harrison 2009). Reports of interbreeding are rare (Collins *et al.* 1999). In the Hunter Region it is not uncommon for both species to be found foraging and roosting together on rocky outcrops, at coastal sites where a sand/rock interface occurs, and on tidal mudflats and high-tide roosts within estuaries.

Implications for the future

The combined impact of human pressure from Australia's coastal culture and the predicted rise in sea level and sea temperature is expected to have an increasing effect on coastlines in coming decades (Hansen *et al.* 2014). It seems inevitable that all marine coastal species will encounter habitat contraction, prey-base decline, increased pollution and greater human disturbance (Harrison 2009; Ens & Underhill 2014). A preference for remote breeding locations may offer some protection for Sooty Oystercatcher; however, shrinkage of inter-tidal foraging zones may place them at great risk, especially in estuarine areas that support immature birds. In long-lived species it may take years before it becomes evident that events affecting one phase of the life-cycle of a species have resulted in population decline (Harrison 2009).

CONCLUSIONS

Conditions within the study area would appear to be favourable for Sooty Oystercatcher, and the steadily increasing population seems to be consistent with similar population increases reported in studies conducted on coastlines to the north and south of the Hunter Region (Dunn & Harris 2009; Harrison 2009; Jarman 2010). An indication of the change is that the status of the species in the Hunter Region has changed from Uncommon Resident (1995) to Resident (2008) (Stuart 1994-2017; Roderick & Stuart 2010). Although this is a positive sign, sadly rare among

shorebirds today, the Hunter population when viewed from a state and national perspective, remains small (Watkins 1993; Delany & Scott 2006; NSW Scientific Committee 2008; Wetlands International 2018). The recovery potential of a small population existing within a limited and ecologically specialised habitat could become compromised by human and environmental pressures, therefore, the continued conservation ranking of Vulnerable seems warranted (NSW Scientific Committee 2008; Harrison 2009).

The extent of Sooty Oystercatcher breeding activity on the Hunter coast is unresolved. The fact that immature birds have been recorded at most mainland locations suggests that successful local nesting has boosted population numbers. However, few nests have been reported, and there have been no follow-up visits to report on the success or failure of known nesting attempts. The possibility that immature birds from outside the region are attracted to the Hunter's estuaries cannot be proven or eliminated. While the common problems of logistics and difficulty of access has protected island environments, it has also impeded ornithological investigation. It is possible that future Broughton Island surveys, should any occur during the nesting season, could provide further insight to breeding on that island. An organised investigation of the other offshore islands seems unlikely at this time.

A contraction of foraging, roosting and nesting habitat has a tendency to bring nature and humans into ever closer contact; historically that association has been disastrous for nature (Harrison 2009). In the case of the Sooty Oystercatcher, further study is clearly needed if the species is to be better understood, protected and sustained in the face of future ecological stress. Continued surveys would seem to be essential to that process.

ACKNOWLEDGEMENTS

My thanks to all those willing volunteers who gather and compile the data that help to clarify the past, present and future understanding of bird populations in the Hunter Region. I also thank an anonymous referee for very helpful comments.

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The *Whistler* – Instructions to Authors

The *Whistler* is an occasional publication of the Hunter Bird Observers Club Inc. (HBOC), which is based in Newcastle. HBOC members are active in observing birds and monitoring bird populations in the Hunter Region. This journal-style publication is a venue for publishing these regionally significant observations and findings. The journal publishes three types of articles:

1. **Contributed Papers**
2. **Short Notes**
3. **Book Reviews**

Authors should consider the appropriateness of their study to this publication. The publication is suitable for studies either geographically limited to the Hunter Region or with obvious relevance to it. Papers attempting to address data and issues of a broader nature should be directed to other journals, such as *Corella, Australian Field Ornithology* and *Emu*. Contributed papers should include analyses of the results of detailed ecological or behavioural studies, or syntheses of the results of bird monitoring studies. These may include comprehensive annotated species lists of important bird areas and habitats. Such data would then be available for reference or further analysis in the many important issues of bird conservation facing the Hunter Region.

Communication of short notes on significant bird behaviour is also encouraged as a contribution to extending knowledge of bird habits and habitat requirements generally. Reviews of bird books are also solicited, with the intention of providing a guide for other readers on their usefulness regionally and more broadly.

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Manuscripts should be submitted electronically; please attach your manuscript to an email as a Microsoft Word document. Charts should be submitted as an Excel file. Authors should adhere to the instructions for each type of submission:

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- Manuscripts should be up to 12 pages in length (longer in exceptional circumstances) and of factual style.
- They should include a summary (abstract) of approximately 250 words.
- An 'Introduction' or 'Background' section introduces the aims of and rationale for the study and cites any other work considered essential for comparison with the study.
- A section on 'Methods' describes the location of the study, citing map co-ordinates or including a map, and describing how observations were made and data were collected and analysed.
- A section on 'Results' includes description and/or analysis of data highlighting trends in the results; this may be divided into subsections if more than one body of data is presented; use of photos, drawings, graphs and tables to illustrate these is encouraged.
- A section headed 'Discussion' should attempt to set the results in a wider context, indicating their significance locally and/or regionally; comparison with national and international work is optional, as is the discussion of possible alternative conclusions and caveats; suggestions for future extension of the work are encouraged.
- A final section headed 'Conclusion[s]' gives a concise summary of findings, usually without introducing any new data or arguments.
- Appendices of raw data and annotated lists of bird species and habitats may be included in tabular form at the end of the submitted article. Usually these will be published on-line and not appear in the hard copy print.
- References should be cited in brief within the text of the article, and full references should be listed at the end of the text after any Acknowledgements. References should be formatted as per the formatting instructions below.
- The preferred layout described above can be modified at the Editors' discretion.

Short Notes

- Should be no more than 4 pages of descriptive or prosaic style.
- Should provide an adequate description of the location of observations, a brief rationale for documenting the observations, and a cogent description of observations; similar relevant observations should be cited with references if appropriate.
- References should be cited and listed as for contributed papers.

Book Reviews

- Should be approximately 2 pages of critical assessment and/or appreciation.
- Should introduce the topics and aims of the book as the reviewer understands them, comment on the thoroughness and rigour of content, and conclude with comments on the effectiveness and originality of the book in meeting its aims, particularly for birdwatchers in the Hunter Region area if appropriate.
- References should be cited and listed as for contributed papers.

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Formatting of an article for publication is the responsibility of the Whistler production team and is done after the submitted manuscript has been finalised and accepted. Authors are requested to note the following requirements when submitting a manuscript:

1. A4 size pages using portrait layout except for large tables or figures. Margins 2cm all sides.
2. Title of article at top of first page
3. Names and the affiliations or addresses of all authors are to be listed next, with at least one email address included. Each author's preferred first name is to be indicated.
4. The author for correspondence is to be clearly indicated.
5. Typescript for manuscripts is Times New Roman 11 pt.
6. Figures and Tables are to be included at the end of the document, in Times New Roman 11 pt. Each Figure and Table is to have a title that clearly describes the content.
7. Nomenclature and classification of bird species shall follow the current version of BirdLife Australia's "Working List of Australian Birds" (download from: http://birdlife.org.au/conservation/science/taxonomy). The scientific names of all bird species shall be shown in italics after the first mention of their English name in both the text and summary (abstract) and not thereafter.
8. References should be cited in the text in parenthesis as close as possible to the information taken from the paper: for one author (Smith 2000), two authors (Smith & Jones 2001b) and more than two authors (Smith *et al*. 2002) with the authors listed in the same order as the original paper.
9. References shall be listed in alphabetical order and secondarily by year of publication; if published in the same year then in alphabetical order with a, b, or c etc after the year to indicate which paper is being cited in the text (see example below). Each reference shall form a separate paragraph.

Reference Format

Journal articles:
Jones, D.N. and Wieneke, J. (2000a). The suburban bird community of Townsville revisited: changes over 16 years. *Corella* **24**: 53-60.

Edited book Chapters:

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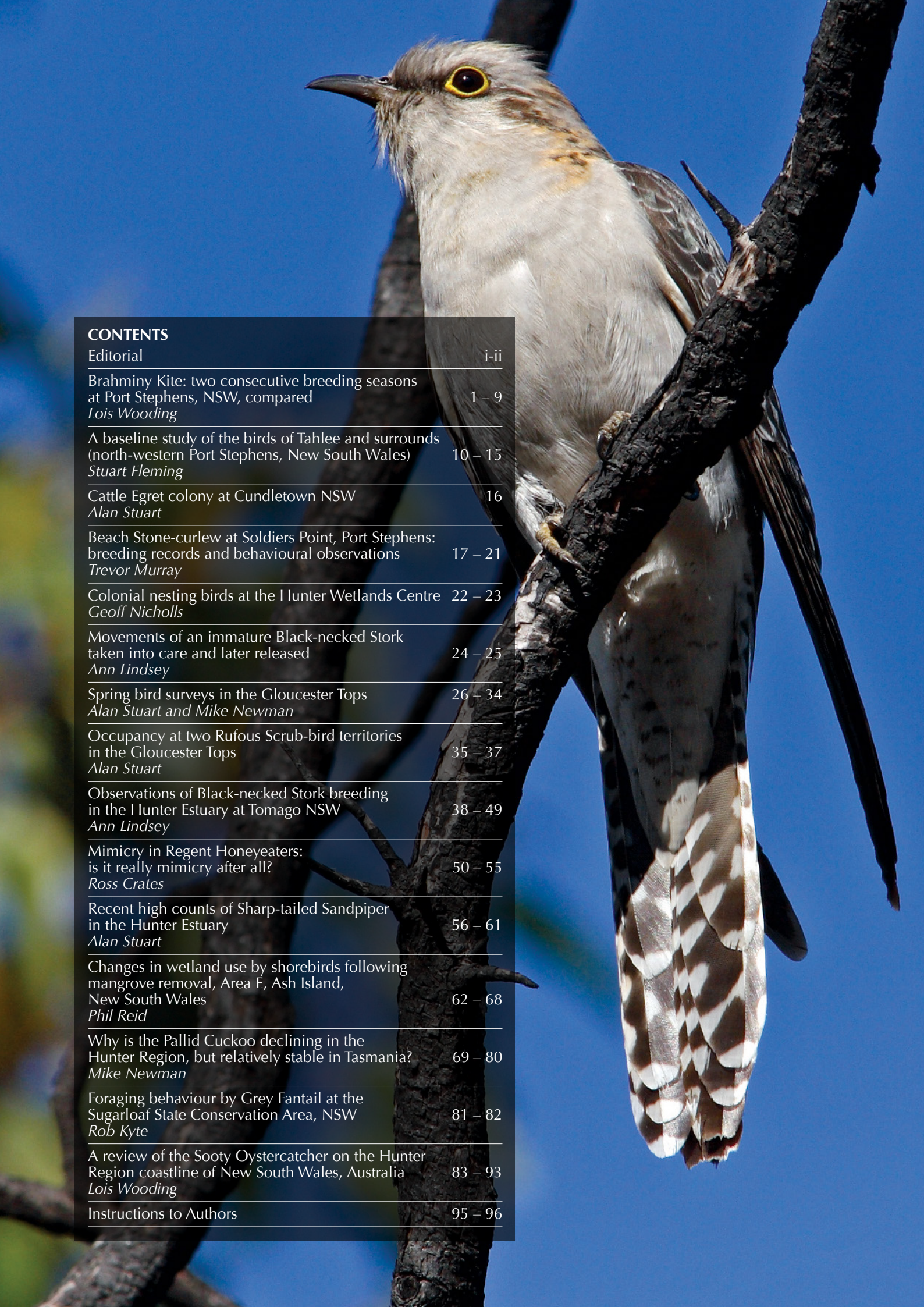

CONTENTS