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Front cover : Letter-winged Kite. Photograph by Mike Reed.

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FEEDING AND ROOST SITE FIDELITY OF TWO MIGRATORY SHOREBIRDS IN MORETON BAY, SOUTH-EASTERN QUEENSLAND, AUSTRALIA

J.T. COLEMAN & DAVID A. MILTON

ABSTRACT

Fidelity of long-distance migratory birds to sites in their non-breeding grounds can have a major influence on their foraging and roosting success and survival as available coastal habitats are reduced by development. Migratory shorebirds' prior knowledge of productive foraging habitats and safe roosts is vital for enabling them to prepare for and recover from long migrations.

Two species of shorebird – Grey-tailed Tattlers (*Tringa brevipes*) and Bar-tailed Godwits (*Limosa lapponica*) – were monitored at their foraging and roosting sites in Moreton Bay for three seasons to determine fidelity to those sites. Fidelity to feeding and roost sites was extremely high for both species, with multiple resightings made at the same location, both within and between seasons. Further, feeding birds were recorded close to roost sites, with very few sightings of individuals more than a few kilometres from their original banding locations (roost sites) either within or between seasons. Evidence for potential fidelity to staging locations was obtained for Grey-tailed Tattlers.

The implications of high site fidelity are discussed in relation to the need for protection of roosting and feeding sites for shorebirds while at non-breeding grounds and in terms of the potential effects of disturbance on different species.

INTRODUCTION

Many species of migratory shorebird return annually to the same region during the non-breeding season. Several studies in Mauritania and Great Britain have demonstrated that some high-tide roosts have been used consistently over long periods (Hale 1980; Burton *et al.* 1996; Rehfisch *et al.* 1996; Sanzenbacher & Haig 2002; Leyrer *et al.* 2006). On the other hand, other studies have found different patterns. For example, certain roosts in Humboldt Bay in western United States were not used predictably by individual Dunlin even from week to week (Conklin & Colwell 2007). The scale and spatial distribution of roost sites are important to both individuals and populations, particularly for species of high site fidelity, as these sites are potentially at risk from disturbance, contamination or habitat destruction (Rehfisch *et al.* 1996, 2003; Warnock & Takekawa 1996).

The fidelity of migratory shorebirds to their non-breeding grounds, broadly speaking, has been well-documented through radio telemetry and band recoveries (Warnock & Takekawa 1996; Leyrer *et al.* 2006) but few studies have been published on the fidelity of shorebirds to feeding and roosting sites within those non-breeding grounds, particularly for the East Asian–Australasian Flyway. The present article examines this subject, with a focus on Moreton Bay, south-eastern Queensland (Figure 1).

Moreton Bay is an important site for migratory shorebirds, with an estimated 40,000 birds present during the non-breeding season (Thompson 1993; Anon. 2004; Bamford *et al.* 2008; Wilson *et al.* 2011). This importance to migratory shorebirds was instrumental in Moreton Bay being designated as a Ramsar site (Harding 1998). The bay supports numbers that exceed the threshold for international importance (one per cent of the population size in the flyway) for eight shorebird species, including Grey-tailed Tattlers (*Tringa brevipes*) and Bar-tailed Godwits (*Limosa lapponica*) (Thompson 1993; Bamford et al. 2008). Over 90% of the East Asian–Australasian Flyway

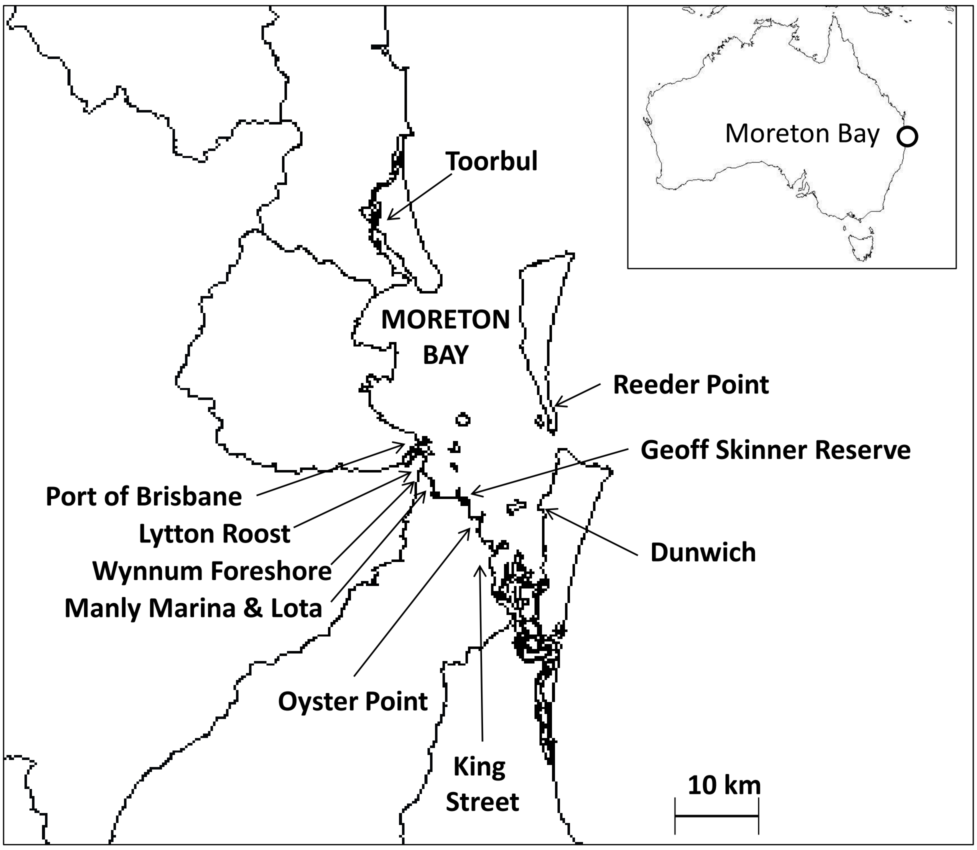

Figure 1. Moreton Bay study sites.

population of Grey-tailed Tattlers spends the non-breeding season in Australia (Bamford *et al.* 2008). For Bar-tailed Godwits, the bay is additionally important as this species makes the longest known non-stop flight of any species of bird – from the breeding grounds in Alaska to New Zealand and eastern Australia in a single flight (Gill *et al.* 2009).

The reliance of large proportions of populations of migratory species upon one bay creates vulnerability to potential major impacts should substantial loss or reduction of habitat or decline in food resources occur (Baker *et al.* 2004). Greater understanding of the habitat use of such species in Moreton Bay can help guide land use to avoid impacts upon populations.

The aim of this study was to monitor individually-flagged Grey-tailed Tattlers and Bar-tailed Godwits to determine their return rates to Moreton Bay, as well as the fidelity of individuals to feeding and roosting sites, both within and between seasons. The term 'season' is used in the context of the non-breeding season of migratory shorebirds, as manifest in their occurrence in Australia: typically late August to early April.

METHODS

Shorebirds in Moreton Bay were trapped in mist nets for two seasons (2006–2007 and 2007–2008) at Manly Marina, Manly (27.45°S, 153.19°E) and Geoff Skinner Reserve (27.48°S, 153.24°E), Wellington Point. Mist-netting was conducted between 1 September and 30 April in each season, to coincide with the period in which the largest numbers of migratory species visiting Australia were present. Manly Marina is an artificial shorebird roost, created through collaboration between the Port of Brisbane Corporation and Manly Marinas Incorporated, whereas Geoff Skinner Reserve is a natural roost on an open clay pan, fringed by mangroves (Figure 1). The main feeding areas at which birds were resighted were Wynnum foreshore, situated to the north of Manly Marina, and Thorneside, situated between the Manly and Geoff Skinner roost sites.

Mist nets were set at night on a rising tide to intercept birds coming in to roost. They were set two hours before high tide and taken down within an hour of high tide peak as, based on past observations, by this time nearly all birds coming into the roost would have been present. The mist nets used were two shelf nets with a mesh size of 22 mm × 22 mm, and were arranged in sets of two or three lines parallel to the water on beaches or freshwater pools used for roosting. A total of 162 m of mist net was erected on each visit. The nets were checked every 20–30 minutes. Trapped birds were removed, placed in a cloth bag and taken to a banding station, which was out of sight of the nets, for processing. Each bird was fitted with a metal band (supplied by the Australian Bird and Bat Banding Scheme (ABBBS)) on the left tarsus and an engraved green leg flag on the right tibia. All flags used were dark green and engraved with two letters, stained white to contrast with the green background. This allowed birds to be individually identified in the field with a spotting scope.

Sighting data for three seasons (2006–2007, 2007–2008 and 2008–2009) were collected and are analysed herein. Sightings of leg-flagged birds were obtained by Queensland Wader Study Group (QWSG) members from monthly high-tide roost counts at the largest roosts throughout Moreton Bay and regular low-tide surveys around southern Moreton Bay. Data were collected in field note books and transferred to a Microsoft Access database, with all resightings linked back to the original banding record for each individual.

Data were analysed by banding season cohort (2006–2007 and 2007–2008) and all birds were included in the same cohort group irrespective of age or sex. Return rates were calculated as a percentage of the total birds of the particular species banded in each cohort, with one or more resightings of a bird in that season indicating a returned bird. The degree of site fidelity was assessed using the number of resightings within a season, with multiple resightings at a location indicating a positive degree of site fidelity.

RESULTS

Over two seasons (2006–2007 and 2007–2008), 345 shorebirds of 13 species were fitted with engraved green leg flags. Eighty-eight of these flags were fitted to Grey-tailed Tattlers (n=53 and 35 respectively for 2006–7 and 2007–8) and 109 to Bar-tailed Godwits (n=16 and 93 respectively: Table 1).

Table 1. Numbers of leg-flagged Grey-tailed Tattlers and Bar-tailed Godwits resighted in Moreton Bay (roost and feeding sites combined) in the banding and subsequent seasons. Figures in brackets are percentages.

Species / banding season	Total number flagged	Number resighted in banding season	Number resighted first season after banding	Number resighted second season after banding
Grey-tailed Tattler				
2006–2007	53	26 (49.1)	41 (77.4)	18 (34.0)
2007–2008	35	35 (100.0)	20 (57.1)	N/A
Bar-tailed Godwit				
2006–2007	16	10 (62.5)	13 (81.3)	11 (68.8)
2007–2008	93	32 (34.4)	49 (52.7)	N/A

Table 2. Numbers of leg-flagged Grey-tailed Tattlers and Bar-tailed Godwits returning to known roost sites in the banding and subsequent seasons.

Species / banding season	Total flagged	Season of banding		First season after banding		Second season after banding	
		Seen only at banding roost	Seen at another roost site	Seen only at banding roost	Seen at another roost site	Seen only at banding roost	Seen at another roost site
Grey-tailed Tattler							
2006–2007	53	19	3	33	1	16	1
2007–2008	35	30	0	19	0	N/A	N/A
Bar-tailed Godwit							
2006–2007	16	11	0	10	2	4	1
2007–2008	93	11	13	29	8	N/A	N/A

Twenty-three (26%) of the Grey-tailed Tattlers were juveniles, the remainder being adult birds, whereas 17 (16%) of the Bar-tailed Godwits were identified as juveniles. Sample sizes were deemed adequate to enable data analysis for both species. Monthly high tide roost counts and regular low tide surveys by QWSG around Moreton Bay provided multiple resightings of many leg-flagged individuals (Table 2). Resightings for individuals banded in 2006–7 were analysed over three seasons (2006–2007, 2007–2008 and 2008–2009) and resightings for those banded in 2007–2008, over two seasons.

Return rates

Rates of return to Moreton Bay in the first season after banding were 69% for Grey-tailed Tattlers and 57% for Bar-tailed Godwits, and in the second season after banding, 34% for Grey-tailed Tattlers and 69% for Bar-tailed Godwits (Table 1).

Fidelity to roost sites

Grey-tailed Tattlers were very faithful to their roosting site, with only five of the 122 roost resightings (4%) being at a roost site other than Manly Marina, the site at which all Grey-tailed Tattlers banded in this study were captured. The other roosts at which individuals of this species were resighted were Port of Brisbane (6 km NNW of Manly), Lytton (5 km NNW) and Toorbul (50 km NNW) (Table 2). An individual sighted at Toorbul, leg-flagged in 2006, was observed there for three consecutive years late in the season

(March). It was not seen in Moreton Bay at other times and presumably spent the non-breeding season elsewhere and stopped over in Moreton Bay on its northward migration. Eighteen individuals that had been banded in 2006–2007 at Manly Marina were seen roosting there two or more times during the season (Figure 2). For the 2007–2008 and 2008–2009 seasons the number of banded individuals seen roosting two or more times at this location was 17 and five, respectively.

During the first and second banding season, 43 (39%) within-season roost resightings were made of Bar-tailed Godwits at their banding site (either Manly Marina or Geoff Skinner Reserve), compared with 13 (12%)

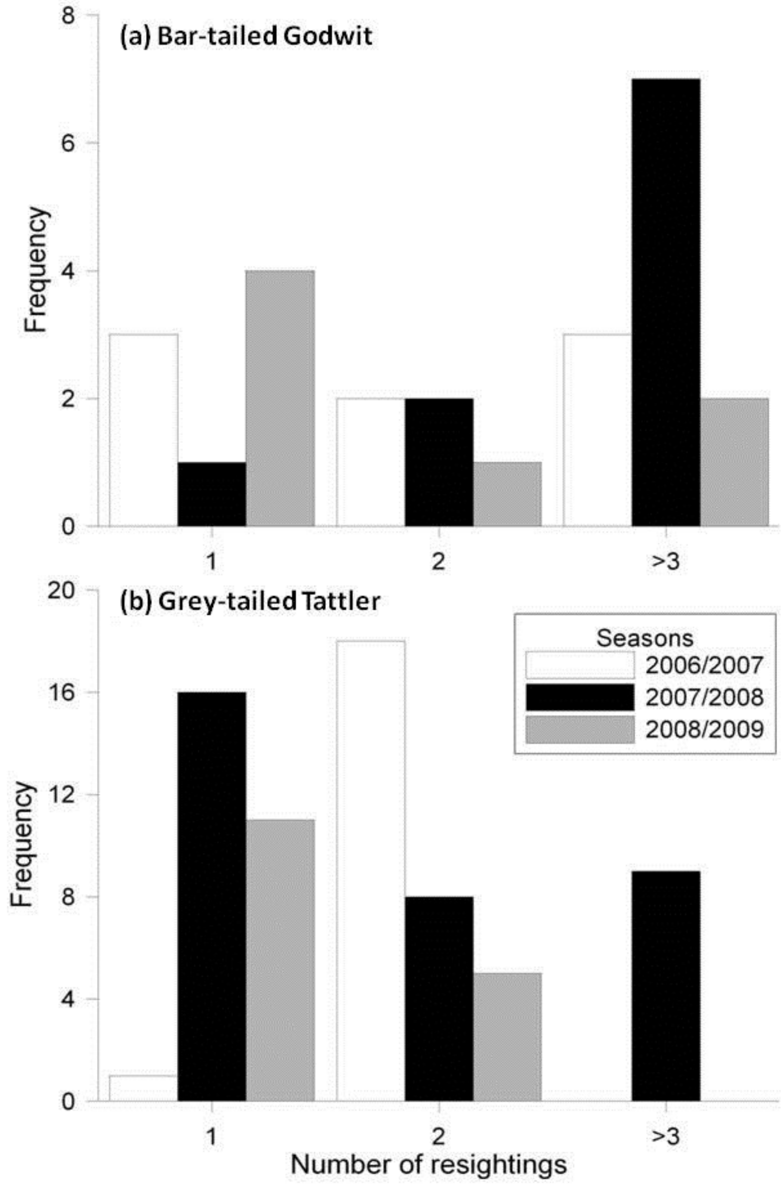

Figure 2. The number of resightings of individually-coded flags on Bar-tailed Godwits and Grey-tailed Tattlers at Manly Marina in each non-breeding season from 2006 to 2008.

resightings made of individuals roosting at another site (Table 2). The majority of these movements (11) involved individuals changing roost site from Geoff Skinner Reserve to Manly Marina (7 km WNW) One individual was recorded at another roost site adjacent to Geoff Skinner Reserve (1 km N) and another recorded on Reeders Point on Moreton Island (26 km ENE of Geoff Skinner Reserve). A further 11 Bar-tailed Godwits changed roost site in subsequent seasons after banding, with individuals moving from Manly to Dunwich (1 record: 20 km E of Manly Marina), Manly to Oyster Point (1 record: 13 km SE), Geoff Skinner Reserve to Oyster Point (1 record: 4 km SE of Geoff Skinner Reserve), Geoff Skinner Reserve to King Street (2 records: 14 km SSE), Geoff Skinner Reserve to Reeders Point (1 record: 26 km ENE) and Geoff Skinner to Thorneside (2 records: 4 km NW). In addition, ABBBS recoveries were received for three of the flagged godwits spending subsequent seasons outside of Queensland: one in Victoria, and two in New Zealand.

The numbers of multiple resightings of identified individual Bar-tailed Godwits that were banded in the 2006–2007 season at the Manly roost site are shown in Figure 2. Again, despite the increased occurrence of roost site changes, the data demonstrate that many birds return to the same roost site multiple times within a season.

Fidelity to feeding sites

Grey-tailed Tattlers leg-flagged at Manly Marina were recorded feeding at Thorneside Esplanade (19 records in total: 40%) and Wynnum foreshore (28 records: 60%). These sites are respectively 4 km south and 2 km north of the Manly roost site. Of the 47 leg-flagged Grey-tailed Tattlers recorded

Table 3. Numbers of leg-flagged Grey-tailed Tattlers and Bar-tailed Godwits returning to the Thorneside feeding area in the banding and subsequent seasons.

Species / banding season	Total flagged	Season of banding		First season after banding		Second season after banding	
		Seen only at Thorneside	Seen at another feeding site	Seen only at Thorneside	Seen at another feeding site	Seen only at Thorneside	Seen at another feeding site
Grey-tailed Tattler							
2006–2007	53	0	0	7	15	0	3
2007–2008	35	11	10	1	0	N/A	N/A
Bar-tailed Godwit							
2006–2007	16	2	0	7	2	8	0
2007–2008	93	11	3	26	0	N/A	N/A

feeding at low tide, only one individual was recorded at a different feeding site from that in which it was originally recorded: this was an individual banded in the 2006–2007 season and recorded feeding at Thorneside in the 2007–2008 season but recorded later that season feeding on Wynnum foreshore.

A total of 59 resightings of feeding leg-flagged Bar-tailed Godwits was obtained, with 54 records (92%) at Thorneside, three records at other locations – Oyster Point (13 km SE of Manly Marina), Lota Beach (1 km S of Manly Marina) and Wynnum foreshore (1 km N of Manly Marina) (1 record at each location) – and records for two individuals for which changed feeding locations were recorded (Table 3). These individuals were recorded feeding at Thorneside in the 2006–2007 season and feeding at Wynnum (1 record) and Lota Beach (1 record) in the following season.

DISCUSSION

The return rate for Grey-tailed Tattlers and Bar-tailed Godwits within Moreton Bay demonstrates the bay's importance for migratory shorebirds. Similar results have been shown in a number of other studies (Sanzenbacher & Haig 2002; Rehfisch *et al.* 2003; Leyrer *et al.* 2006, Conklin & Colwell 2007). The use of individually engraved leg flags, combined with regular monitoring, has provided sufficient data to assess the fidelity of individuals and species returning to roost and feeding sites, as well as to obtain more accurate estimates of return rates.

The use of the same roost site by the majority of surveyed Grey-tailed Tattlers, both within a season and from season to season, demonstrates the importance of traditional roost sites and the need for their ongoing protection from disturbance. Manly Marina roost provides an example of how, with careful planning, shorebirds can be protected even in extremely busy waterways and foreshore environments. The Port of Brisbane outer bund wall is another large artificial roost for Grey-tailed Tattlers and is monitored each month as part of the QWSG high tide roost counts. Although this wall is close to Manly Marina, there was little evidence detected of Grey-tailed Tattlers moving between the two sites. The greater propensity for Bar-tailed Godwits to utilise different roost sites may indicate that this species is more flexible in its use of different roosting and foraging conditions and thus more adaptable to changing environmental conditions.

Zharikov and Milton (2009) found that most shorebird species prefer roosts close to their feeding grounds and with a large field of view. They also found that the roosting habitats of Grey-tailed Tattlers were more restrictive, as these birds required more structurally-complex roosts, including mangroves and artificial structures such as that found at Manly Marina. Owing to their higher roost site fidelity, Grey-tailed Tattlers may be more vulnerable than some other shorebird species to the impacts of the loss of roosting habitat in Moreton Bay.

The sighting of an individual Grey-tailed Tattler roosting at Toorbul late each season presumably represents a bird that spent the non-breeding season farther south than Moreton Bay and passed through the bay on migration. Given their fidelity to roost sites in the non-breeding season, it is possible that Grey-tailed Tattlers may also be faithful to roost sites along their migration routes as well as to sites in their non-breeding areas. This behaviour has been shown in North American shorebird species (Smith & Houghton 1984; Taylor & Bishop 2008), and demonstrates the need for protecting habitat throughout the flyway to ensure effective protection of migratory species.

The majority of feeding Grey-tailed Tattlers and Bar-tailed Godwits were recorded within 4 km of their roosting site. When protecting sites for shorebirds, both roosting and feeding locations need to be considered and protected as a single system. The quality of the non-breeding habitat has a strong influence on the timing of migration and subsequent nesting success (Gunnarsson *et al.* 2006). Thus, changes to quality of the non-breeding habitat can have consequences for these long-distance migratory shorebirds at the population scale, far beyond their survival locally.

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BREEDING OBSERVATIONS OF THE LETTER-WINGED KITE (*ELANUS SCRIPTUS*) IN CENTRAL-WESTERN QUEENSLAND

MIKE REED & ANN REED

ABSTRACT

Four pairs of Letter-winged Kites (*Elanus scriptus*) were found in the early stages of breeding (nest building to incubation) in late March 2010, near Boulia in western Queensland. The event occurred after drought-breaking rains in summer 2009–2010, when rats (apparently *Rattus villosissimus*) were plaguing. Four nests were 6–14 m (mean 9.5 m) above ground in coolibahs (*Eucalyptus coolabah*), dispersed along 440 m of a dry watercourse. A fifth pair of kites, possibly a pre-breeding pair, was also found. Some behavioural observations (e.g. aerial display, copulation, nest building, sex roles and nest defence) are presented.

INTRODUCTION

The Letter-winged Kite (*Elanus scriptus*) is rather poorly known, with nothing published on its breeding behaviour since the summary by Marchant and Higgins (1993). Comprehensive information on the kite's biology and ecology assumes greater importance now that its national conservation status has been reassessed from 'least concern' to 'near threatened' (Garnett *et al.* 2011). Published information is particularly minimal on the kite's pre-laying behaviour.

In mid March 2010 the manager of a cattle station near Boulia, in the channel country in central-western Queensland, reported what he thought to be several flocks of eight to 10 'owls', seen while he was returning one night from a remote part of the station (locality and other details withheld for privacy reasons). Upon referring to his field guide he concluded the birds were probably Letter-winged Kites. He also reported that since his initial observations he had seen a kite on a nest. We therefore visited the station and on 25 March were taken to the nest site where the presence of Letter-winged Kites was confirmed, six in all, including one bird on a nest (Pair 1).

This record of Letter-winged Kites is MR's first of the species on the station in this seventh visit over a period of six years. Dates of MR's previous visits, during which Letter-winged Kites were not recorded, were: 12–14 September 2005; 21 May–22 June 2006; 27 February–31 March 2007;

6–10 July 2007; 13–17 July 2008; and 5–10 August 2009. During these visits, annual pasture monitoring surveys were conducted, requiring 600 km of on-station driving. Hence, extensive areas of the property were observed.

Over this six-year period, the station experienced low rainfall until the summer of 2009–2010, when above-average falls transformed a parched landscape into lush ground cover, with accompanying increases in the numbers of insects, small mammals and birds. In August 2009, large grass structures that were thought to be woven by a species of native rodent were discovered, possibly heralding a change in kite numbers. More than a hundred of the structures, ranging from 2 × 2 m to 2.3 × 7.4 m, were scattered over a 5 km radius on an open plain. Tunnelling was evident in the structures and the underlying soil (Figure 1). No animals were identified.

The manager reported, in January and February 2010, large numbers of 'rats', sufficiently numerous to establish 'pads' or runways in the soil, leading to watering points at 'turkey nest' dams. During a return visit in August 2010 these were identified as Long-haired Rats (*Rattus villosissimus*), which may explain why Letter-winged Kites were attracted to and bred in the area.

METHODS

On 26 March we returned to the nest site, camping on a clearing well back from the nest of Pair 1 and within view of a roosting tree on the opposite side of the creek, frequented by another pair of Letter-winged Kites (Pair 2). Yet another pair (Pair 3) was also observed roosting in a coolibah (*Eucalyptus coolabah*) 170 m east of the nest of Pair 1. Nest disturbance was kept to a minimum, with close approaches to nest trees restricted to one brief visit to acquire photographs, a GPS reading (for Birds Australia atlas purposes) and to measure the distances between nest trees. We remained in the area for just over 24 hours; further exploration and observations were limited by wet roads and time constraints.

The study area was a deep, dry creek lined with coolibahs, scattered specimens of which extended onto the floodplain on each side of the creek that merged into a broad grassy plain supporting a dense cover of Flinders grass (*Iseilema* sp.).

RESULTS

The nest of Pair 1 was estimated to be 14 m above ground in the outer foliage of a coolibah 70 m north of a deep, dry ephemeral creek. Lower on the opposite side of the tree was an active nest of a pair of Black Kites (*Milvus migrans*) (Figure 2).

Figure 1. Open plain with scattered grass structures (rodent nests). Inset: one of the smaller structures and tunnelling. Photos: Mike Reed.

In accordance with some of the literature (e.g. Marchant and Higgins 1993), it was presumed that the Pair 1 nest was occupied by the female, which was observed to sit tightly on the nest almost continuously, leaving for short breaks every few hours to join the male perched high in a coolibah 30 m from the nest tree, from which the latter defended the nest site (Figure 3). The brief absences of a few minutes from the nest usually ended with a direct return, calling, or a tight circular flight over the nest tree. The pair was

Figure 2. Nest of Letter-winged Kite Pair 1 (box), male on watch (circle), and nest of Black Kite, obscured (oval). Photo: Mike Reed.

Figure 3. Letter-winged Kite Pair 1 male interaction with Black Kite. Photo: Mike Reed.

highly vocal, calling to each other throughout the day, typically a fast repeated 'karrr', rather resembling the call of a Dollarbird (*Eurystomus orientalis*), but not as harsh. This was interspersed with a high-pitched

Figure 4. Letter-winged Kite Pair 2 commonly used perches: female left; male right. Nest site obscured (circled). Inset: early stages of nest building. Photos: Mike Reed.

whistle that was also used as an alarm call when a raptor or an Australian Magpie (*Cracticus tibicen*) entered a defended zone of ~100 m radius from the nest.

As sunset approached, the calling was continuous over a period of 20 minutes as the pair maintained their respective positions on the nest and in the tree nearby. At 1840 h the female left the nest and flew directly to a branch close to the male, both birds calling loudly, and the female returned to the nest at 1900 h, calling as she settled on the nest. She remained until 1905 h, when she rejoined the male in the nearby tree, at which time it became too dark to continue observations. Occasional calls were heard throughout the night, both from the direction of the nest and elsewhere in the general area. During our constant surveillance, the male did not leave the immediate area or go to ground during daylight hours, and was not observed to feed the female.

Meanwhile, Pair 2 had also been vocal as they perched high in a coolibah on the southern side of the creek. At 1336 h, calling increased and the male flew up to join the female on a higher perch. Calling loudly, they mated, after which the male flew out of sight to the south, returning to his original, lower perch six minutes later.

Afternoon roosting by Pair 2 was occasionally broken as both birds took short flights around the tree, and calling increased towards sunset. At 1755 h the male flew down to the ground, returning to a concealed branch below his most frequently-used perch with a branched dead stick (i.e. nest material). At 1800 h the male flew up to the female, mated, flew down to the ground and returned with another branched dead stick. No sign of a nest could be seen from our campsite. Throughout the day, the female perched in one of two positions at the top of the tree and the male occupied perches lower down at or near what was later found to be a nest site (Figure 4).

Sunrise the following morning (27 March) was accompanied by continuous loud calling by the three pairs of Letter-winged Kites. Pair 1 was calling from the nest and the nearby tree, Pair 2 from the tree across the creek, and Pair 3 was perched high on dead branches of a coolibah, 170 m east of the Pair 1 nest.

Scanning with binoculars along the creek just after sunrise revealed another four Letter-winged Kites flying in circular patterns over the creek ~600 m west of our campsite, too distant for calls to be heard. Two or three of these kites remained active for several hours, flying in tight circles over the same area at varying heights in, presumably, display flights.

During the morning, a visit to the coolibah frequented by Pair 2 revealed the very early stages of a nest being built where the male was observed taking nest material on the previous day. The nest was centrally located in the tree an estimated 9 m above ground, 15 m from the creek bank and 105 m from the Pair 1 nest. The base of the nest had dead branches, and sprigs of green eucalypt foliage (containing buds and flowers).

A search of the area and roosting sites occupied by Pair 3 failed to locate a nest, their use of several widely-separated roosts possibly indicating that they were yet to determine a nest site or were not going to breed.

We left our campsite early that afternoon, driving west along the creek to the site where the four Letter-winged Kites were observed earlier in the day. We located four kites and two more nests.

Pair 4 was perched in a coolibah 10 m from the creek bank in which there was a nest on which they did not land, but defended from intrusion by Black Kites. The nest contained green foliage, appeared fresh and looked to be nearing completion. It was estimated to be 6 m above ground, and was 340 m west of the nest of Pair 1 and 400 m from the nest of Pair 2. Both birds perched nearby or on dead branches at the top of the tree.

Farther west, Pair 5 was in a coolibah on the northern edge of the creek, the presumed female occupying a nest and the male perched on a dead branch above the nest. Estimated at a height of 9 m, the nest was 50 m west of the Pair 4 nest, 380 m from that of Pair 1 and 440 m from that of Pair 2.

Upon our approaching Pairs 2, 4 and 5, the birds left the nest tree and circled overhead, calling. Pair 1 behaved similarly; however, both birds defended the nest vigorously, frequently swooping in a fast, steep dive to head height. Upon our retreat it was noted that all kites quickly reoccupied nests and roosting sites.

Diurnal incubation during the period of our observations was always by the same bird, a conclusion supported by photographs of Pair 1 which clearly show nest stains in front of the legs and on the lower breast of the presumed female (Figure 5). Plumage of the male was unsoiled (Figure 5).

Nest stains were not visible on the female of Pair 4, possibly indicating that incubation may have recently commenced, and that the breeding cycles of Pairs 4 and 5 were more closely aligned than those of Pairs 1 and 2. Active nests of the Zebra Finch (*Taeniopygia guttata*) were constructed in the side and base of the nests of Pairs 1 and 5.

Figure 5. Letter-winged Kite Pair 1: male left; female right, showing prominent nest stains on underside. Photos: Mike Reed.

Three nests, those of Pairs 1, 4 and 5, were in exposed positions at the extremity of a high branch in the outer foliage. However, the nest of Pair 2 was being constructed in a concealed location in the central area of the tree canopy. The only individual seen to participate in nest building was the male of Pair 2.

The four nests were within an area ~440 × 105 m along the creek, while non-breeding Pair 3 ranged over an adjoining area to the east of ~250 × 150 m. Daylight flights of all pairs were tightly restricted to the watercourse and nest sites, seldom extending beyond the flood-out area of the creek and associated scattered trees. A diagrammatic illustration of nest locations is provided in Figure 6.

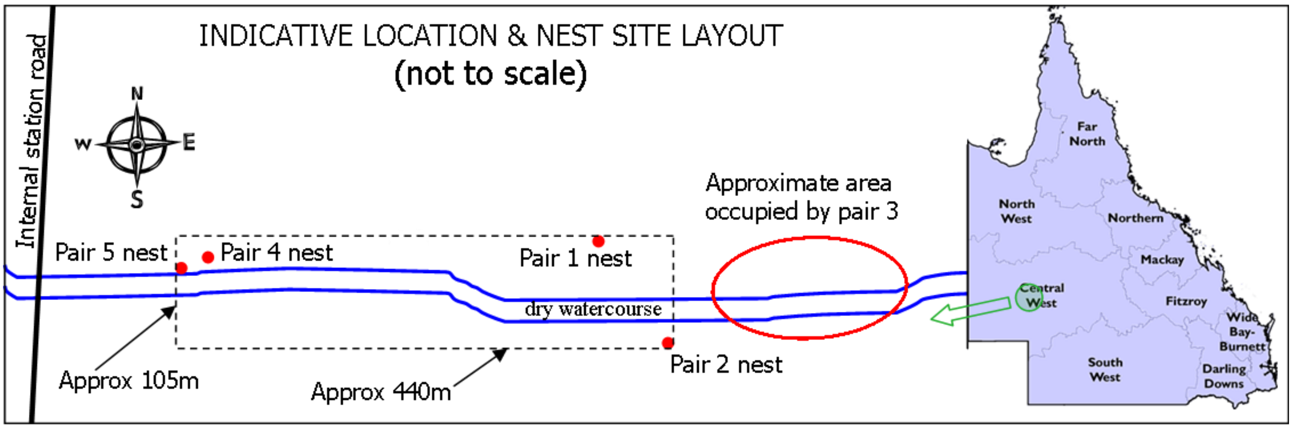

Figure 6. Location map and Letter-winged Kite nest dispersion.

In summary, the four nests ranged between 6–14 m (mean 9.5 m) above ground, dispersed along 440 m of the dry watercourse, 50 and 105 m between nearest neighbours, 340 m between the two pairs of nests, with the pre-breeding Pair 3 between these clusters.

During a return visit in August 2010 a further three nests, one with three, another with four flying young, and a third on which the pair were observed mating, were located near the nests of original Pairs 4 and 5.

DISCUSSION

Observed aspects of the Letter-winged Kite's behaviour and breeding parameters (e.g. season, nest sites and dispersion) were similar to previous descriptions, or within the range of previously recorded parameters (see Marchant & Higgins 1993). One nest (14 m above ground) was placed higher than the previously recorded maximum (11 m), and the completed nests in this study were larger and more exposed than detailed in some literature (e.g. Marchant & Higgins 1993). The Australian Bird Atlas (Barrett *et al.* 2003) has breeding records for the Letter-winged Kite at only three sites: two in central-western Queensland and a third in northern Western Australia. These observations were made in June, August and October, although it was not clear which observation corresponded to which date. What appears to be the small beginnings of a breeding colony in the present study supports the view (e.g. Garnett *et al.* 2011) that repopulation of the kite's core range during 'boom' times occurs from a small nucleus of survivors that remain during lean times.

Both sexes of the Letter-winged Kite are said to build the nest (Marchant & Higgins 1993, quoting an unreferenced source), although in the present, limited study only the male was seen to collect sticks. That both sexes collect material, and the female constructs the nest, is likely in view of such roles in the closely-related Black-shouldered Kite (*Elanus axillaris*) (see Barnes 2005). The breeding cycle and behaviour of the Letter-winged Kite remain to be described as fully as for the Black-shouldered Kite (e.g. see Barnes 2005; Read 2005; Debus *et al.* 2006).

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HABITAT PREFERENCE AND FACTORS CONTRIBUTING TO THE INCREASE IN NUMBERS OF BUSH STONE-CURLEWS (*BURHINUS GRALLARIUS*) ON COOCHIEMUDLO ISLAND, SOUTH-EAST QUEENSLAND

TONI M. CANNARD & DAVID A. MILTON

ABSTRACT

Bush Stone-curlews (*Burhinus grallarius*) occur in high densities on Coochiemudlo Island in southern Moreton Bay and other offshore islands. This contrasts with the situation on the adjacent mainland and in southern Australia. In order to start to understand why Bush Stone-curlews are more abundant on islands, we examined the trend in community counts of this species on Coochiemudlo Island made over 15 years. We also compared habitat preferences based on 18 paired presence/absence sites on the island. Count data show the numbers of Bush Stone-curlews detected increased in the early 2000s and have remained stable since 2007. Habitat data indicate Bush Stone-curlews favour locations with low to moderate shrub cover, low grasses and greater amounts of leaf litter. As well, curlews were most often found within 20 m of septic tanks and 100 m of water sources. Retention of cleared, undeveloped land corridors with a grassy understorey could encourage the maintenance of Bush Stone-curlew population numbers on Coochiemudlo Island. Septic tank trenches may be providing attractive feeding areas, contributing to the high density of Bush Stone-curlews on the island. If this is true, the population may decrease from the current estimate of 77 adult pairs and 37 juveniles when septic tanks become inactive following the installation of sewerage.

INTRODUCTION

Bush Stone-curlews (*Burhinus grallarius*) are large (550–750 g) nocturnal ground-dwelling shorebirds (Order Charadriformes) that are widely distributed across large parts of Australia. They are long-lived (25–30 years) and usually lay only 1–2 eggs annually (Marchant & Higgins 1993; Baltais 2006). Australia is home to 99% of the global population of Bush Stone-curlews, estimated to be about 15,000 (Watkins 1993). The Australian population is under threat and the species is listed as near-threatened in the

Red Data Book (IUCN 2006). It is classified as 'endangered' in Victoria and New South Wales, and 'rare' in South Australia (Victorian Department of Environment and Sustainability 2004; NSW Department of Environment and Conservation 2006). Although densities are also low in the southern half of Queensland, Bush Stone-curlews are not considered threatened under state legislation. On offshore islands, however, Bush Stone-curlews tend to occur in high densities.

Foxes are known to be the major predator of Bush Stone-curlews on the Australian mainland and have substantially reduced populations (Victorian Department of Environment and Sustainability 2004; NSW Department of Environment and Conservation 2006). Feral cat predation is also expected to affect populations, but its impact is difficult to quantify (Barratt 1997; Lepczyka *et al.* 2003). Feral cats and foxes are absent from most islands with healthy Bush Stone-curlew populations, such as Kangaroo Island, South Australia (Gates & Paton 2005), Magnetic Island, northern Queensland (Schuett 2003) and Coochiemudlo Island, southern Moreton Bay. Besides predation, Bush Stone-curlew populations are also known to have declined through poisoning, removal of leaf litter and habitat degradation (BirdLife International 2004).

Loss, degradation, fragmentation, and modification of habitats have all led to the decline of many species of birds (Garnett *et al.* 2011). In some cases, habitat loss has been responsible for species extinctions (May 2005; Miller 2005; IUCN 2006). Bush Stone-curlew habitats in southern Australia coincide with highly modified agricultural lands (Marchant & Higgins 1993); this has probably also contributed to the decline in their populations in these areas. However, a recent study on Kangaroo Island reported that anthropogenic modification of remnant vegetation appeared to favour population growth of Bush Stone-curlews (Gates & Paton 2005).

Habitat preferences can be used to explain population and distribution changes, and to potentially indicate future trends (Redpath 1995; Morris 2003). Bush Stone-curlews are resident and highly territorial in their foraging and nesting areas (Marchant & Higgins 1993). They eat mainly arthropods and small vertebrates, but also some vegetation and seeds. Nests are usually made in areas of sparse open ground cover to allow detection of the approach of predators (Marchant & Higgins 1993; NSW Department of Environment and Conservation 2006) and the birds can use the same nesting site year after year.

The size of the Coochiemudlo Island Bush Stone-curlew population was estimated at around 50 breeding pairs in the February 2006 census

(Indigiscapes, unpublished data 2006). In this study we examine habitat preferences of Bush Stone-curlews on Coochiemudlo Island to help our understanding of population changes over the past 15 years. Analysis of this long-term data set may provide insight into (a) why the abundance of Bush Stone-curlew populations on islands is greater and (b) the likely impacts of ongoing urban development on Coochiemudlo Island.

Specifically, this study aims to identify and assess (a) changes in the Coochiemudlo Island Bush Stone-curlew population based on annual census surveys from 1997–2012; (b) characteristics of sites where Bush Stone-curlews were present and absent; and (c) differences in the potential prey available at these sites.

METHODS

Annual population counts of Bush Stone-curlews have been made on Coochiemudlo Island since 1997 (Redlands City Council unpublished data 2012). The count is made as a community event each February. It starts at around 1730 h, shortly before dusk. The entire island is divided into eight survey areas. Counters are divided into teams of 3–5 members with each team assigned a survey area to visit. Each team is given a copy of the cadastral map of their area on which to mark the location and time of each sighting. Participants record the numbers of adults and chicks sighted and land type (roadside, recreation reserve or park, conservation land, private or public land). Many participants in the survey have been involved for several years and inexperienced participants are always teamed with experienced surveyors.

Habitat data were collected in the first two weeks of October, 2006 via a road-based survey (covering approximately one quarter of the island's urban area). Surveys were made each day for a two hour period starting at 1730 h. The numbers of adults, juveniles and chicks of Bush Stone-curlews were recorded, as were habitat characteristics within 5 m (25 m^2) of the birds. Paired absence sites were selected in a random direction 30 m from each presence site, with a random centre point (e.g. the centre of a vacant block) chosen from which to record habitat characteristics, again within 5 m (25 m^2). Habitat attributes measured at each site were percentage cover of tree canopy (>3 m), shrubs (<3 m), grasses, leaf litter and bare ground, with all percentages rounded to the nearest 10%. Grass height (±2 cm) was also measured at each site. Land use was recorded, defined as vacant block (urban house block), house (occupied), vacant house, or remnant bushland. Vacant blocks included both cleared and uncleared land. Land use on adjacent blocks of land was also recorded, using the same categories.

Trenches that usually extend around 10 m from septic tanks provide attractive areas of soft soil that may have more ground-dwelling prey for Bush Stone-curlews (Marchant & Higgins 1993). For this reason, the proximity of presence and absence sites to a septic tank was estimated. The proximity of sites to the closest known freshwater source (creek or pond) was also estimated. When human-provided water was evident at a site, that distance was recorded and the kind of container (e.g. pot plant base) was noted.

All habitat attribute data were summarised and grouped into ranges. The proportions of attribute groups found in presence and absence sites were calculated. The mean proportion of each attribute was compared between the presence and absence site by a t-test, assuming unequal variances (Sokal & Rohlf 1981).

Infaunal sampling of eight habitat survey sites was undertaken during the survey in October 2006 (four paired presence/absence sites). At each site, a random location was chosen from within the 25 m^2 area. A spade was inserted to approximately 20 cm deep, and lifted to remove approximately 2 –3 kg of soil and organic material. Each sample was sifted through a 2 mm mesh and the number and type of invertebrates present in each sample were recorded, as was the presence of dead and live organic material (Long & Poiner 1994).

RESULTS

Population trend

The numbers of adult and juvenile Bush Stone-curlews on Coochiemudlo Island increased during the period 1997–2006 (Figure 1). During this period, the numbers of birds recorded increased in most years, with 2000 and 2002 being the only exceptions. Since 2007, the number of adult Bush Stone-curlews counted has stabilised. Numbers of adults and juveniles followed similar trends, with a few exceptions (Figure 1): the number of juveniles counted declined dramatically in the period 2004–2006 and in 2010. In 2012, 154 adults and 37 juveniles were detected (Figure 1).

Habitat characteristics

A total of 55 Bush Stone-curlew sightings (42 adults, 11 juveniles and 2 chicks) was recorded during the road-based habitat survey. The data for one presence site (p13) and a paired absence site (a13) were removed from the collated data, as these sites supported birds that were fed by humans. Eight adults and two juvenile birds were seen at this site.

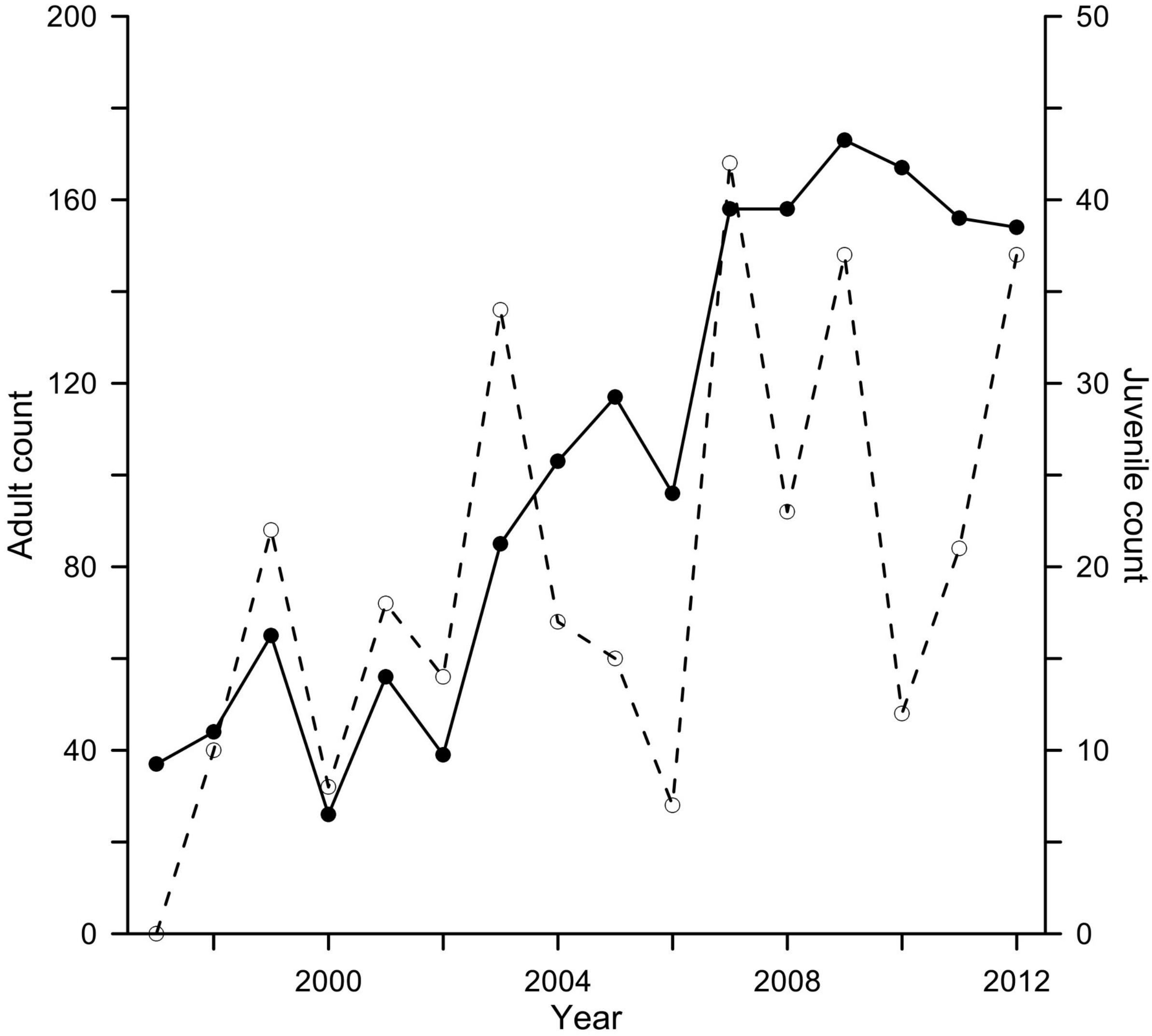

Figure 1. February counts of Bush Stone-curlew adults (closed circles) and juveniles (open circles) from 1997 to 2012.

Figure 2 shows measures of percentage cover of canopy, shrubs, grass, leaf litter and bare ground at presence and absence sites. Canopy and shrub cover estimates at both presence and absence sites were spread over a broad range of values (Figure 2). Only one presence site (6%) had no canopy cover, compared to five absence sites (28%). Bush Stone-curlews showed a preference for sites with 10–30% shrub cover (94% of presence sites) (Figure 2), but this was not statistically significant. Grass height varied from 0 to over 40 cm, but was lower (ranging from 5–15 cm in height) at presence sites than at absent sites (t-tests: DF=17, P(two-tail)<0.03) (Figure 3d). There was no grass at several absence sites (18%). The presence of grass was positively related to territory choice (Figure 2). There were no sightings of Bush Stone-curlews in habitats with zero grass cover. Sites where Bush Stone-curlews were present had significantly greater leaf-litter cover (31%) than sites where these birds were absent (9%) (t-tests: DF=26, P(two-tail)

<0.003). Almost half (47%) of the absence sites did not have any leaf litter (Figure 2). Sites with Bush Stone-curlew also had less bare ground than absence sites, although the pattern was not significant (P>0.1).

Land use

Bush Stone-curlews were present in vacant blocks (59%), and near houses (29%) and vacant houses (12%) (Figure 3). No Bush Stone-curlews were found in remnant bushland (Figure 3a). The majority of absence sites were adjacent to housing (72%), whereas the majority of presence sites were adjacent to vacant blocks (47%) or remnant bushland (41%).

Proximity to septic systems and water sources

Most (76%) of the Bush Stone-curlews were sighted within 20 m of the closest septic tank, while most (71%) absence sites were over 20 m away

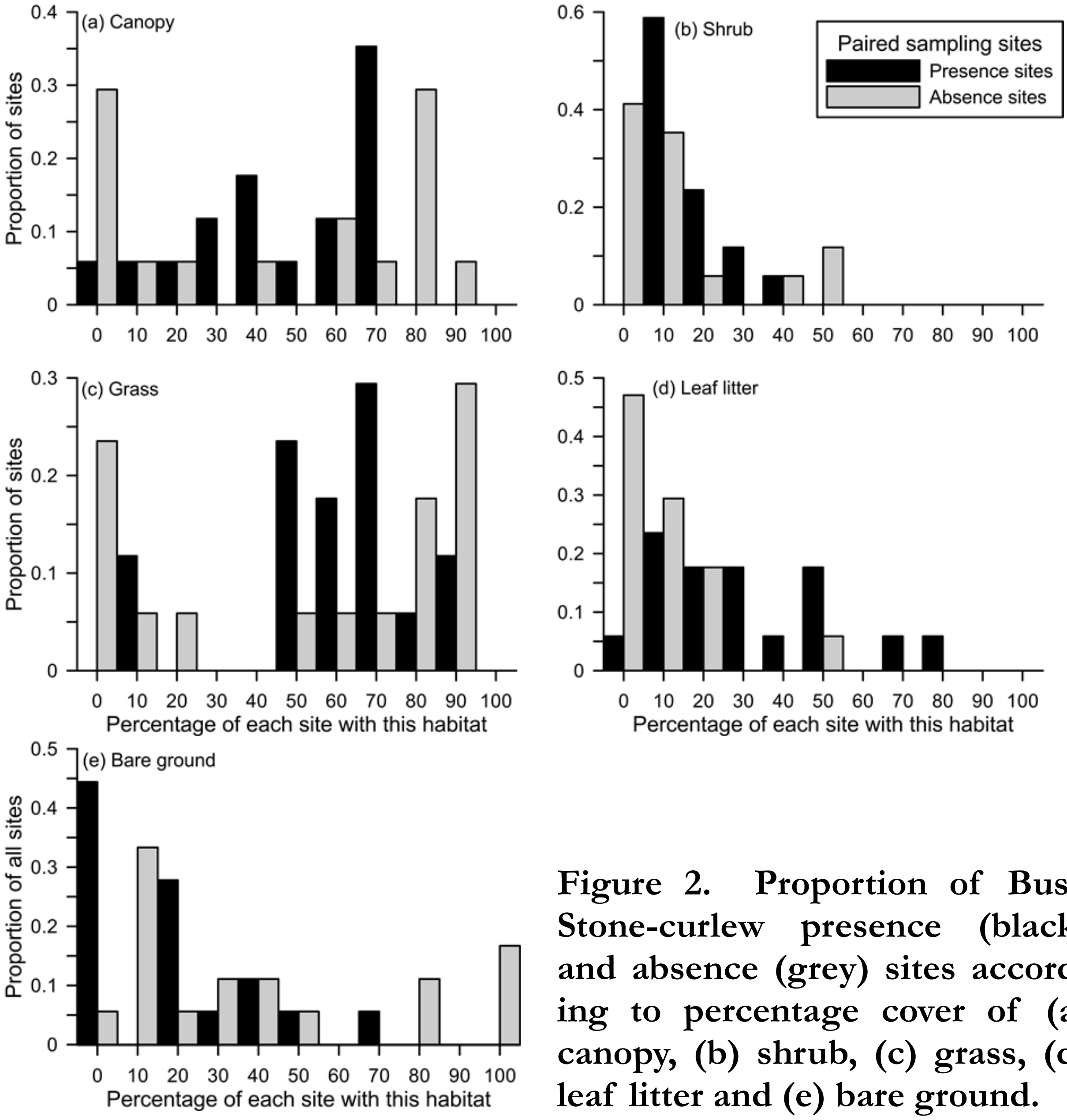

Figure 2. Proportion of Bush Stone-curlew presence (black) and absence (grey) sites according to percentage cover of (a) canopy, (b) shrub, (c) grass, (d) leaf litter and (e) bare ground.

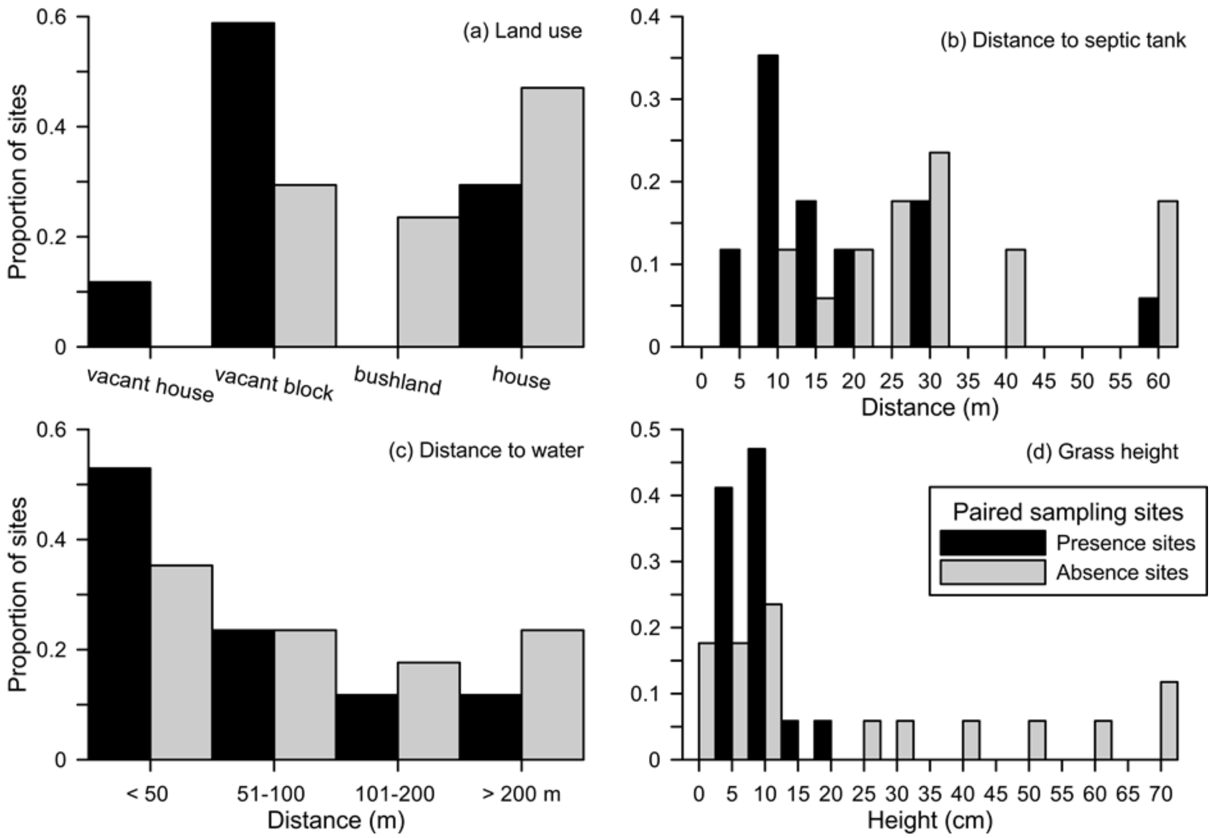

Figure 3. Proportion of Bush Stone-curlew presence (black) and absence (grey) sites according to (a) land use, (b) distance to nearest septic tank, (c) distance to nearest water and (d) grass height.

from a septic tank (Figure 3b). Several Coochiemudlo Island residents confirmed that they frequently see Bush Stone-curlews foraging around septic trenches. However, there was no significant difference in the distance to septic tanks between presence and absence sites (P>0.2).

Most (76%) Bush Stone-curlews were found within 100 m of a known water source (Figure 3c). Evidence of human-provided water was recorded for three presence sites (17%). However, there was no significant difference between presence and absence sites in the distance to water (P>0.8).

Infaunal sampling

Infaunal site sampling found invertebrates only at locations where Bush Stone-curlews were present (Table 1). Live organic material was found in all presence-site infaunal samples, whereas dead organic material was found in all samples. Biomass values could not be obtained due to the very small size of the invertebrates found. A resident who had recently dug up around septic trenches reported large quantities of earthworms, cockroaches and beetles uncovered in the process (M. Kuter personal communication).

Table 1. Numbers and type of invertebrates found at Bush Stone-curlew presence (p) and absence (a) sites.

Site ID	Spiders	Earth-worms	Other worms	Cock-roaches and beetles	Earwigs	Ants	Praying mantis
p1	2	3	2	1	2	0	0
p2	0	0	0	1	0	0	0
p9	0	0	1	1	0	0	0
p11	0	0	0	0	0	3	1
Subtotal	**2**	**3**	**3**	**3**	**2**	**3**	**1**
a1	0	0	0	0	0	0	0
a2	0	0	0	0	0	0	0
a9	0	0	0	0	0	0	0
a11	0	0	0	0	0	0	0
Subtotal	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Total	**2**	**3**	**3**	**3**	**2**	**3**	**1**

DISCUSSION

Bush Stone-curlew populations have been in decline across the Australian mainland, mostly due to predation by foxes (Gates & Paton 2005; NSW Department of Environment and Conservation 2006). Populations on islands appear to be larger and the birds occur in higher densities than on the adjacent mainland (Gates & Paton 2005; Baltais 2006). The reasons for higher densities on islands are unclear, but probably relate to lower predation rates or increased availability of high quality habitat.

Parsons *et al.* (2003) found that urban habitats provide a more comprehensive complement of ecological needs for some bird species. Similarly, Cooper (2002) found that territories of abundant or increasing species may extend into somewhat atypical habitats, often aided by human activity and land use. The growth of the Coochiemudlo Island Bush Stone-curlew population may be linked to an increase in urban dwellings and/or associated clearing of native vegetation, as has been suggested for Kangaroo Island (Gates & Paton 2005). Coochiemudlo Island has experienced an increase in the number of urban dwellings since the annual Bush Stone-curlew census began in 1997. There are currently (as at 2012) 718 individual properties on the island: residential – 556, vacant land – 143, and other use (commercial, etc.) – 19. Since 1998, 109 domestic properties have been given building approval (Redland City Council, personal communication 2006), which equates to a housing increase of 18%. During the habitat attribute survey, it was noted that five adult Bush Stone-curlews and one juvenile were taking refuge beneath an occupied house that was raised off the ground by approximately 50 to 70 cm. Another benefit of urban dwellings may be the associated increase in the number of house lights. These lights would attract more insects that may provide additional food for Bush Stone-curlews.

Understanding habitat selection is important for wildlife conservation and management (Morris 2003). Presence of leaf litter and short grass were significant habitat attributes for Bush Stone-curlews. The curlews showed a preference for sites with moderate to high leaf litter cover, and a grass height of 5–20 cm. Leaf litter could provide habitat for prey. Gates and Paton (2005) found that Bush Stone-curlews on Kangaroo Island have benefited from vegetation clearance. The birds favoured sites with short grass rather than dense native vegetation. Similarly, other species of stone-curlews have been found to prefer short grass habitats for foraging and feeding (Green et al. 2000). The results of our study are consistent with these earlier studies. Our study indicates that the removal of a dense shrub layer in human-modified habitats on Coochiemudlo Island has increased the amount of habitat available. Besides foraging advantages, short grass in cleared areas appears to allow the curlews a full view of approaching predators while sitting on the ground (Baltais 2006). This may explain why the birds are not present in dense bushland, where the grasses are usually much taller. The Bush Stone-curlews' preference for sites with some shrub cover (10–30%) is probably because these shrubs provide hiding places and a camouflaging background. These preferences are not recognised in management recommendations in current recovery plans in Victoria (Victorian Department of Environment and Sustainability 2004), New South Wales (NSW Department of Environment and Conservation 2006) and south east Queensland (Redlands City (Baltais 2006)), although these plans do encourage/require retention of foraging sites.

Bush Stone-curlews were found in close proximity to septic tanks (within 20 m) and water sources (within 100 m). This is most likely associated with feeding, as the earthworms, beetles, bush cockroaches and surface arthropods that Bush Stone-curlews and other stone-curlews feed upon (Marchant & Higgins 1993; Green *et al.* 2000) are associated with moist environments, such as septic tank trenches. It suggests that septic tanks may be important to the maintenance of the Bush Stone-curlew population. The Bush Stone-curlew management plan of Baltais (2006) includes a recommendation that the Redlands City Council consider supporting the continuation of some of Coochiemudlo Island's septic tanks. A recommendation from this study is that residents be encouraged to establish compost heaps around septic trenches before septic tanks become inactive following connection to sewerage, to provide ongoing habitat for invertebrates. Additionally, it may be valuable to conduct a follow-up study during the period when septic trenches become inactive in order to monitor potential impacts due to the expected reduction in invertebrate abundance.

Our data suggest that vacant land corridors in urban areas may be important. Bush Stone-curlews favoured vacant land or houses with a vacant block beside them. This suggests that corridors of cleared land between houses are important habitats. We speculate that the positive relationship between Bush Stone-curlew numbers and increased urban development may be reversed if sufficient vacant cleared land is no longer available to provide suitable habitat corridors.

The recorded declines in the Bush Stone-curlew population in 2000 and 2002 on Coochiemudlo Island may be due to a change in the spatial pattern of census effort, and/or less experienced census participants. A possible cause for actual population decline may be increased predation on chicks by domestic cats (Barratt 1997; Baltais 2006; NSW Department of Environment and Conservation 2006). A night-time cat curfew during the breeding season may be an effective means of reducing possible predation on Bush Stone-curlew chicks (Barratt 1998; Lepczyka *et al.* 2003; Baltais 2006).

An improved understanding of Bush Stone-curlew habitat preferences provides insight into a variety of environmental and human influences upon populations. In this study, land use (including adjacent land use), vegetation variables and proximity estimates are summarised to form an understanding of Bush Stone-curlew habitat preferences on Coochiemudlo Island. We found that Bush Stone-curlews prefer human-modified landscapes with low levels of regular disturbance (Green *et al.* 2000). Additionally, the close proximity of Bush Stone-curlews to septic tanks suggests septic trenches may be important for foraging, thus influencing Bush Stone-curlew abundance. The number of Bush Stone-curlews on Coochiemudlo Island has increased with increasing housing density and land clearance. However, stabilisation of the total population size since 2007 suggests that the available habitat may be at capacity. Factors that were not measured in this study, but may also affect populations, include street and house lighting, disturbance, road use and domestic pets. We suggest the community curlew census data forms be enhanced to collect more data on habitat attributes such as these, and proximity to septic tanks. The results of this study may assist conservation management decisions for Bush Stone-curlews elsewhere in Australia.

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