

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

Lois Wooding

14/4 Muller Street, Salamander Bay, NSW 2317, Australia [woodinglaw@bigpond.com](mailto:woodinglaw@bigpond.com)

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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.



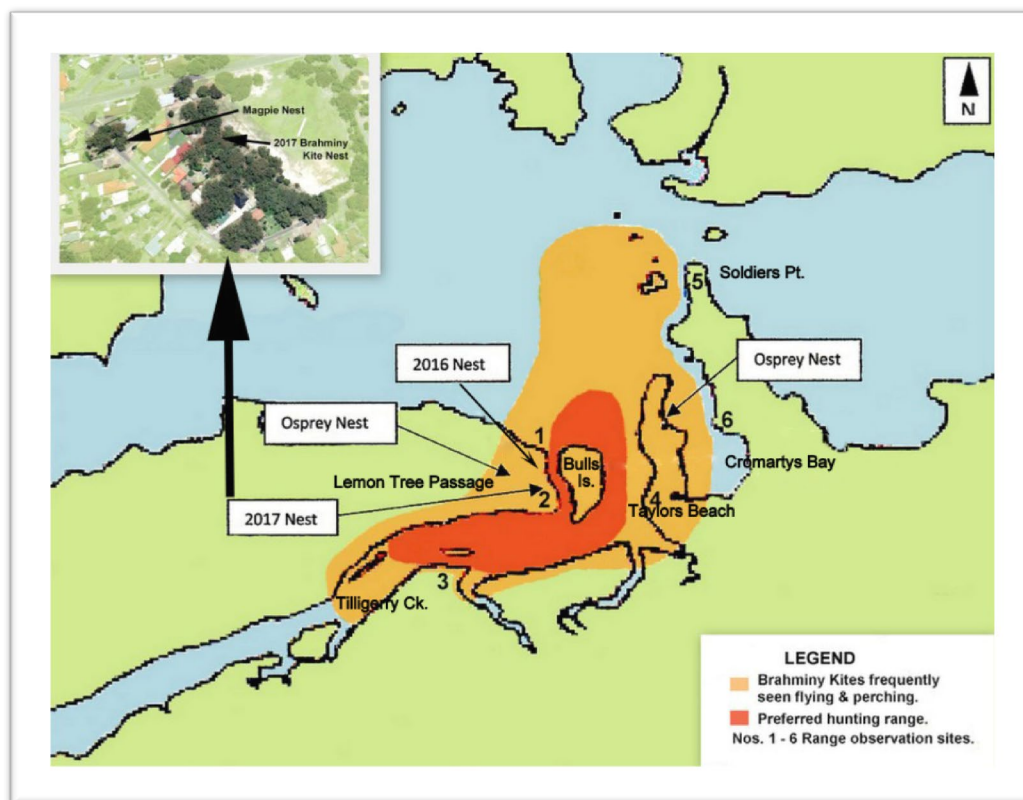
**Figure 1.** The 2016 Brahminy Kite nest, Lemon Tree Passage. Photo: Lois Wooding



**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  $\geq 3$  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 to 16 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 ciliata* 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  $\geq 25$  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 tasmanicus* 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.

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