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Foraging, Breeding Behaviour and Diet of a Family of Black-shouldered Kites *Elanus axillaris* near Tamworth, New South Wales

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Summary

The foraging, breeding behaviour and diet of a family of Black-shouldered Kites *Elanus axillaris* were studied by 68 hours of observation from the incubation period to the end of the post-fledging period, and by analysis of pellets, near Tamworth on the North-west Slopes of New South Wales in April–July 2004. The male Kite foraged mostly in mid morning and early to mid afternoon, aerially (82% of search time), with 77% of 44 attacks successful. Pellets (n = 30) consisted entirely of House Mice *Mus domesticus*, and observed prey items were mice (n = 58) or mouse-sized mammals (n = 3). The male's capture, consumption and prey-delivery rates peaked in the week before fledging (mean 0.9, 1.2 and 1.2 captures/h in the incubation, nestling and post-fledging phases, respectively). The female performed most care of eggs and nestlings, though the male performed a minor share of incubation and brooding. The nestling period lasted 36 days, and post-fledging period at least 36 days with parental feeding for at least 22 days. Parental behaviour, vocalisations, hunting behaviour, and development of juveniles are described.

Introduction

The Black-shouldered Kite *Elanus axillaris* is common and widespread in settled parts of Australia, but aspects of its breeding biology and behaviour were not described in detail until the observational studies of Barnes (2005) and Read (2005). Those studies addressed, respectively, the prelaying period, and the late nestling period to independence of the juveniles, of two families of Kites. Sex-roles in the incubation and nestling periods remain to be quantified, and there is little quantified information on foraging behaviour. The Kite preys mainly on rodents, particularly the introduced House Mouse *Mus domesticus* (Marchant & Higgins 1993; Engel & Rose 1997; Mathieson *et al.* 1997; Barnes 2005; Read 2005).

In April 2004, one of us (GO) found an active Black-shouldered Kite nest towards the end of the incubation period. This paper describes the behaviour and diet of the family of Kites in the final two weeks of incubation, and throughout the nestling and post-fledging dependence periods.

Study area and methods

The study site was a rural property ~ 5 km north-east of Tamworth (31°06′S, 150°56′E), on the North-west Slopes of New South Wales. The Kites' nest-tree and two focal perching trees were ~ 200 m away across an open grassy paddock, in full view, from GO's residence, and the Kites usually hunted in the paddocks around the house. The habitat in the immediate area, within a radius of 1 km, was an open valley in agricultural and pastoral land, with tree-lined roads and driveways, scattered live and dead eucalypts in paddocks, and a creek lined with eucalypt woodland. There was eucalypt woodland on surrounding ridges ~ 200 m north and ~ 1 km west of the nest.

Focal trees in the nesting territory were a dead-topped live eucalypt with protruding dead branches ('lookout tree' = tree L, often used by the male), and a damaged live eucalypt with broken limbs and some dead branches ('broken tree' = tree B), in the paddock 50 m west and 55 m south-south-west of the nest-tree, respectively. Trees L and B (both White Box *Eucalyptus albens*) were 55 m apart. There was also a dead eucalypt (tree D) in the paddock 150 m south-south-east of the nest-tree, in which the adults sometimes perched during the male's hunting forays. Distances between focal trees were measured with a range-finder.

Observations at the Kites' nest were conducted from an unconcealed position on the ground 60 m west-north-west of the nest, with the aid of binoculars and a 20–45× zoom telescope. The viewing point was also 45 and 90 m from the Kites' two favourite perching trees in the nest area. GO usually observed for ~ 0.5 h in early mornings and late afternoons on some weekdays and for variable times totalling several hours on weekends, and SD, NM and JM made separate observation visits of 0.5–2 h (usually 1–1.5 h) to coincide with GO's absences, or to continue when he finished a session. The nest was observed for a total of 12 h over eight days in the incubation period (24 April to 5 May), 42 h over 18 days in the nestling period (hatching to fledging, 7 May to 11 June), and 14 h over seven days to week 3 of the post-fledging period (12 to 27 June), with casual observations on a further five days to week 6 (3 to 18 July, mainly in week 5). Observations spanned all daylight hours (dawn to dusk, 0600 to 1745 h), but were biased towards mid to late morning and mid to late afternoon; there were 64 hours of observation when the foraging male was monitored simultaneously with the nest (Table 1). Sunrise and sunset in mid June were ~ 0700 and 1700 h, respectively.

The adults' time-budgets (including male foraging behaviour when he was visible) were quantified by continuous focal-animal sampling, i.e. observing and recording the start and finish times (i.e. duration) of each behaviour, to the nearest minute. A hunting 'foray' was defined as the male's foraging activity (which might include several bouts of flying/hovering and perching) between leaving and returning to the nest area; a flying/hovering 'bout' was an episode of aerial hunting that started from and finished with perching (e.g. a bout of perch-hunting, distinguished from other perching by the alert Kite scanning the ground apparently for prey).

The Kites' accumulated pellets were collected, on plastic sheeting, from below the favourite perching trees of the adults and juveniles in the post-fledging period (14 June, 2 days post-fledging). No pellets were found below the nest, despite searching. The pellets were air-dried, weighed on a digital balance, then fur, bones and teeth therein analysed microscopically by ABR by comparison with reference material.

The adult Kites were initially sexed by inference, on the basis that the female does all or most of the incubating and brooding of small chicks, and the male does all the food-provisioning until late in the breeding cycle (Marchant & Higgins 1993; Read 2005). Apart from the clear division of sex-roles, with one individual consistently performing nest duties and the other doing the hunting, some minor behavioural differences (described herein) became apparent. When the adults perched side by side, the female was slightly larger and had a faint pale-grey wash on her crown, and she also appeared to have slightly larger and blacker 'shoulder' patches, and slightly longer wing-tips that crossed just beyond her tail-tip at rest. Relative ages of nestlings were inferred from the typically asynchronous hatching of hawks (e.g. Hollands 1984; Marchant & Higgins 1993).

For the purposes of analysis, data from weeks 1 and 2 of the nestling period were pooled, as the watch schedule was unbalanced (15.7 h vs 3.8 h) and observations were skewed towards late afternoons in week 2, when the female brooded for the entire time and the male ate all of the prey. His time-budgets (hunting vs perching) were similar in both weeks.

Results

Foraging

In the incubation period and first week of the nestling period, the male Kite's hunting range was estimated as ~ 100 ha of grassland on the smallholdings in the valley. By week 3 of the nestling period his hunting range had expanded greatly. Some of the tall grass around GO's house paddock was then slashed, and the male hunted over the remaining unslashed grass, often over the boundary with the slashed area, or ranged even farther afield.

Table 1: Daily foraging routine of male Black-shouldered Kite, incubation to post-fledging period (April–June 2004), Tamworth, NSW, during each two-hour interval of daylight hours: % observation time spent hunting, no. hunting forays (including unsuccessful) per hour, no. captures per hour, and no. deliveries to female or fledglings. No. hours observation in each interval through the day in parentheses. Total prey captures = 79.

	0600–0800 (5.4 h)	*0801–1000 (10.6 h)*	*1001–1200 (10.3 h)*	*1201–1400 (5.6 h)*	*1401–1600 (20.8 h)*	*1601–1800 (11.3 h)*
% time hunt:	11	30	16	20	22	16
No. forays/h:	0.2	2.3	1.4	2.0	1.3	1.4
No. captures/h:	0.2	1.6	1.4	1.4	1.3	1.2
No. deliveries/h:	0.2	1.4	0.6	0.9	0.7	0.1

The male foraged least in early morning and late afternoon, when he mostly perched in tree L near the nest, and most in mid morning and mid afternoon, with a slight lull towards midday (Table 1). He foraged by high quartering and hovering, then dropping into long grass. Foraging forays, from departure to return, averaged 7.4 minutes (range 1–21 min., standard deviation, s.d., 6.0; n = 83 timed forays). Of 85 forays, 64 (75%) were successful; he made no strike at prey on 13 forays (15%). Forays consisted of bouts of flying and hovering, bouts averaging 3.8 minutes in duration (range 1–13 min., s.d. 2.8; n = 77 bouts), sometimes interspersed with bouts of perching that averaged 2.5 minutes (range 1–8 min., s.d. 2.1; n = 25 bouts), before he made a capture or gave up and returned to tree L. During hovering bouts, 34 of 44 dives (77%) were successful, with an additional two dives aborted before contact with the ground. On 35 (45%) quartering/hovering bouts, he made no strike at prey. Assuming that perching and scanning between aerial bouts was also foraging (i.e. perch-hunting), 82% of foraging time was aerial and 18% stationary; he made no strikes at prey from a perch.

Typically, in the early mornings the male's hunting forays were long (19–21 min.) and he made no strikes, whereas at other times of the day forays were usually much shorter and often resulted in a quick capture. For example, 33 such later forays (40% of 83) produced a capture within 1–5 minutes, mostly from a single aerial bout and strike. His hourly capture rate peaked in mid morning then levelled off before a slight decline in late afternoon (Table 1); earliest and latest observed captures were ~ 0745 h and ~ 1700 h respectively. His hourly delivery rate to the female and young also peaked in mid morning, with another slight peak in early afternoon and sharp decline in late afternoon (Table 1), supporting our observations that he fed himself in late morning and particularly in the late afternoon.

Nest-site

The Kites' stick-nest was ~ 12 m above the ground in a Rough-barked Apple *Angophora floribunda*, on a creek-bank amid riparian eucalypt woodland. The nest was in the outer edge of the crown, 0.3 m from the top of the live part of the tree; the opposite side of the tree had crown dieback in the top 0.3 m, and the nest-tree was beside another live creekside angophora that had more extensive crown dieback. The nest was readily accessible from above, but was inconspicuous in lateral view (though observable by telescope, once discovered).

Breeding chronology

The nest was discovered, and incubation confirmed (by parental behaviour), on 26 April; incubation was still in progress on 5 May, 9 days later. Hatching, as confirmed by the female taking food to the nest, tearing small pieces and offering them into the nest-cup to small chicks, then brooding, had occurred by 7 May. Fledging occurred on 12 June, 36 days later. Backdating from incubation and nestling periods of ~ 31 days and ~ 35 days, respectively (Marchant & Higgins 1993), places laying as occurring in early April.

Taking 7 May as day 1 of the nestling period, week 1 was thus 7–13 May, week 2 = 14–20 May, week 3 = 21–27 May, week 4 = 28 May–3 June, week 5 = 4–10 June and week 6 = 11–12 June (days 36–37). Taking 12 June as day 1 of the post-fledging period, the respective weeks of that stage were thus 12–18 June (week 1), 19–25 June (week 2), 26 June–2 July (week 3), 3–9 July (week 4), 10–16 July (week 5), and 17–18 July (week 6, i.e. days 36–37).

Incubation

During the final two weeks of the incubation period, the female performed most of the incubation duty. The male provided her with food or he perched on tree L, usually on the topmost dead branches though sometimes on a lower branch. The female ate the prey on a branch of tree L, commonly within ~ 10 minutes, then returned to the nest. On one occasion the male perched in the top of the nest-tree, apparently guarding, for 5 minutes while the female ate his catch, and on another occasion he incubated for 25 minutes while the female was off feeding on his catch and preening. On a further occasion the male arrived at the nest (without prey) and stood on the nest for 2 minutes while the female incubated.

The general routine was for the male to mostly perch or sometimes forage in the early morning, and to forage and feed the female in early to mid afternoon then feed himself in the late afternoon. On four evenings, around sunset to twilight, the male departed from tree L apparently for a roost in some exotic pines *Pinus* sp. 400 m south-east of the nest; on one subsequent morning he was perched atop a pine at dawn before coming to tree L.

At this stage of the breeding cycle, the female Kite tore at delivered prey two or three times then swallowed the whole mouse head first. The male also ate prey on tree L, but tore and ate mice in small pieces until the last larger piece was swallowed.

In early mornings and late afternoons there was little Kite activity, as mornings may have been too cool for rodent activity and by late afternoon the Kites were probably settled for the night. For example, the male was on a branch halfway up tree L rather than on his daytime topmost perches. Close inspection revealed the just-visible tail of the incubating female. At such times the male sometimes arrived on tree L at ~ 0615 h, and the female sometimes fed on his catch in the afternoon before returning to the nest, with the male atop tree L. On cold, wet mornings the Kites were not seen and there was no activity at the nest, when the female was probably sitting low on the eggs.

Table 2: Parental time-budgets of a pair of Black-shouldered Kites (as % observation time) during the nestling period, Tamworth, NSW, May–June 2004 (hours of observation shown in parentheses). W = week, F = female, M = male. Brood = male or female sheltering nestlings; stand = standing on nest; feed chicks = tear food, feed bill to bill; nest-tree = perching in nest-tree; perch = perching on favoured trees in nest area (see text); defend = attacking other birds in nest area; absent = away from immediate nest area (i.e. not on nest or nearby favoured perches). No quantified data for week 6.

Activity	*W1–2 (19.2)*		*W3 (10.1)*		*W4 (6.0)*		*W5 (5.8)*	
	F	*M*	*F*	*M*	*F*	*M*	*F*	*M*
Brood	88	4	29				2[a]	
Stand	1				2		1	
Feed chicks	3		3				1	
Nest-tree		4	1				1	
Perch	8	71	57	74	85	77	67	37
Defend		2					1	1
Absent		19	9	25	13	23	26	62

[a] At sunset, before brooding overnight

The female incubated for 89% of observation time (11 h), and perched in the nest area (tree L or B) for 11%. The male perched in the nest area (mostly atop tree L) for 60% of observation time, was away hunting (though usually visible from the observation point) for 35%, incubating for 4%, in the nest-tree (guarding in the female's absence) for 1%, and defending the nest area for < 1% (total 12 h). Thus, the eggs were uncovered for 7% of time and unattended for 6%. The nest was unattended by either adult for periods of 1–10 minutes, usually ~ 5 minutes (n = 6).

Nestling period: parental behaviour

The female's nest-attendance time decreased steadily from weeks 1–2 to week 5 (Table 2). In weeks 1–2 the female mostly brooded, and occasionally stood on the nest; she sometimes left the nest to perch in tree L. The male mostly perched in the nest area (tree L) or was absent (mostly hunting); he occasionally brooded or perched (apparently guarding) in the nest-tree while the female handled his catch, and he sometimes followed her to the nest and perched in the top of the nest-tree while she fed the chicks. In weeks 1–2 the nest was attended for 96% of observation time, and for the remaining 4% the male was either in the nest-tree or defending the area.

In week 1 the female left the nest only to collect and eat or prepare food delivered by the male, for periods of up to 12 minutes depending on whether she ate the entire item or took it to the nest. When the male delivered a mouse to the female on tree L, she partly dissected the prey, then took it to the nest-rim and fed small pieces to the chicks; she swallowed larger pieces. On day 6 she held a large piece of prey in her bill while the chicks pecked at it.

In week 3 the female was mostly perched in the nest area (trees L and B); she occasionally perched in the nest-tree, and was rarely absent. At that stage she sometimes brooded after feeding the chicks in the morning, and returned to brood in the evening. On days 15–17 her stints off the nest were of 20–45 minutes in the mornings, and 1.5–2.5 h in the afternoons; the larger chick refused day-brooding on day 16, and she last attempted day-brooding on day 17 when the chicks were large and active. From week 3 the male did not go to the nest, and he did not deliver food directly to the young until they fledged; he either perched in the nest area, or was increasingly absent (by week 5) on hunting forays. From day 16 the nest was sometimes unattended by either parent.

From week 4 the female mostly perched in the nest area and was increasingly absent, waiting for the male towards his hunting grounds. On day 22 the smaller chick was too active for day-brooding, so the female stood over it. In week 5 (day 29) she brooded at sunset, in preparation for overnight brooding. At sunset on day 30, and in week 6 (day 36), the chicks were not brooded.

The female tore prey and fed the chicks bill to bill in weeks 1–3 and sometimes to week 5; from week 4 she gave some prey partly plucked and headless, but otherwise whole, to the chicks. On day 30 she gave a whole mouse to one chick.

Only the male hunted and returned with prey, but from week 3 the female occasionally followed him or departed alone. If the female remained behind, commonly on tree B, she was alert to his return, often leaving her perch while the male was distant (appeared 'small' through 10× binoculars) or before the observer had detected his return flight. On day 31 the female started hunting.

Nest-maintenance was observed twice. In week 1, after being fed by the male, the female broke a stick from a neighbouring dead-topped angophora and added the stick to the nest. In week 5, also after being fed by the male, she landed in angophora foliage then briefly visited the nest, possibly with foliage (i.e. nest-lining).

Throughout the nestling phase, both sexes occasionally defended the nest area (~ 300-m radius around the nest-tree). Also throughout the nestling period, the male left tree L at dusk for his roost in the same pines as in the incubation phase (i.e. 400 m south-east of the nest).

Nestling period: development of young

Two juveniles fledged from an initial brood of three hatchlings, from an unknown number of eggs. In week 1 (day 6) three chicks were visible at feeding times, but on day 7 only two were visible and by week 3 (day 16) there were only two nestlings. On day 6 they competed for food, and by day 16 the larger chick was dominant over its smaller, less-developed sibling. On days 16–17 feeding times were competitive, with the smaller chick getting perhaps one-third of a mouse in small pieces from the female, whereas the larger one began pecking at prey in the female's foot on the nest-rim and swallowing much larger pieces. On day 17 the larger chick grabbed the throat of the smaller chick in its bill, but the smaller chick defended itself by returning the peck.

In week 4 (day 22) the female gave half a mouse to one chick (apparently the larger) while one (apparently the smaller) begged; rapid *kik-kik*... calls of apparent distress followed, as though the chicks were squabbling or the larger was dominating the smaller. By week 5 (day 31) the difference in sibling size and development was less apparent and competition for food was becoming more equal, when the female occasionally left portions of prey to be contested and swallowed whole. Growth and development of the chicks are summarised in Table 3.

Table 3: Growth and development of nestling Black-shouldered Kites, Tamworth, NSW, May–June 2004. Chicks not sufficiently visible in weeks 1–2 to ascertain plumage details.

Week	*Day(s)*	*Comments*
3	16–17	Larger chick pin-feathered on back and on top of wings; stood in nest, alert and scanning surrounds, pecked at twig. Smaller sibling had only buff-coloured down visible. Larger chick clambered around nest, on top of and over its sibling, and defaecated over nest-rim.
4	22	Large feathered chick stood and wing-stretched on nest-rim; remiges appeared about half-length; dark eyes and cream feet. Smaller chick much downier.
	24	Head of larger chick tawny (feathers); of smaller chick still downy.
5	29	Chicks feathered: grey back, dark 'shoulders'.
	30–31	Nestlings well developed: almost fully feathered, tail short, with russet head (slightly darker on older chick) and scalloped grey back and upperwings. Perched on nest-rim, wing-stretching but not flapping yet.
6	37	'Branching'; fledged later in day.

Fledging

Both juveniles fledged on 12 June, 36 days after hatchlings were first detected. In mid morning (0815–0915 h), GO observed the juveniles clambering about in the foliage and twigs around the nest, then the older one made a short maiden flight of two small circuits around the nest-tree and returned to the nest. SD then observed the nest for an hour from 1100 h, during which the juveniles remained on the nest and gave no sign of having fledged. In the afternoon GO again observed similar 'branching' behaviour, then the younger juvenile made a short flight to the neighbouring large creekside angophora (30 m away), where it remained for the ensuing 2 hours of observation. Both were back on or beside the nest next morning.

On the fledging day, when both fledglings spent most of the day on the nest, from 1100 h to midday the adults perched in tree L. The female begged with screeches and twice displaced the male from his perch; on the second occasion he remained in the foliage to which he had retreated. The female then caught a mouse below her perch and ate the prey, then begged again. The male gave *tew* calls and flew onto the female's back, trying to mate, but she rejected him with screeches. She then left with screeches, soared high in tight circles to > 100 m above the nest area, and made a long glide out of sight. The male then left with a single abrupt screech and 'flutter-flight' display (Marchant & Higgins 1993) over the treetops in the same direction. Within ~ 10 minutes both returned to tree L, arriving with *tew* and screech calls (female) and *tew* calls (male).

Post-fledging period

On day 1 the male supplied prey to the female, which gave two items whole to the juveniles: once before either had fledged, and once to the older juvenile back on the nest after its first flight, while the other juvenile was still in a nearby tree. In both cases the mouse was swallowed whole. The female was not seen after day 1, and apparently deserted the territory and brood; thereafter, only the male fed and defended the juveniles (further details in Table 4). In their first week the

Table 4: Progress of juvenile Black-shouldered Kites, post-fledging period, Tamworth, NSW, June–July 2004. M = male parent, J1 = older sibling, J2 = younger sibling. Focal trees in nest area (trees L, B and D) defined in text. Female absent after day 1.

Week	*Day(s)*	*Comments*
1	2	M delivered prey to J1 on nest. J2 back in nest-tree, then on nest.
	3	J1 in nest-tree, J2 in adjoining tree. M delivered food to J1 on nest; J2 went to nest.
	7	Both juveniles on nest. M food-called on tree L, one juvenile flew around; M dropped whole prey in nest, juveniles competed for prey on nest.
2	8–9	M fed and protected juveniles.
	14	Juveniles perched in tree B, begging.
3	15	M fed juveniles away from nest, in trees B and D; juveniles flew around when he arrived with prey.
	16	Juveniles perched and ate prey in trees L and B. One aerial prey transfer from M to juvenile; one delivery to nest after juvenile went to nest. Juveniles in tree B, M perched in top of tree, apparently guarding them. Juveniles appeared adult in proportions.
4	22–23	Juveniles perched in tree B; M occasionally provided food to them.
5	29–30	One juvenile performed powerful flying with adult-like behaviour: diving, feinting at objects on the ground, and hovering.
	34	M on tree L, one or two juveniles begging in tree B.

juveniles perched in the angophora nest-stand or on the nest, or made an occasional short flight to perch in neighbouring trees (e.g. a dead-topped angophora 40 m away). The male delivered prey to the nest, where the juveniles waited or returned to feed.

By week 3 (day 16) the juveniles perched in the canopy of tree B, where they were well camouflaged on their perches amid foliage or dead branches. One returned to the nest on day 16, where it was fed; the first aerial transfer of prey from male to juvenile was also observed on that day (Table 4). In week 5 (days 29–30) the juveniles were seldom seen; one performed hunting behaviour, apparently in practice (Table 4), then neither was seen until the morning of day 34 when both were perched in tree B. One (or perhaps both, from differences in the pitch of calls) screeched while the male perched atop tree L.

In week 6 (days 36–37) an adult and one juvenile were present in the early mornings and late afternoons. The juvenile huddled, with feathers fluffed, in cold conditions and gave food-begging calls on the evening of day 37, so it may not have been receiving food from the parent by that stage. The post-fledging period thus lasted at least 36 days, with dependence on parental feeding extending at least to the start of week 4, i.e. at least 22 days after fledging (Table 4).

Vocalisations

Vocalisations, as used by the adult Kites in the specific behavioural contexts described herein, were of three main types: a clear, single or slowly repeated whistling note, either a short chirping *tew* (commonly ~ 1 note/second) or a longer *peep*; a harsh 'scraping' or wheezing screech (like a *Tyto* owl screech), sometimes shortened to an abrupt, rasping, downslurred yelp *kew* when swooping at larger

Juvenile Black-shouldered Kite, Tamworth, NSW, June 2004

Plate 22 Photo: G.S. Olde

raptors; and a rapid musical chatter of *kik-kik-kik*... notes (like an accelerated series of *tew* notes, ~ 3 notes/second). At least sometimes, when they were calling together, it seemed that the female's whistling call was a stronger, higher-pitched *peep* compared with the male's more subdued *tew*. Begging calls of small nestlings were slow upslurred *peep* notes, lasting about a second, changing to a prolonged screech (like the female's begging screeches, though slightly less harsh) as they neared fledging. Begging calls of fledglings were insistent screeches.

The male gave *tew* calls as contact calls when arriving at or departing from tree L, and as a food-call when arriving at tree L with prey. If the brooding female was slow to respond and claim the prey, he alternated *tew* calls with screeches. The incubating or brooding female begged with screeches that became more abrupt and disyllabic ('urgent') if the male was slow to depart on a hunting foray. The perched male also sometimes gave screech calls near the nest, and the female sometimes gave a soft screech, apparently as a food-call, when taking the prey to the nestlings. The *kik-kik-kik*... chatter was given during prey transfers from male to female. When bringing prey to the fledglings, the male gave *tew* calls and subdued, abrupt disyllabic screeches.

Nest-defence

In the incubation period the incoming, food-bearing male Kite was, on separate occasions, harassed by three Nankeen Kestrels *Falco cenchroides* (that had previously nested nearby) and three Black-faced Cuckoo-shrikes *Coracina novaehollandiae*. On both occasions the female Kite flew rapidly from the nest, and in combination both Kites fended off the attackers and the male successfully delivered the prey to the female.

In the nestling period the male Kite sometimes defended the nest area against one or two Little Eagles *Hieraaetus morphnoides*, though not every time the latter appeared. For example, on a morning in week 1 the Kites did not respond to the soaring Eagle, but on the next afternoon, when the Eagle was soaring very high, the male Kite immediately launched off tree L and after several minutes reached the Eagle's altitude and attacked. The Kite then descended in a falcon-like stoop with folded wings, to tree L 5 minutes after launching. When a Little Eagle was perched in a treetop ~ 300 m west of the Kites' nest, the male Kite left tree L with *peep* calls and flew straight to attack the Eagle; the latter then left and soared, and the Kite continued the attack with rapid swooping dives, in an arc that carried both birds to ~ 100 m above and ~ 150 m north of the Kites' nest. Each swoop was accompanied by a harsh *kew* call, then the Kite descended, circling at first, with *tew* whistles to tree D.

In week 1 of the nestling period, the male from tree L once silently swooped a human observer at the observation point, and returned to his perch with *tew* calls. In week 1 the Kites did not attack a pair of soaring Wedge-tailed Eagles *Aquila audax*, and in week 4 the parent Kites (perched in tree L) gave *peep* calls and screeches as a Laughing Kookaburra *Dacelo novaeguineae* flew past below them. In week 3 the male chased an Australian Magpie *Gymnorhina tibicen* from near the base of the nest-tree, then perched on a dead treetop beside the nest-tree. Vigorous defence against a Black Kite *Milvus migrans* (uncommon in the area) occurred in week 5: both adults drove the intruder northwards for 3 minutes, during which time the feathered nestlings crouched low and immobile in the nest, with only their grey backs visible.

In the nestling period (week 1), a Brown Falcon *Falco berigora* attacked the foraging male Kite as he hovered. He avoided the Falcon by circling up tightly, with *tew* calls, then climbed above the Falcon and returned the attack, swooping until both were high in the sky nearly 1 km from the Kites' nest; a Kestrel joined in swooping the Falcon, then an Australian Hobby *F. longipennis* soared near them after the attacks finished. The male Kite then glided steeply down to tree L with *tew* calls as he arrived.

Early in week 2 of the post-fledging period the male Kite, in company with a Hobby, chased a Brown Falcon at treetop level.

Feeding rates

The male's capture rate increased steadily throughout the breeding cycle from 0.9 item/h in the incubation period to 2.6 items/h in week 5 of the nestling period (Table 5). He ate about half his captures, so his hourly food consumption kept pace with his capture rate and foraging effort. His delivery rate to the female, and hence to the young, also increased through the breeding cycle from 0.4 item/h in the incubation and early chick phases to 1.6 items/h in week 5 of the nestling phase (Table 5). The female ate parts of the items taken to the chicks in weeks 1–3 and sometimes in week 4, so her consumption rate either remained fairly constant or peaked slightly in week 5, by which time she was flying more (e.g. towards the male's hunting grounds to collect his prey).

The female did not hunt during the incubation period and most of the nestling period. She was first seen hunting on day 31 of the nestling period, when she made one quartering and hovering foray of 2 minutes then an unsuccessful strike. She was first seen to make a capture on the fledging day, after she unsuccessfully begged to the male. From her perch on tree L, she dropped at a 45° angle to the

Table 5: Parental feeding rates of a pair of Black-shouldered Kites, Tamworth, NSW, April–June 2004: no. deliveries/h. No. hours observation in parentheses. Male (M) captured all prey; female (F) made all deliveries to nest; M made most deliveries to fledglings (F disappeared by day 2 of post-fledging period). F ate = female ate entire item (i.e. did not feed it to chicks). Total captures = 79.

Stage	*M captures*	*M ate*	*M to F*	*F ate*	*Young*
Incubation (12.9 h)	0.9	0.5	0.4	0.4	-
Nestling period:					
Weeks 1–2 (19.2 h)	0.9	0.5	0.4	0.1	0.3
Week 3 (10.1 h)	1.3	0.5	0.8[a]	0.3	0.4
Week 4 (6.0 h)	1.0	0.5	0.5	0.2	0.3
Week 5 (5.8 h)	2.6	1.0	1.6[b]	0.7	0.7
Mean (41.1 h)	1.2	0.6	0.7	0.2	0.4
Post-fledging period:					
Week 1 (8.6 h)	1.2	0.5	0.5	0.2 (0.3)[c]	0.5
Week 3 (4.3 h)	1.4	0.5	-	-	0.9
Mean (12.9 h)	1.2	0.5	-	-	0.6

[a] One item dropped (not retrieved) during transfer
[b] Fate of one item unseen
[c] Including one capture by female

ground, caught a mouse and took it to tree B where she ate the prey.

The male's capture rate in the post-fledging period returned to earlier levels, with the disappearance of the female on day 2 (Table 5). However, the delivery rate to fledglings remained at immediate pre-fledging levels until week 3. At this stage the male ate less than half of his captures, so his hourly consumption rate also returned to earlier levels (Table 5).

Prey transfers

In the incubation period, food transfers by the male to the female were either aerial (once), or on a horizontal branch of tree L (four times). At the transfer perch, the female took food in her bill from the male's foot. In weeks 1 and 2 of the nestling period, all eight food transfers were at the perch after the male called the brooding female off the nest. On one occasion the male returned with prey and called for several minutes, then flew to the nest-tree before the female finally responded. On three other occasions the female did not respond to the calling male on tree L; he ate two of these items, and perched with the other one for 45 minutes before observation ceased. Thus, either prey was plentiful or the family's food demands were not great at that stage.

In weeks 3 and 4 of the nestling period, seven food transfers were at the perch and four were aerial. In week 5 most (five versus two) transfers were aerial, and in the post-fledging period (day 1) all four transfers to the female were aerial. From day 16 of the nestling period (first aerial transfer), the female often waited for the returning, food-bearing male about halfway to his capture point and intercepted him in flight; her perches included tree D and atop a pine ~ 300 m north-west of the nest. By week 4, if the female attempted to take the male's catch but he appeared hungry, he successfully retained and ate it. In week 4 there appeared to be a minor slump in food supply (Table 5). On the fledging day the female appeared to try, unsuccessfully, to induce the male to hunt (see 'Fledging', p. 136).

Diet and feeding behaviour

Twenty-five intact pellets measured 26–48 × 13–24 mm (mean 35 × 20 mm). Twenty-seven dry pellets weighed 0.6–2.7 g (mean 1.5 g, s.d. 0.56), and consisted entirely of House Mice: one adult by its fur characteristics, and 24 juveniles by their teeth. There was very little bone in the pellets, and the fur was packed so tightly that there were probably a least two mice per pellet, except for the five smallest pellets. The sample of 30 pellets (total dry weight 45 g, including fragmented ones) therefore probably represented at least 50 mice. Of 80 observed prey items, 58 (73%) were mice, three (4%) were small mammals, and 19 were unidentified small items that were eaten in the same manner as mice. That is, at least 61 (76%) were probably House Mice and the remainder were likely to have been House Mice too, on the basis that all items in the pellets were House Mice and that species is the only locally available mouse-sized mammal in the farmland habitat used by the male Kite (SD unpubl. survey data; cf. also Debus & Rose 2004).

The adults plucked some fur from captured mice before they ate, or before the female took prey to the nest. The female also ate the head and sometimes a few pieces before feeding the chicks, and on two occasions she appeared to discard a piece of mouse gut. At a perch, when eating a mouse the adults held the prey in one foot after the manner of a falcon or a small *Ninox* owl, rather than the accipitrid manner of standing on it (SD pers. obs.). On four occasions the female ejected a pellet at tree L, before she commenced dealing with a prey item collected from the male.

Discussion

In this study, observations were limited and there were no days of a complete dawn-to-dusk watch; the data are a snapshot of Kite activity, and should only be interpreted as such. Various factors, such as weather, may influence diurnal activity patterns, and the skew in observation times (Table 1) may partly account for the male Kite's foraging routines. A more balanced observation schedule, covering dawn to mid morning and midday to mid afternoon, would overcome these potential biases.

The results of this study are generally similar to previous data on the breeding behaviour, vocalisations and interspecific interactions of the Black-shouldered Kite (Marchant & Higgins 1993; Barnes 2005; Read 2005), with this study adding quantification of sex-roles, parental time-budgets and male hunting behaviour in the incubation and nestling periods. The nestling period (~ 36 days) and post-fledging period (~ 36 days) agree with previous results, and we concur with Read (2005) that undetected fledging, with juveniles returning to and being fed on the nest during the day as well as to roost, accounts for improbable nestling periods of 50+ days quoted (with caution) by Marchant & Higgins (1993). The behaviour and flying skills of supposedly newly fledged juveniles (Hollands 1984) are more typical of young fledged about a fortnight; in their first two weeks they mostly perch on the nest or in nearby trees, and one juvenile at Tamworth was on the nest 15 days after fledging. The female feeds the fledglings (Marchant & Higgins 1993), on prey caught by the male (Read 2005), but in the female's absence (this study) the male feeds the fledglings.

Male Black-shouldered Kites have not previously been reported to share incubation or brooding, but there has been insufficient study of this aspect. The male's minor contribution, while the female is off feeding on his kills, is to be expected in view of similar behaviour in the Black-winged Kite *Elanus caeruleus* (Duchateau *et al.* 2003). Parental behaviour and feeding of juveniles in the post-fledging period were generally similar to those described by Read (2005), except that the adult female did not participate beyond day 1. There was no aggression towards or 'herding' of the juveniles by the male as described by Read (2005), and in our study there was no second breeding attempt.

In this study, the female rejected the male's attempts to copulate after their brood fledged, and she disappeared on the day after fledging, leaving the male to rear the fledglings. Female desertion of territory and fledglings has not been reported previously in this species, pairs of which sometimes raise a second brood. However, mate fidelity in this species has not been confirmed by individual marking, and desertion of territory and fledglings by females, with serial polygamy, sometimes occurs in the Black-winged Kite, depending on food supply (Mendelsohn 1983, 1989; Bustamante 1993). Food supply appeared to decline through this study, perhaps exacerbated by the loss of some prey harbour or hunting habitat when part of the male's territory was slashed, and this aspect may have influenced the female's behaviour. Towards the end of the nestling period the male sometimes did not feed her, despite her begging and apparent attempts to induce him to hunt (e.g. repeatedly displacing him from his perch). Read (2005) also recorded a shift in foraging area after burning and ploughing of part of a pair's hunting range, which suggests that land management around nests may influence hunting success, chick growth and perhaps breeding success.

The Kites' home-range size, habitat and perch use, and hunting behaviour and diet at Tamworth were similar to previous results for this species (cf. Marchant & Higgins 1993; Engel & Rose 1997; Mathieson *et al.* 1997; Barnes 2005; Read 2005). As near Canberra, ACT (Barnes 2005), the pair at Tamworth had a core territory of ~ 100 ha and a larger foraging range of perhaps twice this area, and the adults and juveniles had favourite perching-trees as reported by Read (2005). The adults' prey-transfer routines during the nestling phase at Tamworth, with use of perches at intermediate distances to intercept the returning male between his capture point and tree L, were similar to those reported by Read (2005). The male's prey-delivery rate at Tamworth was similar to that recorded by Read (2005) for the latter half of the nestling period, but was lower in the post-fledging period (1.2 items/h cf. 2.2), although in Read's case brood size was larger (four vs two) and the female stayed.

The taxonomic position of the *Elanus* kites, traditionally placed in the hawk family, has been challenged since the advent of DNA studies. They are now considered basal to the hawks, and a genetic link between the owls and falcons (reviewed by Debus 2004, 2005, 2006). Certain aspects of the Black-shouldered Kite's behaviour and vocalisations, e.g. prey-handling behaviour and owl-like screeches (this study), unaccipitrid plumage, rather falcon-like (heavily pigmented) eggs, maternal frog-like (*chup*) call (Hollands 1984), and owl-like nocturnal or crepuscular foraging of members of the genus (Marchant & Higgins 1993), support such an interpretation and a proposed separate family, Elanidae. Further study—behavioural and biological as well as taxonomic or genetic—could test these suggestions.

The breeding behaviour of the Black-shouldered Kite is now reasonably well known and quantified, although sample sizes are small and there is still no description of a complete cycle from nest-building through to juvenile independence for a given pair (or pairs). Nevertheless, the pairs so studied for parts of a cycle and parts of the day (Hollands 1984; Barnes 2005; Read 2005; this study) provide a series of snapshots assembled to form a composite picture that may be typical for the species, depending on whether a second brood is started. Further study might usefully concentrate on population aspects with individually marked birds, as for its congeners (e.g. Mendelsohn 1983, 1989; Bustamante 1993; Dunk & Cooper 1994). The species remains to be as well studied as the Nankeen Kestrel, although providing similar opportunities and, in some respects, greater ease of study (e.g. simpler diet, open rather than cavity nests). It would also lend itself readily to a study of energetics, and comparison with a congener (cf. Tarboton 1978).

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