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Breeding Behaviour and Diet of the Square-tailed Kite *Lophoictinia isura* in South-eastern Queensland

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Summary

A pair of Square-tailed Kites *Lophoictinia isura* and their offspring were observed in coastal southern Queensland through incubation, nestling and post-fledging periods (total 196 hours over 103 days, 3 September to 14 December 1998). Behaviour patterns, sex roles, voice, and growth and development of the young are described. Previously undocumented behaviour in the wild, e.g. sunning and sibling rivalry, is described. The male shared incubation, but little of the brooding; the nestling period lasted 55–59 days. Prey delivery rates during each phase of breeding were: incubation, 0.2 item/hr; nestling period, 0.4–0.5/hr (highest in the first half); post-fledging, 0.6/hr (of which half was contributed by the female). The Kites' diet, by number, consisted of small birds (mostly nestlings or fledglings, 43%), birds' eggs (15%), and insects (mostly ants and beetles, 42%; n = 31 pellets, of which all contained feathers and/or eggshell). One juvenile Kite fledged successfully, spending only 5–7 days in the immediate nest area; the other fledged in poor condition and probably would have died without human intervention.

Introduction

The Square-tailed Kite *Lophoictinia isura* is an endemic Australian raptor widely but sparsely distributed in Queensland (Debus & Czechura 1992), breeding north to Mt Molloy (Anon. 1999). As it is considered a rare species, studies on its ecology and biology are required in order to develop appropriate conservation measures (Garnett 1993). This need is even greater now (Debus 1996) since its status has been revised to Vulnerable, i.e. likely to move into the Endangered category in the near future (Collar et al. 1994). For instance, pairs are disappearing in south-eastern Queensland as their habitat is removed for urban or rural-residential developments (Thornton 1999).

Aspects of the Kite's breeding cycle have been summarised by Marchant & Higgins (1993), with new data added by Debus (1996). Various observers have described its breeding behaviour over parts of the breeding cycle (Cameron 1976, Cupper & Cupper 1981, Johnston 1983, Schulz 1983, Hollands 1984, Cameron 1992, Debus et al. 1992, Debus 1996, Borella & Borella 1997). However, as noted by Debus (1996), no previous account has described an entire breeding cycle from nest-building to post-fledging, and there has been little quantification of aspects of the cycle. Similarly, the Kite's diet has not been quantified.

This paper describes the breeding behaviour (from incubation to post-fledging) and diet of a pair of Square-tailed Kites and their two young over one successful breeding season near Bundaberg, south-eastern Queensland.

Study area and methods

The study site was located on a 25-hectare private property 20 km west of Bundaberg, Queensland (24°53′S, 152°22′E), on the edge of a 2 km × 3 km block of open eucalypt woodland bordered by areas of cleared land and cultivation, mainly sugar cane. The trees dominating the

immediate area were Lemon-scented Gum *Corymbia citriodora* and White Mahogany *Eucalyptus acmenoides*. Other species present included Narrow-leaved Ironbark *E. crebra*, Forest Red Gum *E. tereticornis*, Pink Bloodwood *C. intermedia*, Brown Bloodwood *C. trachyphloia*, Queensland Peppermint (Messmate) *E. exserta*, Brush (Queensland) Box *Lophostemon confertus*, Swamp Mahogany (Turpentine) *L. suaveolens*, Cocky Apple *Planchonia careya* and wattle *Acacia flavescens*. Broad-leaved Paperbark *Melaleuca quinquenervia* was present in a nearby seasonal watercourse. The understorey was sparse with some grasses and few low shrubs, possibly in part related to the presence of goats on the property.

Observations (CPB & EEZ) were essentially opportunistic between 3 September and 14 December 1998, almost daily in each phase of the cycle. A total of 196 hours 5 minutes was spent at the nest-site as follows: incubation period 44 hours 5 minutes (3–30 September); nestling period 126 hours 40 minutes (2 October–23 November); post-fledging period 25 hours 20 minutes (26 November–14 December). Observation sessions ranged from 30 minutes to 7 hours, usually at least 2 hours, with 2–3 times as many sessions and 3–4 times as much time in the mornings as in the afternoons. Observations were made from the ground, with the aid of binoculars and sometimes a telescope.

Twenty-six intact pellets and fragments of a further five pellets (total 31 pellets) were collected, mainly under the nest-tree but also beneath nearby perches and favoured roosts. Pellets were analysed by ABR, microscopically as necessary, with the aid of manuals (CSIRO 1970, Beruldsen 1980) and a reference collection of insects.

Results

Morphology

One notable aspect of the adult Kites' morphology, not highlighted in any field guide or handbook, was the obvious breast-shield of heavy black streaks, sharply demarcated from the plain rufous belly (Plate 40). Such a breast-shield, although not as solid as on the Black-breasted Buzzard *Hamirostra melanosternon*, is a prominent field character readily distinguishing the Kite from other raptors.

Nest-site and territory

In 1997 Square-tailed Kites were observed building the present nest, although it was then estimated as one-third of its completed size. Breeding was not attempted at this site in that year.

The nest was located c. 20 m high in a live 28 m tall Lemon-scented Gum, 4–5 m from the outer foliage, situated in a sturdy fork rising at about a 30-degree angle. The bulky, untidy stick nest, obvious from the ground, had an estimated diameter of 100 cm and external depth of 30 cm. No attempt was made to examine the nest or its contents. The cup appeared shallow, as much of the incubating adult could be seen even from the ground at a 30-degree viewing angle. The nest-tree was situated near the top of a gently sloping 10 m ridge, 35 m above sea-level and approximately 2 km from the Kolan River. The farmhouse was <80 m from the nest.

Two dead trees <15 m from the nest were regularly used by the adults for various activities. The trees were above an open chicken-pen where there was regular human activity. Roosts were generally within 50 m of the nest, but no plucking post was present near the nest. During the nestling period, Pacific Bazas *Aviceda subcristata* and Collared Sparrowhawks *Accipiter cirrhocephalus* built nests within 60 m of the Kites. The Bazas' nest failed during the early nestling phase and the Sparrowhawks abandoned their nest, possibly before egg-laying.

The nearest other pair of Square-tailed Kites was seen 35–40 km from the

Adult Square-tailed Kite sunning

Plate 40 Photo: C.P. Barnes & E.E. Zillmann

subject nest-site. No other Square-tailed Kite nests were found during the 1998 breeding season, although two active nests were observed in previous seasons 60 km from the study site.

Voice: adult

The female was the more vocal of the adults. Her commonest call was the high-pitched, wheezing *whee-peee-pee-pee-pee* begging call (see Marchant & Higgins 1993), often repeated frequently, up to 80 times in one 15-minute period. Each bout lasted 3–8 seconds, with variations in intensity and pitch. When calling more insistently, she appeared to drop the first syllable, *ee-ee-ee-ee-ee*, the notes becoming more rapid as the sequence progressed. This call was most often heard soon after dawn during the incubation and nestling periods, when the female was on the nest. She stopped calling when the male took over incubation or left the area. The male made the call from the nest in the early morning, having relieved the incubating female 26 minutes earlier on one occasion and when the female returned to the nest-tree on another. This call has previously been described (Debus 1996) as *ee-ee-ee...* and (in Debus & Czechura 1989) as *whee...whee...*

A call commonly given by the female during allopreening was similar, but a two-syllable rising *whee-ep whee-ep* or more prolonged *whee-ep-ep-ep-ep*, usually repeated for minutes at a time. When the male made the call it was at a higher pitch and much softer, often not carrying more than 20–30 m. The male gave the call infrequently during allopreening, and on only one occasion repeated it more than twice.

A soft, brief chitter by the female, only audible within 20 m, was also given

during allopreening. This was infrequent, heard only twice, and may be the chitter described by Debus et al. (1992) when the male and female Kites were together on the nest.

Both adults also gave a two-syllable yelp, frequently in flight when mobbed by other birds. This *kle-eep kle-eep* call was often given more stridently when the adult was mobbed whilst bringing prey to the nest, and seemed slightly longer than a clipped, rising *ke-ep, ke-ep* more frequently heard. Possibly this is the cheep described in Baldwin (1975) and the yelp, *keaw-keaw*, described by Debus & Czechura (1989) and Debus et al. (1992).

A much quieter *quip-quip* or *kip-kip* was made by both adults when perched in response to birds flying nearby, e.g. Torresian Crow *Corvus orru*, Australian Magpie *Gymnorhina tibicen*, Laughing Kookaburra *Dacelo novaeguineae* or a Pacific Baza. On two occasions the call was loud, harsh and given in an agitated fashion by the female within 50 m of the nest: once when flying at a Torresian Crow and once on landing following an aerial encounter with a Pacific Baza.

The female gave an extremely rapid, excited squealing, shrill *eep-eep-eep-eep* or *eee-ee-ee-ee* when the male delivered prey to the nest, as described by Debus et al. (1992) and Hollands (1984).

A soft *peep-peep* or *whee-whee* was heard twice when both adults were on the nest and one had brought in some nesting material. Both occasions were in the incubation period, but it was not possible to ascertain which bird made the call.

The female was once heard to make a quiet, rasping *preeep-preep-preep-preep* while on the nest with nestlings. This call did not carry far and could be heard only within 10 m of the nest. This made it difficult to judge how often the call was made.

Voice: nestlings and fledglings

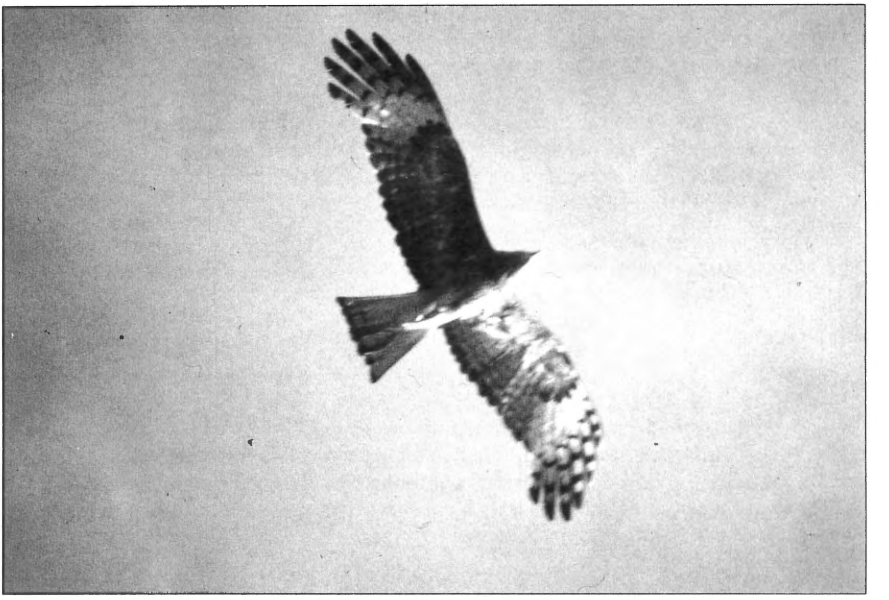
Soft peeping notes were made by the downy nestlings. The nestlings frequently called *ki-ki-ki-ki* or *pee-pee-pee-pee* early in the mornings before any feeds, and in response to the adults arriving at the nest. The call had a begging quality and often was loud, high-pitched, rapid and insistent. The tone became harsher as the nestlings grew. This may be the *kik-kik-kik*, uttered softly, described by Cameron (1992). It was also given frequently by the nestling that missed out on food brought to the nest. The call often continued constantly for several minutes.

The younger nestling made a distressed shrill chittering, when the older sibling showed aggression by biting the base of its bill and making shaking movements. The call was a high-pitched, loud, rapid twitter lasting 2–3 seconds. Two episodes of such aggression were witnessed, with the call made on each occasion. Once, the call was made but the nestlings were not visible.

On one occasion the younger nestling gave a whistle-like *flu-flu-flu* whilst flapping, exercising its wings in the nest.

Territorial defence: incubation period

The adults generally ignored birds more than 40 m from the nest. Noisy Friarbirds *Philemon corniculatus*, Blue-faced Honeyeaters *Entomyzon cyanotis* and Figbirds *Sphecotheres viridis* <5 m from the nest drew no response. The soft *kip-*



Adult Square-tailed Kite in flight

Plate 41 Photo: C.P. Barnes & E.E. Zillmann

kip call was given when a Pacific Baza, Australian Magpie or Torresian Crows flew over the nest-site. When the Crows were closer in nearby trees, the female on the nest held her neck erect and raised the feathers of her crest, mantle and nape, uttering the same call but in a harsh and more agitated fashion.

Twice, direct flights were made towards intruders. A White-bellied Sea-Eagle *Haliaeetus leucogaster* being chased by an Australian Magpie low over the canopy induced the female to fly towards them. However, as they travelled rapidly past the nest, no interaction ensued. Two Pacific Bazas inspecting a potential nest-site 50 m from the Kites' nest flew and called *wee-choo wee-choo* as they arrived. One strayed within 30 m of the Kites' nest, and the female Kite flew at it. The Baza appeared more aggressive, stooping at the Kite from above. The Kite twisted and made short tumbles, sometimes stalling, extending neck, raising crest, opening bill, and extending legs forward towards the Baza. This encounter lasted 3 minutes, ending with the Kite landing in a live tree near the nest and the Baza flying off. The Kite gave a loud, agitated *kip-kip* which was repeated once.

Territorial defence: nestling period

Again, the general pattern was to ignore most birds nearby, and give the soft *kip-kip* at the presence of some larger birds. This *kip-kip* call was recorded when a Square-tailed Kite flew very high over the nest-site, a female Collared Sparrowhawk flew past below the level of the nest, White-winged Choughs *Corcorax melanorhamphos* called while surrounding the male Kite (the female on the nest gave the call), and when Pacific Bazas, an Australian Magpie, Laughing Kookaburra or Torresian Crows were near the nest.

A Magpie-lark *Grallina cyanoleuca* landed just above the unattended nest eight days into the nestling period, inducing the male Kite to fly at it. The female flew directly to the nest. On day 14 of the nestling period, while the female was on the nest, she was mobbed by a male Magpie-lark. The female called *ke-ep ke-ep* loudly and sat with neck erect, crest raised and bill partly opened. On day 26 the nestlings were in the unattended nest when a Grey Butcherbird *Cracticus torquatus* landed in the nest-tree. The female Kite flew at the Butcherbird calling *kle-ep kle-ep*, moving it away from the nest-tree.

There was virtually no response to human presence, even when directly under the nest, except that the birds occasionally peered down over the edge.

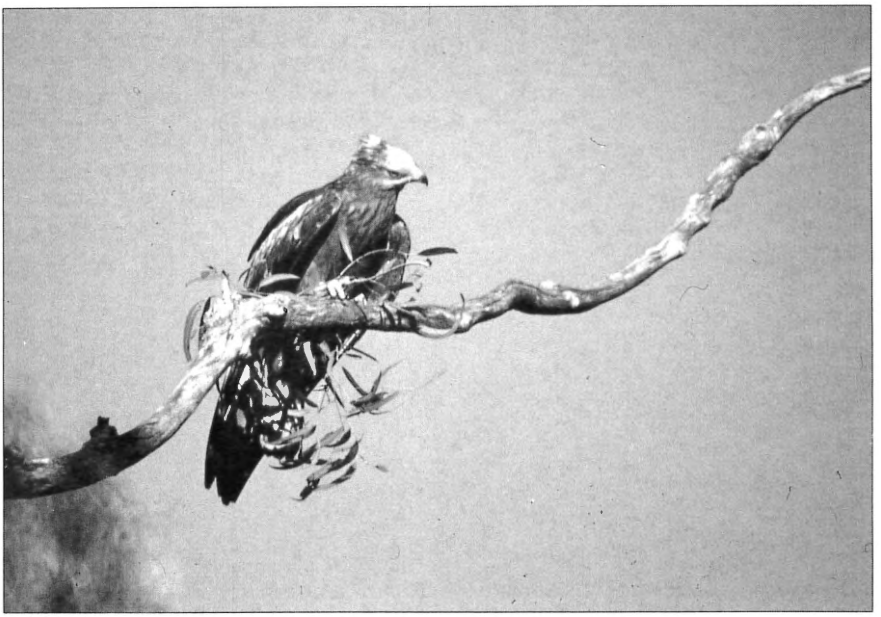
Incubation

The nest was discovered on 3 September when the female was presumably incubating. This was surmised by her behaviour, as she always remained on the nest unless receiving food from the male or when she was relieved by the male, which took turns at sitting on the nest. The sexes were separable by size and wear of the feathers: the male had extremely worn central rectrices and was generally paler than the female. Size was only useful to distinguish the sexes when they were together. It is not known when laying occurred.

The female did most of the incubating, lying low in the nest, and was always on the nest at daybreak (five visits). The male roosted with his head on his back, tucked under a wing, within 40 m of the nest in any of a number of live trees situated slightly higher on the ridge than the nest-tree.

Early in the morning, the female gave the begging *whee-peee-pee-pee* call almost constantly until the roosting male came to the nest or left the area. Only on one morning did the female, after calling for 25 minutes, leave the nest before the male arrived; he flew directly to the nest after she left. No change-over display was observed. Often, the female flew to a dead tree <15 m from the nest, where she carried out a range of activities such as defecating, preening (often standing on one foot with the other clenched), scratching, and stretching each wing in turn while fanning her tail. Sometimes she leaned forward, lifting both wings together at right angles to her body, and stretched them out horizontally at the carpal joint before fluffing and shaking her body. She also made short flights around the immediate vicinity. On seven occasions, the male incubated for more than 10 minutes (stints of 12–62 minutes, mean 35 minutes). All these took place early in the morning while the female performed the above-mentioned activities. Twice, the male took over incubation briefly (<10 minutes) after delivering prey to the female, which took it to a perch on a dead tree to consume. An approximate total of 230 minutes was spent by the male at the nest, i.e. 9% of the incubation period observed.

Twice, bare twigs were snatched in flight with the feet and brought to the nest. On eight occasions, the female brought fresh sprays of leaves to the nest (62% of 13 sprays; Plate 42). These were collected by wrenching with the feet and, if not successful, biting or twisting off the branches with the bill, while clinging to the foliage, hanging backwards. Sometimes the branch and leaves were carried to a perch and trimmed using the bill to snip off foliage. The nesting material was either dropped completely or brought to the nest in the bill or feet. It was usually not possible to see how the twigs or leaves were worked into the nest. Dipping movements of the body and rocking movements of the feet could be seen as the



Adult Square-tailed Kite with spray of green eucalypt leaves for nest-lining
Plate 42 Photo: C.P. Barnes & E.E. Zillmann

nesting material was added. Once, a branch was placed into the nest by the female using her bill. The male brought fresh leaves to the nest on five occasions (39% of sprays) during incubation. One leafy branch was twisted or bitten off while he was perched, rather than clinging to the foliage as was the usual mode of collecting the leafy material. No nesting material was seen to be added after 0800 h.

The male was not seen to hunt near the nest-site. The female never left the area and was fed entirely by the male, which was observed to bring prey eight times. He arrived in a steady gliding, level flight (rather than the lazy, soaring flight, rocking with wings in a dihedral, characteristic of Square-tailed Kites). Calling by the male usually heralded his approach, with the inevitable mobbing by a variety of passerines. The prey was always brought to the nest clutched in his feet. He usually left within 30 seconds, more often <10 seconds. The prey was often small, estimated at <30 g. Two of the prey items appeared substantially larger.

Anticipating the male's arrival, the female leaned forward with a slightly hunched appearance, calling vociferously with bill agape, giving the loud, excited, squealing *ee-ee-ee-ee* call. When the male arrived at the nest, the female usually grasped the prey with one foot before manipulating it with her bill. Of the eight prey items, four were swallowed whole within 30–40 seconds, three took up to 3 minutes to finish as they were torn into pieces, and one took 10 minutes to complete the feeding. Twice, the prey was taken to the dead tree <15 m away where the female fed. Other prey items were eaten at the nest; the female stood or remained seated, and once fed after walking about 0.5 m along the branch from the nest. Twice, bill-wiping on the perch was observed after a feed. No pellets were found, despite regular searches under the nest and favoured bare perches.

Adult Square-tailed Kites allopreening

Plate 43 Photo: C.P. Barnes & E.E. Zillmann

Allopreening was witnessed twice at the nest in the morning, before the male's first departure. These were both of short duration, 2 minutes and 15 minutes (<1% of observation time), and involved mainly preening of the head, chin, nape and neck (Plate 43).

One morning the female Kite perched away from the nest in the nest-tree, when an Australian Magpie flew from behind and knocked her off her perch with an audible rustle of feathers. No retaliation followed as the Magpie flew off. Both adult Kites were frequently mobbed by Australian Magpies, Magpie-larks, Grey Butcherbirds, Noisy Friarbirds, Little Friarbirds *Philemon citreogularis* and Noisy Miners *Manorina melanocephala*, even in the immediate vicinity of the Kites' nest.

After a wet night, at 0712 h on 13 September, the female perched on the dead tree and spread her wings, with her back to the sun, for 13 minutes. Her plumage was saturated and bedraggled at this time. The episode ended with her preening. Three days later at 0615 h on a fine morning, brief (<1 minute) sunning by the female on the dead tree was disrupted when a Little Friarbird mobbed the Kite. These were the only times when sunning was seen in the incubation stage.

Nestling period: parental behaviour

From 2 October, peeping was heard from the nest and the female's behaviour changed. She was more restless on the nest, frequently moving and standing, and she fed standing on the nest, facing the centre. This was taken as the beginning of the nestling period. At least two chicks hatched from an unknown number of eggs.

Only once, on 3 October, was the male seen to brood (12 minutes) during the

early morning. He spent a negligible time at the nest (<1% of the observation time). More often, the male preened before flying from his roost to a dead tree, bringing in nesting material (which was manipulated by the female), or flying out of the area. The female still started the day with the begging *whee-pee-pee-pee* call from the nest, but frequently joined the male on the dead tree for prolonged allopreening. Much of the allopreening (and reciprocal allopreening) was of the head, chin, neck and nape although the male also preened the female's wing-coverts and tail. Brief bill-touching also occurred. Intermittently, the female stopped to hunch forward with tail raised level and turn around on the limb while calling, in a manner suggesting invitation to copulate, or she flew off for more nesting material. Only once, on 3 October, was allopreening noted at the nest. This lasted only a minute, compared with lengthier sessions on the dead tree near the nest (a total of 239 minutes over seven mornings, 3% of the observation time). No copulations were witnessed.

The male was seen to bring leaves to the nest three times (9% of material-gathering forays), last recorded on 18 October, whereas the female brought leaves throughout the nestling phase (23 times). Once, she trimmed a leafy branch on a perch before carrying some in her bill as well as her feet to the nest. She brought bare twigs to the nest nine times. At the nest, the female snipped off either individual leaves or small bunches of two or three to place in different areas of the nest with her bill.

At times the female picked up debris in her bill from within the nest, and made small swallowing movements while flicking material out. A regurgitated pellet, dried and not fresh when retrieved by the observer, was picked up by the female from within the nest and dropped over the edge.

Fifty-seven prey deliveries were witnessed. Only twice did the female bring prey back to the nestlings. On at least five of the 55 prey deliveries by the male, more than one prey item was deposited in the nest. The male's arrival was as previously described, but his departure was often immediate. No sooner was the prey released than he seemed to leave with only a slight hesitation in his wing-beats. On leaving the nest, he sometimes circled for a short time, rarely staying in the area for more than 20 minutes. It was usual for him to be out of view within 2–3 minutes.

Only the female was seen to feed the nestlings. Initially the prey was held in one foot and torn into small pieces to present to the chicks with her head tilted to one side. As the nestlings grew and attempted to feed themselves, the female often tugged on the prey and took it from their bills. She fed herself before the nestlings in the first two or three weeks of this period. Sometimes she dropped the prey in front of the nestlings, allowing them to pick it up. A nestling first fed itself on day 26. Before this date, 20 timed feeds averaged 11.4 minutes, compared with 21 feeds averaging 4.7 minutes after this date. No aggression between adult and nestlings was witnessed.

From day 26 the female often left, out of view of the nest, for short periods of up to 20 minutes. After this date, she was not seen to depend on the male for food. The only day on which the female delivered prey to the nestlings (twice) was 27 October. The female allopreened the nestlings briefly around the head and neck on days 28 and 31. After day 31, the female left the nestlings unattended for longer periods of up to 2 hours. On her return to the area she perched nearby, but did not bring prey to the nestlings.

Table 1

Sunning behaviour of adult Square-tailed Kites during the nestling period. Sunning was not always continuous, e.g. on day 46, 55 minutes of sunning occurred over 73 minutes.

Days into nestling period	*Perch*	*Time of day*	*Time sunning (mins)*	*Gender of adult*
10	nest	0853 h	6	F
14	dead tree	0658 h	10	F
14	dead tree	0704 h	4	M
18	dead tree	0712 h	9	F
26	dead tree	1007 h	8	F
27	live tree	0921 h	3	F
27	dead tree	0926 h	27	F
28	dead tree	0745 h	11	F
30	dead tree	0745 h	15	F
42	dead tree	0741 h	7	F
46	dead tree	0656 h	55	F
54	dead tree	0624 h	48	F
54	dead tree	0727 h	7	M

On 4 November, before dawn, the female was roosting next to the male. On three of six visits before 0530 h after this day, the female was perched next to the male in live trees <50 m from the nest. On only one of these visits – on a rainy morning – was she on the nest brooding.

The first pellets were found on 18 October, despite regular searches before this date. From then on, they were frequently collected below the nest, the nearby dead tree, and roosts in live trees. At her perch on the dead tree, on 3 November at 0542 h, the female bobbed her head up and down while opening and closing her bill. After about a minute, she regurgitated a pellet consisting of eggshells (see Diet).

Sunning behaviour, mostly by the female, was observed on 10 days over the nestling period (Table 1, Plate 40). She sunned for 3–55 minutes, mean 18 minutes, in 11 sessions over 10 mornings, frequently carrying out this behaviour after the male's departure to hunt in the mornings. On the two occasions when sunning started after 0900 h, it had rained the previous night or in the morning. The wings were extended to varying degrees, from the leading primary dropping at right angles from the carpal joint to being held in line with the carpal joint. The wings were held out drooping slightly, and sometimes the tips of the primaries were rotated and angled upward. Once, only one wing was partially extended and rested against a dead branch. The tail was usually, but not necessarily, spread to a variable extent. The head was often fairly erect or angled forward. Twice, during prolonged sunning, the neck was extended to rest on the back, with the bill pointing vertically and eyes closed. Sunning was always carried out with the back facing the sun, and seemed to occur irrespective of the weather conditions. No signs of heat stress, e.g. panting, were noted during these episodes. No aggression between the adults occurred when they sunned next to each other in a live tree, with wings entwined.

Nestling period: development of young

In the first few days only peeping could be heard from the nest. The female was seen to tear up the food delivered and lean into the centre of the nest. The

Table 2

Growth of nestling Square-tailed Kites. Day = days from hatching.

Day	*Comments*
19	Nestlings mostly white and downy.
23	Primaries appearing.
26	Nestlings still mostly white and downy. Smaller nestling had all-white, downy head with a few dark feathers developing behind eyes. Bill creamy yellow with dark distal third; cere slightly paler; bluish-grey skin at base of bill extended up to and around the dark eyes. Some dark mantle feathers emerging, giving a V-like marking when viewed from behind. Dark, short primaries and tail-feathers also visible. Larger nestling had rich rusty feathers on nape, back and wing-coverts. Primaries noticeably darker; the two nestlings easily separable by size and colour.
30	Smaller nestling had well-feathered upperparts, although some down present on lesser wing-coverts. Much of plumage ginger-coloured with dark primaries and wing-coverts, the latter with ginger edges. Face still downy and white; feathering on nape and behind eyes had developed. Chest and belly white with some ginger-coloured feathers distributed in a patchy fashion on upper chest and flanks.
	Larger and presumably older nestling almost completely feathered, with patchy down on forehead, throat and upper chest. Rump, vent and underwing-coverts had more extensive down. Bluish-grey bare skin still present around eyes; gape yellowish. Estimated at about one-third adult size; rich rust overall coloration; wing-coverts black with thick rust-coloured edges.
34	Down still on heads of both nestlings, restricted to chin and centre of nape in the larger bird and more extensive on the smaller bird. Pale feathers still present on lower belly and underwing-coverts.
40	Larger nestling had fully feathered head, whereas smaller retained scanty down on head and upper chest.
45	Bare skin around eyes less prominent; skin at gape yellowish; cheeks a shade paler than rest of richly coloured head. Down still present on underwings, noticeably on secondary coverts. Scapulars and mantle black with neatly patterned rust fringes; legs pale creamy yellow with black talons. Larger bird estimated at half to three-quarters of adult size.
	Smaller nestling also well feathered. Overall coloration remained noticeably paler with more down on throat, above and behind eyes and on forehead. Bill pale grey with black distal half of upper mandible and tip of lower mandible; cere prominent and paler than bill, having a pinkish tinge.
53	Gape pink, as in adult.
55–57	Fledging. Nearly same size as adult, but with noticeably shorter tail and primaries.

peeping became more strident and excited as the female called before the male delivered the feeds. In the first week, peeping also occurred in response to the female leaving or returning to the nest. The bill and white downy head of one chick was seen for the first time on day 8, and two chicks were first seen on day 14. Stages of growth are summarised in Table 2.

Day 18 was the first time a chick was seen to walk backwards towards the edge of the nest and defecate in a projectile fashion over the side. On day 23 one nestling was seen to stand on the nest and flap its wings. On day 34 the smaller nestling regurgitated a pellet after bobbing its head up and down. Although pellets were

manipulated by the nestlings, only once was the female seen to deposit one over the edge. Often, after manipulating pellets with their bills, the adult and nestlings made opening and closing movements of their bills as well as what appeared to be swallowing movements. Debris, presumably as the pellets flaked, was flicked off with a sideways motion of the head.

The nestlings were first seen to preen themselves on day 26, an activity frequently observed after this date. The female preened the nestlings, mainly on the head and nape, on days 28 and 31. These sessions were brief, <1 minute, the first occurring early in the morning and the second after a feed. Brief bill-touching occurred, within an hour of a feed, between the female and the larger nestling (day 30), and between both nestlings (day 50). The smaller nestling preened the larger on day 45, and the reverse happened on day 53; allopreening again was brief, <30 seconds, and mainly around the head and nape.

From day 26 the nestlings became more visible from the ground. They called vigorously as prey was about to be delivered. The hunched posture, assumed by the female during the incubation period before food delivery, was first noted in the nestlings on day 53.

Aggression between the siblings was first witnessed on day 27. The larger, dominant bird struck the smaller sibling with a downward movement of its bill and partly spread its wings as food was delivered. The smaller bird's response was to turn away and walk towards the edge of the nest, calling constantly (see Voice) with head bowed. The calling continued for up to 15 minutes. Sometimes the smaller sibling, after a short time, rushed in to attempt to snatch the food from the female or dominant sibling. In one such episode, the food was dropped on the edge of the nest and had to be retrieved by the female. Another prey item was found under the nest during this phase. On day 34, the smaller sibling was successful in snatching the food and mantled over it while tearing at it, clutched in its foot. Only the smaller sibling mantled over food during this phase. This behaviour did not always prevent the dominant sibling from wrestling back the prey item in a flurry of wings, as on day 34.

Aggression was also shown by the dominant nestling as food was delivered, and once as it manipulated a pellet, by grasping its sibling by the forehead with its bill in a biting fashion. This was less frequently witnessed than the simple striking. The smaller sibling emitted the distressed chittering call (see Voice). When released, it reacted as it did after being struck at (see above). Only on day 54 did the smaller nestling show any signs of retaliation, when it spread its wings and raised its nape and head feathers while opening its gape at its sibling. This was in response to being struck at while exercising its wings on the nest-platform.

Competition and aggression between the nestlings were largely restricted to times of prey delivery and feeding. The aggression was rarely intense and no visible wounds were made. The smaller nestling did, however, seem to be missing a few feathers above its bill where its sibling had gripped it. The more frequent striking with the bill usually banished the smaller nestling to one edge of the nest and brought no further assaults. Most of the time, the nestlings appeared indifferent to each other's presence.

The nestlings were first seen to feed themselves on day 26. From days 26 to 35, they fed themselves eight times out of the 17 feeds witnessed. Usually, the assisted feeds were slightly larger items. The female pulled the prey item from the nestling's bill before either dropping it back at its feet or tearing at the item and feeding the

nestling on small portions. After day 35, all 15 observed feeds occurred without the female's assistance.

Wing-flapping became a more common observation after day 40, and the larger nestling was able to lift itself off the nest by day 50. The nestling not flapping was usually forced to one edge of the nest. Panting was noted briefly, once, on day 45 by the larger nestling during a hot afternoon. It also reacted to a pair of Grey-crowned Babblers *Pomatostomus temporalis* that called vociferously next to the nest, by raising its nape and mantle feathers and sitting with neck erect, facing them. Sunning was first noted by the nestlings on day 45 and subsequently on days 46 and 54, for up to 2 minutes. Most episodes on the nest involved the bird sitting upright, although the larger nestling once appeared to lie flat on the nest while opening its wings.

The nestling period was calculated at 55–59 days from 1 October, assuming asynchronous hatching over 2–5 days (from Newton 1979), with fledging between 24 and 26 November for the older nestling and 29 or 30 November for the younger.

Fledging

Fledging was not observed. At 0605 h on 30 November, after a rainy night, the smaller fledgling was perched in a live tree <15 m from the nest-tree, only 5 m above the ground. It was a cloudy morning and its plumage did not look saturated; it allowed approach to within 7–10 m without any sign of concern. Both adults were near the nest where the larger fledgling was, and paid no attention to the smaller fledgling. No calls were heard.

The younger fledgling was mobbed by Noisy Miners and was able to fly low through the trees before landing on the ground. It then flew to a bare perch about 5–7 m off the ground, staying here until it was knocked off the perch from behind by a Laughing Kookaburra. It flew to the ground and tried to get through a wire fence before reversing out of it and flying, then attempted to land in the outer foliage of a nearby eucalypt. It achieved this awkwardly by using its wings for balance and its bill to grasp the foliage, taking some time before it perched precariously on a thin limb. Grey Butcherbirds then mobbed it, forcing it to take flight to another perch some 40 m from the nest. After further mobbing by the Grey Butcherbirds, the younger fledgling flew to a log <0.5 m high (Plate 39, front cover). It stayed here for some time until a Laughing Kookaburra again directly knocked it off its perch from behind, leaving with some feathers in its bill. The Kite appeared stunned and stayed still, standing on the ground for about 10 minutes. It then flew into a paddock and towards a wire fence, which it climbed using its feet to hang on and bill to pull itself up, with the wings also opened for balance. The posture was that of the adults as they clung, hanging backwards, to break off fresh leaves from the outer foliage of trees. The fledgling managed to balance on the wire fence before flying to a wooden fence-post.

Again the Kookaburra knocked it to the ground. The Kite then walked with a slightly loping, shuffling gait in the grassy paddock. When the sun shone through the clouds, the Kite began sunning itself with wings spread and back to the sun. Eventually, the Kite flew back to the area under the nest-tree. It landed on the ground before perching on a post about 4 m high. The adults and its sibling completely ignored it. By mid afternoon, it had not managed to return to the nest, and allowed itself to be picked up. The sternum was prominent, indicating poor condition, and the young Kite was handed over to the Department of Environment

and Heritage for care. A small nestling bird, fallen from the nest some days earlier and frozen for later identification, was fed to the young Kite, which tore the carcass apart while grasping it in one foot and swallowed it in 3–4 pieces.

Post-fledging period: parental behaviour

Of the 25.3 hours observation time post-fledging, about half was conducted in the two weeks after the successfully fledged young Kite had left the nest area (at about a week post-fledging). The adult female was seen to bring one branch with fresh leaves once before the fledgling left the area, and once after it had left. A twig was brought to the nest on one morning, in the fledgling's absence. The female also broke off a branch with fresh leaves but, after trimming away some leaves, dropped the branch.

Seven feeds were recorded in the 12.5 hours of observation in the first week, before the older fledgling left the area. In contrast with earlier stages of the cycle, the female fed the young more frequently, delivering four of the seven food items. All feeds were brought to the nest. On the three mornings of observation before the fledgling left the area, both adults were absent from the nest-site.

On 30 November the fledglings were not on the nest when the female delivered a feed. The younger fledgling looked up but made no attempt at flying. The female stayed on the nest as the larger fledgling called and begged from a nearby tree, easily visible from the nest. It took 30–40 seconds before it came to the nest, landing on the female's back. The female responded by opening her wings, turning her head round and gaping before leaving hurriedly. A similar episode followed after the male brought food to the nest later that morning. The fledgling landed on his back and immediately pecked at the base of his tail, whereupon he left quickly.

On the day the successful fledgling left the nest area, 1 December, only the female was present late in the afternoon (1630 h). She left the area before 1800 h and no Kites were present at 1820 h. The next morning at 0540 h, only the female was present near the nest-tree. On 6 December, both adult Kites roosted in the area. On 7 December only the female was seen to roost there. Their fidelity to the area appeared to wane over the period following the departure of the juvenile Kite from the immediate nest area.

The adults were seen together on three of the eight days the area was visited between 1 and 14 December. Allopreening, reciprocal allopreening, preening and sunning behaviour were all observed in this period. As the female spread her tail whilst stretching her wing, the male next to her took the opportunity to preen her tail-feathers. When they departed one morning, they did not travel together although they were seen leaving within 10 minutes of each other in different directions. Only the male roosted near the nest-site on 14 December. He had moulted a primary feather (?P5), collected on 7 December, which gave him a distinctive outline in flight.

Post-fledging period: development of the young

During the brief post-fledging observations (12.5 hours), the larger fledgling spent time off the nest on the nest-branch, on the nearby dead tree, or perched in live trees within 60 m of the nest. When the adults were present, it called and begged. As it called, it hunched forward with bill agape, looking at the adults. On

Older fledgling Square-tailed Kite sunning

Plate 44 Photo: C.P. Barnes & E.E. Zillmann

the dead tree, it was seen to tear away bark with its bill and make some unsuccessful attempts to peck at an insect it had disturbed. It was generally quiet when the adults were not present.

At the nest, aggression towards the smaller fledgling was noted at one feed when the larger arched its wings, raised its nape and crest feathers with neck erect, and pecked at its sibling. A flurry of wings between the squabbling birds resulted in the prey being dropped from the nest. The larger fledgling mantled over a food item on 28 November. Of the seven nestling birds delivered by the adults, the smaller young Kite was seen to receive only one.

Sunning behaviour was observed in both fledglings. The older bird was seen to sun itself on the dead tree, making the begging call in the adults' presence (Plate 44). No direct contact with the adults was noted, apart from the feeds already described. The larger fledgling was last seen on 30 November in the morning, although the property owner reported its presence on the morning of 4 December. Its presence was not detected by the authors on the eight days on which the area was visited between 30 November and 14 December (12.5 hours). It spent 5–7 days in the immediate nest area post-fledging.

The successful fledgling did not roost in the immediate vicinity of the nest with the adults 5–7 days post-fledging. However, whether it maintained contact at other times remains unknown. Single adults were seen on five occasions 20 km from the nest-site in January 1999 (CPB), a pair of adults once (EEZ), and a single juvenile on 28 February 1999 (EEZ). It is not known if any of the birds were from the nest observed. The rescued juvenile was successfully released back to its natal area on 8 January 1999; no adults birds were seen there on that morning.

Table 3

Prey delivery rates at Square-tailed Kite nest. h = hours of observation; n = no. times prey delivered; M = male, F = female.

Stage	*h*	*n*	*Deliveries/hr obs.*		
			M	*F*	*Total*
Incubation	44.6	8	0.2	0	0.2
Nestling:	126.7	57	0.4	<0.1	0.4
days 1–14	40.3	19	0.5	0	0.5
days 15–28	27.5	15	0.5	<0.1	0.5
days 29–42	32.7	13	0.4	0	0.4
days 43–56	26.2	10	0.4	0	0.4
Post-fledging	12.5	7	0.2	0.3	0.6

Feeding rates

The male's hourly feeding rate varied throughout the breeding cycle (Table 3). The lowest was, as expected, in the incubation period. Hunting appeared to take place throughout the day. The rates differed when they were separated into the period before and after midday (Table 4), suggesting that the overall rate might be higher, as there was a bias towards morning observations. The shortest time between deliveries was 3 minutes and the longest 3 hours 13 minutes, both in the nestling period. The female was observed to deliver prey only twice (4% of deliveries observed) in the nestling period.

It was not possible to accurately gauge the size of the prey delivered, but the majority appeared <30 g, as were both prey items dropped from the nest. No obvious difference in prey size delivered by the two sexes was noted. Some larger items were delivered, though infrequently.

Diet

All 31 regurgitated pellets, including fragments, were from the nestling and post-fledging periods. Overall, 26 intact pellets measured 24–50 × 14–30 mm (mean 31.7 × 20.1 mm). Macroscopically the pellets were of two types (Plate 45). The commoner type was a greyish, matted and roughly cylindrical pellet of feathers which, when freshly produced, was slightly damp but odourless. These tended to dry out fairly quickly, although still holding their general shape. On one occasion a pellet was observed to be regurgitated, though not immediately ejected from

Table 4

Prey delivery rates at Square-tailed Kite nest in the morning (a.m.) versus afternoon (p.m.). n = no. deliveries of prey to nest, h = hours of observation.

	h (a.m.)	*h (p.m.)*	*deliveries (n)*		*deliveries/hr obs.*	
			a.m.	*p.m.*	*a.m.*	*p.m.*
Incubation	34.7	9.5	4	4	0.1	0.4
Nestling	104.9	21.8	42	15	0.4	0.7

Regurgitated pellets of Square-tailed Kite: spheroidal pellets containing eggshell, and cylindrical pellets of feathers

Plate 45 Photo: C.P. Barnes & E.E. Zillmann

the nest, by a nestling Kite. The female was seen to drop a pellet over the edge of the nest once; when retrieved, the pellet was not moist or fresh. Nineteen pellets of this type measured 24–50 × 14–30 mm (mean 33.6 × 20.6 mm).

The other type of pellet was a smaller, more spherical, moist pellet which had obvious eggshells on the surface. These pellets were in the minority and tended to be sticky when first produced. They had a pungent, ammoniacal smell. When old, they tended to lose their shape and disintegrate to mainly eggshell fragments. Seven pellets of this type measured 20–35 × 15–23 mm (mean 26.7 × 18.6 mm).

Analysis of the pellets did not produce any skulls, and the few bones found were small and soft. Evidence of avian prey, either eggshells or feathers, was in all 31 pellets: eggshells in 11 (35%); feathers or down in 25 (81%). Insect remains were present in 19 pellets (61%). Vegetable matter, such as pieces of grass and dead leaf probably collected and ingested accidentally with prey, was present in nine pellets (29%). In at least four cases, these were pieces of passerine nest or nest-lining such as soft plant fibre, sometimes bound with cobweb. Seeds, including Sorghum *Sorghum vulgare*, Millet *Panicum miliaceum*, wattle *Acacia*, grass and wheat or oats, probably in the digestive tracts of prey, were present in eight pellets (26%).

By number, the Kites' diet consisted of small birds (43%), birds' eggs (15%) and insects (42%), of which a few of the bird chicks may have been still inside the egg (Table 5). Feathers were almost all of juvenile type or still ensheathed, except for shiny black feathers which, together with nest material (plant fibre and cobweb) in the pellet, suggested male Mistletoebird *Dicaeum hirundinaceum*. Thus, the

Table 5

Breeding diet of a family of Square-tailed Kites at Bundaberg, Queensland, 1998: nestling and post-fledging periods, October–November. Minimum no. of prey individuals in 31 pellets.

Species	*n*	%
Birds:		
downy chicks[a]	17	
feathered[b]	17	
total birds	34	43
eggs	12	15
Beetles (Coleoptera):		
scarabs *Anoplognathus olivieri*	3	
Elephant Weevil *Orthorrhinus cylindrirostris*	1	
unidentified	3	
Bugs (Hemiptera)	3	
Grasshoppers (Orthoptera)	2	
Ants (Formicidae)	16	
Cicada (Cicadidae)	1	
Unidentified insects	4	
Total insects	33	42
Total	79	100

[a]Four of these may have been unhatched chicks within eggs
[b]16 of these were nestlings or fledglings with juvenile or ensheathed feathers

majority of prey was juvenile birds, nestlings and eggs. Avian prey was mostly unidentifiable. White eggshell and seeds suggested a finch species or small dove; three birds' feet were in the tarsus range of a finch. Olive-brown, dark-spotted eggshell matched that of Rufous Whistler *Pachycephala rufiventris*. Pale-pink, dark-spotted eggshell was possibly of a honeyeater, as were greenish grey-brown feathers. White, finely black-spotted eggshell was possibly of a flycatcher. The larger insects were probably caught by the Kites, but the smaller kinds, particularly the ants, may have been picked off the Kites' nest or in the digestive tracts of avian prey.

Of the prey items delivered to the nest, all that could be seen well were birds thought to be nestlings. One small passerine nestling about 10 g, partly decomposed, was retrieved from under the Kites' nest (presumably dropped from the nest), and another was dropped by the fledgling Kites. The eggshell in the Kites' pellets is likely to derive from the adults foraging for themselves and eating their catch while away from the nest.

Discussion

The Kites' nest was typical of those previously described, particularly for south-eastern Queensland, in terms of site and habitat, tolerance to nearby human habitation, and the clustering of raptor nests (Cameron 1976, Debus & Czechura 1989, Debus et al. 1992, Marchant & Higgins 1993, Debus 1996). The presence of a dead tree at the site was also a feature of a nest 60 km away (1995 and 1996), where Square-tailed Kites bred successfully (EEZ & CPB pers. obs.). Its use as a focus for a range of activities was also noted there, and it may be a regular feature of Kite nests.

The Kites' vocal repertoire was as previously described (Debus et al. 1992, Marchant & Higgins 1993, Debus 1996), but with additional, subtle variations related to specific activities.

Aspects of the breeding cycle and breeding behaviour were generally as previously described (summarised in Marchant & Higgins 1993). An estimated incubation period of 37–42 days (Marchant & Higgins 1993) would place laying between mid and late August, in keeping with previous data (Debus & Czechura 1989). Gender roles, and their change through the cycle, were as described for this species (Marchant & Higgins 1993) and as expected for raptors (see Newton 1979). For instance, the male's attendance at the nest decreased over time: he shared incubation but did little brooding, and his contribution of nest-lining also decreased from incubation to the nestling phase. However, social interaction (allopreening) increased from incubation to the nestling phase. The estimated nestling period of 55–59 days agrees with previous assessments (in Marchant & Higgins 1993). The post-fledging dependence period is likely to be much longer than the few days that the older fledgling was readily found near the nest-site; it is likely that this fledgling was in the wider area but not detected.

Sibling rivalry was previously undescribed for this species, although the disparity in development of siblings has been noted and one sibling has occasionally been found dead in nests (see Marchant & Higgins 1993). In this study, the onset of sibling competition was later than is usual for raptors, in which siblicide manifests itself in downy chicks (Newton 1979).

In this study, sibling rivalry was probably related to food supply. Feeding rates were higher than for a failed nest (see Debus et al. 1992), but lower than for a nest that successfully fledged two young without sibling rivalry (Cameron 1976, Hollands 1984), and seemed sufficient to sustain only one fledgling. The fate of the smaller sibling was that of a food-stressed weakling likely to die at fledging. In a similar case, a starving female fledgling weighed 426 g when found and 648 g when it had regained condition (D. Roach per S. Debus). It seems likely that in the Square-tailed Kite sibling rivalry, brood size and fledging success are dependent on the male's feeding rate, a function of food supply, as the female contributes little to food provisioning during the nestling period.

Sunning was previously undescribed for this species, although known for a captive bird (Debus 1991). Sun-basking is thought to reduce the energy needed to raise body temperature, and also to speed up recovery of the shape of flight-feathers by heating the keratin (del Hoyo et al. 1994). New World vultures, which soar for prolonged periods leading to an upward curling of their feathers, frequently sun themselves (del Hoyo et al. 1994). Perhaps both the energy-saving and feather-conditioning benefits of sun exposure are employed by the Square-tailed Kite. Sunning by both juveniles suggests that this behaviour may be common.

The Kites' breeding diet consisted mostly of eggs, nestlings and fledglings of small birds, along with evidence of nests or part thereof taken with the contents, and some insects. Many of the last may have been taken incidentally, and would have contributed little by biomass. The heavy reliance on avian prey, determined quantitatively in this study, confirms previous conclusions on the Kite's ecology (summarised in Marchant & Higgins 1993).

This study has provided further insights into the Square-tailed Kite's requirements for successful breeding. There remains the task of determining the area of foraging habitat required by a breeding pair of Kites. An important factor

is the quality of the habitat, to support sufficient populations of nesting passerines which are the major component of the Kite's diet. Habitat clearance and fragmentation, or proposals for such, are ongoing, cumulative threats to the Kite population (e.g. Anon. 1999, Thornton 1999). Conversely, effective conservation of the Square-tailed Kite would automatically conserve the other bird species and habitats on which it depends.

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References

Anon. (1999), 'Mareeba Shire Council—again!', *Harrier* **1**(2), 7.
Baldwin, M. (1975), 'Birds of the Inverell district', *Emu* **75**, 113–120.
Beruldsen, G. (1980), *A Field Guide to Nests and Eggs of Australian Birds*, Rigby, Adelaide.
Borella, M.C. & Borella, M. (1997), 'Square-tailed Kite breeding near Ararat, Victoria', *Aust. Bird Watcher* **17**, 157–158.
Cameron, A.C. (1976), 'Nesting of the Square-tailed Kite', *Sunbird* **7**, 42–47.
Cameron, C.A.C. (1992), 'Further notes on Square-tailed Kites nesting in south-east Queensland', *Sunbird* **22**, 30–32.
Collar, N.J., Crosby, M.J. & Stattersfield, A.J. (1994), *Birds to Watch 2. The World List of Threatened Birds*, BirdLife International, Cambridge.
CSIRO (1970), *The Insects of Australia,* Melbourne University Press, Melbourne.
Cupper, J. & Cupper, L. (1981), *Hawks in Focus*, Jaclin, Mildura, Vic.
Debus, S. (1991), 'Black-breasted Buzzard and Square-tailed Kite sunbathing', *Australasian Raptor Association News* **12** (2), 27.
—— (1996), 'Further observations on the Square-tailed Kite', *Aust. Birds* **29**, 44–53, 62.
—— & Czechura, G.V. (1989), 'The Square-tailed Kite *Lophoictinia isura*: a review', *Aust. Bird Watcher* **13**, 81–97.
—— & —— (1992), 'The Square-tailed Kite *Lophoictinia isura* in Queensland', *Sunbird* **22**, 1–18.
——, Earle, R.D., Millard, G.J. & Parker, C.R. (1992), 'Breeding behaviour of a pair of Square-tailed Kites', *Aust. Birds* **26**, 1–13.
del Hoyo, J., Elliott, A. & Sargatal, J. (Eds) (1994), *Handbook of the Birds of the World,* vol. 2, Lynx, Barcelona.
Garnett, S. (Ed.) (1993), *Threatened and Extinct Birds of Australia*, RAOU Report **82**, Royal Australasian Ornithologists Union, Melbourne.
Hollands, D. (1984), *Eagles, Hawks and Falcons of Australia*, Nelson, Melbourne.
Johnston, D. (1983), 'Nesting of the Square-tailed Kite in the Baradine area', *Aust. Birds* **17**, 35–37
Marchant, S. & Higgins, P.J. (Eds) (1993), *Handbook of Australian, New Zealand and Antarctic Birds,* vol. 2, Oxford University Press, Melbourne.
Newton, I. (1979), *Population Ecology of Raptors*, Poyser, Berkhamsted.
Schulz, M. (1983), 'Nesting of the Square-tailed Kite in south-eastern New South Wales', *Aust. Birds* **18**, 6–8.
Thornton, T. (1999), 'Where have all the raptors gone?', *Qld Ornithol. Soc. Newsl.* **30**(1), 1, 5.

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