AUSTRALIAN BIRD WATCHER 1989, **13**, 81-97

The Square-tailed Kite *Lophoictinia isura:* A Review

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Summary

The literature concerning the Square-tailed Kite's morphology, habitat, diet, hunting methods and breeding biology is reviewed and supplemented with field observations and museum data. The Square-tailed Kite is considered a specialised inhabitant of passerine-rich *Eucalyptus* open forests, woodlands, and heathlands, preying primarily on the young of small foliage-nesting birds by means of low, slow searching flight. It nests in mature living *Eucalyptus* and *Angophora* trees in sclerophyllous vegetation, usually near water in the inland though not necessarily so in coastal areas. It apparently has a low breeding density, large home range and traditional nest site. Aspects of its biology indicate that it is related to the Black-breasted Buzzard *Hamirostra melanosternon*, but neither species seems close to the milvine kites. The Square-tailed Kite appears to be threatened by habitat destruction; this suggests an urgent need for a detailed study of its biology and ecology.

Introduction

The Square-tailed Kite *Lophoictinia isura* is one of the unusual Australian raptors which are uncommon, rather poorly known and placed in endemic, monotypic genera (the others being the Black-breasted Buzzard *Hamirostra melanosternon* and Red Goshawk *Erythrotriorchis radiatus*). It is apparent that the Black Kite *Milvus migrans* has often been mistaken for the Square-tailed Kite and that this has led to erroneous statements in the literature on the Square-tailed Kite. Only recently has the latter become reasonably well known, and then only at the nest (Cameron 1976, Cupper & Cupper 1981, Johnston 1983, Schulz 1983, Hollands 1984). Here we review the literature on its biology, and supplement this with data from museum specimens, the RAOU Atlas of Australian Birds, Nest Record Scheme and Bird of Prey Watch scheme, the Bird Observers Club unusual record files, field notes from colleagues and our own field experience. A comparison of the Square-tailed Kite's biology is made with that of the milvine kites and the Black-breasted Buzzard; this may shed some light on its relationships.

Field identification

The field characters of the Square-tailed Kite have been reviewed by Badman & Debus (1987). We stress the reliance on silhouette (shape, relative proportions) and flight behaviour (the way a bird holds and flaps its wings) as the best way to accurately and quickly identify this and other raptors. Fine plumage details are usually of little importance. However, outstanding field marks can be helpful during extended views at reasonably close range. In the Square-tailed Kite's case these include the white cap, barred 'fingers', 'windows' in the wings, and the dark carpal patch and distinctly buffy tone on the under-wing. It is apparent that Square-tailed Kites are occasionally misidentified as Red Goshawks or Little Eagles *Hieraaetus morphnoides*, which serves to illustrate how different they really are from Black Kites. If there is some doubt about whether a bird is a Black Kite or a Square-tailed Kite, it is almost certainly a Black Kite.

Several identification points have been inadequately covered in previous discussions. As noted by Condon & Amadon (1954) some Square-tailed Kites may show a pale rump/lower back, recalling the Swamp Harrier *Circus approximans*, except that the pale area is more diffuse and extends further up the back (SD). A Square-tailed Kite gliding at a great distance or height is a nondescript brown raptor with very long, slightly to moderately upswept, pointed wings bent back at the carpals; it can be distinguished from the Wedge-tailed Eagle *Aquila audax* by the long, flat (not wedge-shaped, dished) tail (SD). The dark and pale pattern on the upper-wing distinguishes it from some other raptors. In some light conditions the Square-tailed Kite may appear buff above and below, or show marked changes from light to dark (GVC).

The juvenile and adult plumages of the Square-tailed Kite have been adequately described elsewhere, and well illustrated by photographs in Cupper & Cupper (1981) and Hollands (1984); a good photograph of an adult in flight is provided in Trounson & Trounson (1987) and reproduced here in black and white (Plate 27). It appears that there is an intermediate (immature) plumage stage, paler on the head, redder on the underparts and darker above than the juvenile (cf. Anon. 1906). A presumed first-year bird (rufous juvenile) moulted in October into the immature plumage which lasted until May-July almost two years later; at its second moult it acquired full adult plumage when almost three years old (Anon. 1906). It appears that the immature plumage is attained at the first complete moult and adult plumage at the second complete moult, but the data were obtained from one captive bird. Nutrition in captivity may influence the timing and duration of moult, so it is not clear whether wild birds undergo a complete annual moult or a partial moult taking two years to replace all feathers. Square-tailed Kites may breed in subadult plumage (Serventy & Whittell 1976).

The Square-tailed Kite seldom calls away from the nest but if heard, its voice is distinct from that of the other large kites and Little Eagle. Limited information suggests that it utters two main types of call (see, for example, Baldwin 1975, Cameron 1976, Cupper & Cupper 1981, Hollands 1984, Morcombe 1986, Slater et al. 1986). One call, given by both sexes (male lower pitched) is a hoarse repeated yelp, breaking into a high-pitched squealing or wailing in begging females and young (Hollands 1984) or in alarmed birds (SD); that of females and young is a whining *whee . . . whee . . .* (P. Olsen). The other call, also given by adults and young, is a shrill chatter or twitter like that of the Collared Sparrowhawk *Accipiter cirrocephalus* and similar to the chittering distress call given by some other hawks (P. Olsen). In some circumstances these calls are given loudly, with the chatter and yelp apparently run together (see displays, below). The yelp is quite different from the commonly heard calls of the milvine kites, and is similar in quality to the yelp of the Black-breasted Buzzard (SD). Captive Square-tailed Kites call frequently in the breeding season, with calls similar to those of the Buzzard (J. Olsen).

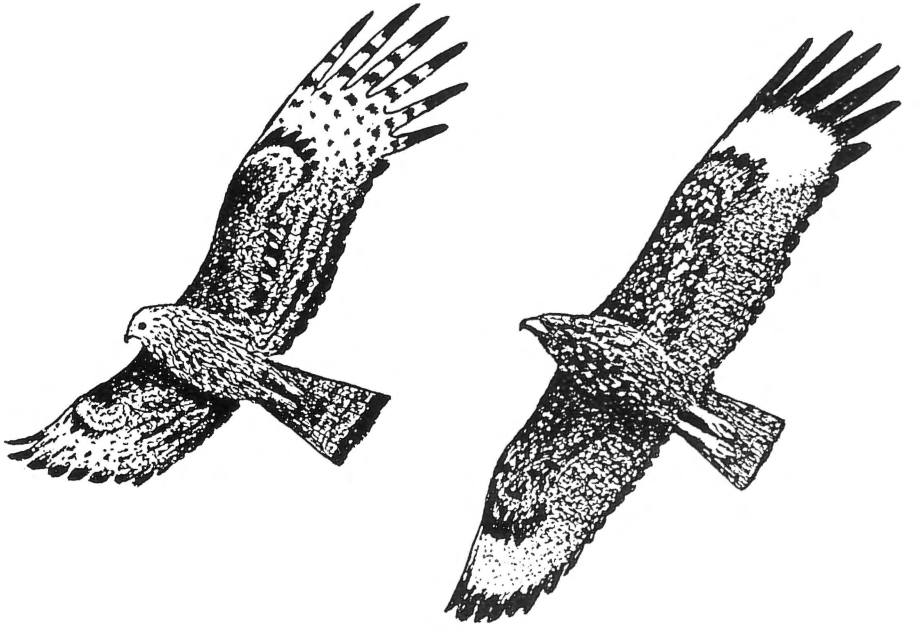
Morphology

The most striking feature of the Square-tailed Kite's morphology is its longer wings, especially the primaries, than other hawks of similar size. The Square-tailed Kite's mean wing length is 37-61 mm longer than that of the Black Kite and 47-56 mm longer than that of the Whistling Kite *Haliastur sphenurus* (means of corresponding sexes: Table 1). Its wing span is thus about 70-120 mm greater than that of the Black and Whistling Kites. Combined with its lower body weight, this gives the Square-tailed Kite a lower wing loading than hawks of similar size. One male weighed 501 g and two females 590 and 680 g (mean 635 g; Hitchcock & McKean 1969, Price-Jones 1983), compared with the Black Kite (mean 574 and 592 g for male and female) and

Whistling Kite (mean 710 and 830 g for male and female: Baker-Gabb 1984). The formula in Cade (1982) gives a wing-loading index of 0.19 and 0.21 g/sq. cm for male and female Square-tailed Kite respectively, compared with the Black Kite (0.25 and 0.26 g/sq. cm) and Whistling Kite (0.33 and 0.35 g/sq. cm). In addition, the Square-tailed Kite's long, flexible primaries (Brown & Amadon 1968) are widely splayed to produce a pronounced wing-slotting effect which reduces stalling speed and increases lift. Its aerodynamic characters permit slow soaring or gliding at low altitude for long periods. For comparison, the buoyant Spotted Harrier *Circus assimilis* has a calculated wing-loading index of 0.25 and 0.28 g/sq. cm for male and female respectively.

Another notable aerodynamic feature of the Square-tailed Kite is its tail shape. Its tail-tip configuration (slightly forked with projecting central rectrices: Badman & Debus 1987) is similar to that of some woodswallows *Artamus* sp., particularly those (e.g. Dusky *A. cyanopterus*) that spend considerable time soaring low over and hawking between tree crowns (Schodde & Tidemann 1986, SD pers. obs.). Its flight behaviour (tail movement at low speeds and agility) recalls that of woodswallows (GVC).

The Square-tailed Kite's bill length is similar to that of the Black and Whistling Kites (Table 1). However, its bill is noticeably finer and more slender (cf. photographs in Cupper & Cupper, Hollands 1984). Its tarsus is shorter than that of the Black and Whistling Kites (Table 1), suggesting less terrestrial agility. Its toes are intermediate in length between those of the Black and Whistling Kites, but the proportions differ slightly: the Square-tailed Kite's outer toe is relatively shorter and closer to the inner toe in length (Table 1). Its claws are also less curved than those of most other Australian raptors except the Pacific Baza *Aviceda subcristata* (museum specimens: D. Baker-Gabb, SD, GVC).



Adult Square-tailed Kite (left), pale phase Black-breasted Buzzard (right).

Plate 26 Drawing: David Noakes

General habits and behaviour

The Square-tailed Kite gives the impression of being a highly aerial bird, able to spend long periods soaring or sailing slowly with scarcely a flap of the wings. It is buoyant and agile at low altitude, gliding with a dihedral and jinking sideways between or below the treetops (GVC), and it is capable of rapid and effortless height gain on the slightest air current (e.g. Cameron 1976). In keeping with its powers of sustained gliding flight and minimal expenditure of energy in active flapping, it is migratory in southern Australia and apparently on the tropical coasts (see Debus 1983, Blakers et al. 1984, Debus & Silveira 1989).

Despite some early claims to the contrary, the Square-tailed Kite is not a sociable species and there is no conclusive evidence that it gathers in flocks. It is usually seen singly, although pairs sometimes soar together during the breeding season and family groups of adults and 1-2 dependent young may be seen during the post-fledging period (see displays and breeding biology, below). For instance, in south-western Australia it is most often reported at the start of the breeding season (as pairs seek and claim territory?), with another flush of records post-fledging (R. Jaensch). However, in the tropics single birds or pairs may sometimes associate with flocks of Black or Whistling Kites (Thomson 1935, Morris 1973, S. Johnson/Atlas, G. Wilson/Atlas). Several inconclusive Atlas reports raise the possibility that in the tropics, small numbers of Square-tailed Kites (three or so birds) may gather at a concentrated food source such as insects or rodents disturbed by farming activity. This deserves investigation. One such claim in south-east Queensland proved to involve Whistling Kites and a juvenile Spotted Harrier (GVC).

The Square-tailed Kite seldom comes to the ground, where it appears awkward though it has been observed walking about (K. Coate/BOPWatch), anting (P. Olsen) and bathing (McCulloch 1988). It occasionally forages on the ground (see below), but it is not a scavenger. It may alight briefly but makes little movement while on the ground (GVC).

Virtually all other accounts, and our own field experience, indicate that the Square-tailed Kite is usually approachable and extraordinarily confiding. Its secretiveness and reluctance to flush from the nest when breeding (e.g. Cameron 1976) may have been a successful strategy for avoiding detection, but its 'tameness' now renders it easily shot (e.g. Johnston 1983). For instance, in south-east Queensland one bird flew directly overhead at 4 m and regularly flew low over houses, gardens and along roadways at the level of overhead wires (GVC, R.E. Czechura). Captive birds are gentle and unagressive, in disposition tame and unraptor-like (J. Olsen); perched wild birds seem similarly lethargic (SD).

Table 1

Mean length (mm) of some morphological parameters of the Square-tailed Kite *Lophoictinia isura*, **Black Kite** *Milvus migrans* **and Whistling Kite** *Haliastur sphenurus*. **Sources: Baker-Gabb 1984 and D. Baker-Gabb unpublished data from museum and other specimens. For toes, I=inner, M=middle, O=outer; I/O=ratio of inner to outer. M=male, F=female.**

Species		*n*	*wing*	*bill*	*tarsus*	*toes*			
						I	*M*	*O*	*I/O*
Square-tailed Kite	M	4	448	31.3	47.2	22.5	36.6	25.7	0.88
	F	8	476	34.0	48.7	24.5	38.5	27.6	0.89
Black Kite	M	35	411	31.1	49.9	20.1	34.6	25.5	0.79
	F	25	415	32.1	51.1	20.8	35.7	26.1	0.80
Whistling Kite	M	31	401	33.2	56.3	24.4	40.3	29.7	0.82
	F	37	420	35.8	58.5	25.7	42.6	31.0	0.83

Table 2
Queensland Square-tailed Kite records by habitat (GVC)

Habitat	*No. sightings*	*Comments*
Coastal lowlands	4	'Wallum' country
Riverine forest		
open	6	
closed	2	Coastal south-east
Woodland	9	Predominantly grassy understoreys
Open forest	5	Often in mixed associations or broken canopy
Open (grassland, pasture etc.)	3	Mostly overflying
Open with some mixed remnant trees	7	
Urban	5	
Roadways	4	Two urban, two over coastal highway; usually roadside trees present
Urban – Caboolture	many	Regularly seen over GVC's residence: mostly along Caboolture River and parkland/golf course alongside, also frequently soaring low over gardens with numerous trees and shrubs, occasionally overflying main street apparently inspecting shrubs on median strip

Distribution and habitat

The Square-tailed Kite was formerly believed by some to be an inland bird, not occurring on the coast in south-eastern Australia (e.g. McKean 1976, Beruldsen 1980). On the contrary, it is clearly a bird of coastal and subcoastal habitats (for instance to the 'eucalypt line' in south-western Australia: R. Jaensch), extending inland mainly along timbered watercourses, and is absent from true deserts (e.g. McGilp 1934, Cupper & Cupper 1981, Blakers et al. 1984, Debus & Silveira 1989). As predicted (Debus 1983), it is being found (sometimes breeding) in many coastal areas in New South Wales and Victoria (Blakers et al. 1984, Debus & Silveira 1989, G. Clancy, D. Geering, R. Jaensch, R. Noske, D. Secomb, SD pers. obs.). Recent observations in south-east Queensland indicate that it is a resident breeding species (GVC) where it was formerly thought to be irregular or vagrant (Czechura 1984, 1985). Beruldsen (1980) stated its breeding range to be throughout its distribution, but recent confirmed breeding records have come only from south-western Australia and from south-eastern and eastern Australia north to 18°S (Blakers et al. 1984, Debus & Silveira 1989).

In southern Australia the Square-tailed Kite shows a clear preference for eucalypt open forest and woodland (e.g. Blakers et al. 1984), and it avoids *Acacia* shrublands (J. Dell unpubl. data) though commonly seen over shrublands with sparse eucalypts in south-western Australia (R. Jaensch). In the north it appears to inhabit a wider variety of habitats, including those dominated by *Pandanus, Melaleuca* or rainforest species (Hitchcock & McKean 1969, Schodde 1973, Storr 1980). An analysis of 137 recent hunting observations from ornithological data banks (see introduction) and SD's personal records produced the following breakdown: eucalypt open forest 47 (34%), eucalypt woodland 38 (28%), mallee 5 (4%), low shrubland/heath 18 (13%), grassland/crops 14 (10%), wetland (swamp/rushland) 3 (2%), non-eucalypt scrub 3 (2%), orchard/plantation 2 (1%), riverine rainforest 1 (1%) and urban trees 6 (4%). Habitats of GVC's sightings are presented in Table 2. Forest or woodland habitats used by Square-tailed Kites tend to be on fertile soils (R. Loyn pers. comm.) and are rich in nesting passerines (e.g. Cameron 1976, Johnston 1983). The Kite appears to make use of ecotones between timbered and open habitats (see hunting behaviour, below).

The Square-tailed Kite appears to inhabit many of the common *Eucalyptus* open forest and woodland associations, but there are few detailed descriptions of habitat structure and floristics and then only for northern Australia (see Schodde 1973). There are several descriptions of breeding habitat: nests are placed in mature, living *Eucalyptus* and *Angophora* species, usually near water in (climax?) sclerophyllous vegetation communities (see breeding biology below, Table 4). One nest was within 300 m of an occupied farmhouse (Johnston 1983), and one was in woodland on the edge of suburbia (N. Gibson/NRS). There appears to be a minimum area of forest or woodland, of unknown size but presumably some hundreds of hectares, required in the vicinity of the nest by breeding Square-tailed Kites.

The Square-tailed Kite may have suffered considerable habitat degradation and loss. At least half the area of forest and woodland in eastern and south-western Australia has been cleared, and much of the remaining area is subject to forestry practices which reduce the abundance and diversity of bird communities (see Keast et al. 1985). The widespread pastoral practice of annual burning may also have an adverse effect on forest and woodland bird communities, particularly those species that breed in the understorey; this deserves investigation. It is likely that the Square-tailed Kite's population has declined somewhat in response to loss of habitat and decline of food supplies. However, some Kites displaced from extensively cleared woodlands of the sheep/wheat belts in southern Australia may have been able to move into coastal open forests and tall open forests where openings in the canopy have been created by logging and limited partial clearing. This is suggested by the apparently increasing number of sightings in such forests (Debus & Silveira 1989).

Diet

The Square-tailed Kite eats mostly small birds, some insects, frogs and reptiles and rarely small mammals (Table 3). Birds taken have an adult weight of not more than about 100 g, but most are taken as nestlings although the Kite is capable of catching birds surprised into flight from the forest canopy (J. Dell) and from ground vegetation (McGilp 1934). The size of rabbits taken is not known, but they are presumably newly emerged kittens of not more than about 200 g. The Kite's major prey is nestling birds, particularly those of honeyeaters which build suspended nests in foliage; it sometimes removes the nest or part of it along with the contents (Barnard 1934, Schulz 1983, Hollands 1984, Morcombe 1986). In addition to the prey items in Table 3, the Square-tailed Kite has been seen chasing a rabbit and subsequently perching with large prey (lizard or mammal), 'flying after' a flock of Common Bronzewings *Phaps chalcoptera* (A. Lyneham/Atlas), supposedly attacking domestic 'chickens' (=small chicks?) (Carter 1913) and hunting over Bell Miner *Manorina melanophrys* colonies (R. Loyn). The three unidentified birds recorded by GVC (Table 3) were all sparrow-sized.

Most of the diet data were obtained from the southern two-thirds of Australia in the breeding season. However, most of the non-avian prey records are from the northern half of Australia. In the non-breeding season, it appears that most southerly breeding Square-tailed Kites migrate to the tropics where few passerine nestlings are available in the austral winter (see Frith & Davies 1961, Debus & Silveira 1989). In south-east Queensland where it is resident, the Kite causes much consternation among nesting birds but they ignore it outside its breeding season (GVC). Perhaps in the tropics, other prey is important in the Kite's non-breeding diet.

The Square-tailed Kite has been said to eat carrion, but this appears to be based on misidentified Black Kites, or on assumption because it physically resembles carrion-eating kites or occasionally associates with them (e.g. Morris 1973). There is no convincing evidence that it eats carrion.

Table 3
Species recorded as prey of the Square-tailed Kite

Species	*Life stage*	*Source(s)*
Rodents		Morris 1976
Rabbit *Oryctolagus cuniculus*	?	Schulz 1983
Stubble Quail *Coturnix novaezelandiae* (?)	adult	McGilp 1934
Pallid Cuckoo *Cuculus pallidus*	egg	Carter 1913
Richard's Pipit *Anthus novaeseelandiae*	egg	Carter 1913
	adult	Cameron 1976
Rufous Whistler *Pachycephala rufiventris*	fledgling	Schulz 1983
Brown Songlark *Cinclorhamphus cruralis*	adult	McGilp 1934
Noisy Friarbird *Philemon corniculatus* (?)	nestlings	Cameron 1976
Little Friarbird *Philemon citreogularis*	nestlings	Cupper & Cupper 1981
Blue-faced Honeyeater *Entomyzon cyanotis*	fledglings	Hollands 1984
Noisy Miner *Manorina melanocephala*	nestlings/ fledglings	Barnard 1934, Cameron 1976, Cupper & Cupper 1981, Hollands 1984, Tarrant in Anon. 1988
Miner *Manorina* sp./ wattlebird *Anthochaera* sp.	hatchlings	Lea & Gray 1935
Fuscous Honeyeater *Lichenostomus fuscus*	nestling	Barnard 1934
White-throated Honeyeater *Melithreptus albogularis*	young	Barnard 1934
White-naped Honeyeater *Melithreptus lunatus*	nest contents	Schulz 1983
Honeyeater sp.	adult?	A. Clucas/Atlas
Silvereye *Zosterops lateralis*	nestlings	Blakers et al. 1984
House Sparrow *Passer domesticus*	nestlings	Clancy 1980
Double-barred Finch *Poephila bichenovii*	nest contents	Barnard 1925
Unidentified small birds	adult	Lea & Gray 1935, McAllan 1981, Schulz 1983, J. Dell, GVC
	eggs	S.A. Museum, J. Dell
	nestlings/ fledglings	North 1912, Lea & Gray 1935, Schulz 1983, Hollands 1984, Morcombe 1986, S.A. Museum, J. Dell, B. Wells, J. Jolly
Frilled Lizard *Chlamydosaurus kingii*	juvenile	Barnard 1934
Skink sp.		Hitchcock & McKean 1969
Lizard sp.		G. Holmes/Atlas
Snake sp.	small	J. Start/BOPWatch
Unidentified reptile (snake?)		S. Garnett/NRS
Green Tree Frog *Litoria caerulea*	adult	GVC
Graceful Tree Frog *Litoria gracilenta*	adult	GVC
Insects:		
Case moth		A. Clucas/Atlas
Mantis		Barnard in North 1912
Ants		Hitchcock & McKean 1969
Grasshoppers		Hitchcock & McKean 1969, S. Johnson/Atlas
Crickets		Schulz 1983
Beetles		Hitchcock & McKean 1969, Schulz 1983
Phasmids		Barnard 1934
Unidentified (flying)		Larkins in Rogers 1976, GVC

Hunting and feeding behaviour

Almost entirely aerial in its searching behaviour (e.g. Barnard 1934), the Square-tailed Kite uses low, slow quartering and transect hunting to locate prey (see Baker-Gabb 1980 for terminology). Where the habitat is linear, e.g. riverine woodland in the inland or disturbed areas, it uses transect hunting, sailing into view from one direction and continuing out of sight as it follows the course of the river (GVC, SD). In blocks of forest or woodland it sometimes follows a circuitous path low amongst tree crowns, but it also sails in a straight line. Of 87 observations of birds hunting over extensive (non-linear) habitat, 49 (56%) were of birds low quartering and 38 (44%) were of birds flying transects (sources: Atlas and BOC files, colleagues, pers. obs.). Hunting birds make use of ecotones, e.g. sailing along a heath/forest interface, forest/paddock interface, mallee/paddock interface, woodland fringe, and green belts in urban or semi-urban areas, or circling over clearings in forest (Lane 1976, Jaensch 1987, R. Bigg/Atlas, S. Garnett/Atlas, D. Secomb, GVC, SD). They sometimes skim low over grass or heath as well as treed habitats (McGilp 1934, Serventy & Whittell 1976, Morris 1973, Price-Jones 1983, GVC).

Hunting birds closely follow the contours of the land, soaring into a breeze (though not a strong wind) and sometimes systematically quartering an area repeatedly (Lane 1976, King 1988, P. Curry/Atlas, I. Rooke/Atlas, J. Weinecke & D. Moffatt/Atlas, GVC, SD). They appear to have a regular routine, hunting in the mornings and afternoons or evenings, and to have a large hunting range (>3 km between sightings) with parts of it used in a regular pattern (King 1988, S. Sandstrom/Atlas). In south-east Queensland one pair works along 6 km of watercourse (GVC). Some hunting is done throughout the day when breeding, and most is done away from the immediate vicinity of the nest (Cameron 1976, Cupper & Cupper 1981, Hollands 1984).

Less frequently used hunting methods are mediated flushing, flushing from cover and ground hunting and stalking. Square-tailed Kites have been observed on the fringe of bushfires in the tropics (Thomson 1935), catching birds flushed by a motor vehicle (McGilp 1934) and catching birds that they flush into flight from the forest canopy (J. Dell). A Kite has been observed feeding on the ground during a grasshopper plague (N. Schrader/Atlas), and walking around a small waterhole in rocky country (K. Coate/BOPWatch).

There are few observations of the Square-tailed Kite's attack methods, but its main method appears to be a drop attack to the tree canopy to snatch prey from the outer foliage, and sometimes to the ground. One bird made a 'swoop' just above the treetops (Ashton & Ashton 1983), another 'crashed' into a tree canopy like a Pacific Baza (D. Secomb), and another raised its wings above its back as it dropped vertically to snatch small prey from the foliage (Hollands 1984). A Kite quartering the tree canopy similarly raised its wings high like a Black-shouldered Kite *Elanus notatus* as it dropped vertically to the ground to take a lizard (G. Holmes/Atlas). A coursing Kite dipped to the tree canopy and apparently snatched a bird, causing an 'explosion' of lorikeets and honeyeaters (GVC). Birds are sometimes taken in a stoop as they flush from cover (McGilp 1934), and a tail chase is occasionally used in an attempt to take fleeing prey, though perhaps unsuccessfully (A. Lyneham/Atlas). One hunting Kite dipped sideways, plummeted and hovered above grass (A. Clucas/Atlas). The Kite often uses a high dihedral when descending near cover and snatches prey like the Pacific Baza, in two instances tree frogs that were resting in the outer foliage (GVC).

Several observations indicate the methods used to rob nests. Hunting Kites landed in trees containing the domed nests of a Double-barred Finch *Poephila bichenovii* and House Sparrows *Passer domesticus*, balanced themselves in the foliage with outstretched wings and thrust their bills into the entrance holes to remove the contents (Barnard 1925, Clancy 1980). Another Kite descended onto the top of a bush, with

its wings up like a Black-shouldered Kite then enveloping the bush as it reached its leg down, tore a domed nest apart with its foot and removed the nestling (B. Wells).

One report suggests that flying insects may be caught (Larkins in Rogers 1976). A Kite took flying insects around the canopy of a flowering eucalypt; species present included dragonflies, beetles, bees and flower wasps (GVC). Small prey is sometimes eaten on the wing, although larger prey is eaten at a tree perch (Morris 1973, Hollands 1984, GVC).

The above hunting methods, and the usually small prey items taken, are consistent with the Square-tailed Kite's morphology, i.e. long, deeply 'fingered' wings, low wing loading, slender bill, short legs and small feet with short outer toe and rather straight claws (see above). These adaptations permit sustained, thorough searching flight and the capture of small prey in arboreal hiding places, and are associated with the nest-robbing habit (see Brown & Amadon 1968, Burton 1978).

Courtship and advertisement displays

Little has been recorded on the Square-tailed Kite's displays. A solitary bird in the presence of Black Kites, but with no conspecifics in the area, performed a series of aerial undulations, swooping with half-closed wings and rising again, while giving a loud call like the scream of a Brown Falcon *Falco berigora* (S. Garnett/Atlas). A lone bird performed a similar flight, without calling, in a suspected breeding area (GVC). Pairs often soar together and sometimes call with a 'quick quaver and yelp' (Loaring & Serventy 1952). Soaring pairs perform mock aggression, the presumed male pursuing or diving at the other which takes evasive action, sometimes rolling or tumbling (Debus 1981, I. Rooke/Atlas). A perched pair allopreened and touched beaks during the nestling period (M. Crawford/NRS), and a pair copulated 20 m from their nest at 1900 h around the egg-laying stage (S. Garnett/NRS).

Breeding biology

There are no measurements of the Square-tailed Kite's breeding density, but the birds are said to be well dispersed in territorial pairs (Schodde & Tidemann 1986), to have an 'enormous' home range of 100+ sq. km (Slater et al. 1986), and to have a large home range per pair like the Wedge-tailed Eagle (J. Masters/Atlas). Two pairs in south-east Queensland were approximately 20 km apart (GVC). Two active nests were 10 km apart in Queensland (Cupper & Cupper 1981), but it is not certain that they were neighbours, and three pairs occupied one gully system each (5-10 km long x 1 km wide) on the Darling Scarp in Western Australia (home range limits not known: Jaensch 1987 and pers. comm.). In South Australia two active nests were 6-7 km apart over several years, and in one year only a third pair nested 1 km from one of the other pairs (J. Jolly unpubl. data). Apparently breeding individuals can be seen flying out of sight in both directions along inland watercourses, suggesting a linear hunting range of several kilometres (Queensland: SD), and one pair hunted over an area of eucalypt open forest at least 8 x 6 km or c. 50 sq. km (New South Wales: SD). In south-east Queensland one pair occupied a linear, river-based hunting range of 5-6 km (GVC).

Data for tropical northern Australia are limited, but it appears that the breeding season (months in which eggs are laid) is longer in the north (Northern Territory?, Queensland), occupying most of the dry season, than in the south (New South Wales, Victoria, South Australia, south-western Australia), where it is restricted to the spring months (Table 4). However, the Northern Territory breeding records in Frith & Davies (1961) may be erroneous: their species list contains errors (e.g. some honeyeaters) and there have been no confirmatory breeding records of the Kite north of 18°S (Blakers et al. 1984). Darwin bird-watchers presume that the few Kites they see in the 'dry'

Table 4
Breeding parameters of the Square-tailed Kite

Habitat[a]	*Nest tree species*	*Nest height (m)*	*Month*	*Stage of cycle*	*Clutch/ brood size (n)*	*Sources*
Top End, Northern Territory:						
			June	laying		Frith & Davies 1961[b]
			July	laying		
Northern Queensland:						
Riverine W	*Eucalyptus* sp.	14	April	building		C. Cameron/NRS
Riverine TOF			Sept	incubating/ brooding		B. Traill/NRS
Southern Queensland:						
Eucalypt OF on ridge	*Eucalyptus crebra*	15	Sept	hatching	3	North 1912
	Eucalyptus crebra	15	Oct	hatching	3	
	Eucalyptus crebra	15	Oct	nestlings	3	
Riverine W	*Eucalyptus microtheca*		Aug	building		Macgillivray 1924a
Eucalypt OF	*Eucalyptus crebra*		Sept	eggs	3	Barnard 1934
	Eucalyptus citriodora	25+		eggs	3	
Riverine trees	*Angophora intermedia*	20	Oct	eggs	2	Cameron 1976
	Angophora intermedia	20+	Oct	eggs	2	
	Angophora intermedia	21	Oct	chicks	2	
Eucalypt OF	*Eucalyptus citriodora*	22	July	building		Cupper & Cupper 1981
			Aug	eggs		
Riverine trees	*Eucalyptus* sp.	21		chick	1	
Eucalypt OF		17	Sept	chick	1	
Eucalypt OF		16		eggs	2	
Riverine trees			Nov	nestling	1	
Riverine trees	*Angophora intermedia*	22	July	building		
Eucalypt OF		17	Oct	nestling	1	
Riverine trees			Oct	hatchlings	2	
Eucalypt OF	*Eucalyptus tessellaris*	15	Sept	chick	1	Hollands 1984
Eucalyptus microtheca riverine W			Sept	building		Nye 1987
W	*Eucalyptus* sp.	10	Nov	nestling	1	N. Gibson/NRS
			Dec	fledged		
W	*Eucalyptus tereticornis*	18	Aug	egg(s)		M. Crawford/NRS
			Oct	chick	1	
New South Wales:						
			Oct	eggs	3	North 1912
Angophora floribunda/ Eucalyptus blakelyi/ Callitris columellaris OF	*Angophora floribunda*	24	Aug	building		Johnston 1983
			Sept-Oct	eggs	3	
			Nov	nestlings		
			Dec	fledglings	2	
Eucalyptus radiata/E. dalrympleana/E. pauciflora/E. viminalis OF	*Eucalyptus radiata*	15	Nov	building, incubation		Schulz 1983
			Dec	chicks	2	
			Jan	fledglings	2	
Victoria:						
Coastal eucalypt OF			Dec	fledglings	2	Hollands 1984
Eucalyptus obliqua/E. viminalis TOF	*Eucalyptus viminalis*	20	Oct	building		S. Garnett/NRS
			Nov	incubation		
			Dec	chick	1	
			Jan	fledged		
South Australia:						
Riverine OF	*Eucalyptus camaldulensis*	20	Sept	building		Fraser 1983
			Oct	incubation		
Eucalyptus cladocalyx W	*Eucalyptus cladocalyx*					J. Jolly
Eucalyptus camaldulensis OF x 2	*Eucalyptus camaldulensis* x 2			eggs	3	
			Jan	fledglings	2	
Southern Western Australia:						
			Sept	eggs	3	Carnaby 1933
			Sept	eggs	3	Storr 1987
			Nov	chick	1	M. Howard/NRS
Eucalypt OF	*Eucalyptus wandoo*	8	Sept-Oct	eggs	C/3 x 6 C/2 x 2	J. Dell
	Eucalyptus wandoo		Dec	incubation		J. Dell
	Eucalyptus cornuta x 30+ *Eucalyptus wandoo*	9-12[c]	Sept-Oct	laying	2-3	T. Bush
	Eucalyptus marginata x 2 *Eucalyptus salmonophloia* x 1					

[a] OF=open forest, TOF=tall open forest, W=woodland
[b] possibly erroneous records (see text)
[c] modal heights of 30+ nests; range 5-20 m

are migrants from farther south (D. Baker-Gabb pers. comm.). Beruldsen (1980) stated that the nesting season is May to August in the north but there have been no confirmed May records, and it is apparent that egg laying extends to at least late September in Queensland (Cupper & Cupper 1981) and perhaps to October in south-east Queensland (GVC). The date and locality of Keartland's record (in North 1912) of a large nestling in central Western Australia in July is problematical; it may be referable to the Black-breasted Buzzard.

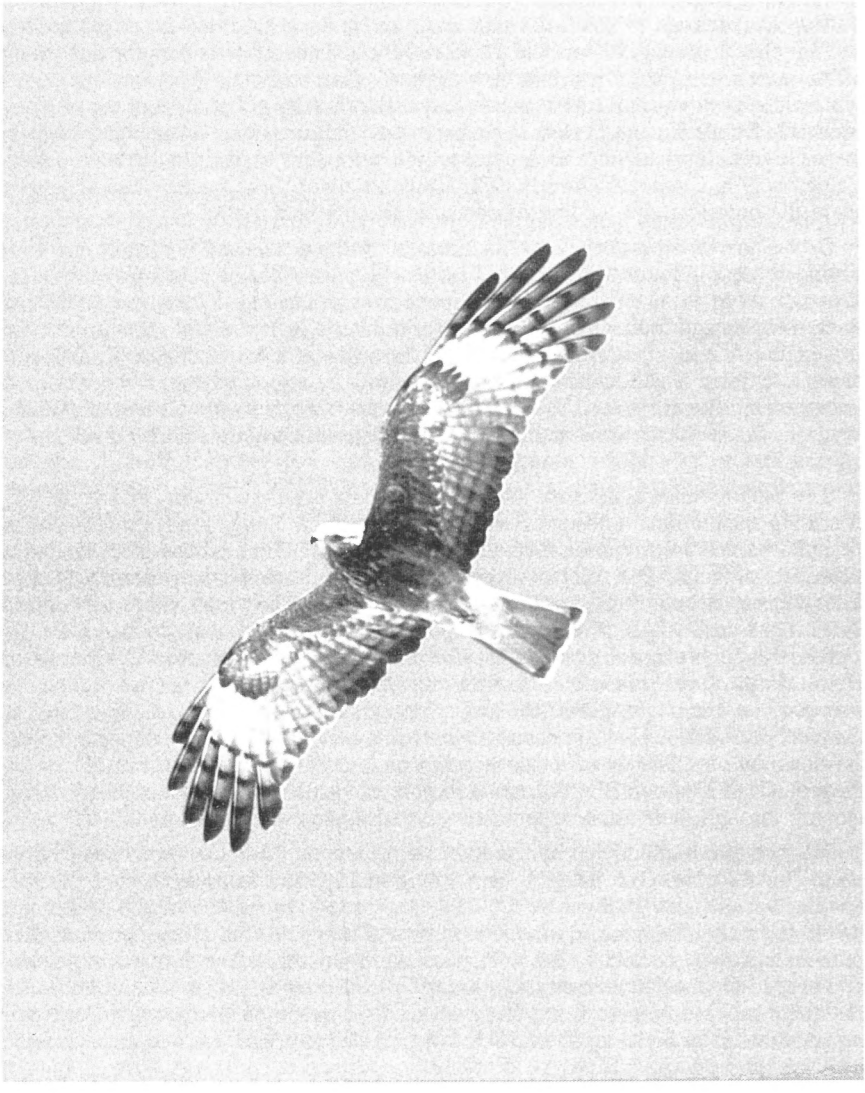
Square-tailed Kites apparently have traditional nesting territories to which they return in successive years, renovating a previous season's nest or building a new one nearby, sometimes in the same tree (e.g. Barnard 1934, Cameron 1976, Cupper & Cupper 1981, Hollands 1984). One nesting territory was used for 10 years (Cupper & Cupper 1981) and another was used for about 15 years (J. Jolly). In south-east Queensland, one pair appears to be present throughout the year (GVC).

The Square-tailed Kite sometimes nests in association with other raptors, and the different species may interchange nests in different seasons (Barnard 1934, Schulz 1983). Pairs attempt to breed annually (e.g. North 1912, Cameron 1976, Cupper & Cupper 1981).

One nest took about three weeks to build, and sticks are added during the incubation period (Johnston 1983, Schulz 1983). Both sexes build, collecting material in flight by breaking dry sticks from trees (Macgillivray 1924a,b, Schulz 1983, Nye 1987). The nest is lined with green leaves which are renewed almost daily throughout the cycle, in the early morning; some green leafy branches are incorporated in the nest structure (Cameron 1976, Cupper & Cupper 1981, Johnston 1983, Schulz 1983). Nests are placed at 8-26 m up (mean 18 m) in living trees (n=25: Table 4 and sources therein), usually within 100 m of watercourses in subcoastal or inland areas (North 1912, Cameron 1976, Cupper & Cupper 1981) though not necessarily near water in coastal forests (M. Schulz, R. Jaensch). Nest heights indicate selection of mature trees, and the birds also select species that provide a thick horizontal fork (e.g. Cameron 1976, Cupper & Cupper 1981, Johnston 1983).

The clutch size is two or three eggs, usually three, for Australia as a whole (C/2 x 10, C/3 x 16, mean 2.6: Table 4 and sources therein). However, there is an apparent trend of increasing clutch size with increasing latitude. Analysis of these data by region reveals a modal clutch size of two in Queensland (C/2 x 8, C/3 x 5, mean 2.4) and three in New South Wales, Victoria, South Australia and south-western Australia combined (C/2 x 2, C/3 x 11, mean 2.8). If the eggs are taken the birds lay a repeat clutch in the same or a new nest, but the second clutch is of two not three eggs (Barnard 1934).

The incubation period has not been determined accurately, but it is estimated at about 40 days (Price-Jones 1983) and has been stated as 5-6 weeks (McKean 1976, restated as '35-42 days' in Schodde & Tidemann 1986). The latter figure is thought to have been obtained from the literature (J. McKean in litt.), but we cannot trace the source. Nevertheless, about 40 days is likely to be correct (cf. Black-breasted Buzzard: Cupper & Cupper 1981). Data in Johnston (1983) suggest an incubation period of c. 5½ weeks. In at least some pairs, the male shares part of the diurnal incubation; changeovers occur without displays but food presentation by the male sometimes occurs when he relieves the female, and the male may also bring food to the incubating female (Cupper & Cupper 1981, Schulz 1983, M. Crawford/NRS, D. Johnston/NRS). An incubating bird chattered briefly when its mate arrived with food, and on a subsequent occasion the food-bearing bird called a high-pitched *keaw-keaw* as it arrived (S. Garnett/NRS).



Adult Square-tailed Kite, Drysdale River, Kimberley Division, Western Australia

Plate 27 Photo: Graeme Chapman

Hatching is asynchronous (cf. Cameron 1976). The nestling period is said to be 8-10 weeks (McKean 1976; source not traced) and c. 8 weeks (Price-Jones 1983). One nestling flew at 59 days (Cupper & Cupper 1981), and another was flapping and lifting off the nest several days before its first flight (S. Garnett/NRS). The nestling period at a nest with two young was at least nine weeks (J. Jolly). Throughout the nestling period the female remains in close attendance at the nest, roosting on it at night, whereas the male usually visits only to deposit prey; he supplies virtually all the food (e.g. Cameron 1976, Cupper & Cupper 1981, Hollands 1984). In some pairs the male may share the brooding and feeding of downy chicks (Schulz 1983).

Broods are sometimes reduced, as indicated by the occasional finding of one dead sibling in nests (Barnard 1934). This raises the possibility of cainism (fratricide), although there is usually no competition between nestlings (Cameron 1976) and starvation through food shortage may be more likely. In successful nests brood size at fledging is one or two, usually one for Australia as a whole (B/1 x 11, B/2 x 7, mean 1.4: Table 4 and sources therein). Analysis by region reveals a modal brood size of one in Queensland (B/1 x 10, B/2 x 3, mean 1.2) and two in New South Wales, Victoria, South Australia and south-western Australia combined (B/1 x 1, B/2 x 4, mean 1.8).

The Square-tailed Kite does not defend its nest against humans, and is usually confiding and tolerant of observers visiting the site or climbing to the nest (e.g. North 1912, Barnard 1934, Cameron 1976, Cupper & Cupper 1981, Johnston 1983, Hollands 1984, T. Hordacre/Atlas, M. Howard/NRS). However, some birds are readily flushed from the nest (Schulz 1983, Fraser 1983, B. Traill/Atlas). The adults will readily defend the nest or territory against other raptor species such as Little and Wedge-tailed Eagles and other large birds such as the Great Cormorant *Phalacrocorax carbo*, White-faced Heron *Ardea novaehollandiae*, Cattle Egret *Ardeola ibis* and ravens *Corvus* sp. by swooping at them (Johnston 1983, S. Johnson/Atlas, R. & D. Long/Atlas, S. Garnet/NRS, GVC). They are not always as benign and inoffensive as they may seem, as shown by one Kite which chased, grappled and fought with a Brown Falcon on the ground (D. Kingston/BOPWatch). However, one pair seems tolerant of Pacific Bazas moving through their territory, sometimes soaring in close proximity (GVC).

Young Square-tailed Kites appear to be dependent on the adults for a considerable time after fledging. One fledgling was 100 m and <150 m from the nest in the first few days post-fledging (S. Garnett/NRS). One brood returned to be fed at the nest for 10 days after fledging, during which time the female was always present; they remained close to the nest for 2-3 weeks and after more than a month they still perched and begged for food in the nest area, flying little (Hollands 1984). Two months after fledging, two young were 8 km from the nest (Johnston 1983). Young of one pair remained with the adults for about 15-16 days post-fledging, and one was seen six weeks later 14 km away (GVC).

There are few data on the Square-tailed Kite's reproductive success. Data for an area in south-east Queensland (13 young in 10 pair years: Cameron 1976, Cupper & Cupper 1981) give a success rate of 1.3 young per pair per year. However, these data come from a small sample of successful pairs. In order to measure recruitment rate, more data are needed from a larger sample including pairs that fail or do not breed in some years.

Discussion

Despite its superficial similarity to the Black Kite, the Square-tailed Kite is quite different ecologically. The Black Kite is a generalist and scavenger (e.g. Cupper & Cupper 1981, Hollands 1984), whereas the Square-tailed Kite is highly specialised. Aptly described as a 'treetop harrier' (Slater et al. 1986), it is the Australian ecological

counterpart of other species that methodically scan the vegetation canopy from low soaring flight for eggs and nestlings, in particular the Black Eagle *Ictinaetus* which also removes entire nests (Brown & Amadon 1968). Hollands (1984) raised the question of why such a long-winged species should occur in forest, but the key lies in the Square-tailed Kite's aerial foraging and capture of prey in the outer foliage rather than hunting below or within the canopy, and its use of ecotones. Contrary to Brown & Amadon (1968), it takes most of its prey from the canopy, not from the ground.

To sustain its moderately large body on small prey, the Square-tailed Kite may need to consume several such items daily and have a large enough home range to supply sufficient prey. It does indeed appear to occur at low density, perhaps 5-8% that of the scavenging Black and Whistling Kites and 13% that of the predatory Little Eagle for Australia as a whole (cf. number of records, blocks and records per block recorded for these species in Blakers et al. 1984). Dependence on small prey may also entail problems in energetics; captive Square-tailed Kites eat comparatively little food and may have a low metabolic rate (P. Olsen). The Square-tailed Kite's 'tameness' when perched (reluctance to flush) and use of soaring rather than flapping flight may be energy-saving devices. For instance, its high dihedral may increase lift and confer high stability. A partial rather than complete annual moult would also reduce energy demands; details of moult would be valuable. In general disposition the species seems geared to minimal energy expenditure.

In southern Australia at least, the Square-tailed Kite and Black-breasted Buzzard appear to complement each other in distribution and ecology. Both are highly aerial species that rob nests, but the larger Buzzard is an inland bird, takes larger prey and eats some carrion (see North 1912, Cupper & Cupper 1981, Hollands 1984). It also searches from higher in the air and courses more rapidly at low levels (Hollands 1984). In keeping with its longer tarsi (64-68 mm: Brown & Amadon 1968), the Buzzard can walk well and does some searching on the ground (SD). The two may complement each other in the north as well: in north-central Queensland the Kite inhabits woodlands and the Buzzard grasslands and black-soil plains farther west (GVC); in the Top End (N.T.) the Buzzard is a common breeding resident (Blakers et al. 1984, D. Baker-Gabb, SD) whereas the Kite may be a non-breeding migrant.

Such are the similarities in anatomy and juvenile plumage that the Square-tailed Kite and Black-breasted Buzzard are clearly related (Condon & Amadon 1954, Brown & Amadon 1968, Schodde & Tidemann 1986). Other similarities include breeding behaviour (Hollands 1984), upperparts in adult plumage, crest and voice. Neither belongs to the milvine group of kites (*Milvus, Haliastur* and sea-eagles *Haliaeetus*: Olson 1982), despite the Square-tailed Kite's striking resemblance to the European Red Kite *Milvus milvus* in plumage (cf. Cramp & Simmons 1980). This resemblance may be convergent, because the Square-tailed Kite and Black-breasted Buzzard differ in many respects from the milvine kites. Both the Buzzard (SD) and the Square-tailed Kite perform undulating advertisement displays common to many raptor species, but these displays are not performed by the milvine kites (see Brown & Amadon 1968, Cramp & Simmons 1980). Both species have a longer nestling period (59-60 days) than the Black and Whistling Kites (38-54 days: Cupper & Cupper 1981, Hollands 1984); the Red Kite also has a nestling period usually of 48-50 days but occasionally up to 60-70 days (Cramp & Simmons 1980). Both the Buzzard (Slater et al. 1986, D. Pepper-Edwards & L. Notley unpubl. data) and the Square-tailed Kite have an immature plumage stage, whereas the Black Kite, Whistling Kite and Brahminy Kite *Haliastur indus* moult directly from juvenile to adult plumage at the end of their first year (Price-Jones 1983, Schodde & Tidemann 1986, D. Fleay unpubl. data). The striking rufous of the juvenile Buzzard and Square-tailed Kite also contrasts with the streaked or spotted brown juvenile plumage of these three milvine kites. A hypothesis which

we will explore elsewhere is that the Square-tailed Kite, Black-breasted Buzzard and Red Goshawk are part of an old endemic group of raptors, which radiated in isolation in Australasia to convergently resemble the kites, buzzards and goshawks on other continents. A similar idea has been independently proposed by Olsen & Olsen (1989). A study of the relationship of the endemic Australian raptors to those in Africa and South America (i.e Gondwanaland remnants), and elsewhere, would be valuable.

The Square-tailed Kite's specialised feeding ecology, apparently specific hunting and breeding habitat requirements and low density suggest that it may be sensitive to climatic change and variation in food supply, and possibly threatened by the habitat destruction that has occurred and is continuing to occur. However, loss of habitat may be offset to some extent by the creation of suitable openings in formerly extensive forest, and the increase in certain prey species such as miners *Manorina* spp. in disturbed areas. Further (quantitative) details are required on its hunting and breeding habitat, nest site characteristics, diet (particularly outside the breeding season), breeding biology (density, reproductive success, incubation, nestling and post-fledging dependence periods) and seasonal movements. Although bird-watchers can assist with contributions to the various schemes and ideally their own field studies for publication, the Square-tailed Kite deserves thorough investigation. A comprehensive study would produce the data needed to conserve the species; effectively conserving it would entail conservation of the bird species and habitats on which it depends, and thus have wider benefits.

Acknowledgements

We thank David Baker-Gabb, Tony Bush, John Dell, Roger Jaensch, Jeff Jolly and Penny & Jerry Olsen for comments on the manuscript and/or additional data; staff at the Museum of Victoria, Australian Museum, South Australian Museum and Queensland Museum for access to specimens, data and/or library; David Baker-Gabb for measuring specimens; Jon Starks for access to the Nest Record Scheme; and Dr Stephen Davies for access to Atlas data. We used field notes by the following observers and schemes. Atlas: R. Bigg, A. Clucas, P. Curry, S. Garnett, G. Holmes, T. Hordacre, S. Johnson, R. & D. Long, A. Lyneham, J. Masters, I. Rooke, S. Sandstrom, N. Schrader, B. Traill, J. Weinecke & D. Moffat and G. Wilson. Nest Record Scheme: C. Cameron, M. Crawford, S. Garnett, N. Gibson, M. Howard and D. Johnston. BOPWatch: K. Coate, D. Kingston and J. Start. We thank colleagues for information: David Fleay, Richard Loyn, David Pepper-Edwards & Liz Notley, David Secomb and Brice Wells. David Noakes and Graeme Chapman kindly provided sketches and a photograph respectively.

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Received 19 December 1988 ■