



Captive adult female Collared Sparrowhawk

Plate 12

Photo: N.J. Mooney

The Collared Sparrowhawk
Accipiter cirrocephalus:
A Review and Comparison with
the Brown Goshawk
Accipiter fasciatus

By
G.V. CZECHURA¹, S.J.S. DEBUS²
and N.J. MOONEY³

¹ Queensland Museum, P.O. Box 300, South Brisbane, Qld 4101

² P.O. Box 1015, Armidale, N.S.W. 2350

³ National Parks and Wildlife Service, P.O. Box 210, Sandy Bay, Tas. 7005

Summary

The literature concerning field identification, physical characters (size, weight), diet, hunting/feeding behaviour, displays and breeding biology of the Collared Sparrowhawk *Accipiter cirrocephalus* is reviewed and supplemented with field observations and other data. Quantitative data on the diet of the Collared Sparrowhawk show that it preys predominantly on birds (<50 g (c. 3-40% of Sparrowhawk body weight)). Quantitative data on the diet of the Brown Goshawk *Accipiter fasciatus* demonstrate partitioning between the two species in terms of prey size, taxonomic group and foraging zone: the Brown Goshawk's more diverse diet includes relatively larger prey, more mammals and more ground/understorey birds than that of the Collared Sparrowhawk, which takes relatively more canopy/aerial birds. The Sparrowhawk also appears to use more aerial hunting methods than the Brown Goshawk, in accordance with data on their aerodynamic properties. In diet, hunting behaviour and breeding biology the Collared Sparrowhawk closely resembles the other small sparrowhawks. Data on its biology are limited, and further investigation is required.

Introduction

The Collared Sparrowhawk *Accipiter cirrocephalus* is a little-known raptor. It coexists with two other accipiters (Brown Goshawk *A. fasciatus* and Grey Goshawk *A. novaehollandiae*) in coastal areas and with three others (Brown Goshawk, Grey Goshawk and Red Goshawk *Erythrotriorchis radiatus*) in the tropics (e.g. Blakers et al. 1984). Over its entire Australian distribution it coexists with the Brown Goshawk. Studies of sympatric accipiters elsewhere in the world (reviewed by Wattel 1973 and Brown 1976) have revealed considerable differences in their ecology, related to differences in body size, bill and foot structure and hence the prey that each species can take; some partitioning of habitat is also reflected in differences in wing structure. Morris (1973), Mason (1976) and Schodde & Tidemann (1986) alluded to some of these differences in Australia, stating that the Collared Sparrowhawk and Brown Goshawk avoid competition because they take prey in different size classes and use different hunting methods. Wattel (1973) and Aumann (1986) characterised the Brown Goshawk as a generalist and the Collared Sparrowhawk as a bird specialist; Schodde & Tidemann (1986) characterised the Sparrowhawk as a specialist chaser of flying

prey and the Goshawk as usually taking stationary prey on the ground or on perches. Mooney (1982) presented preliminary data on niche separation between the Collared Sparrowhawk, Brown Goshawk and Grey Goshawk in Tasmania, in terms of their habitat, hunting methods, body weight, relative bill and foot size and preferred prey.

Other statements in the literature on the Collared Sparrowhawk conflict with the above ecological considerations, with recent first-hand observations (e.g. Cupper & Cupper 1981, Price-Jones 1983) and with our own field experience. For example, the size and/or type of alleged prey may be based on misidentified Brown Goshawks or other raptor species, on inaccurate size comparisons (predator:prey) or on the misinterpretation of aggressive behaviour. Many raptor species including the Brown Goshawk, Australian Hobby *Falco longipennis*, Brown Falcon *F. berigora* and Australian Kestrel *F. cenchroides* are indiscriminately called 'sparrowhawks' by non-ornithologists. This must cast doubt on the accuracy of some statements on these species obtained from local informants. Some writers have considered the female Collared Sparrowhawk and male Brown Goshawk inseparable in the field (e.g. McGilp 1934, Condon 1973 and earlier editions), while the early practice of describing or illustrating the adult Brown Goshawk as brown or grey-brown above and only the Sparrowhawk as blue-grey above (e.g. Leach 1958, Cayley 1959) may have contributed to many misidentifications. The main distinguishing field character, tail shape, has been common knowledge only since 1970 (Slater 1970). As an example of misidentification by competent ornithologists, the 'Brown Goshawk' photograph (Plate 8, p. 24) in Hindwood (1966) is actually a Collared Sparrowhawk: note the long middle toe and the longer outer rectrices relative to the central rectrices.

The purpose of this paper is to assemble and critically review the literature on the Collared Sparrowhawk, supplement it with our own field observations and data from the RAOU Nest Record Scheme (NRS), and identify aspects of the Sparrowhawk's ecology that differentiate it from the Brown Goshawk.

Field identification

The field differences between the Collared Sparrowhawk and Brown Goshawk have been noted in a number of guides (Slater 1970, Morris 1976, Storr & Johnstone 1979, Pizzey 1980, Thomas & Wheeler 1983, Price-Jones 1983, Hollands 1984, Slater et al. 1986). While the difference in tail shape is real and important, our field experience and a check of museum specimens suggest that some qualification is required. It is important to distinguish between a folded and a fanned tail, since a tail which is square when folded is often rounded when fanned. Female Sparrowhawks tend to have a more rounded tail than males: the average female has a square tail whereas the average male has a notched tail (NJM). Feather disarray, moult or abrasion can affect tail shape, for instance some Brown Goshawks can show a nearly square tail or even a false notched effect (note photographs in Frauca 1971 and Hollands 1984, opposite p. 76). Conversely, a Sparrowhawk's tightly furled tail can appear slightly rounded unless the relative lengths of inner and outer rectrices can be discerned, and fledglings may have a rounded tail until the rectrices are fully grown. The difference in tail shape is seen to best advantage in birds soaring overhead with the tail fanned to about a quarter of its full extent. Much depends on the length and quality (e.g. light conditions) of the view obtained, and caution is needed in separating the two species. We suggest that other characters (e.g. silhouette, flight pattern) be used to supplement field identification, and that observers be aware of exceptions to the general rule.

A feature of accipiters is the sideways shaking or 'wagging' of the tail upon alighting. In the Collared Sparrowhawk this action is more rapid and less pronounced than in the Brown Goshawk, and can be a useful adjunct to field identification.

The male Sparrowhawk and female Brown Goshawk are said to be distinguishable on size, but caution should be exercised (particularly in the range of *A.f. didimus*) since absolute size is not an infallible guide, especially when viewing through binoculars without a reference object to judge relative size (cf. Grant 1983). However, the relative thickness and length of tarsi and toes can be helpful in a close view in good light. The Brown Goshawk's more heavily hooded eyes are also discernible at close range, and give the Goshawk a more menacing expression (see Figure 2).

Despite some statements to the contrary, there does not appear to be any plumage feature (e.g. ventral markings of juveniles, dorsal colour of adults, including nuchal collar) that will reliably separate Collared Sparrowhawks from Brown Goshawks in the field. Dorsal colour varies with age, sex (Aumann 1986, R. Schodde in litt.) and feather wear (cf. plates in Cupper & Cupper 1981), and is not a specific character. Furthermore, most sightings are of birds in flight when it is difficult to determine plumage differences. A further difficulty is posed by light effects on plumage, related to the attitude of the bird and environmental conditions at the time (Hankin 1913).

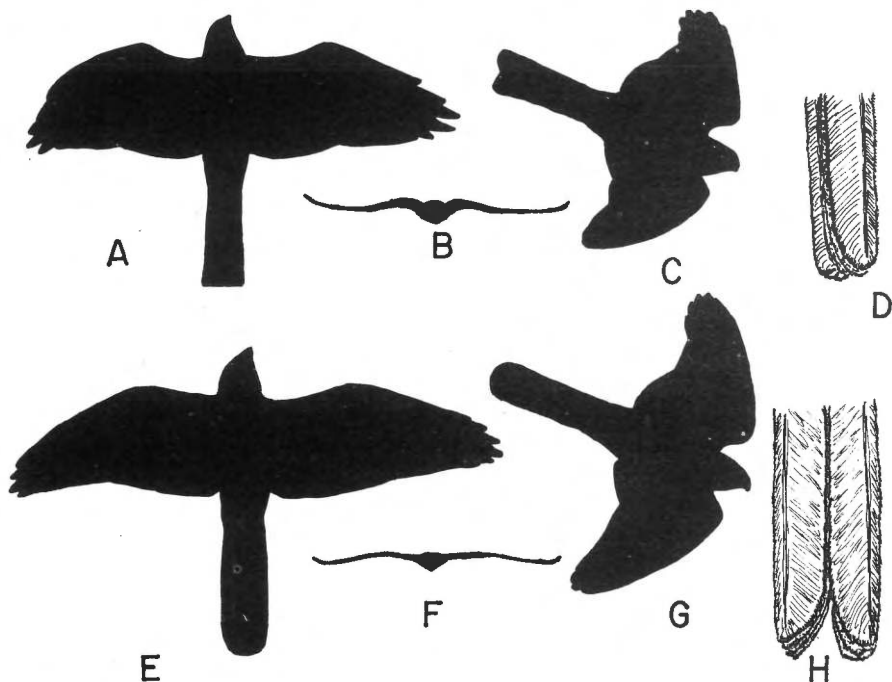


Figure 1.
Diagrammatic views of Collared Sparrowhawk *Accipiter cirrocephalus* and Brown Goshawk *Accipiter fasciatus*.

A-D. Collared Sparrowhawk:

- A. Flight silhouette
- B. Gliding (front view)
- C. Gliding (partial profile)
- D. Abnormal tail shape with tightly furred tail creating impression of rounded tip.

E-H. Brown Goshawk:

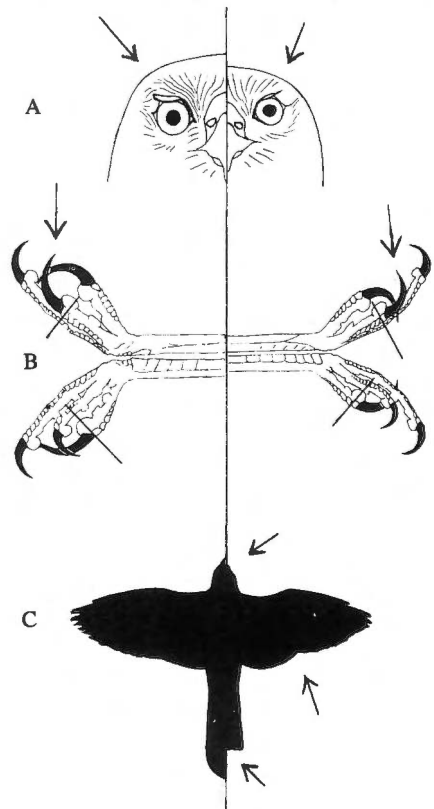
- E. Flight silhouette
- F. Gliding (front view)
- G. Gliding (partial profile)
- H. Abnormal tail shape with disarrayed central rectrices creating impression of notched tip.

There are some subtle differences in the flight silhouettes of the Collared Sparrowhawk and Brown Goshawk. Pizzey (1980) noted that the Sparrowhawk has somewhat shapelier wings than the Brown Goshawk. This is due in part to the relative curvature of the wing: the trailing edge of the Sparrowhawk's wing is more curved, whereas that of the Goshawk's wing often appears nearly straight (Figures 1-3; cf. photographs of Sparrowhawk in Coates 1985 and Goshawk in Hollands 1984). The Sparrowhawk also has a relatively broader proximal section of the wing, and somewhat more prominent 'fingers' (Figure 3). In end-on view, a gliding Sparrowhawk's wings may appear flat to slightly drooped but somewhat curved near the body and tips, whereas the Brown Goshawk's wings appear slightly bowed (Figure 1; Pizzey 1980). In soaring flight, both species hold their wings slightly upswept or in a very shallow dihedral.

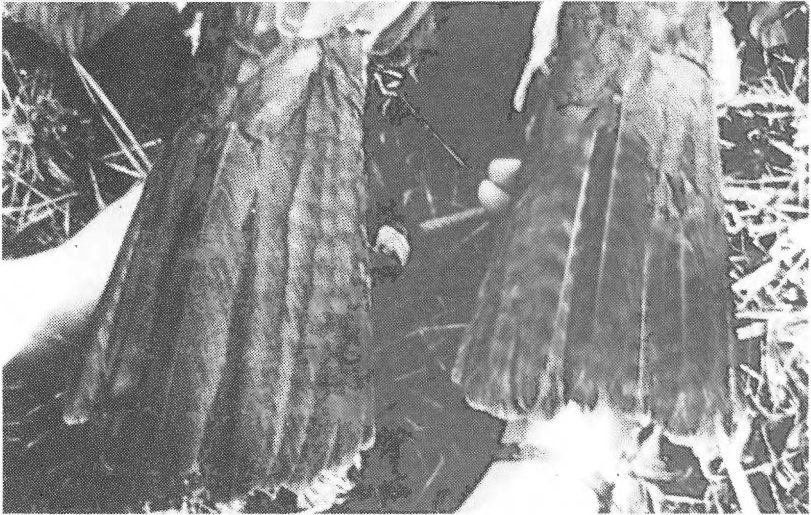
The Sparrowhawk appears somewhat longer-winged and shorter-tailed than the Brown Goshawk, due to a relatively shorter tail (McGilp 1934, Slater et al. 1986). This is reflected in tail:wing ratios of 0.72 for the Sparrowhawk and 0.77 for the Goshawk (Wattel 1973; cf. Schodde & Tidemann 1986 who incorrectly state the Sparrowhawk to have the proportionally longer tail). However, Brown Goshawks appear quite variable in shape — some stocky and short-winged, others rakish like harriers — whereas Sparrowhawks show little individual variation in morphology (J. Olsen in litt.). Adult Brown Goshawks also have a shorter tail than juveniles (Aumann 1986).

Figure 2.
Outstanding relative anatomical differences between Brown Goshawk *Accipiter fasciatus* (left) and Collared Sparrowhawk *Accipiter cirrocephalus* (right).

- A. Head.** Goshawk: eyes heavily hooded (more prominent brow-ridge). Sparrowhawk: eyes more staring, head rounder and smaller, bill smaller.
- B. Inside (upper) and outside (lower) view of foot and lower tarsus.** Goshawk: toes shorter, especially outside and middle; claws and tarsus heavier. Sparrowhawk: toes long and slender, tarsus slender, claws lighter and sharper.
- C. Flight profile.** Goshawk: tail longer and rounded, head larger, wings less featureful. Sparrowhawk: tail shorter and square or notched when closed, head small and wings more shaped.



Drawing by N.J. Mooney



Normal tail of Brown Goshawk *Accipiter fasciatus* (left) and Collared Sparrowhawk *Accipiter cirrocephalus* (right)

Plate 13

Photo: N.J. Mooney

Pizzey (1980) and Thomas & Wheeler (1983) noted respectively that the Collared Sparrowhawk has a 'lighter, more airy style of flight' or a 'more fluttering' flight than the Brown Goshawk. In direct, non-hunting flight the Sparrowhawk often has a more winnowing flight action than the Brown Goshawk, and in fast contour hunting flight the Sparrowhawk has a more flickering, jerky flight action. In direct flight, the Sparrowhawk also at times adopts an undulating, cuckoo-shrike style of flight in which the wings are closed to the body as the bird loses a little height between each series of wing beats (Hollands 1984; H. Ford, J. Olsen and C. Corben pers. comm.; GVC, SD, NJM). The Brown Goshawk has not been recorded performing such a flight. This 'cuckoo' style of flight is performed by both sexes and is distinct from the vigorous undulations performed by both species in display.

This section is intended for identification in the field, but some characters (tail tip, feet, brow-ridges) are also useful for separating the two species in the hand. Disney (1974) and Baker-Gabb (1984a) have provided critical morphometric data for distinguishing them in the hand. This section also applies to southern Australia where the Sparrowhawk coexists with nominate *A.f. fasciatus*. Northern *A.f. didimus* is more difficult to distinguish from the Sparrowhawk, even in the hand, since it is smaller than *fasciatus* (Wattel 1973, Aumann 1986), is said to have (relatively?) longer toes (Slater et al. 1986, though this conflicts with Wattel 1973 and Aumann 1986) and some adults may show a nearly square tail (museum specimens: SD). More data are needed on the field characters of these three taxa in the overlap zone.

Physical characters

The purpose of this section is to compare the predatory capabilities and aerodynamic properties of the Collared Sparrowhawk and Brown Goshawk. Baker-Gabb (1984a) gave the weight of male Sparrowhawks from south-eastern Australia as 110-150 g (average 125 g, n=10) and females as 180-280 g (av. 242 g, n=14). Males from Western Australia weigh 105-130 g (av. 122 g, n=12, s.d.=8.6) and females 180-240 g (av. 213, n=7, s.d.=18.8) (data from the Western Australia Museum and Australian Bird Banding Scheme). Anomalous weights of 375 g (13¼ oz.) and 347 g for females (Serventy & Whittell 1976, Hall 1974) suggest misidentified *A.f. didimus* (see above),

while the 189 g 'male' in Hall (1974, p. 53) was actually a misprint for 'female' (see text, p. 54). Female *A.f. didimus* weigh 264-405 g (av. 356 g, n=14, s.d.=36.8) and males 178-260 g (av. 219 g, n=13, s.d.=23.4) (specimens in CSIRO collection Canberra, Australian Museum, Western Australian Museum and Hall 1974). Brown Goshawks *A.f. fasciatus* are considerably heavier than Sparrowhawks (sex for sex about 2½ times heavier): males weigh 230-375 g, av. 311 g and females 480-700 g, av. 569 g (south-eastern Australia: Baker-Gabb 1984a). There are few weight data for Western Australia, but on linear dimensions Brown Goshawks from the south-west are slightly larger and more sexually dimorphic in size than birds from south-eastern Australia (Aumann 1986); thus there might be an even greater size difference between the two species in the south-west. Although the female Sparrowhawk approximates the male Brown Goshawk in linear dimensions (wing length 92%), it is of slighter build (only 78% of the male Goshawk's weight) and has a relatively smaller and finer bill (culmen 86% that of male Goshawk; data from Baker-Gabb 1984a). The Sparrowhawk also has relatively weaker legs and feet, with slender tarsi and long, thin toes and fine claws compared with the Goshawk's more massive tarsi and heavier claws and toes (Wattel 1973, Disney 1974, Mooney 1982).

These differences in weight and relative strengths of legs and feet are of critical importance to the prey killing and carrying capabilities of the two species, for instance smaller size confers less momentum and less strength and penetration in killing (Aumann 1986). Like other raptors, accipiters are capable of killing prey heavier than themselves although they have an upper loading capacity of about half their own body weight (Brown & Amadon 1968, Brown 1976, Cade 1982). These expectations are confirmed by field observations: a Brown Goshawk, presumably male, failed to carry a Red-winged Parrot *Aprosmictus erythropterus* (Hindwood 1966) and a male of c. 300 g (weighed) carried a Spotted Turtle-Dove *Streptopelia chinensis* in both feet for only a short distance (SD). Respective prey weights are 141-159 g (Hall 1974) and c. 152 g (Table 1). Such restrictions on prey size mean that the largest female Sparrowhawks could kill prey not much in excess of 400 g and could carry prey items of not more than about 140 g.

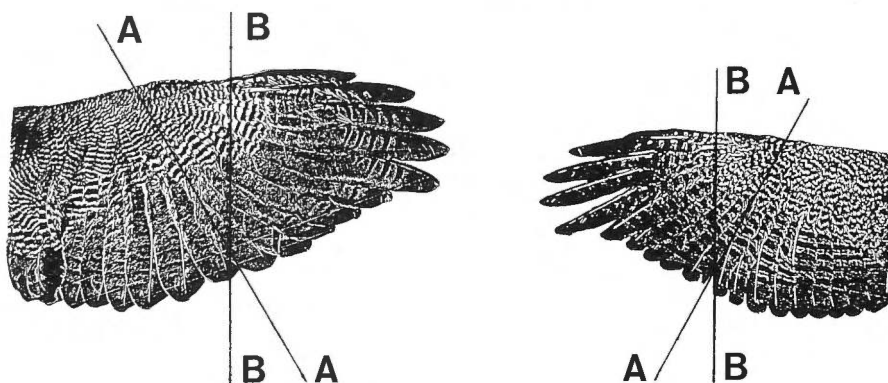


Figure 3. Left wing of adult female Brown Goshawk *Accipiter fasciatus* (left) and right wing of juvenile male Collared Sparrowhawk *Accipiter cirrocephalus* (right) (photoreductions of actual specimens: NJM). Measurement lines (see text): A-A between inner primary and outer secondary; B-B half way between base and tip of wing. (Note: within each species there are no sexual differences in the shape of the wing tip, cf. Wattel 1973).

The Collared Sparrowhawk has a typically accipitrine wing shape, whereas the wings of the Brown Goshawk appear more buteonine (J. Olsen pers. comm.). Measurements of wing areas support this conclusion. For three females of each species, NJM measured the ratio of proximal:distal wing area in two ways (measurements A and B, Figure 2). The ratios ($\bar{x} \pm \text{s.d.}$) for Goshawk and Sparrowhawk respectively were: 0.95 ± 0.13 and 1.08 ± 0.11 (A); 1.51 ± 0.1 and 1.72 ± 0.1 (B). A large ratio means that the proximal area of the wing is relatively large. The results show that the Sparrowhawk has relatively less area in the primary section. The aspect ratio (total wing length:total wing width) is 2.0 in both species, therefore the Sparrowhawk's relatively deeper secondary section is compensated by relatively longer (and narrower) primaries. Figures 16 and 21 in Wattel (1973) show that the Sparrowhawk has both relatively broader wings at the base and a relatively longer wing tip than the Brown Goshawk. The Sparrowhawk's wing shape and shorter, squarer tail suggests faster, more sustained flapping flight and greater aerial agility than the Brown Goshawk (cf. Wattel 1973, Cade 1982, Olsen & Olsen 1985).

The following wing-loading measurements were obtained on birds in Tasmania (NJM). Collared Sparrowhawk: male 0.26 g/sq. cm ($n=3$), females 0.35 g/sq. cm ($n=10$); Brown Goshawk: males 0.40 g/sq. cm ($n=4$), females 0.53 g/sq. cm ($n=16$). A larger sample produced the following wing loadings for Brown Goshawks: males 0.40 g/sq. cm, females 0.48 g/sq. cm (south-eastern Australia, all seasons: Aumann 1986). These differences offer an explanation for the Sparrowhawk's more buoyant and agile flight.

Prey

The literature contains a number of records of prey of the Collared Sparrowhawk. The unequivocal records are detailed in Table 3, and most involve small birds. It has been claimed that the Sparrowhawk attacks or kills birds larger (or supposedly larger) than itself, such as a duck (by decapitation from a blow) and even an Australian Bustard *Ardeotis australis* of unstated size (Keartland 1896). Unspecified cockatoos, pigeons, ducks and a Galah *Cacatua roseicapilla* (McGilp 1934), and Grey Teal *Anas gibberifrons*, unspecified parrots and cuckoo-shrikes *Coracina* sp. (Mason 1976) have also been reported. In some of these records the prey are actually smaller than female if not male Sparrowhawks, e.g. broad-tailed parrots (Stone 1912, Sedgwick 1952, Mooney 1984), Black-faced Cuckoo-shrike *Coracina novaehollandiae* (Table 3), and were in fact taken by females (Table 3). The only Grey Teal recorded (Hall 1974) concerns an unsuccessful attack by a 347 g hawk that may have been a Brown Goshawk *A.f. didimus* (see above) and was in any case scarcely smaller than a small teal (minimum 350 g: Frith 1977). Of the reports of attacks on larger species, kills were not recorded in some instances (ducks, pigeons, Galahs, cockatoos: Keartland in North 1912, McGilp 1934) while in others it cannot be safely assumed that reports of 'sparrowhawks' do in fact refer to Collared Sparrowhawks (see above). The reports in Keartland (1896) and that of a male Sparrowhawk repeatedly striking a Galah until it was dead and then sharing the kill with its mate (McGilp 1934) almost certainly refer to other raptor species. McGilp (1923, 1934) admitted to difficulty in identifying the Collared Sparrowhawk in the field; some other observers (e.g. Wheelwright 1861) appear not only to have confused the Sparrowhawk and Brown Goshawk but compounded the error by failing to recognise adult and juvenile plumages and also sexual size differences.

In assessing Collared Sparrowhawk prey records, it must be recognised that *Accipiter* attack and strike methods impose a restraint on the maximum size of prey. Unlike falcons which can deliver a quick incapacitating or lethal blow (usually from a stoop)

on prey too large to seize (Bond 1936, Goslow 1971), or can quickly kill struggling prey with a bite to the neck (Cade 1982), *Accipiter* species grapple with their prey. While body velocity and leg extension deliver some force on contact, the actual kill is made by a kneading action of the talons soon after an accipiter grasps its prey (Goslow 1971). Unless the prey is quickly killed, accipiters may risk serious injury in any resulting struggle with large, dangerous or vigorous prey. Based on these considerations and on body weight data, ducks and cockatoos would seem unlikely prey (common duck species 500-1000 g: Frith 1977; most cockatoos > 300 g: Hall 1974, Olsen & Olsen 1983). In addition, even small cockatoos such as Galahs (minimum 215 g) are capable of determined self-defence, and small raptors attacking them may risk crippling (and therefore fatal) damage to legs and feet. NJM has a record of an adult male Brown Goshawk seizing (but failing to carry) a Galah, and then having its tarsus broken by the Galah's bill. Much smaller birds may prove too difficult for Sparrowhawks to subdue: a male Sparrowhawk was almost killed by a Grey Butcherbird *Cracticus torquatus* (75-97 g: Table 1), and males often have difficulty in killing birds such as Common Starlings *Sturnus vulgaris* (c. 75 g: Mooney 1986). If Collared Sparrowhawks do attempt to prey on ducks, cockatoos or other large species then such attacks are exceptional and unlikely to succeed. Confirmed prey records in this weight range (c. 400 g: Table 1) involve defenceless and easily killed birds (pigeons).

A record (Macgillivray 1918) of a Collared Sparrowhawk locked in combat with a small monitor lizard *Varanus* sp. (*V. scalaris* or *V. prasinus*) must be treated cautiously when assessing Sparrowhawk prey records. Either species could have initiated the attack, or it may have resulted from nest defence or mobbing by the Sparrowhawk.

Misinterpretation of aggressive behaviour (mobbing, territorial defence) and exploratory or unsuccessful attacks on large birds by juveniles may further confuse the issue. An attack by a Sparrowhawk (or other raptor) on another species need not mean that the hawk is attempting to obtain prey. For instance, adult Sparrowhawks have been observed chasing birds, including potential prey species (pigeons, parrots and large passerines), from the vicinity of the nest (Olsen 1981; Metcalf 1982 and NRS). Harassment of large birds also occurs, not necessarily in the breeding season or near nests, e.g. Grey Currawongs *Strepera versicolor* (Anon. 1973), Masked Lapwings *Vanellus miles* (NJM) and various diurnal and nocturnal raptors (Czechura 1981a, SD, NJM). Mutual aggression may occur between the Sparrowhawk and other birds mobbing it, e.g. Galahs and Port Lincoln Ringnecks *Barnardius zonarius* (SD) and a pair of Australian Kestrels (GVC), or the Sparrowhawk may itself be subject to harassment by other raptors (Kestrel: GVC, Australian Hobby: NJM) or other large birds (Appleby 1985, Metcalf & Metcalf 1986). A female Sparrowhawk was seriously injured by Pied Currawongs *Strepera graculina* (c. 300 g) that attacked it (P. & J. Olsen pers. comm.). Juvenile Sparrowhawks have been observed attacking an Australian Magpie-lark *Grallina cyanoleuca* (Metcalf 1982), chasing Galahs and other large birds (Badman 1981), and making 'flying passes' at birds ranging from Red-rumped Parrots *Psephotus haematonotus* to ravens *Corvus* sp. in size (Hayward & McFarlane 1971). Sparrowhawks appear to be more inclined than Brown Goshawks to harass animals (e.g. large birds) unsuitable as prey, and in 'temperament' are reminiscent of Australian Hobbies (NJM). Slater (1962) also described the Sparrowhawk as 'more temperamental' than the Brown Goshawk.

Tables 1-3 summarise what is presently known of the Collared Sparrowhawk's diet: breeding and non-breeding diet in Tasmania (Table 1) and south-eastern Queensland (Table 2), and literature and other records of Sparrowhawk prey (Table 3). In Tasmania, the breeding diet is 81% birds and 19% insects, and most (82%) of avian prey items are 50 g or less; by biomass, birds contribute 98%. The non-breeding diet is 85%

birds, 1% mammals, 1% lizards and 12% insects by number. In south-eastern Queensland, the diet (breeding and non-breeding season combined) is entirely birds, of which 94% are 50 g or less. Table 7 shows that the Sparrowhawk takes mostly small prey with a mean weight considerably less than its own body weight. Birds also predominate in records used to compile Table 3; prey weights range from 9 to 199 g but the relative number of reports suggests a bias towards the smaller species (≤ 75 g).

Carnaby (1933) gave the Collared Sparrowhawk's diet as 'lizards, young rabbits and a few small birds', but this list is more typical of the Brown Goshawk (see below). Sharland (1958) listed 'birds, young rabbits, mice and other ground animals and insects' as prey of the Sparrowhawk, but he later amended it to 'birds, rodents and insects' (Sharland 1981). Tables 1-3 suggest that mammals are a very minor component of the Sparrowhawk's diet, and we have not located any specific record of rabbits as prey although kittens may be within the female Sparrowhawk's capability (110-170 g on emergence: Myers & Poole 1963). In addition to the few rodents recorded (Tables 1-3), Taplin (1982) reported a Sparrowhawk 'hunting' bats (presumably small, insectivorous species) and W. Rooke (pers. comm.) has observed a Sparrowhawk taking small insectivorous bats emerging from their cave roosts near Rockhampton, Queensland. The data indicate that reptiles, amphibians and insects are likewise minor components of the Sparrowhawk's diet.

Table 1

Breeding and non-breeding diet of the Collared Sparrowhawk *Accipiter cirrocephalus* in Tasmania. Breeding: three nests in open forest in north-east Tasmania, 1976-84; pellets and prey remains (NJM). Non-breeding: sight records 1979-85 (NJM)

Species	Weight (g) ^a range (mean)	n	%
Breeding:			
Brown Quail <i>Coturnix ypsilophora</i>	75-106(95)	1	2
Swift Parrot <i>Lathamus discolor</i>	65	3	5
Fan-tailed Cuckoo <i>Cuculus pyrrhophanus</i>	50	2	3
Blackbird <i>Turdus merula</i>	72-109(87)	2	3
Flame Robin <i>Petroica phoenicea</i>	13	1	2
Satin Flycatcher <i>Myiagra cyanoleuca</i>	18	2	3
Grey Fantail <i>Rhipidura fuliginosa</i>	8	3	5
Superb Fairy-wren <i>Malurus cyaneus</i>	10	7	11
Brown Thornbill <i>Acanthiza pusilla</i>	8	2	3
Tasmanian Thornbill <i>Acanthiza ewingii</i>	c. 10	2	3
Yellow-rumped Thornbill <i>Acanthiza chrysorrhoa</i>	9	3	5
Yellow-throated Honeyeater <i>Lichenostomus flavicollis</i>	29	1	2
White-fronted Chat <i>Ephthianura albifrons</i>	12	2	3
Silvereye <i>Zosterops lateralis</i>	12	3	5
Canary <i>Serinus canarius</i>	17	1	2
House Sparrow <i>Passer domesticus</i>	25	4	6
Beautiful Firetail <i>Emblema bella</i>	c. 15	1	2
Common Starling <i>Sturnus vulgaris</i>	55-96(75)	3	5
Unidentified small passerines	c. 22 ^b	7	11
Total birds		50	81
Orthoptera		2	12
Total		62	100

Table 1 cont.

<i>Species</i>	<i>Weight (g)^a</i> <i>range (mean)</i>	<i>n</i>	<i>%</i>
Non-breeding:			
Poultry <i>Gallus gallus</i> to two weeks old	30-200(100)	4	
Domestic Pigeon <i>Columba livia</i> — racing pigeon ^c	c. 400	2	
— fan-tailed pigeon ^c	c. 400	1	
Collared (Barbary) Dove <i>Streptopelia decaocto</i>	138-156(147)	1	
Spotted Turtle-dove <i>Streptopelia chinensis</i>	105-205(152)	1	
Green Rosella <i>Platycercus caledonicus</i>	110	3	
Blackbird <i>Turdus merula</i>	87	2	
Dusky Robin <i>Melanodryas vittata</i>	c. 20	1	
Grey Fantail <i>Rhipidura fuliginosa</i>	8	3	
Superb Fairy-wren <i>Malurus cyaneus</i>	10	5	
Yellow-rumped Thornbill <i>Acanthiza chrysorrhoa</i>	9	1	
Little Wattlebird <i>Anthochaera chrysoptera</i>	44-83(65)	1	
Yellow-throated Honeyeater <i>Lichenostomus flavicollis</i>	29	1	
Black-headed Honeyeater <i>Melithreptus affinis</i>	14	1	
Silvereye <i>Zosterops lateralis</i>	12	4	
European Goldfinch <i>Carduelis carduelis</i>	17	3	
House Sparrow <i>Passer domesticus</i>	25	5	
Common Starling <i>Sturnus vulgaris</i>	75	11	
Grey Butcherbird <i>Cracticus torquatus</i>	75-97(85)	1	
Unidentified small passerines	c. 37 ^b	6	
Total birds		57	85
Black Rat <i>Rattus rattus</i> (subadult) ^c	c. 80	1	1
Metallic Skink <i>Leiopisma metallica</i>	c. 10	1	1
Orthoptera	2	8	12
Total		67	100

^a sources for weight data: Hall (1974), Ford & Bell (1981), Long (1981), Baker-Gabb (1982), Henderson & Green (1982), Strahan (1983), Saunders et al. (1984), Recher et al. (1985), specimens in the Australian Museum. Note that for Brown Quail, Blackbird and Common Starling, mean and range were obtained from different sources

^b mean of identified passerines ^c taken by immature female Sparrowhawk

Table 2

Diet of the Collared Sparrowhawk *Accipiter cirrocephalus* in sub-coastal south-east Queensland. Breeding and non-breeding season combined: pellets, prey remains and sight records (GVC).

<i>Species</i>	<i>Mean weight (g)^a</i>	<i>n</i>	<i>%</i>
Brown Quail <i>Coturnix ypsilophora</i>	95	2	6
King Quail <i>Coturnix chinensis</i>	c. 50	1	3
Little Button-quail <i>Turnix velox</i>	41	1	3
Peaceful Dove <i>Geopelia placida</i>	47	1	3
Little Lorikeet <i>Glossopsitta pusilla</i>	41	1	3
Tree Martin <i>Cecropis nigricans</i>	15	1	3
Golden-headed Cisticola <i>Cisticola exilis</i> (?)	7	1	3
Red-backed Fairy-wren <i>Malurus melanocephalus</i>	7	2	6
Fairy-wren <i>Malurus</i> sp. (female)	7	1	3
Lewin's Honeyeater <i>Meliphaga lewinii</i>	34	1	3
Yellow-faced Honeyeater <i>Lichenostomus chrysops</i>	17	1	3
White-throated Honeyeater <i>Melithreptus albogularis</i>	11	3	10

Table 2 cont.

<i>Species</i>	<i>Mean weight (g)^a</i>	<i>n</i>	<i>%</i>
Scarlet Honeyeater <i>Myzomela sanguinolenta</i>	9	2	6
Brown Honeyeater <i>Lichmera indistincta</i>	10	1	3
House Sparrow <i>Passer domesticus</i>	25	4	13
Unidentified passerines	15 ^b	5	16
Unidentified birds	27 ^c	3	10
Total		31	100

^a sources for weight data as in Table 1, plus specimens in the Queensland Museum

^b mean of identified passerines

^c mean of identified birds

Table 3

Additional records of prey species of the Collared Sparrowhawk *Accipiter cirrocephalus*, excluding those records considered doubtful (see text). Criteria for inclusion: species captured, carried and/or eaten (e.g. prey remains, stomach contents).

<i>Species</i>	<i>Weight (g)^a</i> <i>range (mean)</i>	<i>Source</i>
Brown Quail <i>Coturnix ypsilophora</i>	75-106(95)	Czechura 1979
King Quail <i>Coturnix chinensis</i>	c. 50	Czechura 1979
'Small chickens' <i>Gallus gallus</i>	<100	Carter 1923
Painted Button-quail <i>Turnix varia</i>	97	SD
Little Button-quail <i>Turnix velox</i>	41	Czechura 1979
Feral Pigeon <i>Columba livia</i> (?) 'very young squab'	<100	Metcalf & Metcalf 1986
Spotted Turtle-dove <i>Streptopelia chinensis</i>	105-205(152) ^c	Bigg 1979
Crested Pigeon <i>Ocyphaps lophotes</i>	133-257(199) ^d	SD
Purple-crowned Lorikeet <i>Glossopsitta porphyrocephala</i>	35-55	Carter 1923
Green Rosella <i>Platycercus caledonicus</i>	110	Mooney 1984
Swift Parrot <i>Lathamus discolor</i>	65	N. Mooney (NRS)
Budgerigar <i>Melopsittacus undulatus</i>	c. 30	Cameron 1932, Lea & Gray 1935
'Parakeet' (=Budgerigar?)		Anon. 1970
'Young parrot' (Platycercinae)	<100	Stone 1912
Welcome Swallow <i>Hirundo neoxena</i>	c. 15	North 1912
Black-faced Cuckoo-shrike <i>Coracina novaehollandiae</i>	110 ^d	I. Mason & R. Schodde
Red-capped Robin <i>Petroica goodenovii</i> (?)	9	Cupper & Cupper 1981
Scarlet Robin <i>Petroica multicolor</i>	13	N. Mooney (NRS)
Eastern Yellow Robin <i>Eopsaltria australis</i>	19	North 1912
Willie Wagtail <i>Rhipidura leucophrys</i>	22	Lenz 1980
Yellow-rumped Thornbill <i>Acanthiza chrysorrhoa</i>	9	J. Purnell
Thornbill sp. (=Yellow-rumped?)	c. 10	Brandon 1938
Thornbill sp. (?)	c. 10	Cupper & Cupper 1981
Wattlebird <i>Anthochaera</i> sp. (=Red, <i>A. carunculata</i> ?)	125	Sutton 1927
Friarbird <i>Philemon</i> sp. (Little/Noisy)	46-92	Taplin 1982
Yellow-plumed Honeyeater <i>Lichenostomus ornatus</i>	22	Anon. 1926 ^b

Table 3 cont.

<i>Species</i>	<i>Weight (g)^a</i> <i>range (mean)</i>	<i>Source</i>
Honeyeaters (Meliphagidae)	10-30	Morris 1973, Price-Jones 1983
European Goldfinch <i>Carduelis carduelis</i>	17	Metcalf 1982, Price-Jones 1983, Metcalf & Metcalf 1986
Canary <i>Serinus canarius</i> (caged)	17	Carter 1923
House Sparrow <i>Passer domesticus</i>	25	North 1912, Fletcher 1918, Hobbs 1961, Mollison 1961, Metcalf 1981, Aust. Museum ^b , Price-Jones 1983, Metcalf & Metcalf 1986
Zebra Finch <i>Poephila guttata</i>	12	I. Mason & R. Schodde ^b , GVC
Double-barred Finch <i>Poephila bichenovii</i>	11	GVC
Grassfinch (Ploceidae)	10-20	Blakers et al. 1984
Common Starling <i>Sturnus vulgaris</i>	75	Sutton 1927, Hood 1935, Symon 1948, Wilson 1982, Price-Jones 1983, Hollands 1984, N. Mooney (NRS)
Common Mynah <i>Acridotheres tristis</i>	82-138 ^d	Appleby 1985
Spotted Bowerbird <i>Chlamydera maculata</i>	135-154(142) ^d	Butler 1977
Thornbill-sized bird	c. 10	Veerman 1985, SD
Unidentified small passerines	20-30	SD
Unidentified passerines		I. Mason & R. Schodde ^b
Nestling/'young' birds		Anon. 1926, Lea & Gray 1935, J. Hobbs (NRS)
Unidentified small bird(s)		Keartland 1896 ^b , Tonge 1925, Barrett 1925, Milledge 1979, Aust. Museum ^b
Rat (Long-haired Rat <i>Rattus villosissimus</i> ?)	54-280(134) ^c	Cox & Pedler 1977
Bat sp(p.). (Microchiroptera)	c. 20	W. Rooke
'Spinifex Lizard' (Desert Skink <i>Egernia inornata</i> ?)		Bound 1963
Lizard (skink?)		Mollison 1961
Lizard sp(p).		Keartland 1896 ^b
Frog sp(p).		Keartland 1896 ^b
Orthoptera		Hall 1974 ^b
Coleoptera		Metcalf 1982
Insects		Keartland 1896 ^b

^a sources for weights as in Table 2^b species recorded in stomach contents^c taken by male Sparrowhawk^d taken by female Sparrowhawk

The largest species reliably recorded as prey of the Collared Sparrowhawk is the Feral Pigeon *Columba livia* (c. 400 g), 165% of the female Sparrowhawk's weight. The three records (Table 1) all involve starving juvenile female Sparrowhawks (NJM), and are thus exceptional items taken only under stress. These pigeons fall within the limitations imposed by prey body weight and *Accipiter* attack and strike methods and, as noted above, cannot defend themselves.

The Sparrowhawk's upper loading capacity should be in the order of 65 g for males and 120 g for females. The heaviest prey reported to be carried by a male is a probable Long-haired Rat *Rattus villosissimus* (Cox & Pedler 1977), minimum 54 g and by a female, a Green Rosella *Platycercus caledonicus* (Mooney 1984), c. 110 g (weights from Tables 1-3). Males can carry Common Starlings (c. 75 g), albeit with some difficulty (NJM); a probable female carried a Collared (Barbary) Dove *Streptopelia decaocto* (138-165 g, NJM) and a female carried a Black-faced Cuckoo-shrike (c. 110 g, I. Mason in litt.), both with considerable difficulty; and a female carried a Crested Pigeon *Ocyphaps lophotes* (minimum 133 g) upon which it had started to feed (SD). Sparrowhawks appear to prefer prey of a size that they can carry, since they usually eat their prey on a low plucking post or a sheltered tree perch (Symon 1948, Mollison 1961, Milledge 1979, Metcalf 1981, 1982, Schodde & Tidemann 1986, GVC, SD, NJM). They will also eat prey on the ground if it is too heavy to carry (Butler 1977, I. Mason in litt., NJM).

Our quantitative data on the Brown Goshawk's diet are presented in Tables 4-5 and discussed below.

Hunting behaviour

Stealth and surprise are the prime ingredients of Collared Sparrowhawk hunting behaviour. When searching for avian prey these raptors wait in ambush on a perch (Symon 1948, Wattel 1973, Morris 1976, Slater 1979, Schodde & Tidemann 1986) which may (Czechura 1979, SD) or may not (Mollison 1961, Czechura 1979) be concealed by foliage or cover. They also do much searching from the air and regularly course their habitat (Mooney 1982), usually in fast contour-hugging flight through or over the vegetation canopy (Brown & Amadon 1968, Wattel 1973, Cox & Pedler 1977, GVC, SD) or towns (Hobbs 1961, GVC). The Sparrowhawk's prime hunting method appears to be surprise during flight, for instance by 'hedge-hopping' and dashing into flocks of birds, rather like a low-level Australian Hobby but with more perching (NJM). It also occasionally hunts from high direct flight (Hollands 1984, GVC) and from quartering or soaring flight (SD). Sparrowhawks search from high direct flight when they are hunting along roadways through dense subtropical rainforest-wet sclerophyll forest in eastern Queensland and along watercourses in northern Queensland (GVC): they reach maximum height by soaring prior to positioning themselves above the road or watercourse. However, non-aerial hunting methods may be used regularly but seldom detected by observation (cf. Newton 1986).

The Collared Sparrowhawk sometimes flushes prey from cover by flying low over vegetation in which prey are sheltering (Symon 1948, Czechura 1979). It also takes prey flushed by other raptors such as the Peregrine Falcon (Wilson 1982) or flushes birds from the ground in order to exploit their panic-stricken collisions with obstacles (Blakers et al. 1984). Taplin (1983) claimed that a Sparrowhawk tried to flush prey from cover by flying about and calling loudly. This bird may have been chattering in frustration after an unsuccessful strike or perhaps in alarm or aggression at the observer. In our experience the Collared Sparrowhawk is a most silent hunter;

vocalisation would spoil the element of surprise which is such an important feature of Sparrowhawk hunting tactics (Morris 1976, Slater 1979, Mason 1976, Schodde & Tidemann 1986). Consequently, some other explanation for Taplin's observation seems warranted.

In the actual attack, a Collared Sparrowhawk will often appear suddenly from behind cover (Brown & Amadon 1968, Morris 1976, Slater 1979, Wilson 1982, Hollands 1984, Schodde & Tidemann 1986, GVC, SD). Direct flying attacks (Mollison 1961, Morris 1976, Hollands 1984) or glide attacks (Hollands 1984, SD) are made on birds that are usually in the air but sometimes on perches or on the ground (Schodde & Tidemann 1986). For example, GVC has observed an adult male Sparrowhawk making a short, horizontal dash from its concealed perch to snatch a House Sparrow that was flying into an evening roost; SD has observed a Sparrowhawk soaring in a forested gorge and then launch a horizontal direct flying attack, with powerful thrusting wing beats, through the tree canopy along the gorge side. Such attacks and others made at groups of birds near cover may develop into a tail chase (McGilp 1923, Cameron 1932, Slater 1979, Hollands 1984, GVC, SD, NJM). The tail chase may develop into a twisting, corkscrew flight around trees or bushes (Czechura 1981b), or the Sparrowhawk may pursue the bird into cover or even along the ground (Price-Jones 1983). Tail chases usually involve very close pursuits that present little opportunity for the hawk to get above prey and stoop; they usually last less than five seconds but may last longer in cover (NJM). Attack flights are seldom longer than 50 metres (Schodde & Tidemann 1986). Prey are occasionally attacked in a vertical or near-vertical stoop (Cameron 1932, Symon 1948, Hall 1974, GVC, NJM), a vertical dive into the vegetation canopy (Brown & Amadon 1968, SD, NJM) or in a 'swoop' to the ground (mammal prey: Cox & Pedler 1977). Sparrowhawks occasionally stoop from several hundred metres up into flocks of ground-feeding birds, but this may be opportunism while the hawks are soaring for other reasons (NJM). Flying insects are taken in circling flight around the tops of trees (Metcalf 1982 and NRS), and terrestrial insects (e.g. crickets) are taken in grass from a low perch (NJM).

Collared Sparrowhawks hunt at dawn and dusk to exploit birds entering or leaving communal roosts (Symon 1948, Hobbs 1961, Wilson 1982, GVC). It appears that bats are taken on the outward journey from their roosts at dusk (Taplin 1982, W. Rooke pers. obs.). In the evening, Sparrowhawks may extend their hunting to beyond the onset of darkness (Bateman 1975).

Co-operative hunting of flocking birds by male and female Collared Sparrowhawks has been reported (Diggles 1875), but further confirmation is required.

Limited data suggest that perch hunting is the Brown Goshawk's main searching method: in open habitat in winter, Brown Goshawks were seen perch hunting 15 times (63%), soaring and prospecting 5 times (20%) and fast contour hunting 4 times (17%), with perch hunting considered under-recorded because of the difficulty of detection (Baker-Gabb 1984c); 57 records of hunting behaviour consisted of perch hunting (42%), fast contour hunting (23%), soaring and prospecting (7%), flushing from cover (7%) and ground hunting and stalking (21%, mainly by juveniles) (Aumann 1986).

In summary, using the terminology of Baker-Gabb (1980), the Collared Sparrowhawk's hunting methods include fast contour hunting, perch hunting (concealed and unconcealed), high quartering, flushing from cover, mediated flushing and possibly co-operative hunting. Attack methods include direct flying attacks, glide attacks, tail chasing, stooping and dive attacks. This contrasts with the more sedentary perch and dive on to still prey by the Brown Goshawk, as stressed by Schodde & Tidemann (1986).

Table 4

Breeding and non-breeding diet of the Brown Goshawk *Accipiter fasciatus* in Tasmania, 1978-1984. Breeding: five nests in urban/rural areas and two nests in wilderness areas (open forest); pellets and prey remains (NJM). Non-breeding: adults in non-breeding season and birds in immature plumage; sight records (NJM).

Species	Weight (g) ^a range(mean)	Urban/rural		Wilderness		Total	%
		n	%	n	%		
Breeding:							
Barred Bandicoot							
<i>Perameles gunnii</i> (juv.)	c.100	2	2			2	1
Black Rat <i>Rattus rattus</i>	280	10	11	2	4	12	8
Brown Rat <i>Rattus norvegicus</i>	320	2	2			2	1
House Mouse <i>Mus musculus</i>	17	8	8			8	6
Rabbit <i>Oryctolagus cuniculus</i>	200-1200(350)	12	13	4	9	16	9
Total mammals		34	35	6	13	40	28
Cattle Egret <i>Ardeola ibis</i>							
	c. 350	1	1			1	1
Poultry <i>Gallus gallus</i> (half-grown bantams)							
	c. 250	6	6			6	4
Masked Lapwing <i>Vanellus miles</i>	253	1	1			1	1
Common Bronzewing <i>Phaps chalcoptera</i>							
	303			3	6	3	2
Musk Lorikeet <i>Glossopsitta concinna</i>							
	c. 70	1	1			1	1
Swift Parrot <i>Lathamus discolor</i>	65	3	3	4	9	7	5
Green Rosella <i>Platycercus caledonicus</i>							
	110	14	15	13	28	27	19
Eastern Rosella <i>Platycercus eximius</i>							
	110	2	2	3	6	5	3
Pallid Cuckoo <i>Cuculus pallidus</i>	95	1	1			1	1
Fan-tailed Cuckoo <i>Cuculus pyrrhophanus</i>							
	50	1	1	1	2	2	1
Shining Bronze-Cuckoo <i>Chrysococcyx lucidus</i>							
	23	1	1			1	1
Blackbird <i>Turdus merula</i>	87	6	6	1	2	7	5
Flame Robin <i>Petroica phoenicea</i>	13	1	1			1	1
Dusky Robin <i>Melanodryas vittata</i>	c. 20	1	1	1	2	2	1
Satin Flycatcher <i>Myiagra cyanoleuca</i>							
	18	1	1			1	1
Grey Fantail <i>Rhipidura fuliginosa</i>	8	2	2	2	4	4	3
Spotted Quail-thrush <i>Cinlosoma punctatum</i>							
	c. 100			1	2	1	1
Superb Fairy-wren <i>Malurus cyaneus</i>							
	10	3	3	3	6	6	4
White-browed Scrubwren <i>Sericornis frontalis</i>							
	13			1	2	1	1
Brown/Tasmanian Thornbill <i>Acanthiza pusilla/ewingii</i>							
	c. 10	1	1	1	2	2	1
Yellow Wattlebird <i>Anthochaera paradoxa</i>							
	152			1	2	1	1
Yellow-throated Honeyeater <i>Lichenostomus flavicollis</i>							
	29	2	2	1	2	3	2
New Holland Honeyeater <i>Phylidonyris novaehollandiae</i>							
	20	1	1	1	2	2	1

Table 4 cont.

<i>Species</i>	Weight (g) ^a range(mean)	Urban/rural		Wilderness		Total	%
		n	%	n	%		
House Sparrow <i>Passer domesticus</i>	25	2	2			2	1
Beautiful Firetail <i>Emblema bella</i>	c. 15			1	2	1	1
Common Starling <i>Sturnus vulgaris</i>	75	6	6	3	6	9	6
Total birds		57	59	41	87	98	69
Unidentified small skinks	c. 10	3	3			3	2
Wolf spiders (Lycosidae)	2	2				2	1
Total prey items		96	100	47	100	143	100
Non-breeding:							
Barred Bandicoot <i>Perameles gunnii</i> (ad.)	450-900(640)					1	
Little Brown Bat <i>Eptesicus pumilis</i>	c. 5					2	
Brown Rat <i>Rattus norvegicus</i>	320					1	
Rabbit <i>Oryctolagus cuniculus</i>	200-1200(350)					7	
Hare <i>Lepus capensis</i> (imm.)	c. 1500					1	
Cat <i>Felis catus</i> (juv.)	c. 800					1	
Total mammals						13	7
White-faced Heron <i>Ardea novaehollandiae</i>	564					1	
Common Quail <i>Coturnix coturnix</i>	c.100					2	
Brown Quail <i>Coturnix ypsilophora</i>	95					1	
Tasmanian Native-hen <i>Gallinula mortierii</i> (juv.)	c. 400					2	
Masked Lapwing <i>Vanellus miles</i>	253					2	
Silver Gull <i>Larus novaehollandiae</i>	311					1	
Feral Pigeon <i>Columba livia</i>	465					10	
Common Bronzewing <i>Phaps chalcoptera</i>	303					2	
Swift Parrot <i>Lathamus discolor</i>	65					2	
Green Rosella <i>Platycercus caledonicus</i>	110					6	
Eastern Rosella <i>Platycercus eximius</i>	110					3	
Pallid Cuckoo <i>Cuculus pallidus</i>	95					1	
Southern Boobook <i>Ninox novaeseelandiae</i>	c. 200					1	
Tawny Frogmouth <i>Podargus strigoides</i>	374					1	
Laughing Kookaburra <i>Dacelo novaeguineae</i>	382					1	
Blackbird <i>Turdus merula</i>	87					8	
Grey Shrike-thrush <i>Colluricincla harmonica</i>	76					1	
Grey Fantail <i>Rhipidura fuliginosa</i>	8					1	
Superb Fairy-wren <i>Malurus cyaneus</i>	10					2	

Table 4 cont.

<i>Species</i>	<i>Weight (g)^a</i> <i>range(mean)</i>	<i>Urban/rural</i> <i>n %</i>	<i>Wilderness</i> <i>n %</i>	<i>Total</i>	<i>%</i>
Yellow Wattlebird <i>Anthochaera paradoxa</i>	152			1	
Yellow-thoated Honeyeater <i>Lichenostomus flavicollis</i>	29			1	
New Holland Honeyeater <i>Phylidonyris novaehollandiae</i>	20			2	
European Goldfinch <i>Carduelis carduelis</i>	17			3	
Canary <i>Serinus canarius</i>	17			1	
House Sparrow <i>Passer domesticus</i>	25			3	
Common Starling <i>Sturnus vulgaris</i>	75			14	
Grey Butcherbird <i>Cracticus torquatus</i>	85			3	
Total birds				76	43
Unidentified small skinks	c. 10			3	
White-lipped Snake <i>Drysdalia coronoides</i>	c. 50			1	
Total reptiles				4	2
Wolf spiders (Lycosidae)	2			3	
Coleoptera	2			51	
Orthoptera	2			28	
Total arthropods ^b				82	47
Total prey items				175	100
Carrion ^c					
Brush-tailed Possum <i>Trichosurus vulpecula</i>				5	
Tasmanian Pademelon <i>Thylogale billardierii</i>				2	
Red-necked Wallaby <i>Macropus rufogriseus</i>				3	
Sheep <i>Ovis aries</i>				3	
Cattle <i>Bos taurus</i>				1	
Brown Trout <i>Salmo trutta</i>				2	

^a weight sources as in Table 1

^c n = number of occasions recorded

^b taken mainly by juveniles in autumn

Table 5

Diet of the Brown Goshawk *Accipiter fasciatus* in subcoastal south-east Queensland. Breeding and non-breeding season combined: pellets, prey remains and sight records (GVC).

<i>Species</i>	<i>Mean weight (g)^a</i>	<i>n</i>	<i>%</i>
Stubble Quail <i>Coturnix novaehollandiae</i>	104	1	1
Brown Quail <i>Coturnix ypsilophora</i>	95	4	6
Poultry <i>Gallus gallus</i>	c. 200	2	3
Painted Button-quail <i>Turnix varia</i>	97	1	1
Buff-banded Rail <i>Rallus philippensis</i>	168	3	4
Dusky Moorhen <i>Gallinula tenebrosa</i>	547	1	1
Sandpiper <i>Calidris</i> sp.(?)	c. 50	1	1
Bar-shouldered Dove <i>Geopelia humeralis</i>	118	2	3
Crested Pigeon <i>Ocyphaps lophotes</i>	199	2	3
Pale-headed Rosella <i>Platycercus adscitus</i>	121	1	1

Table 5 cont.

<i>Species</i>	Mean weight (g) ^a	<i>n</i>	%
Richard's Pipit <i>Anthus novaeseelandiae</i>	23	2	3
Clamorous Reed-Warbler <i>Acrocephalus stentoreus</i>	18	2	3
Tawny Grassbird <i>Megalurus timoriensis</i>	17	3	4
Noisy Miner <i>Manorina melanocephala</i>	68	5	7
Lewin's Honeyeater <i>Meliphaga lewinii</i>	34	1	1
Brown Honeyeater <i>Lichmera indistincta</i>	10	1	1
Silvereye <i>Zosterops lateralis</i>	12	1	1
House Sparrow <i>Passer domesticus</i>	25	4	6
Red-browed Firetail <i>Emblema temporalis</i>	11	1	1
Common Starling <i>Sturnus vulgaris</i>	75	3	4
Figbird <i>Sphecothebes viridis</i>	135	2	3
Australian Magpie-lark <i>Grallina cyanoleuca</i>	90	2	3
Australian Magpie <i>Gymnorhina tibicen</i>	314	3	4
Unidentified birds	106 ^b	4	6
Total birds		52	75
Rats <i>Rattus</i> sp(p).	185 ^c	2	3
Other rodents (Muridae)	150 ^c	4	6
Total mammals		6	9
Skink <i>Sphenomorphus</i> sp.	c. 15	2	3
Dragon <i>Physignathus</i> sp.(?)	c. 200	1	1
Total reptiles		3	4
Insects	2	8	12
Total		69	100
Carrion ^d			
Cattle <i>Bos taurus</i>		1	

^a weight sources as in Table 1, plus Aumann (1986) ^c mean of local species

^b mean of identified birds

^d n = number of occasions recorded

Table 6

Taxonomic group (passerine vs non-passerine) and main foraging zone (ground/understorey vs canopy/aerial) of avian prey of the Collared Sparrowhawk *Accipiter cirrocephalus* and Brown Goshawk *Accipiter fasciatus* (summarised from Tables 1-2 and 4-5).

<i>Species</i>	Avian prey (%)				
	passerine	non-passerine	g/u	c/a	
Sparrowhawk:	Tasmania				
	breeding	88	12	58	42
	non-breeding	79	21	78	22
South-east Queensland (breeding and non-breeding)	79	21	57	43	
Goshawk:	Tasmania				
	breeding	44	56	73	27
	breeding (wilderness)	46	54	73	27
	non-breeding	53	47	79	21
	South-east Queensland (breeding and non-breeding)	63	38	79	21

Comparison with Brown Goshawk feeding ecology

No detailed comparative studies of the Collared Sparrowhawk and Brown Goshawk exist. However, there are sufficient data to suggest that where the two species breed sympatrically, they differ in the size and type of prey items. In north-western Victoria, Cupper & Cupper (1981) only observed small passerines (c. 10 g) as prey at Sparrowhawks' nests whereas prey at Brown Goshawks' nests was mainly immature rabbits and an occasional passerine (in both hawk species, delivered by males during the nestling period). On the Southern Tablelands of New South Wales (Price-Jones 1983), the Collared Sparrowhawk's prey consists mainly of House Sparrows and Common Starlings with some European Goldfinches and honeyeaters (i.e. passerines 10-75 g), whereas the Brown Goshawk preys on rabbits, birds such as Feral Pigeons, Galahs, rosellas (*Platycercus* spp.) and Common Starlings (c. 75-465 g), and occasionally waterfowl, poultry and Ring-tailed Possums *Pseudocheirus peregrinus* (adults of which ≥ 700 g; Strahan 1983).

The data in Tables 1-2 and 4-5 enlarge on data presented in Mooney (1982), and confirm that there is some prey partitioning between the two species. In Tasmania, the Collared Sparrowhawk takes small birds (especially honeyeaters and insectivorous species) to a maximum weight of c. 400 g for females and 150 g for males, whereas the Brown Goshawk takes mammals, reptiles and small-medium birds to a maximum weight of 2 000 g for females and 750 g for males (Mooney 1982, this study). It appears that the two species' non-breeding diets contain larger prey than their respective breeding diets, and show even greater separation, but note that in Table 4 the contribution of arthropods to the Brown Goshawk's diet is inflated by juvenile dependence on such prey in autumn. In addition to Table 4, NJM has received many reports from the public of Brown Goshawks (mainly juvenile females) taking domestic poultry up to 2 000 g (average 600 g). In south-eastern Queensland the diets of the two species show similar separation, despite the absence of rabbits over much of this region (Czechura 1979, 1980, Table 5). Sparrowhawks prey mainly on House Sparrows or Common Starlings where these are available, and/or on native finches, honeyeaters and insectivorous species. Brown Goshawks usually take birds in the 75-400 g range (e.g. doves, parrots, Australian Magpies, Common Starlings), mammals (especially rodents) and some reptiles (juvenile monitors, medium to large skinks and dragons). In the absence of rabbits, it appears that more ground-dwelling birds (such as rails and quail), rodents and reptiles are taken by Brown Goshawks. In some areas, Brown Goshawks could be regarded as bird specialists. Table 6 demonstrates partitioning of avian prey by taxonomic group and foraging zone: the Sparrowhawk takes relatively more passerine and canopy/aerial species than the Brown Goshawk.

As well as the proportion of each prey class in the diets of the two species, Table 7 compares other parameters such as mean weight of vertebrate and avian prey and the percentage of vertebrate prey items greater than 50 g and 100 g. The data show that the Brown Goshawk has a more diverse diet, takes more mammals and takes larger vertebrate prey (including larger birds). Although 2½ times the Sparrowhawk's weight (sex for sex), the Brown Goshawk takes vertebrate prey up to five times heavier than the Sparrowhawk's prey (or twice as heavy in relation to body weight). These differences apply even in areas where the Brown Goshawk preys mainly on birds, e.g. south-east Queensland and forested areas in Tasmania: avian prey averages at least three times the weight of the Sparrowhawk's avian prey.

The largest prey items recorded for the Brown Goshawk are penned poultry of 2 000 g (NJM), over 2½ times the weight of the largest female Goshawks, but they cannot escape and are easily killed. Some authors (e.g. Hollands 1984) have stated that Brown Goshawks can take adult rabbits (1 500 g; Strahan 1983), but the heaviest

Table 7

Dietary parameters of the Collared Sparrowhawk *Accipiter cirrocephalus* and Brown Goshawk (summarised from Tables 1-2, 4-5)

Species	Diet (%) ^a				Mean weight prey items (g)		Vertebrate prey items (%)	
	M	B	R	A	vertebrate	avian	> 50 g	> 100 g
Sparrowhawk:								
Tasmania								
breeding	0	81	0	19	27	27	18	0
non-breeding	1	85	1	12	65	66	49	25
South-east Queensland (breeding & non-breeding)								
	0	100	0	0	25	25	6	0
Goshawk								
Tasmania								
breeding	28	69	2	1	130	85	74	52
breeding (wilderness)	13	87	0	0	116	85	74	55
non-breeding	7	43	2	47	195	163	80	45
South-east Queensland (breeding and non-breeding)								
	9	75	4	12	110	106	70	46

^a M = mammals, B = birds, R = reptiles, A = arthropods

^b mean vertebrate prey weight as a percentage of mean body weight

rabbit prey actually recorded are 1 200 g (Myers & Pooles 1963, this study). This is still twice the weight of the average female Goshawk, and the birds often have considerable difficulty in killing large rabbits (Aumann 1986).

A further dietary difference is carrion feeding: Brown Goshawks occasionally eat carrion (Tables 4-5, Czechura 1980, Price-Jones 1983, Baker-Gabb 1984a, Aumann 1986), but Collared Sparrowhawks are not known to do so.

The Brown Goshawk and Collared Sparrowhawk are said to differ in hunting techniques, but the lack of quantitative data for the Sparrowhawk makes comparison difficult. The Sparrowhawk is said to specialise much more in seizing birds in flight, whereas the Brown Goshawk takes mostly stationary prey on the ground or on perches (Hollands 1984, Schodde & Tidemann 1986). Such a conclusion on attack methods is supported by the dietary differences in Tables 1-2 and 4-7 (e.g. the relative number of terrestrial prey items of the two species). The two species may also differ considerably in searching methods. Mooney (1982) considered that Sparrowhawks use more aerial hunting methods and perch hunt less regularly than the Brown Goshawk. This accords with data on relative wing loading and wing shape of the two species. The Brown Goshawk is a typical perch hunter (Wattel 1973) and its wing shape suggests a 'glider', whereas the Sparrowhawk's wing structure suggests a 'flapper' that spends more time on the wing. Data on the Sparrowhawk's hunting methods are required; a problem is to distinguish soaring to hunt from soaring for other reasons such as display, thermoregulation and long-distance movements. Techniques such as radio-tracking may be required to detect some hunting methods (cf. Newton 1986).

It appears that there is also some habitat partitioning between the two species. In Tasmania, Collared Sparrowhawks utilise the canopy of rainforests, eucalypt forests and woodlands for hunting purposes, extending to ground level where the shrub canopy does so (e.g. in coastal scrub), and Brown Goshawks utilise the entire vertical spectrum to ground level except in rainforest where they are absent (Mooney 1982). Brown

<i>Accipiter fasciatus</i>	
male	female
Mean prey weight/body weight (%) ^b	
o	o
22	11
52	27
20	9
42	23
37	20
63	34
35	19

Goshawks may be more inclined to undertake seasonal movements and to winter in more open habitats than Sparrowhawks. In Tasmania, adult Sparrowhawks of both sexes seem to be present all year in known breeding areas, and remain in some high-altitude areas through winter; in some areas adult female Brown Goshawks appear to move after breeding and return the following spring (3 out of 5 colour-banded individuals have returned to the same nest), but adult males seem to be resident all year in known breeding areas (3 colour-banded: NJM). Females may simply extend their home range in winter. Far more Brown Goshawks than Sparrowhawks are seen wintering in open coastal areas in south-eastern Australia, e.g. the hinterland of Sydney and Melbourne (Debus 1982, Baker-Gabb 1984c); Brown Goshawks are partial migrants over much of their Australian range and there is some evidence that they winter in habitats that are more open than their breeding areas (Aumann 1986). Data are required on the Sparrowhawk's seasonal movements and wintering areas, including age and sex differences in ecology (cf. Newton 1986).

It seems reasonable to conclude that the Sparrowhawk is far more specialised than the Brown Goshawk, certainly in diet and perhaps also in hunting methods and habitat.

Courtship and advertisement displays

Little has been recorded on the Collared Sparrowhawk's displays. During territory establishment at the start of the breeding cycle, both sexes perch and call, soar and call (sometimes in pairs) and perform undulating or diving aerobatics, also sometimes in pairs (Pizzey 1980; Metcalf & Metcalf 1986; S. Marchant in litt.; GVC, SD, NJM). The female is said to be the main defender of territory during the establishment phase, whereas the male becomes more aggressive and defensive during nest-building and incubation (Metcalf & Metcalf 1986). In one case, the female was detected first in the nesting area and she frequently uttered a raucous call from a perch; the male was detected 10 days later and he frequently uttered a mellow whistling call from a perch (Metcalf & Metcalf 1986). The 'cuckoo' style of direct flight may be a shallow undulating display of the type performed by other accipiters such as the European Sparrowhawk *Accipiter nisus* (Brown & Amadon 1968).

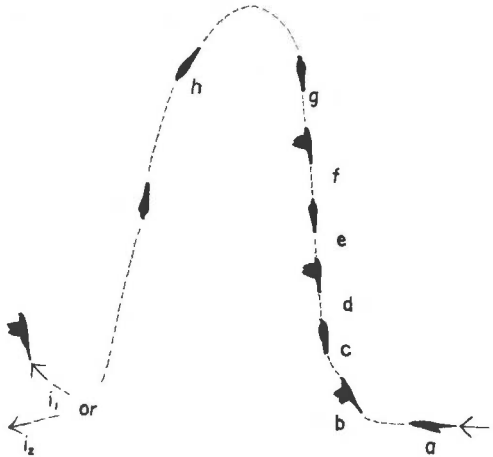
SD has observed slow flight and vigorous undulating displays at the start of breeding activities, similar to those described for the Brown Goshawk (Debus 1980, Hollands 1984, Aumann 1986) and Grey Goshawk (Hollands 1984, Baker-Gabb 1985b). These observations are described below.

- (1) A female patrolling her territory with slow, regular wing beats very reminiscent of the flight action of a harrier *Circus* sp.
- (2) One or both members of a pair soaring together over the nest site, during which the male performed an undulating display: he flew in level harrier-like flight,

increased the rate of wing beats rapidly to climb vertically with closed wings, giving a couple of single flaps as he neared the apex, and then dived to level out and repeat the performance, sometimes soaring briefly before the next series (Figure 4). On a few occasions he dived at his mate soaring below; she dived to avoid contact and then performed an undulation of her own before continuing her circling while the male completed his series of undulations. This display was performed silently, though rapid chattering was heard from soaring birds and single soft, mellow notes from the perched male between bouts of undulations.

Figure 4.
Undulating display of male Collared Sparrowhawk *Accipiter cirrocephalus* (SD: see text).

- a. 'Harrier' style of flight followed by fast flickering flight
- b. Climb with vigorous wing beats.
- c. 'Shoot' with closed wings
- d. Single deep flap
- e. 'Shoot'
- f. Single deep flap
- g. 'Shoot' and stall
- h. Steep dive with closed wings
- i₁. Repeat sequence
- OR
- i₂. Soaring then repeat sequence



Drawing by G.V. Czechura

Little has been recorded on the Collared Sparrowhawk's mating behaviour. Copulation has been observed through the breeding cycle to the fledging stage (peaking in the week before laying), and occurs before, during or after provisioning of the female with food by the male; the male also occasionally proffers nesting material (Sedgwick 1947, Slater 1979, Metcalf 1982, Metcalf & Metcalf 1986). Intense courtship activity has been observed (Metcalf 1982): a pair in a state of high excitement, the male carrying food and following the female in an attempt to copulate while she hopped rapidly about in a tree. A probable pre-copulatory display has been described (Metcalf & Metcalf 1986): a male carried prey with a 'fluttering beat' (the 'cuckoo' flight?) to the perched female, whereupon she sidled up and both hopped about the branches with spread wings before she took the food and he mounted. D. Baker-Gabb (in litt.) has observed a male pursuing a female from perch to perch with much chattering.

Breeding biology

The Collared Sparrowhawk is elusive and little is known of its breeding biology. There are no data on breeding density and few accurate data on incubation and nestling periods. Where a new nest is built, both sexes share in the construction though (unmated?) males may do all the construction; both sexes bring fresh green sprays of leaves to the nest throughout the cycle, mainly in the early morning, up to the fledging stage (Sedgwick 1947, Sedgwick & Crosbie Morrison 1949, Cupper & Cupper 1981, Metcalf 1981, 1982, N. Lamb/NRS). Small sticks and sprays of leaves are broken off trees by pulling with the bill and flapping (Olsen 1981, Metcalf 1982), or by walking along a dead branchlet until the bird's weight breaks it off (Metcalf & Metcalf 1986).

In one case a female took 10 days to select a nest site from six potential sites, a further eight days to build the nest (mainly in the late morning, with little contribution from the male), and a further 2-3 weeks to lay eggs (Metcalf & Metcalf 1986).

The incubation period has been stated as 19 days (Serventy & Whittell 1976) and 'about three weeks' (Schodde & Tidemann 1986, from an estimate only in Cupper & Cupper 1981). Such short periods are considered doubtful (Brown & Amadon 1968). Elsewhere the incubation period has been given (without source data) as approximately 28 days (Price-Jones 1983). Available data suggest a minimum period of 34-35 days (one clutch: Tonge 1925), between 29 and 33 days (one clutch: J. Hobbs/NRS) and c. 30-34 days (one clutch: Metcalf & Metcalf 1986). One clutch from captive birds hatched in 35 days (J. Olsen pers. comm.). The nestling period has been given as 28 days (Slater 1962), c. 5 weeks (Price-Jones 1983) and c. 4 weeks (Hollands 1984). Date in Tonge (1925) and Metcalf (1982) suggest a maximum period of 26-29 days and 29-30 days (one brood each), and NRS data indicate a nestling period of >28 days (one brood: N. Mooney) and >27 days (one brood: N. Lamb). A single male nestling left the nest for surrounding branches at 26 days (P. & J. Olsen in litt.), and another single nestling first flew at c. 32 days (Metcalf & Metcalf 1986).

Both sexes share incubation and the brooding and feeding of chicks (Tonge 1925, Hyem 1936, Hollands 1984, Metcalf & Metcalf 1986, J. Hobbs/NRS). The male performs a number of duties during the breeding season, including: provisioning of the incubating female, sometimes transferring food in an aerial pass (Bound 1963, Metcalf 1982); supplying plucked prey to the female and nestlings, either brought to the nest or collected by the female away from the nest, at a regular exchange perch (Cupper & Cupper 1981, Metcalf 1982, Metcalf & Metcalf 1986); bringing whole and unplucked prey to flying young, sometimes transferred in an aerial pass by dropping it for the young to catch in the air (Badman 1981, Metcalf 1982). Both sexes defend the nest vigorously during the nestling and immediate post-fledging period (Cupper & Cupper 1981, J. Groves and N. Mooney/NRS). Fledglings spend several days in the branches of the nest tree or neighbouring trees, and return to the nest to be fed (Tonge 1925, Price-Jones 1983, B. & M. Wright/NRS). Young may be branchers 'long before' fledging properly (Slater 1962). Young are said to hunt for themselves at c. 5 weeks old (a week or so post-fledging: Tonge 1925) on the basis of fledgling Sparrowhawks carrying birds (which may have been provided by the adults). The young start catching insects about 10 days after fledging, and start to chase birds (unsuccessfully at first) about two weeks after fledging (Metcalf 1982). Their first flights range 20-30 m from the nest, and within two weeks post-fledging they are flying competently and range up to 1 km from the nest (Metcalf 1982). The post-fledging dependence period appears to last 2½-6 weeks and the young may remain in the nest area for 2-2½ months (Metcalf 1982, B. & M. Wright and E. & R. Metcalf/NRS) though sometimes as little as 3 weeks (Metcalf & Metcalf 1986). Observations in Metcalf (1982) suggest that adults may entice fledglings to fly by carrying food past the nest, and induce independence of the young by surrendering prey after a chase and ultimately by withholding food (cf. Newton 1979, Aumann 1986).

Tentative incubation and nestling periods of c. 28-35 days and 26-35 days respectively for the Collared Sparrowhawk are very similar to those of the Brown Goshawk (incubation 29-32 and possibly up to 35-36 days; nestling period 28-37 days: Olsen et al. 1982, Hollands 1984) and to those of other small sparrowhawks (Jones 1979, Newton 1979, 1986, Cramp & Simmons 1980, Allan & Huxler 1984). Confirmation of these values for the Collared Sparrowhawk is still required.

Discussion

It is apparent that some statements in the literature on the Collared Sparrowhawk are insufficiently substantiated, and our remarks on the Australian Hobby (Czechura & Debus 1986) apply with respect to misidentification and misinterpretation of aggressive behaviour: the intentions and identity of an attacking Sparrowhawk should be carefully verified. Confusion is even more likely between the Collared Sparrowhawk and Brown Goshawk than between the Australian Hobby and the Peregrine Falcon, and we suggest that reports concerning 'sparrowhawks' be treated with caution. Critical study of the field characters of the Brown Goshawk and Sparrowhawk in northern Australia is required, particularly on behaviour and vocalisations (e.g. displays) that might confirm or deny whether *A.f. fasciatus* and *A.f. didimus* are behaving as separate species (cf. Ford 1986).

Our data do not support claims (e.g. Mason 1976) that the Collared Sparrowhawk attacks prey 'often' larger than itself. We conclude that like other small accipiters of the 'sparrowhawk' type (long, thin legs and toes), it preys mainly on passerines much smaller than itself and that it is not built to deal with the larger prey it has been alleged to kill. Our conclusions on the Collared Sparrowhawk's diet and prey size are supported by data on the European Sparrowhawk of similar size and structure. The latter species preys mainly on birds (82% of avian items < 50 g), insects (20%) and mammals (6%), and its mean prey weight is 39 g; males take prey up to 40 g regularly and occasionally to 150 g, and females take prey up to 150 g regularly and occasionally (pigeons *Columba* spp., <1% of diet) up to 400-500 g (Brown & Amadon 1968, Cramp & Simmons 1980, Opdam 1980, Newton 1986). The small sparrowhawks on the other continents likewise prey mainly on small birds and take few mammals, reptiles, amphibians and insects (Sharp-shinned Hawk *Accipiter striatus* in North America: Storer 1966, Sherrod 1978, Jones 1979, Mueller et al. 1981, Reynolds & Meslow 1984; several southern African species: Steyn 1982).

In hunting behaviour the Collared Sparrowhawk also appears to resemble other small sparrowhawks. The European Sparrowhawk hunts mainly on the wing inside wooded areas and by fast contour hunting in the open, surprising prey from behind cover and seizing it in a tail chase (Brown & Amadon 1968, Cramp & Simmons 1980, Newton 1986). In aerodynamic characters and flight performance, the Collared Sparrowhawk appears to continue the trend from Grey Goshawk to Brown Goshawk (cf. Olsen & Olsen 1985).

Because they are sympatric, the Collared Sparrowhawk and Brown Goshawk should show ecological separation (Gause's principle). Our data on diet and morphology support previous deductions (Wattel 1973, Mooney 1982, Schodde & Tiedemann 1986) about ecological differences (prey types and modes of hunting) between the two species. Our data also support expectations about relative prey sizes based on relative strengths of prey-catching apparatus. The two species conform to the general rule among sympatric accipiters elsewhere that the larger species take relatively larger prey and more mammals (e.g. European Sparrowhawk and Northern Goshawk *Accipiter gentilis*: Opdam 1980; Sharp-shinned Hawk, Cooper's Hawk *Accipiter cooperii* and Northern Goshawk: Storer 1966, Reynolds & Meslow 1984). They also conform to the finding (Reynolds & Meslow 1984) that even where prey is mainly birds, there is partitioning by prey size, taxonomic group and foraging zone. The apparent dietary expansion and increased ecological separation in winter is also not unexpected in view of Opdam's (1980) findings on the European Sparrowhawk and Northern Goshawk. Possible explanations for larger prey in the non-breeding season include: (a) prey availability; (b) release from the necessity of carrying prey to the nest (larger items can be eaten

where caught); (c) increase in body weight in winter (Aumann 1986, NJM), perhaps increasing the weight advantage when tackling large prey; (d) many observations of hungry, inexperienced juveniles resorting to exceptional prey (presumably they soon learn to select prey that they can more easily deal with).

In south-western Australia, where the Collared Sparrowhawk is much the same size as in the east (this study) but the Brown Goshawk is slightly larger and more sexually dimorphic than in the east (Aumann 1986), there may be even greater prey partitioning. Breeden & Slater (1968) stated that in some areas the Brown Goshawk's breeding diet is 90% rabbit; this was apparently based on Slater's (1961) study in the south-west where a male Brown Goshawk brought several rabbit kittens to the nest daily but very few birds. It is possible that the Brown Goshawk has a wider niche in the south-west in the absence of the larger Grey Goshawk (Aumann 1986). In northern Australia there is potential for niche partitioning between the different-sized forms of Brown Goshawk (*fasciatus* and *didimus*), if the two do in fact breed sympatrically (cf. Ford 1986). This deserves investigation.

Studies of niche separation are complicated by sexual size dimorphism within each species. Studies of other *Accipiter* species indicate that food differentiation patterns range from simple (Mueller et al. 1981) to complex (Opdam 1980, Reynolds & Meslow 1984), especially where interspecific competition exists and/or regional variation occurs. Critical study is needed on prey partitioning between the sexes of the Collared Sparrowhawk in the breeding and non-breeding seasons and on other sexual differences in ecology (e.g. hunting behaviour, habitat), since such differences are known in the European Sparrowhawk (Opdam 1980, Newton 1986) and in the Brown Goshawk. In the latter species, females perch hunt more, take larger prey and more mammals (rabbits), hunt more in open habitats and winter in more open habitats than males, whereas males fast contour hunt and more often and take more birds than females do (Aumann 1986).

Various studies indicate that the introduction of the rabbit has had major consequences for Brown Goshawk ecology (as with many other raptor species: see Baker-Gabb 1984b). Rabbits have become a major prey in many areas. It is unclear whether Brown Goshawks have simply exploited an increasingly numerous addition to the Australian fauna or have been forced to take rabbits as equivalent native species (mammals, ground-dwelling birds, reptiles) declined. Studies in the tropics, outside the range of the rabbit and where the native terrestrial fauna is still reasonably intact, would be valuable. Quantitative data already exist for the Brown Goshawk's breeding and non-breeding diet in the south (Baker-Gabb 1984b,c, 1985a; Aumann 1986), in areas where the Collared Sparrowhawk also breeds (Blakers et al. 1984). There is clearly a need for further study of these species in sympatry. Further authentic records of species captured and carried by the Collared Sparrowhawk are also required.

The Collared Sparrowhawk's displays conform to the general accipitrine pattern of perching and calling, harrier-like flight, high soaring sometimes with calling, and undulating dives (Brown & Amadon 1968: various *Accipiter* species). Its undulating displays are very similar to those of the Brown and Grey Goshawks (cf. Debus 1980, Hollands 1984, Baker-Gabb 1958b, Aumann 1986), differing only in minor details and in being more vigorous than those of the Brown Goshawk. The Sparrowhawk's courtship activities, e.g. pair pursuit, food presentation and precopulatory postures also resemble those of other accipiters (Brown Goshawk: Aumann 1986; Northern Goshawk and European Sparrowhawk: Cramp & Simmons 1980).

In details of its breeding biology, the Collared Sparrowhawk resembles other similar-sized *Accipiter* species elsewhere in the world. For example the European Sparrowhawk, Ovambo Sparrowhawk *Accipiter ovampensis*, Levant Sparrowhawk *Accipiter brevipes* and Shikra *Accipiter badius* have incubation periods of 28-35 days and nestling periods of 26-32 days (data from Newton 1979, 1986, Olsen et al. 1982, Allan & Hustler 1984). Data are needed on the Collared Sparrowhawk's breeding density, incubation and nestling periods and on other aspects of its biology, and further detailed study is clearly warranted.

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References

- Allan, D.G. & Hustler, C.W. (1984), 'The biology of the Ovambo Sparrowhawk' (abstract), in Mendelsohn, J.H. & Sapford, C.W. (Eds), *Proceedings of Second Symposium on African Predatory Birds*, 57-58, Natal Bird Club, Durban.
- Anon. (1926), 'North-east Eyre Peninsula', *S. Aust. Orn.* **8**, 171-219.
- (1970), 'Collared Sparrowhawk', *Fauna Bull. (West Aust.)* **4**, 43.
- (1973), 'Early naturalists' writings — 4', *Vic. Nat.* **90**, 332-340.
- Appleby, C. (1985), 'The saga of the Sparrow Hawk', *Bird Obs.* **646**, 118.
- Aumann, T. (1986), Aspects of the biology of the Brown Goshawk *Accipiter fasciatus fasciatus* in south-eastern Australia, M.Sc. thesis, Monash University, Melbourne.
- Badman, F.J. (1981), 'Birds of the Willouran Ranges and adjacent plains', *S. Aust. Orn.* **28**, 141-153.
- Baker-Gabb, D.J. (1980), 'Raptor Prey Record Scheme - an ARA project proposal', *A'sian Raptor Assn News* **1**(4), 9-12.
- (1982), Comparative ecology and behaviour of Swamp Harriers *Circus approximans*, Spotted Harriers *C. assimilis* and other raptors in Australia and New Zealand, Ph.D. thesis, Monash University, Melbourne.
- (1984a), 'Morphometric data and dimorphism indices of some Australian raptors', *Corella* **8**, 61-63.
- (1984b), 'The breeding ecology of twelve species of diurnal raptor in north-western Victoria', *Aust. Wildl. Res.* **11**, 145-160.
- (1984c), 'The feeding ecology and behaviour of seven species of raptor overwintering in coastal Victoria', *Aust. Wildl. Res.* **11**, 517-532.
- (1985a), 'Accessory publication: the feeding ecology and behaviour of seven species of raptor overwintering in coastal Victoria', *A'sian Raptor Assn News* **6**, 4-9.
- (1985b), 'Display of the Grey Goshawk *Accipiter novaehollandiae*', *Aust. Bird Watcher* **11**, 67.
- Barrett, C. (1925), 'Sparrowhawks at home', *Emu* **25**, 27-28.
- Bateman, M. (1975), 'Nocturnal hunting by raptors', *Aust. Bird Watcher* **6**, 84-85.
- Bigg, R. (1979), 'Predators and their prey in our garden in Castle Hill', *N.S.W. Field Orn. Club Newsl.* **41**, 3-4.
- Blakers, M., Davies, S.J.J.F. & Reilly, P.N. (1984), *The Atlas of Australian Birds*, Melbourne University Press, Melbourne.
- Bond, R.M. (1936), 'Eating habits of falcons with special reference to pellet analysis', *Condor* **38**, 72-76.
- Bound, E. (1963), 'The nesting of the Collared Sparrowhawk', *Aust. Bird Watcher* **2**, 17-18.
- Brandon, T. (1938), 'Bird notes from Wilmington district', *S. Aust. Orn.* **14**, 218-221.
- Breeden, S. & Slater, P. (1968), *Birds of Australia*, Angus & Robertson, Sydney.
- Brown, L. (1976), *Birds of Prey, Their Biology and Ecology*, Hamlyn, London.
- & Amadon, D. (1968), *Eagles, Hawks and Falcons of the World*, Country Life, London.
- Butler, H. (1977), *In the Wild with Harry Butler*, Aust. Broadcasting Commission, Sydney.
- Cade, T.J. (1982), *The Falcons of the World*, Collins, London.
- Cameron, A.C. (1932), 'Birds at Quilpie, western Queensland', *Emu* **32**, 104-105.

- Carnaby, I.C. (1933), 'The birds of the Lake Grace district, W.A.', *Emu* **33**, 103-109.
- Carter, T. (1923), 'Birds of the Broome Hill district', *Emu* **23**, 125-142.
- Cayley, N.W. (1959), *What Bird is That?*, 3rd edn., Angus & Robertson, Sydney.
- Coates, B.J. (1985), *The Birds of Papua New Guinea, Vol. 1, Non-passerines*, Dove, Brisbane.
- Condon, H.T. (1973), *Field Guide to the Hawks*, Bird Observers Club, Melbourne.
- Cox, J.B. & Pedler, L.P. (1977), 'Birds recorded during three visits to the far north-east of South Australia', *S. Aust. Orn.* **27**, 231-250.
- Cramp, S. & Simmons, K.E.L. (1980), *Handbook of the Birds of the Western Palearctic*, vol. 2, Oxford University Press, Oxford.
- Cupper, J. & Cupper L. (1981), *Hawks in Focus*, Jaclin, Mildura.
- Czechura, G.V. (1979), 'Observations on quail-hunting strategies in some Australian raptors (Aves: Falconiformes)', *Sunbird* **10**, 59-66.
- (1980), 'Carriion utilization by two species of Australian goshawks', *Raptor Research* **14**, 62-63.
- (1981a), 'New records of harriers on Cape York Peninsula, Queensland', *Aust. Bird Watcher* **9**, 92-93.
- (1981b), 'Predation on a small colony of bats by an Australian Hobby, *Falco longipennis*', *Vic. Nat.* **98**, 200-203.
- & Debus, S.J.S. (1986), 'The Australian Hobby *Falco longipennis*: a review', *Aust. Bird Watcher* **11**, 185-207.
- Debus, S.J.S. (1982), 'Seasonal changes in raptor numbers near Sydney, New South Wales', *Aust. Birds* **16**, 60-61.
- Diggles, S. (1875), 'Birds of Australia — II', *Brisbane Courier* 27 March 1875, 7.
- Disney, H.J. de S. (1974), Brown Goshawk and Collared Sparrowhawk, in Lane, S.G. (Ed.), *Bird in the Hand*, 40-42, Aust. Bird Banders Assn, Sydney.
- Fletcher, J.A. (1918), 'Bird notes from Boat Harbour (Tasmania) district', *Emu* **18**, 96-101.
- Ford, H.A. & Bell, H. (1981), 'Density of birds in eucalypt woodland affected to varying degrees by dieback', *Emu* **81**, 202-208.
- Ford, J. (1986), 'Avian hybridization and allopatry in the region of the Einasleigh Uplands and Burdekin-Lynd Divide, north-eastern Queensland', *Emu* **86**, 87-110.
- Frauca, H. (1971), *Australian Bush Birds*, Lansdowne, Sydney.
- Frith, H.J. (1977), *Waterfowl in Australia*, Reed, Sydney.
- Goslow, G.E. (1971), 'The attack and strike of some North American raptors', *Auk* **88**, 815-827.
- Grant, P.J. (1983), 'Size-illusion', *Brit. Birds* **76**, 327-334.
- Hall, B.P. (Ed.) (1974), *Birds of the Harold Hall Australian Expeditions 1962-70*, British Museum of Natural History, London.
- Hankin, E.H. (1913), *Animal Flight: A Record of Observation*, Iliffe, London.
- Hayward, J. & McFarlane, N. (1971), 'Bird predators and a mouse plague', *Aust. Bird Watcher* **4**, 62-66.
- Henderson, D.G. & Green, R.H. (1982), 'Ageing and sexing endemic Tasmanian honeyeaters', *Corella* **6**, 44-45.
- Hindwood, K. (1966), *Australian Birds in Colour*, Reed, Sydney.
- Hobbs, J.N. (1961), 'The birds of south-west New South Wales', *Emu* **61**, 21-55.
- Hollands, D. (1984), *Eagles, Hawks and Falcons of Australia*, Nelson, Melbourne.
- Hood, J.B. (1935), 'Nesting, etc.', in the Bool Lagoon district, South East, S.A., *S. Aust. Orn.* **13**, 107-119.
- Hym, E.L. (1936), 'Notes on the birds of Mernot, Barrington, N.S.W.', *Emu* **36**, 109-127.
- Jones, S. (1979), 'The accipiters — Goshawk, Cooper's Hawk and Sharp-shinned Hawk', *Habitat Series for Unique or Endangered Species* **17**, 1-51.
- Keartland, G.A. (1896), 'Ornithological notes from central Australia. Part 1 — raptors', *Vic. Nat.* **13**, 58-63.
- Lea, A.M. & Gray, J.T. (1935), 'The food of Australian birds', *Emu* **34**, 275-292.
- Leach, J.A. (1958), *An Australian Bird Book*, 9th edn, Whitcombe & Tombs, Melbourne.
- Lenz, M. (1980), 'Bird report, 1 July 1978 to 30 June 1979', *Canberra Bird Notes* **5**, 2-23.
- Long, J.L. (1981), *Introduced Birds of the World*, Reed, Sydney.
- Macgillivray, W.D.K. (1918), 'Ornithologists in north Queensland. Part 3', *Emu* **17**, 180-212.
- Mason, I.J. (1976), 'Collared Sparrowhawk' and 'Brown Goshawk', in *Reader's Digest Complete Book of Australian Birds*, 1st edn, 123-125, Reader's Digest Services, Sydney.
- McGill, J.N. (1923), 'Birds of the Lake Frome district, South Australia. Part 2', *Emu* **22**, 274-287.
- (1934), 'The hawks of South Australia', *S. Aust. Orn.* **11**, 225-293.
- Metcalf, E.C. (1981), 'Collared Sparrowhawk: extracurricular activities?', *Canberra Bird Notes* **6**, 84-85.
- (1982), 'The nestling and post-fledging of a family of Collared Sparrowhawks', *Canberra Bird Notes* **7**, 48-53.
- , R. & Metcalf, E.C. (1986), 'Notes on a breeding pair of Collared Sparrowhawks: arrival to hatching', *Canberra Bird Notes* **11**, 114-120.
- Milledge, D. (1979), 'Notes on three species of hawk breeding on Middle Brother Mountain, N.S.W.', *Corella* **3**, 31-32.
- Mollison, B.C. (1961), 'The Collared Sparrowhawk at the kill', *Emu* **61**, 58-60.

- Mooney, N. (1982), 'Reasons for size differences within forest hawks', *Tas. Bird Report* 11, 4-11.
- (1984), 'Hawk lifts prey from water', *A'sian Raptor Assn News* 5, 33.
- (1986), 'Plight of a Sparrowhawk', *A'sian Raptor Assn News* 7, 35-36.
- Morris, F.T. (1973), *Birds of Prey of Australia*, Lansdowne, Melbourne.
- (1976), *Birds of Prey of Australia, A Field Guide*, Lansdowne, Melbourne.
- Mueller, H.C., Mueller, N.S. & Parker, P.G. (1981), 'Observation of a brood of Sharp-shinned Hawks in Ontario, with comments on the function of sexual dimorphism', *Wilson Bull.* 93, 85-92.
- Myers, K. & Poole, W. (1963), 'A study of the biology of the wild rabbit in confined populations. V. Population dynamics', *CSIRO Wildl. Res.* 8, 153-179.
- Newton, I. (1979), *Population Ecology of Raptors*, Poyser, Berkhamsted.
- (1986), *The Sparrowhawk*, Poyser, Calton.
- North, A.J. (1912), *Nests and Eggs of Birds Found Breeding in Australia and Tasmania*, Vol. 3, Australian Museum, Sydney.
- Olsen, J. & Olsen, P. (1983), 'Raptor prey selection', *A'sian Raptor Assn News* 4(3), 7-8.
- Olsen, P. (1981), 'Collared Sparrowhawk collecting twigs for nest', *Canberra Bird Notes* 6, 87.
- & Olsen, J. (1985), 'A natural hybridization of the Brown Goshawk *Accipiter fasciatus* and Grey Goshawk *Accipiter novaehollandiae* in Australia, and a comparison of the two species', *Emu* 85, 250-256.
- , Olsen, J. & Mooney, N.J. (1982), 'Growth and development of nestling Brown Goshawks *Accipiter fasciatus*, with details on breeding biology', *Emu* 82, 189-194.
- Opdam, P. (1980), *Feeding Ecology and Niche Differentiation in Goshawk *Accipiter gentilis* L. and Sparrowhawk *Accipiter nisus* L.*, Rijksinstituut voor Natuurbeheer, Leersum.
- Pizzey, G. (1980), *A Field Guide to the Birds of Australia*, Collins, Sydney.
- Price-Jones, H. (1983), *Australian Birds of Prey*, Doubleday, Sydney.
- Recher, H.F., Holmes, R.T., Schulz, M., Shields, J. & Kavanagh, R. (1985), 'Foraging patterns of breeding birds in eucalypt forest and woodland of southeastern Australia', *Aust. J. Ecology* 10, 399-419.
- Reynolds, R.T. & Meslow, E.C. (1984), 'Partitioning of food and niche characteristics of coexisting *Accipiter* during breeding', *Auk* 101, 761-779.
- Saunders, D.A., Smith, G.T. & Campbell, N.A. (1984), 'The relationship between body weight, egg weight, incubation period, nestling period and nest site in the Psittaciformes, Falconiformes, Strigiformes and Columbiformes', *Aust. J. Zool.* 32, 57-65.
- Schodde, R. & Tiedemann, S.C. (Eds) (1986), *Reader's Digest Complete Book of Australian Birds*, 2nd edn, Reader's Digest Services, Sydney.
- Sedgwick, E.H. (1947), 'Northern Territory bird notes', *Emu* 46, 294-308.
- (1952), 'Bird life at Leonora, Western Australia', *Emu* 52, 285-296.
- & Crosbie Morrison, P. (1949), 'Observations on the Lower Murchison RAOU Camp, September 1948', *Emu* 48, 212-242.
- Serventy, D.L. & Whittell, H.M. (1976), *Birds of Western Australia*, University of Western Australia Press, Perth.
- Sharland, M. (1958), *Tasmanian Birds*, Angus & Robertson, Sydney.
- (1981), *A Guide to the Birds of Tasmania*, Drinkwater, Hobart.
- Sherrill, S. (1978), 'Diets of some North American Falconiformes', *Raptor Research* 12, 49-121.
- Slater, P. (1961), 'Nesting of the Australian Goshawk (*Accipiter fasciatus*)', *Emu* 61, 134-136.
- (1962), *Western Australian Birds*, Mercantile Press, Perth, for BP Pty Ltd, Kwinana.
- (1970), *A Field Guide to Australian Birds, Non-Passerines*, Rigby, Adelaide.
- (1979), *The Observer's Book of Birds of Australia*, Methuen, Sydney.
- , Slater, P. & Slater, R. (1986), *The Slater Field Guide to Australian Birds*, Rigby, Sydney.
- Steyn, P. (1982), *Birds of Prey of Southern Africa*, David Philip, Cape Town.
- Stone, A.C. (1912), 'Birds of Lake Boga, Victoria', *Emu* 12, 112-122.
- Storr, G.M. & Johnstone, R.E. (1979), *Field Guide to the Birds of Western Australia*, W.A. Museum, Perth.
- Strahan, R. (Ed.) (1983), *The Australian Museum Complete Book of Australian Mammals*, Angus & Robertson, Sydney.
- Sutton, J. (1927), 'A week in the Robe district', *S. Aust. Orn.* 9, 5-29.
- Symon, O.S. (1948), 'A Sparrowhawk's breakfast', *S. Aust. Orn.* 18, 74-76.
- Taplin, R. (1982), 'Sparrowhawk enters house', *A'sian Raptor Assn News* 3(4), 15.
- (1983), 'Collared Sparrowhawk hunting', *A'sian Raptor Assn News* 4(3), 17.
- Thomas, R. & Wheeler, J. (1983), *Birds of the Ballarat Region*, Dominion Press, Maryborough.
- Tonge, W.C. (1925), 'Sparrow-hawks at home', *Vic. Nat.* 42, 4-5.
- Veerman, P. (1985), 'Report on the Prey Record Scheme', *A'sian Raptor Assn News* 6, 44-50.
- Wattell, J. (1973), 'Geographical differentiation in the genus *Accipiter*', *Publs Nuttall Orn. Club* no. 13.
- Wheelwright, H.W. (1861), *Bush Wanderings of a Naturalist* (facsimile, 1979), Oxford University Press, Melbourne.
- Wilson, G.W. (1982), 'Raptors preying on exotic birds at Healesville, Victoria', *A'sian Raptor Assn News* 3(4), 12-14.

that this book did not follow suit, as one has to flick back and forth between the text, plates and master map of zoogeographic regions. Although bird distribution is imperfectly known in New Guinea, 'spot' maps or shading would have been more meaningful than a list of regions inhabited.

Despite these few criticisms, this book is a most significant and welcome event in Australasian ornithology. The authors freely acknowledge that it is a first attempt and that revision will be required. This edition is nevertheless a vast improvement on earlier handbooks on the region, in the number of species illustrated and the information on voice, ecology and behaviour critical for field identification.

This guide will be of most use to bird-watchers residing in or visiting New Guinea, but it is also a very valuable introduction to the rich and interesting tropical component of the Australasian avifauna. I would highly recommend it to Australians, even those not intending to visit New Guinea, but for one major misgiving — the price! It is apparent that the book was produced mainly for the benefit of visiting Americans (as reflected in the spelling and the choice of English names for birds). The previous Wau Institute books on birds were printed in Hong Kong and published by the Institute for a few kina per copy (retail). This guide was entirely produced in the USA, with currency exchange rates and importing costs seriously disadvantaging residents of the region covered by the book. Harry Bell hoped that it would sell for about 20 kina and thus be within the means of the New Guinean people, a necessary precondition for them to become interested in their birds and thus motivated to conserve them. It is most unfortunate that this book was not produced locally for a price comparable to that of recent Australian guides of similar size, content and standard of production. For \$A60 one gets a very well produced book with weather-resistant binding and sewn signatures for durability in the field, but it is very expensive when compared with say the new *Slater Field Guide*. For the price of the beautifully produced hardback version one may as well buy Brian Coates' two magnificent volumes, illustrated with colour photographs and containing more biological information.

Birds of New Guinea is available through museum bookshops, Andrew Isles (Melbourne) or may be ordered from Princeton's Australian distributor: Cambridge University Press, 10 Stamford Road, Oakleigh, Victoria 3166. If you cannot afford it then at least try to borrow it from a library.

Stephen Debus

CORRIGENDA

Vol. 12 no. 2 'The Collared Sparrowhawk *Accipiter cirrocephalus*: a review and comparison with the Brown Goshawk *Accipiter fasciatus*': in Table 7 (p. 55), the last two columns under mean prey weight/body weight (%) should have been sub-headed 'male' and 'female'; in the discussion (2nd para, p. 58) the European Sparrowhawk's diet should read <1% pigeons (not <11%).