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Comparative Feeding Ecology of the Grey Goshawk *Accipiter novaehollandiae* and Brown Goshawk *Accipiter fasciatus*

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Summary

A comparison of the diet, foraging behaviour and morphology of the Grey Goshawk *Accipiter novaehollandiae* and Brown Goshawk *A. fasciatus* in south-eastern Australia shows that there is some niche partitioning by prey size, prey type and foraging habitat. Overlap in diet between the two species is about 50%. Grey Goshawks take larger prey and more mammals and often hunt through or just above the canopy, by making short flights from a perch. Brown Goshawks are both more terrestrial and more aerial than Grey Goshawks, stalking prey on the ground or by active chasing through the air. Similar trends are evident in intraspecific comparisons: females, particularly the female Grey Goshawk, take larger prey than do males. Competition may limit the Brown Goshawk's diet somewhat where the two goshawks are sympatric.

Introduction

Australia has two medium-sized goshawks, the Grey Goshawk *Accipiter novaehollandiae* and the Brown Goshawk *A. fasciatus*. Broadly, the breeding distribution of the Brown Goshawk completely overlaps that of the Grey Goshawk (e.g. Blakers et al. 1984). Although the Grey Goshawk prefers taller, more densely timbered habitats and the Brown Goshawk can tolerate drier, more open country (Olsen & Olsen 1985, Mooney & Holdsworth 1988), the two species are often sympatric.

When two goshawks live in the same area, they potentially compete for food and other resources. Typically, the diets of co-existing species of accipiter are related to body size: the smaller hawks capture smaller prey than the larger hawks (Storer 1966, Opdam 1975, Reynolds & Meslow 1984). Moreover, because females are larger than males, where a smaller species occurs with a larger species there are four body and prey size classes.

Differences in prey size and in morphology of the two Australian goshawks indicate some differences in foraging ecology and food niche (Olsen & Olsen 1985). This paper presents some new data on Grey Goshawk diet, foraging behaviour and morphology and compares them with those for the Brown Goshawk (see Czechura et al. 1987). Some comparison is also made with the remaining, and smallest, Australian accipiter, the Collared Sparrowhawk *A. cirrocephalus*.

Methods

Prey remains and pellets were collected from nests (breeding season), and identified from sightings of hawks with prey, gut contents from hawks found dead, and pellets from goshawks held overnight (non-breeding season) (by NJM for Tasmania and GVC for Queensland). Remains were identified to species where possible. A search of the Australian literature was collated with unpublished sightings (SD & PDO). Measurements of wild-caught goshawks and hunting observations in Tasmania were collected by NJM. Some data on the Brown Goshawk, and all data on the Collared Sparrowhawk, were extracted from Czechura et al. (1987).

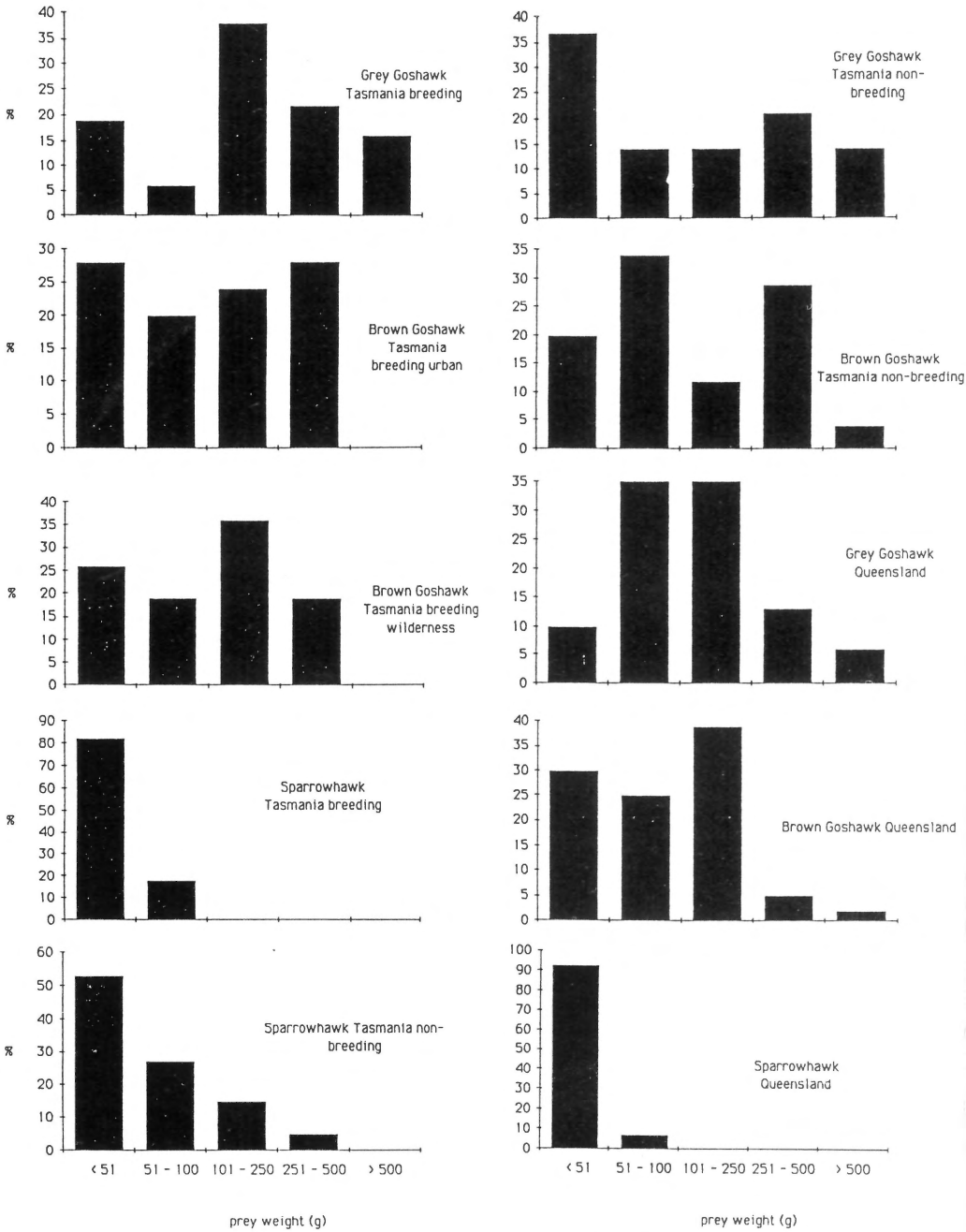


Figure 1. Distribution of prey weights (% in each weight class) of Grey Goshawk, Brown Goshawk and Collared Sparrowhawk in Tasmania and south-east Queensland. Vertebrate prey is divided into five weight classes.

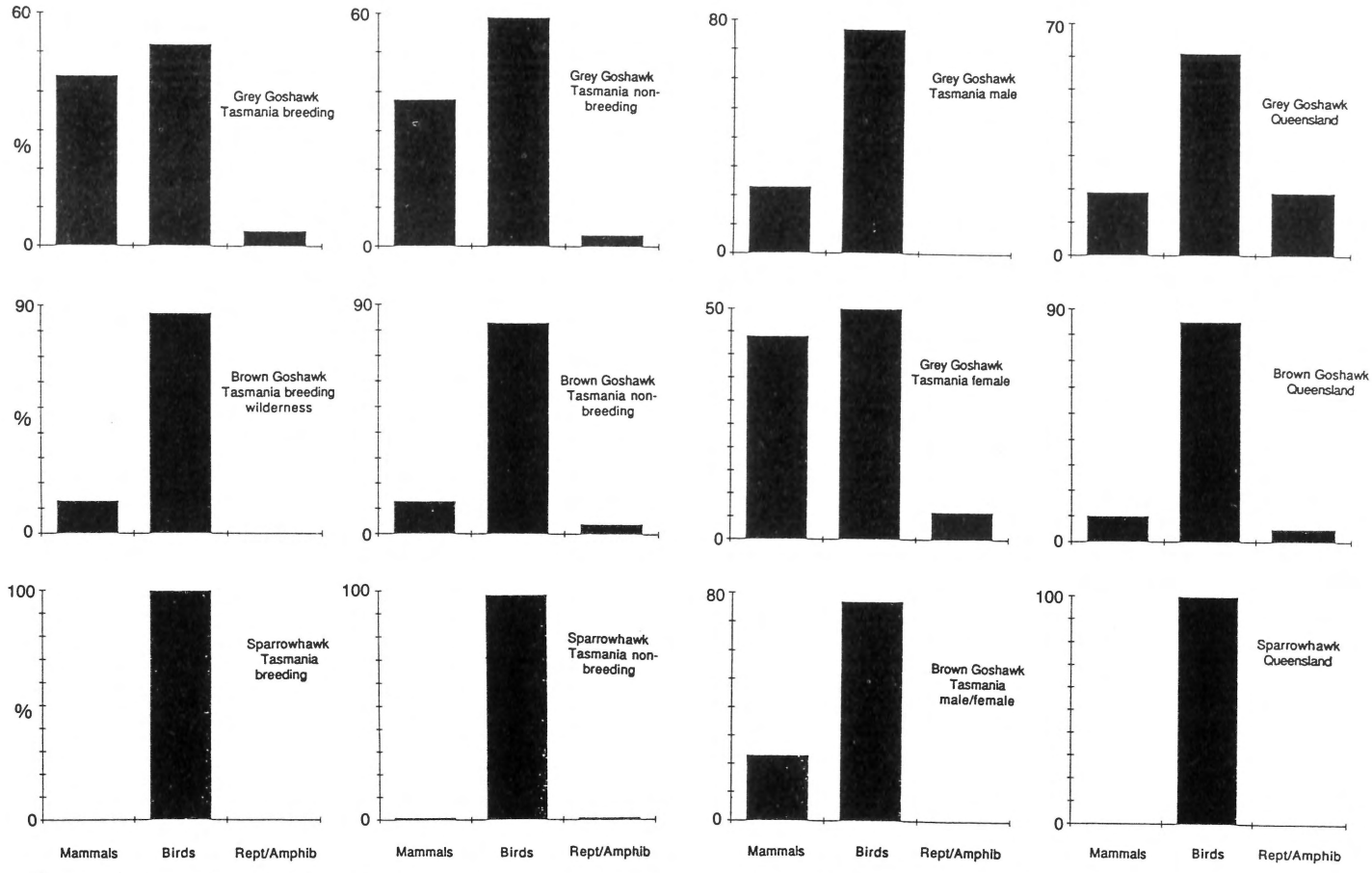


Figure 2. **Proportions (%) of vertebrate prey class (mammal, bird or reptile/amphibian) in the diet of the Grey Goshawk, Brown Goshawk and Collared Sparrowhawk in Tasmania and south-east Queensland.**

Diet

Interspecific differences

The Grey Goshawk is a generalist (Tables 1-3, Appendix 2) and takes a similar range of prey to the Brown Goshawk (Table 4, Appendix 3, and Czechura et al. 1987). Nevertheless, the Grey Goshawk takes more mammals and its vertebrate prey tends to be larger than that of the Brown Goshawk particularly during the breeding season (Figures 1, 2). At least in the non-breeding season, this dietary difference between the species is attributable mainly to the female Grey Goshawk; the diet of male Grey Goshawks tends to be more similar to that of Brown Goshawks (Figures 1, 2). However, in the breeding season, when males would be expected to be catching most of the prey, the prey of the Grey Goshawk is larger and contains more mammals than that of the Brown Goshawk. This indicates that male Grey Goshawks may switch to larger prey when breeding. Both species capture more small prey during the non-breeding season than while breeding (Figure 1).

The diet of both goshawks contains more birds and reptiles in Queensland than in Tasmania. Interspecific differences in foraging zone are evident, particularly in Queensland where the Grey Goshawk captures more canopy-feeding non-passerines (e.g. rainforest pigeons) than the Brown Goshawk which prefers ground-feeding passerines (Table 5). In Tasmania, however, the prey types and foraging zones of the two species are more similar. This is consistent with the greater dietary overlap between the two species in Tasmania than in Queensland (Table 6). In Queensland, the greater dependence of the Grey Goshawk on rainforest pigeons of the tree canopy, which are absent from Tasmania, accounts for much of the greater divergence in diet between the two species.

The general diet of the Grey Goshawk is similar in both the breeding and non-breeding seasons, with a slight decrease in mammals and corresponding increase in insects during the non-breeding period. Brown Goshawks make a much greater switch away from mammals and birds to more insects in the non-breeding season. The dietary overlap between the two species when not breeding is therefore even less than the 51% indicated in Table 6 which refers to vertebrate prey only.

Dietary diversity (Table 7) is greater in Grey Goshawks, that is, they catch more types (taxa) of prey, and those prey are more evenly represented in the diet, than in the diet of the Brown Goshawk.

The Collared Sparrowhawk, in both States, takes much smaller prey than the other two species and specialises on birds (Figure 2). Birds make up over 80% of the diet with insects the only other significant prey. As with the goshawks, birds are a bigger part of the diet in Queensland (perhaps an artefact of differences in sampling techniques and weather; for example, pellets made up of insects may deteriorate more rapidly in Queensland). Dietary overlap between the Sparrowhawk and the two goshawks is generally small. However, in Tasmania, Sparrowhawks take larger prey in the non-breeding season and their diet then overlaps significantly with that of the Brown Goshawk. Sparrowhawks have a very narrow functional niche, particularly in Queensland.

Intersexual differences

Male Grey Goshawks take more birds and smaller prey than females, which have a greater percentage of mammals in their diet and a greater average prey weight (Figures 1, 2). On the other hand, the sexes of the Brown Goshawk take similar prey taxa to each other; the male, however, takes smaller prey on average than the female. The

bimodal distribution of prey weights in both species (Figure 1) reflects the different prey sizes taken by the two sexes. In both species, females have been observed eating carrion about twice as often as males.

In the non-breeding season in Tasmania, the diet of the female Brown Goshawk overlaps equally with that of both the male Brown Goshawk and the male Grey Goshawk (Table 6). The female Grey Goshawk diet overlaps little with that of the Brown Goshawk. These relations reflect the size relationships between the goshawks, particularly, as well as some morphological differences.

Foraging

Primarily, both goshawks hunt from a perch. The Grey Goshawk hunts from a perch more often than the Brown Goshawk, and searches aerially or by stalking on the ground less often (Table 8). There are also intraspecific differences: female Grey Goshawks depend more on perch hunting than do males. In Tasmania, males (n=105) were first seen perched on 59% of occasions and females (n=203) on 74%. Males were rarely seen away from forest but the average distance females perched in the open away from forest was 45 m, suggesting a difference in habitat preference. Most individuals seen away from forest are juveniles. In Queensland, females are frequently seen patrolling forest margins or clearings (where Brown Cuckoo-Doves *Macropygia amboinensis* typically forage), peering into the trees. Chases through forest, by Grey Goshawks, sometimes occur and can be rapid over short distances. Grey Goshawks also use a slow, more buoyant, owl-like flight and glide (Macdonald 1973), from tree to tree.

Grey Goshawks raid the nests of other birds, e.g. Superb Lyrebird *Menura novaehollandiae*, and dreys of the Common Ringtail Possum *Pseudocheirus peregrinus*, flushing or dragging the prey from the nest.

Grey Goshawks use a glide attack more often than Brown Goshawks and female Grey Goshawks use it more than do males (Table 8). The Brown Goshawk uses more active attack methods (tail chase, direct flying attack) and shows no significant intersexual differences (Aumann 1988a).

Foraging success rates indicate that, for the Grey Goshawk, perch hunting is the most successful foraging method whereas more active foraging yields greater success for Brown Goshawks (Table 8). Adult Grey Goshawks are more successful hunters than juveniles: of 44 attacks by adults in Tamania, 48% were successful; of 19 attacks by juveniles, 16% were successful. Searches ended in capture of prey on 41% of 29 occasions for adults, and 14% of 21 searches by juveniles.

Morphology

The Grey Goshawk is larger and slightly more sexually dimorphic, in various body dimensions and weight, than the Brown Goshawk (Wattel 1973, Baker-Gabb 1984a, Olsen & Olsen 1985; see Figure 3). Grey Goshawks are also relatively more heavily armed than Brown Goshawks, with comparatively large, heavy beaks, legs and talons, especially female Grey Goshawks (Olsen & Olsen 1985; see Figure 3).

Although it has never been detailed, there appears to be a cline in body size in both species (larger birds in colder areas), and Tasmanian birds, particularly the Grey Goshawk, are larger than those on the mainland. Average weights for south-east mainland goshawks are about 361 g and 688 g for the Grey Goshawk (n=22, PDO), and 349 g and 561 g for the Brown Goshawk (n=203, Aumann 1988b). These weights give dimorphism indices (D.I. of cube root of body weight: Storer 1966) of 22 for the Grey Goshawk and 16 for the Brown. Tasmanian Brown Goshawks are more

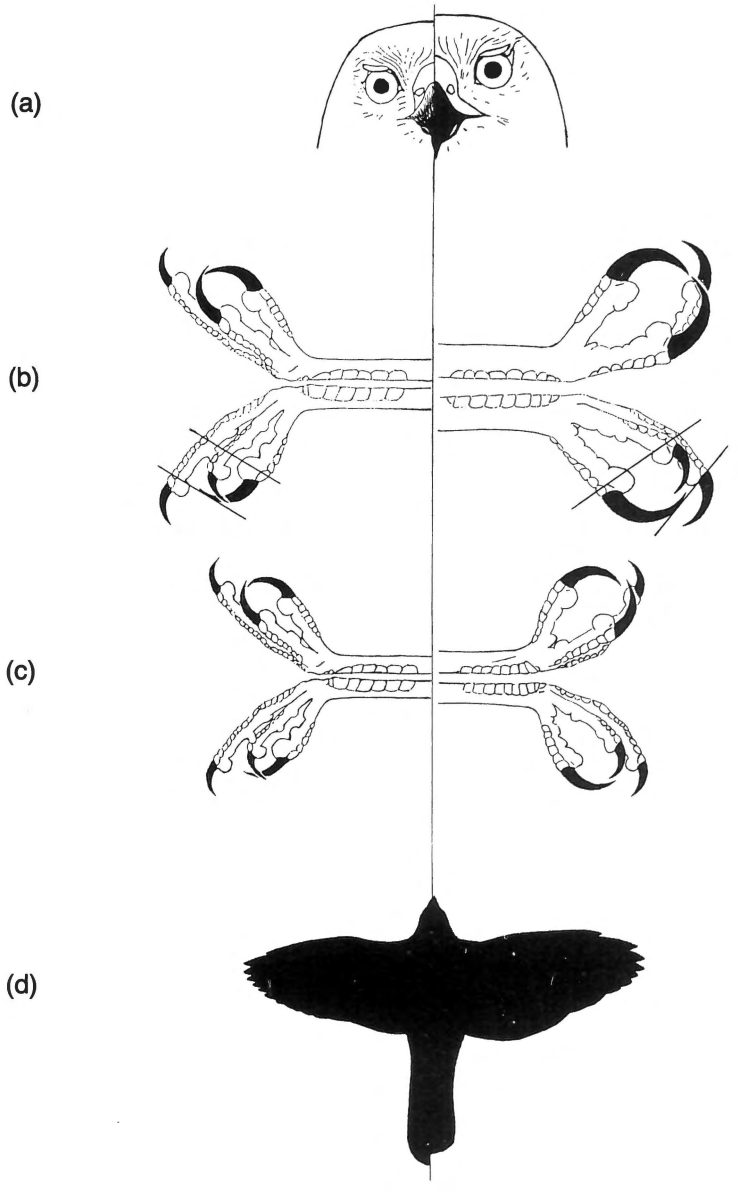


Figure 3. Anatomical differences between Brown Goshawk (left) and Grey Goshawk (right) to same scale.
A. Head and bill.
B-C. Inside (upper) and outside (lower) view of foot and tarsus, female (B) and male (C), from specimens.
D. Flight profile.

Drawing: N.J. Mooney

dimorphic than those on the south-eastern mainland, because of the relatively large size of the female (Appendix 1). Interestingly, Brown Goshawks in south-western Australia, where the Grey Goshawk does not occur, may also be more dimorphic (Aumann 1988b).

Wing length is very similar in the two species (Wattel 1973, Olsen & Olsen 1985, Appendix 1). Although there is a substantial difference in weight, wing loading is only slightly heavier for the Grey than the Brown Goshawk (Appendix 1); it is also lighter in first-year birds than in adults of both species. Wing loading is similar in the two goshawks because the greater weight of the Grey Goshawk is compensated for by an increase in wing area. The Grey Goshawk has a relatively longer forearm and secondaries (Olsen & Olsen 1985), and larger inner wing area compared with its outer wing area, than the Brown Goshawk (Appendix 1, Figure 4). The Grey Goshawk's relatively long, broad secondaries and short primaries and concave wing suggest greater buoyancy (lift), perhaps to allow a slower stalling speed than is possible for Brown Goshawks; useful for hunting in forest. On the other hand, the Brown Goshawk's relatively long, narrow, flat, pointed wings are probably an adaptation to life in open habitats (Wattel 1973). The wing of the Brown Goshawk has a higher aspect ratio than that of the Grey Goshawk (2.0 vs 1.7, estimated as wing length:wing breadth); a wing with a high aspect ratio is associated with high-speed flight. Both species are agile fliers, the Grey Goshawk possibly more so, and are capable of rapid flight.

The sexes of the Brown Goshawk are more alike morphologically than those of the Grey Goshawk. In both species, males tend to be comparatively longer-legged and have smaller beaks than females. Male Grey Goshawks also have relatively shorter tails and more pointed wings than females (Wattel 1973).

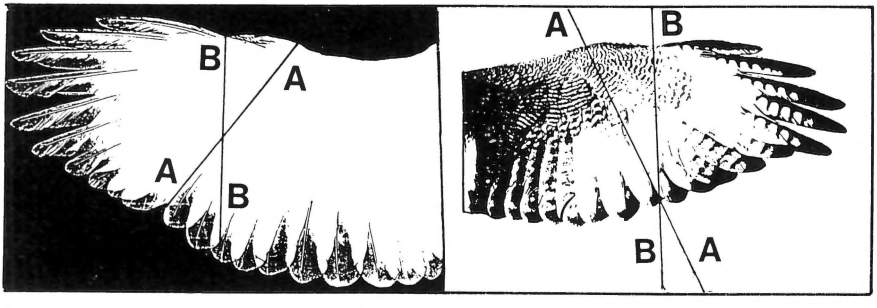
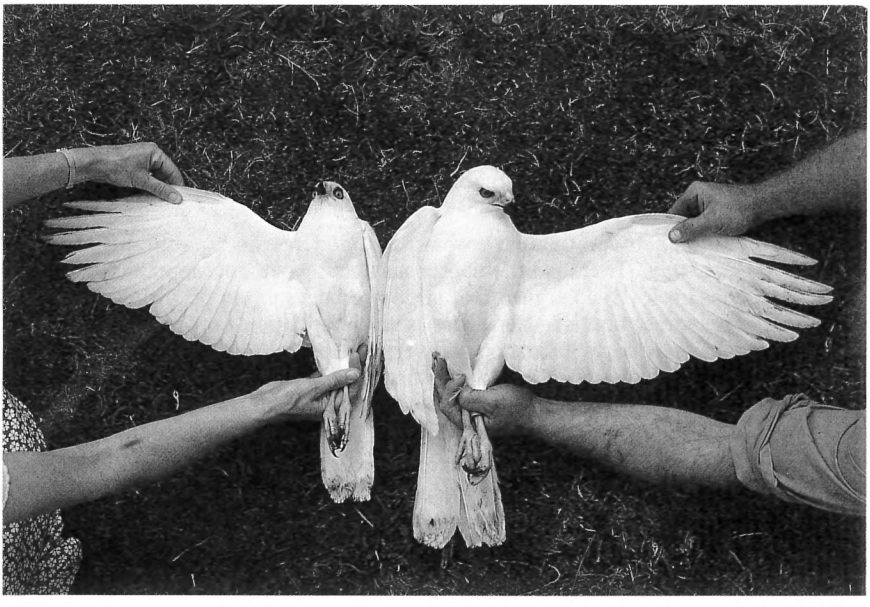


Figure 4. Right wing of female Grey Goshawk and left wing of male Brown Goshawk (photoreductions of specimens: NJM). Measurement lines (see Appendix 1): A-A between inner primary and outer secondary; B-B half way between base and tip of wing. See Czechura et al. (1987) for female Brown Goshawk.

Discussion

The differences in diet suggest some niche partitioning between the two goshawks. The larger hawks tend to take larger prey and more mammals whereas the smaller species tend to capture small birds and insects after more aerial pursuit. Size differences, and therefore differences in prey, are not as marked as those for some other accipiter complexes (e.g. Reynolds & Meslow 1984). The males of both species are quite close in weight but the male Grey Goshawk has more massive beak, legs and feet. There is little overlap in diet between either goshawk and the Collared Sparrowhawk, both



Size dimorphism and wing shape of Grey Goshawk: male (smaller) and female (larger)
Plate 45 Photo: N.J. Mooney

Camouflage of Grey Goshawk (white morph) perch hunting in pale-barked eucalypt, Tasmania
Plate 46 Photo: N.J. Mooney

sexes of which are smaller than the male Brown Goshawk, except in the non-breeding season when prey overlap with the Brown Goshawk is high. Sizes range from the substantial female Grey Goshawk through the female Brown Goshawk, male Grey Goshawk, male Brown Goshawk and female Sparrowhawk to the tiny male Sparrowhawk. The differences between their respective weights are not regular and seem to vary geographically. A study of geographic differences in size relationships between the three hawks (and two sexes) and dietary differences would provide interesting insights into prey-size/predator-size relationships.

Overlap in diet between the two goshawks is moderate in both the breeding and non-breeding seasons. There is little consensus about whether competition occurs in such situations. Lack (1946) argued that large overlaps in food occur when prey are not a scarce resource, that is, when there is no competition for food. On the other hand low overlap may be an indication of divergence through prior (in an evolutionary sense) competition (Lawlor 1980). Still another view is that high overlap may indicate that competition is occurring but may also be the result of an abundance of food being exploited without competition (Pianka 1973).

Changes in overlap may be more revealing about competition than degree of overlap, and seasonal or annual decreases in overlap are often associated with lean conditions (Perrins & Birkhead 1983). Breeding diet data were obtained for Brown Goshawks, in the absence of Grey Goshawks, in an urban habitat. Compared with Brown Goshawks nesting in wilderness, these urban goshawks seem to expand their dietary niche slightly into that typical of the Grey Goshawk. This indicates that, in the absence of competitive exclusion from Grey Goshawks, Brown Goshawks may be able to occupy a broader niche. The urban Brown Goshawk's dietary overlap with the wilderness Grey Goshawk's is 62%, greater than the 52% overlap between the two species in wilderness. Their dietary diversity is 0.87 (compared with 0.39 of Brown Goshawks and 1.13 of Grey Goshawks in wilderness), and prey size is greater (Figure 1), averaging 144 g for vertebrate prey and 97 g for avian prey (compared with 116/85, respectively for Brown Goshawks and 250/139 for Grey Goshawks in wilderness).

On Christmas Island (Indian Ocean) where there are no Grey Goshawks, a subspecies of the Brown Goshawk lives and hunts in rainforest. This also suggests some ability of the Brown Goshawk to expand into typical Grey Goshawk niche when the latter species is absent. There is, however, some suggestion that this subspecies is in fact a hybrid of the Brown Goshawk and Grey Goshawk (e.g. Olsen & Olsen 1985).

The larger Grey Goshawk appears dominant and may be aggressive towards Brown Goshawks. Adult female Grey Goshawks have been seen displacing adult female Brown Goshawks from a tree perch and from carrion (NJM) and a male Grey Goshawk was observed pungnaciously chasing a male Brown Goshawk (B. Mace pers. comm.). Male Grey Goshawks may also displace male Brown Goshawks from their territories and partners (see Hollands 1984 and Aumann 1988c for some evidence of this).

In Queensland there appears to be little overlap in diet between any of the three accipiters. This may have been an artefact of the sampling method but could reflect the greater diversity and abundance of prey species in more tropical areas.

Some separation of habitat is evident; in areas of sympatry Grey Goshawks prefer more closed forest for breeding than do Brown Goshawks. Brown Goshawks rarely hunt in temperate rainforest whereas Grey Goshawks commonly do (NJM). Grey Goshawks, juveniles especially, spend time wandering in open woodland (typical Brown Goshawk habitat) during the non-breeding season. Separation of habitat, if not diet, is less distinct in the non-breeding season.

Table 1

Breeding diet of the Grey Goshawk *Accipiter novaehollandiae* in Tasmania, 1980-1987: pellets and prey remains from two nests in wilderness (mixed rainforest, tall teatree heath, wet sclerophyll and some wetland) and one nest in semi-wilderness (mixed rainforest and wet sclerophyll, some improved pasture) (NJM). % = percent by number.

Species	*Age*	*Mean weight (g)*[a]	*n*	*%*
Short-beaked Echidna *Tachyglossus aculeatus*	imm.	c. 1000	1	1
Dusky Antechinus *Antechinus swainsonii*		53	1	1
Southern Brown Bandicoot *Isoodon obesulus*	ad.	775	1	1
	imm.	c.200	1	1
Eastern Barred Bandicoot *Perameles gunnii*	imm.	c.250	1	1
Common Ringtail Possum *Pseudocheirus peregrinus*	imm.	c.400	2	3
Long-nosed Potoroo *Potorous tridactylus*	imm.	c.500	1	1
Red-bellied Pademelon *Thylogale billardierii*	juv.	c.600	3	4
Water-rat *Hydromys chrysogaster*		691	1	1
Swamp Rat *Rattus lutreolus*		104	6	8
Black Rat *Rattus rattus*		280	3	4
House Mouse *Mus musculus*		17	3	4
Rabbit	ad.	1200	2	3
Oryctolagus cuniculus	imm.	400	2	3
Total mammals			28	37
White-faced Heron *Ardea novaehollandiae*		564	1	1
Cattle Egret *Ardeola ibis*		c.350	1	1
Lewin's Rail *Rallus pectoralis*		120	1	1
Masked Lapwing *Vanellus miles*		253	1	1
Brush Bronzewing *Phaps elegans*		206	3	4
Green Rosella *Platycercus caledonicus*		110	6	8
Fan-tailed Cuckoo *Cuculus pyrrhophanus*		50	1	1
Southern Boobook *Ninox novaeseelandiae*		c.200	1	1
Blackbird *Turdus merula*		87	2	3
Pink Robin *Petroica rodinogaster*		9	1	1
Olive Whistler *Pachycephala olivacea*		33	1	1
Superb Fairy-wren *Malurus cyaneus*		10	2	3
White-browed Scrubwren *Sericornis frontalis*		13	1	1
Brown/Tasmanian Thornbill *Acanthiza pusilla/ewingii*		c.10	2	3
Yellow-throated Honeyeater *Lichenostomus flavicollis*		29	2	3
Common Starling *Sturnus vulgaris*		75	1	1
Black Currawong *Strepera fuliginosa*		c.300	4	5
Unidentified passerines		100[b]	2	3
Total birds			33	44
Southern Blue-tongued Lizard *Tiliqua nigrolutea*	subad.	c.200	2	3
Emperor Gum Moth *Antheraea eucalypti*		3	2	3
Coleoptera		2	10	13
Total insects			12	16
Total prey items			75	100

[a]weight sources as in previous related papers (Czechura et al. 1987, Debus & Czechura 1988), plus Appendix 1 of Yom-Tov (1987).
[b]mean of identified passerines

Table 2

Non-breeding diet of the Grey Goshawk *Accipiter novaehollandiae* in Tasmania, showing prey partitioning by sex: pellets from roosts and trapped birds, prey remains (birds flushed from prey), gut contents and sight records (NJM). Data from breeding areas (Table 1), wet and dry sclerophyll forest and urban areas. For sex of hawk, M = male, F = Female, ? = unknown. % = percent by number.

Species	*Age*	*Mean weight (g)*[a]	*n taken by*			*Total*	*%*
			M	*F*	*?*		
Eastern Barred Bandicoot							
Perameles gunnii	ad.	640			1	1	
Common Ringtail Possum							
Pseudocheirus peregrinus	ad.	900			1	1	
Sugar Glider							
Petaurus breviceps		130			1	1	
Little Forest Eptesicus							
Eptesicus vulturnus		5			2	2	
Swamp Rat *Rattus lutreolus*		104			2	2	
Black Rat *Rattus rattus*		280		1		1	
House Mouse *Mus musculus*		17	1		2	3	
Brown Hare *Lepus capensis*	imm.	c.1500		1		1	
Rabbit	ad.	1200		2		2	
Oryctolagus cuniculus	imm.	400	2	2		4	
Cat *Felis catus*	imm.	c.800		1		1	
Total mammals			3	7	9	19	30
Cattle Egret *Ardeola ibis*		c.350		1		1	
Collared Sparrowhawk (female)							
Accipiter cirrocephalus		242			1	1	
Swift Parrot *Lathamus discolor*		65	1			1	
Green Rosella							
Platycercus caledonicus		110	2	1	1	4	
Shining Bronze-Cuckoo							
Chrysococcyx lucidus		23			1	1	
Tawny Frogmouth							
Podargus strigoides		374			1	1	
Laughing Kookaburra							
Dacelo novaeguineae		382		1		1	
Blackbird *Turdus merula*		87	1	1	1	3	
Golden Whistler							
Pachycephala pectoralis		25	1			1	
Grey Shrike-thrush							
Colluricincla harmonica		76		1		1	
Grey Fantail							
Rhipidura fuliginosa		8	1			1	
Superb Fairy-wren							
Malurus cyaneus		10	1	1		2	
Brown/Tasmanian Thornbill							
Acanthiza pusilla/ewingii		c.10	1		3	4	
European Goldfinch							
Carduelis carduelis		17	1	1		2	
House Sparrow							
Passer domesticus		25			1	1	
Common Starling							
Sturnus vulgaris		75	1			1	
Grey Butcherbird							
Cracticus torquatus		85			1	1	
Black Currawong							
Strepera fuliginosa		c.300		1		1	
Forest Raven *Corvus tasmanicus*		680			1	1	
Total birds			10	8	11	29	46
Frog sp.		5		1		1	2
Coleoptera		2	6	8		14	22
Total prey items						63	100
Carrion[b]							
Spotted-tailed Quoll							
Dasyurus maculatus				1		1	
Tasmanian Devil							
Sarcophilus harrisii			1	1		2	
Common Wombat							
Vombatus ursinus			1	1		2	
Brush-tailed Possum							
Trichosurus vulpecula			2	1		3	
Red-bellied Pademelon							
Thylogale billardierii				1		1	
Red-necked Wallaby							
Macropus rufogriseus				3		3	
Dog *Canis familiaris*				1		1	
Cat *Felis catus*			1			1	
Cattle *Bos taurus*				1		1	
Sheep *Ovis aries*				1		1	
Goat *Capra hircus*				1		1	
Brown Falcon *Falco berigora*			1			1	
Short-finned Eel							
Anguilla australis			1			1	
Blackfish							
Gadopis marmoratus				1		1	
Total			7	13		20	

[a]weight sources as in Table 1
[b]n = number of occasions recorded

Table 3

Diet of the Grey Goshawk *Accipiter novaehollandiae* in south-east Queensland. Breeding and non-breeding season combined: pellets, prey remains and sight records (GVC). % = percent by number.

Species	*Age*	*Mean weight (g)*[a]	*n*	*%*
Water-rat *Hydromys chrysogaster*		691	1	3
Fawn-footed Melomys *Melomys cervinipes*		c.80	3	10
Rattus sp. (*R. fuscipes*?)		125	2	6
Total mammals			6	19
Brown Quail *Coturnix ypsilophora*		95	1	3
Painted Button-quail *Turnix varia*		97	2	6
Topknot Pigeon *Lopholaimus antarcticus*		518	1	3
Brown Cuckoo-Dove *Macropygia amboinensis*		183	1	3
Australian King-Parrot *Alisterus scapularis*		235	1	3
Crimson Rosella *Platycercus elegans*		122	2	6
Pheasant Coucal *Centropus phasianinus*		366	1	3
Little Shrike-thrush *Colluricincla megarhyncha*		35	1	3
Grey Shrike-Thrush *Colluricincla harmonica*		61	1	3
Pied Currawong *Strepera graculina*		275	3	10
Unidentified birds		190[b]	5	16
Total birds			19	61
Eastern Water Dragon				
Physignathus lesueurii (?)	juv.	55[c]	1	3
Bearded Dragon *Pogona barbata*	juv.	55	1	3
Skink sp. *Sphenomorphus tenuis* (?)		18	1	3
Green Tree Snake *Dendrelaphis punctulatus*		90	1	3
Brown Tree Snake *Boiga irregularis*		90	1	3
Unidentified snake		20	1	3
Total reptiles			6	19
Total prey items			31	100
Carrion[d]				
Red-necked Pademelon *Thylogale thetis*			1	

[a]weight sources as in Table 1
[b]mean of identified birds
[c]reptile weights calculated from snout-vent lengths and formula in Pough (1980)
[d]n = number of occasions recorded

Table 4

Prey partitioning by sex in the Brown Goshawk *Accipiter fasciatus*, Tasmania 1978-1986: sight records, pellets from trapped birds and gut contents (NJM). M = male, F = female (data not included where sex of hawk unknown).

Species	*Age*	*Mean weight (g)*[a]	*n taken by*	
			M	*F*
Eastern Barred Bandicoot *Perameles gunnii*	ad.	640		1
Black Rat *Rattus rattus*		280	1	1
House Mouse *Mus musculus*		17	2	
Rabbit *Oryctolagus cuniculus*	ad.	1200		1
	imm.	400	1	2
Cat *Felis catus*	imm.	800		1
Total mammals			4	6
Peafowl *Pavo cristatus*[b]	imm.	400		4
Poultry *Gallus gallus*[b]	all ages	30-2000(600)		27
	imm.	250	2	
Common Pheasant *Phasianus colchicus*[b]	imm.	400		2
Feral Pigeon *Columba livia*		465	1	6
Common Bronzewing *Phaps chalcoptera*		303		1
Galah *Cacatua roseicapilla*		313	1	
Swift Parrot *Lathamus discolor*		65	1	1
Green Rosella *Platycercus caledonicus*		110		2
Eastern Rosella *Platycercus eximius*		110	1	1
Blackbird *Turdus merula*		87	2	3
Grey Fantail *Rhipidura fuliginosa*		8	1	
Superb Fairy-wren *Malurus cyaneus*		10	1	1
Yellow Wattlebird *Anthochaera paradoxa*		152		1
European Goldfinch *Carduelis carduelis*		17	2	
Common Starling *Sturnus vulgaris*		75	3	4
Grey Butcherbird *Cracticus torquatus*		85		1
Total birds			13	21
Coleoptera		2	2	3
Wolf spiders (Lycosidae)		2	1	1
Total arthropods			3	4
Total prey items			20	31
Carrion[c]				
Brush-tailed Possum *Trichosurus vulpecula*			1	4
Red-bellied Pademelon *Thylogale billardierii*			2	1
Red-necked Wallaby *Macropus rufogriseus*			1	2
Cattle *Bos taurus*				1
Sheep *Ovis aries*			1	2
Brown Trout *Salmo trutta*			1	1
Total			6	11

[a]weight sources as in Table 1
[b]excluded from analyses because these records derive from complaints to the Tasmanian Department of Parks, Wildlife & Heritage, and would bias results
[c]n = number of occasions recorded

Table 5

Taxonomic group (passerine versus non-passerine), main foraging zone (ground/understorey v canopy) and habitat (open versus forest/dense cover) of avian prey of the Grey Goshawk and Brown Goshawk in areas of sympatry (summarised from Tables 1-4 this study, Tables 4-5 of Czechura et al. 1987).

Species	*Avian prey (% by no.)*					
	passerine or non-passerine		*g/u or canopy*		*open or forest*	
Grey Goshawk:						
Tasmania						
breeding	55	45	55	45	12	88
non-breeding	66	34	52	48	21	79
male only	70	30	50	50	20	80
female only	63	37	50	50	25	75
Queensland						
(all records)	36	64	29	71	7	93
Brown Goshawk:						
Tasmania						
breeding						
(wilderness)	46	54	73	27	15	85
non-breeding	53	47	79	21	57	43
male only	69	31	85	15	62	38
female only	48	52	76	24	52	48
Queensland						
(all records)	63	37	79	21	65	35

Table 7

Diet diversity, calculated according to Shannon's Index (Shannon & Weaver 1949) using low dietary resolution as recommended by Greene & Jaksić (1983). A higher number indicates a broader functional niche than a lower number.

Species	*Tasmania Breeding*	*Tasmania Non-breeding*	*Queensland All records*
Grey Goshawk	1.13	1.13	0.94
Brown Goshawk	0.39 (wilderness)	0.99	0.82
Collared Sparrowhawk	0.49	0.48	0

Table 6

Dietary overlap calculated according to the method of Pianka (1973) using the vertebrate prey (from similar habitats) in this paper and Czechura et al. (1987).

Interspecific comparisons:	*Tasmania*		*Queensland*
	Breeding	*Non-breeding*	*All Records*
Grey Goshawk vs Brown Goshawk	52%	51%	23%
Brown Goshawk v Collared Sparrowhawk	29%	70%	32%
Grey Goshawk vs Collared Sparrowhawk	17%	32%	5%

Intersexual comparisons, Tasmania, non-breeding season:

	Male Grey	Female Grey	Male Brown	Female Brown
Male Grey Goshawk	—	58%	64%	50%
Female Grey Goshawk		—	31%	33%
Male Brown Goshawk			—	65%
Female Brown Goshawk				—

Brown Goshawk:

(Brown) urban vs (Brown) wilderness 75%	Grey (wilderness) vs Brown (urban) 62%

Table 8

Search and attack methods of the Brown Goshawk and Grey Goshawk. Sources: Baker-Gabb 1984b (Brown Goshawk 1, woodland/open); Aumann 1988a (Brown Goshawk 2, woodland/open); NJM (Grey Goshawk, Tasmania, mainly forest). PH=perch hunting, SP=soaring and prospecting, FC=fast contour hunting, Fl=flushing from cover, G=ground hunting and stalking. D=dive attack, G=glide attack, DF=direct flying attack, TC=tail chase, P=pounce and snatch. Success rates (%) are underlined.

Species/sex	*Search method (%)*						*Attack method (%)*					
	PH	*SP*	*FC*	*Fl*	*G*	*n*	*D*	*G*	*DF*	*TC*	*P*	*n*
Brown Goshawk (1)	63	20	17	0	0	24						
Brown Goshawk (2)	44	8	19	6	23	52	0	17	50	11	22	54
	39	50	30	33	33							
Grey Goshawk												
male	63	13	19	0	6	16	14	29	36	14	7	14
	39	50	30	0	0		50	50	20	50	0	
female	80	5	5	5	0	34	3	57	20	10	10	30
	31	0	0	20	0		0	41	17	0	66	

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Appendix 1

Comparative morphological data for the Grey Goshawk and Brown Goshawk in Tasmania (live-trapped and fresh museum specimens: NJM). Adults are >1 year old.

Species	*Weight (g)*				*Wing loading (g/sq. cm)*				*Wing length (mm)*	*Wing area ratio*[a]
	$\bar{x}$	*range*	*s.d.*	*n*	$\bar{x}$	*range*	*s.d.*	*n*	$\bar{x}$	*A/B*
Grey Goshawk:										
juvenile male	376	254-445	51.4	14	0.38	0.35-0.42	0.08	8		
adult male	415	380-470	20.4	9	0.43	0.40-0.44	0.05	6		
all ages	391				0.40				260	1.66/1.70
juvenile female	774	515-1050	106.4	24	0.50	0.47-0.54	0.07	11		
adult female	797	740-835	42.8	5	0.56	0.52-0.58	0.06	3		
all ages	778				0.51				310	1.57/1.55
Brown Goshawk:										
juvenile male	348	250-410	49.3	8	0.37	0.34-0.39	0.08	4		
adult male	351	250-415	43.9	14	0.41	0.38-0.43	0.06	7		
all ages	350				0.40				263	1.09/1.61
juvenile female	581	550-715	64.5	23	0.44	0.40-0.50	0.08	21		
adult female	614	465-740	86.9	15	0.54	0.50-0.55	0.10	10		
all ages	594				0.47				301	0.95/1.51

[a]proximal:distal ratio (see Figure 4)

Appendices 2 and 3

Appendix 2, additional records of vertebrate prey species of the Grey Goshawk in Australia and Appendix 3, additional prey records of the Brown Goshawk from within the Australian range of the Grey Goshawk, are available from the second author (Debus) as an accessory publication which will be printed in *Australasian Raptor Association News* **11(2)**, June 1990, 23-29.