SHORT COMMUNICATIONS

A NATURAL HYBRIDIZATION OF THE BROWN GOSHAWK *ACCIPITER FASCIATUS* AND GREY GOSHAWK *ACCIPITER NOVAEHOLLANDIAE* IN AUSTRALIA, AND A COMPARISON OF THE TWO SPECIES

There are two medium-sized goshawks in Australia, the Grey Goshawk *Accipiter novaehollandiae novaehollandiae*, and the more southern form of the Brown Goshawk *Accipiter fasciatus fasciatus*. Both these subspecies are probably endemic to Australia, and belong to species confined to the Australasian region.

The Grey Goshawk has two colour morphs, grey and white. It nests in subcoastal and coastal eastern and northern Australia, and Tasmania, whilst the Brown Goshawk nests throughout Australia.

Wattel (1973), in his study of the genus *Accipiter*, considered that *fasciatus* and *novaehollandiae* were geographically and ecologically complementary forms, and that because of this, and their morphological similarity, they had evolved from a common ancestor. Differences in plumage and structure, and overlap in range, indicated to him that they had been separated as species for a long time.

The subsequent finding of at least one successfully hybridising pair in the wild at Orbost, Victoria, a male *novaehollandiae* (white morph) with a female *fasciatus* (Cupper 1976; Hollands 1984), has lent support to Wattel's (1981) conclusion that they are close relatives. A hybrid female, one of the progeny of this wild pair, was taken into captivity soon after fledging. She died at three years of age before her fertility had been verified (Cupper & Cupper 1981).

Interspecific hybrids, at least some of which were fertile, have been recorded in a number of birds of prey, both in the wild (Gray 1958; Murray 1970) and in captivity (Cade & Weaver 1976). This paper reports on some of the morphological and behavioural characteristics of the hybrid female *novaehollandiae* × *fasciatus*, particularly in relation to those of the parent species. The parent species are examined, according to two of the conventional characteristics of species — morphological distinctness and ecological difference (Mayr 1963).

METHODS

The hybrid female was measured and photographed at about six months of age, that is, in first-year plumage. Subsequent photographs and, after her death, her skin (National Museum of Victoria No. B 12562) and some of her skeletal remains were examined. For comparative purposes a series of museum skins of Brown Goshawk and Grey Goshawk from south-eastern Australia were also measured and examined.

The distance from the tip of the longest primary (number four in each species) to the tip of primaries 1, 2, 3, 5, 6, 7 and 8 (numbered outermost to innermost) is referred to as wt 1 to wt 8 respectively; length of the carpometacarpus was from the carpal joint to the distal end of the carpometacarpus; distance from the tip of the longest (central) rectrix to the tip of the first (outer) and second rectrices is referred to as tt1 and tt2 respectively; tarsal width was the distance between the lateral surfaces, approximately mid-tarsus, and tarsal depth the distance between the anterior and posterior surfaces; claw depth was the distance between the upper and lower surface at the widest point; beak depth was the chord from the top of the beak at the point of emergence from the cere to the base of the upper mandible at the widest point; cere length was taken from the edge of the feathers to the distal rim; other measurements are according to Biggs *et al.* (1977) and Wattel (1973). It should be noted that the wing was not flattened, and that some measurements can only be regarded as approximations due to variability in shrinkage of the skins. The number of bars (where present) on the inner edge of rectrix four and five was counted as were the number of rectangular (scutellate) scales on the tarsus and upper surface of the mid-toe. Wing loading index was calculated according to (a) Temple (1972) and (b) Greenewalt (1962). Interspecific differences in (mensural) morphology were tested for significance using analysis of variance.

RESULTS AND DISCUSSION

Characteristics of hybrid and comparison with parent species

Colour

Adequate descriptions and illustrations of the colours of the parent species are given in Brown & Amadon (1976), Wattel (1973) and Mason (1976), and will not be repeated here except to exemplify differences or similarities with the hybrid (Table I). The colours of the hybrid are described according to Kornerup & Wanscher (1963). However, the plumage had a rich, silvery lustre not adequately described by their terminology. It should be noted that the colour of soft parts can be affected by diet.

(i) First-year (see colour plates, Cupper & Cupper 1981, pp 152–3): Dorsal surface medium grey with very slight, pale rufous tinge to edge of scapulars and wing coverts, and to edge of collar. Typical accipitrid, cryptic, triangular white spot on upper nape. Remiges: medium grey, darker near shaft; shaft dark. Rectrices: medium grey with definite, dark grey bars, very slight

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TABLE I

A comparison of, mostly qualitative, characters that differ between fasciatus *and* novaehollandiae, *with those of the hybrid. For* novaehollandiae, *plumage colours refer to the grey morph. The final column indicates which subspecies the hybrid most resembles for that character: f =* fasciatus, *n =* novaehollandiae. *a. same in first year plumage; b. relative lengths of outer six primaries numbered ascendantly — arrows indicate alternate order; c. outer rectrix relatively short in Brown Goshawk (Fig. 2).*

	fasciatus	hybrid	*novaehollandiae*	Hybrid resembles
Adult:				
Dorsal surface:				
general colour	dark grey-brown	dark grey	medium-dark grey	n
collar	rufous	slightly rufous	absent	f
Ventral surface:				
chin	marked, coloured	unmarked, white-pale grey	unmarked, white	n
barring	medium grey + rufous	med. grey + pale rufous	medium grey	—
chest bar width (max.)	>3 mm	>3 mm	>3 mm	n
lower abdomen, venter, under tail coverts and leggings	barred, coloured	unmarked, white-pale grey	unmarked, white	n
Iris	yellow	yellow	red	f
Cere, base of mandible, legs[a]	variable yellow-grey (sometimes greenish)	deep yellow	chrome yellow	n
Orbit[a]	pale grey or yellow	pale grey	deep yellow	f
Lips[a]	grey	yellow	chrome yellow	n
First year:				
Dorsal surface:				
general colour	brown + rufous	medium grey, slight pale rufous wash	medium-dark grey some with slight pale rufous wash	n
Ventral surface:				
chin	relatively heavy vertical streaks	fine vertical streaks, heavier medial line	white mottled with grey	—
crop markings	relatively large, more or less vertical	mainly horizontal	mainly horizontal	n
Iris (3 month old +)	yellow	yellow	yellow-apricot	f
Nestling:				
Mesoptile down	pale salmon	white	white	
Wing formula[b]	1 <6 <2 <3 <5 <4	1 <2 <6 <5 <3 <4	1 <2 <6 <3 <5 <4	—
Distance T5 to T6	long	short	short	n
Step in tail[c]	yes	yes	no	f
Cere	see figure	most like *fasciatus*	see figure	f
Stance	often 'splay-legged'	often 'splay-legged'	straight-legged	f
Underside of shaft:				
remiges	dark	dark	white	f
rectrices	dark or light barred dark	white-pale grey	white	n
No. bars inner edge rectrice 4, 5	*c.* 15+	15–16	*c.* 12	f
No. tarsal scutes	usually 16+	16	usually 13–14	f
No. midtoe scutes	20+	20–21	<20, usually 17	f

pale rufous tint in lighter areas near shaft; tips light grey with pale rufous tinge; shaft dark.

Ventral surface white to pale grey. Chin white-pale grey with fine, vertical, grey streaks, thicker grey medial line. Other markings medium grey washed pale rufous in the centre. Markings largely horizontal, heart shaped on crop grading into narrower m shape on chest and upper abdomen, the latter becoming finer and disappearing into the white to pale grey, unmarked lower abdomen and venter. Inner tarsus, lower leggings and under tail coverts white. Remiges and rectrices pale grey darkening to medium grey at tips, barred medium grey on proximal half; shafts white.

Iris at six months light chrome yellow; cere, "lips", and legs pale yellow with slight grey tinge; orbit light grey; talons and beak glossy black.

(ii) Adult (three year old) — differs from first-year as follows: Dorsal surface medium to dark grey. Remiges dark grey faintly barred on proximal inner edge. Rec-

trices medium-dark grey barred dark grey; barring barely visible and incomplete on central rectrices and on outer edges of the remaining rectrices, more obvious on inner edges.

Ventral surface with narrow horizontal bars, increasing in width from the neck to the chest (widest 2.5 mm), then decreasing to disappear into the white-pale grey, unmarked lower abdomen and venter. Bars mainly pale greying rufous (upper half) and medium grey (lower half), faint rufous edged with grey on flanks, pale rufous slightly washed with grey on leggings, and grey on the abdomen. Chin white-pale grey. Remiges light grey darkening to outer edge and tip, with faint broken bars on proximal inner edges, shaft dark. Rectrices light grey, faintly barred medium grey especially on inner edges; shaft white. Iris orange-yellow, cere and legs deep yellow.

Morphology

The hybrid shows a number of similarities to both parent species, most notably *novaehollandiae*, and is intermediate in some characters (Tables I and II, Fig. 1).

TABLE II

Measurements of adult female fasciatus, novaehollandiae *and the hybrid (mean ± S.E.).* P *is the significance of the difference between* fasciatus *and* novaehollandiae. *Number of specimens was 15* fasciatus *(8 for weight) and 17* novaehollandiae *(11 for weight).*

Measurement	Absolute measurements (cm)				As % of cube root of body weight			
	Hybrid	*fasciatus*	*novaehollandiae*	*P*, <	Hybrid	*fasciatus*	*novaehollandiae*	*P*, <
weight (g)	690	509.5 ± 6.9	688.0 ± 12.6	0.001	—	—	—	
wing length	30.6	30.0 ± 0.2	30.2 ± 0.1	ns	346.2	375.1 ± 2.4	344.0 ± 2.1	0.001
wing shape: wt — 1	8.5	9.0 ± 0.1	8.2 ± 0.1	0.001	—	—	—	
wt — 2	—	3.7 ± 0.2	3.1 ± 0.1	0.01	—	—	—	
wt — 3	0.3	0.5 ± 0.1	0.5 ± 0.03	ns	—	—	—	
wt — 5	0.7	0.5 ± 0.1	0.3 ± 0.1	0.05	—	—	—	
wt — 6	2.7	4.4 ± 0.2	1.7 ± 0.2	0.001	—	—	—	
wt — 7	5.3	6.5 ± 0.2	4.0 ± 0.2	0.001	—	—	—	
wt — 8	6.7	7.9 ± 0.1	5.5 ± 0.1	0.001	—	—	—	
secondaries (length)	24.0	21.8 ± 0.1	24.2 ± 0.3	0.001	271.5	272.3 ± 1.4	278.9 ± 2.5	0.05
radius/ulna (r-u)	10.3	9.0 ± 0.03	10.3 ± 0.1	0.001	116.6	112.8 ± 0.5	117.6 ± 1.0	0.001
carpo-metacarpus (c-m)	5.0	4.9 ± 0.03	5.1 ± 0.04	0.001	56.6	61.2 ± 0.4	57.9 ± 0.5	0.001
tail length	24.0	23.6 ± 0.3	22.4 ± 0.2	0.01	271.6	298.4 ± 3.3	258.7 ± 1.8	0.001
width inner rectrix	4.00	3.73 ± 0.06	4.08 ± 0.06	0.001	—	—	—	
tail shape: tt — 1	3.3	2.6 ± 0.1	1.5 ± 0.1	0.001	—	—	—	
tt — 2	1.7	1.6 ± 0.1	1.0 ± 0.1	0.001	—	—	—	
tarsus: length	8.28	8.29 ± 0.06	8.18 ± 0.06	ns	93.7	104.6 ± 0.6	93.4 ± 0.7	0.001
depth	0.83	0.77 ± 0.02	0.94 ± 0.02	0.001	9.4	9.3 ± 0.1	10.5 ± 0.1	0.001
breadth	0.58	0.53 ± 0.02	0.66 ± 0.01	0.001	6.6	6.2 ± 0.1	7.5 ± 0.1	0.001
toe length: hind	2.55	2.22 ± 0.03	2.65 ± 0.04	0.001	28.9	27.7 ± 0.3	29.6 ± 0.6	0.05
inner	2.80	2.48 ± 0.02	2.99 ± 0.03	0.001	31.7	31.1 ± 0.1	33.8 ± 0.5	0.001
mid	4.84	4.38 ± 0.04	4.84 ± 0.03	0.001	54.8	54.1 ± 0.4	54.1 ± 0.4	ns
outer	3.30	3.11 ± 0.04	3.41 ± 0.03	0.001	37.3	38.1 ± 0.3	38.3 ± 0.3	ns
claw length: hind	2.85	2.28 ± 0.03	2.81 ± 0.03	0.001	32.2	28.6 ± 0.3	31.6 ± 0.1	0.001
inner	2.65	2.21 ± 0.03	2.65 ± 0.02	0.001	30.0	27.7 ± 0.4	30.1 ± 0.3	0.001
mid	2.10	1.70 ± 0.02	1.97 ± 0.02	0.001	23.8	20.9 ± 0.2	22.3 ± 0.3	0.001
outer	1.63	1.55 ± 0.03	1.74 ± 0.02	0.001	18.4	19.7 ± 0.3	19.7 ± 0.1	ns
claw depth: hind	0.56	0.50 ± 0.01	0.65 ± 0.01	0.001	6.3	6.0 ± 0.1	7.1 ± 0.1	0.001
inner	0.56	0.50 ± 0.01	0.65 ± 0.01	0.001	6.3	6.0 ± 0.1	7.3 ± 0.1	0.001
mid	0.46	0.37 ± 0.01	0.47 ± 0.01	0.001	5.2	4.5 ± 0.05	5.1 ± 0.1	0.001
outer	0.37	0.35 ± 0.01	0.44 ± 0.01	0.001	4.2	4.4 ± 0.03	4.8 ± 0.1	0.001
head (skull) width	3.41	3.57 ± 0.04	3.84 ± 0.05	0.001	38.6	44.5 ± 0.5	44.1 ± 0.4	ns
cere	1.08	0.94 ± 0.03	1.26 ± 0.02	0.001	12.2	12.2 ± 0.3	14.5 ± 0.2	0.001
beak: length	2.35	1.91 ± 0.02	2.26 ± 0.02	0.001	26.6	24.0 ± 0.2	25.9 ± 0.3	0.001
depth	1.35	1.17 ± 0.01	1.41 ± 0.02	0.001	15.3	14.5 ± 0.1	15.9 ± 0.2	0.001
'lips' (gape)	3.30	3.02 ± 0.03	3.41 ± 0.03	0.001	37.3	37.9 ± 0.2	38.7 ± 0.2	0.05
total claws/weight	1.34	1.52 ± 0.03	1.34 ± 0.03	0.001				
wing loading index a	0.289	0.267 ± 0.002	0.291 ± 0.002	0.001				
b	0.55	0.42	0.56	0.001				
tail/wing %	78.4	78.9 ± 0.9	74.4 ± 0.6	0.001				
secondaries/wing %	78.4	72.9 ± 0.5	80.1 ± 1.1	0.001				
r-u/wing %	33.7	30.2 ± 0.2	34.3 ± 0.2	0.001				
c-m/wing	16.3	16.3 ± 0.1	16.8 ± 0.1	0.01				

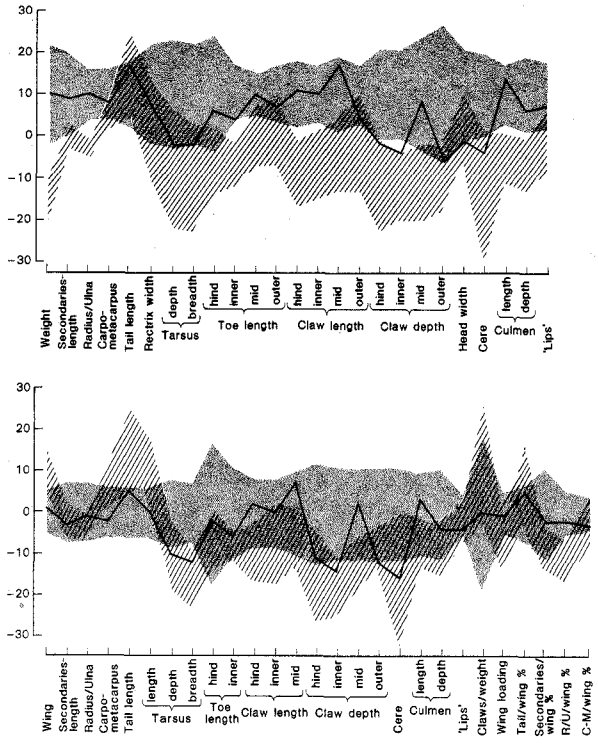

Figure 1. Values for various body measurements of the hybrid (continuous line), using female *novaehollandiae* as a standard (i.e. mean of *novaehollandiae* equal to 0). 95% confidence limits shown for *novaehollandiae* (dotted area) and *fasciatus* (striped area): a. absolute measurements (top); b. derived values (bottom).

For most absolute measurements there are significant differences between *fasciatus* and *novaehollandiae*, the exceptions being wing length, wt 3 and tarsal length. However, *novaehollandiae* is a more massive bird, evidenced here by its greater weight, so that differences relative to body weight are probably more meaningful for making comparisons with the hybrid.

The weight of the hybrid was taken in captivity and so may have been different from that had she been wild, although she was not excessively fat. Her weight (690 g) was similar to that of Victorian female *novaehollandiae*. However, wild female *fasciatus* have been trapped at weights of at least 700 g (Baker-Gabb 1984).

The hybrid female is most like *novaehollandiae* in body proportions, having relatively short wings, short tarsi, long narrow beak, and long claws (the latter two could be influenced by captivity). However, her tarsi and some claws are relatively narrow, like those of *fasciatus*, and the number of tarsal and mid-toe scutellations are similar to those of *fasciatus*. In addition, her tail tends to be relatively long, lying within the 95% confidence limits for *novaehollandiae* but reaching the lower limit for *fasciatus* (Fig. 1). It has a similar number of dark bars to that of *fasciatus* (Table I) and relatively short outer rectrices like *fasciatus* (Table I and II, Fig. 2). The cere of the hybrid is like *fasciatus* in length (Fig. 1) and most like *fasciatus* in shape (Fig. 2), although the facial (rictal) bristles tend to cover the "lips" less, as in *novaehollandiae* (Fig. 2).

The inner wing (antebrachial length) of *novaehollandiae* is relatively long compared with that of *fasciatus*. However, the outer wing (carpometacarpus) and primaries are relatively short. This, coupled with relatively long secondaries, a tendency for broader feathers, slightly curved primaries with more extensive buckling on their inner edges, and different relative lengths of the primaries (Table II, Fig. 2) produces a relatively short, rounded wing with greater camber in *novaehollandiae* (Fig. 2). In these characters, and wing-loading, the hybrid is most like *novaehollandiae*.

Other characteristics of the hybrid lay within the 95% confidence limits of both species and so could be considered intermediate (Fig. 1).

General appearance

In silhouette, the Grey Goshawk appears broader than the Brown Goshawk and stands squarely on its solid legs, whereas the Brown Goshawk tends to splay its relatively long thin legs (Fig. 2). The hybrid was similar in general appearance to a Grey Goshawk, but with legs and stance more like those of a Brown Goshawk.

Voice

Both parent species appear to use similar 'accipitrid' calls. However, their calls differ qualitatively. Those of the Grey Goshawk are more resonant and drawn out whilst those of the Brown Goshawk are more staccato.

The alarm call (i.e. that made when disturbed, in this case, by man) of the Grey Goshawk is about 0.5 Hz higher than, and each note is more than twice as long as that of the Brown Goshawk (Fig. 3a). The call of the Grey Goshawk is also less complex (Fig. 3b). The hybrid's alarm call is very similar to that of the Grey Goshawk, suggesting a single dominant recessive gene complex.

Ecological differences between novaehollandiae and fasciatus

Because the breeding distribution of *fasciatus* more or less completely overlaps that of *novaehollandiae* and the

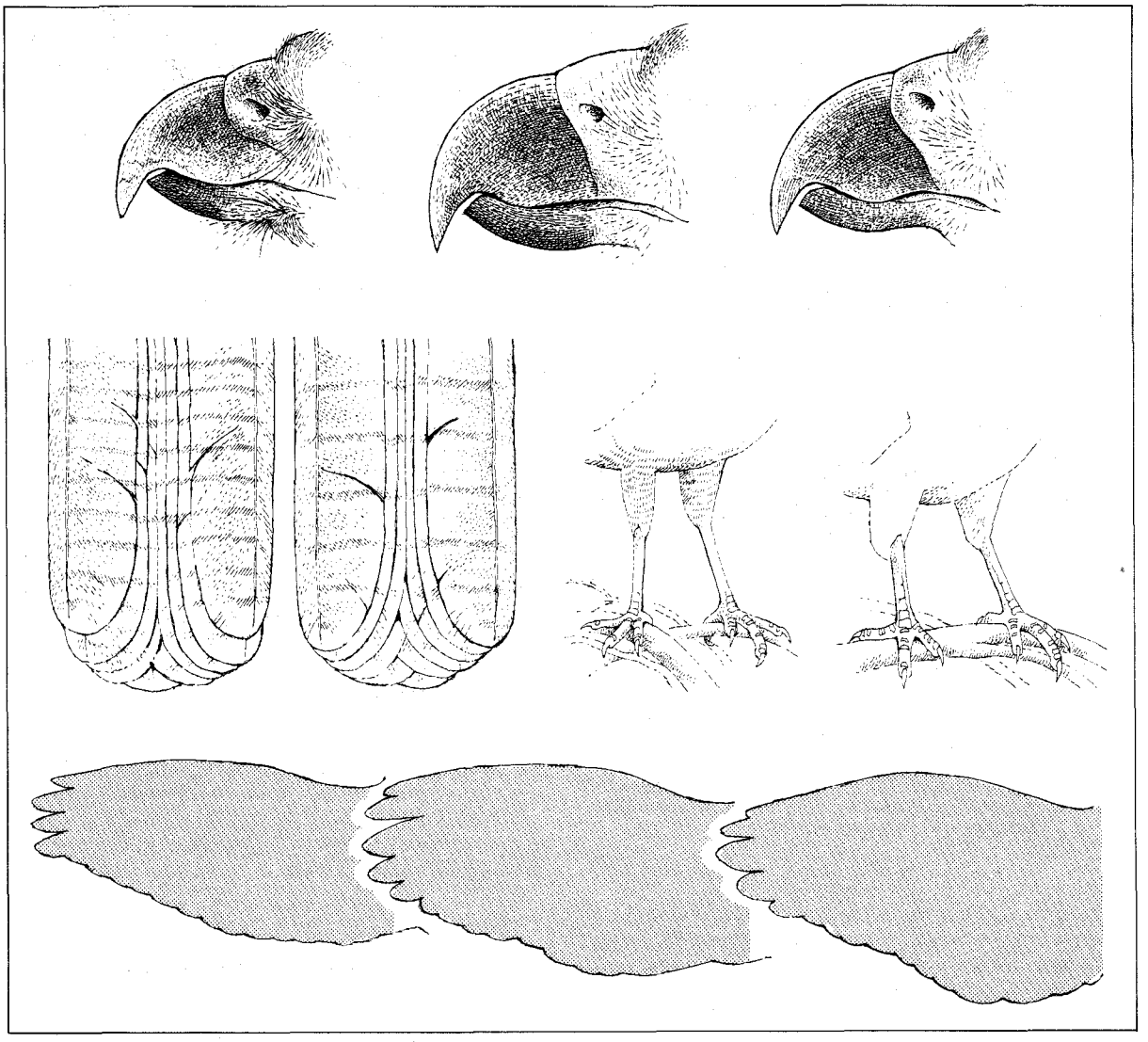

Figure 2. Distinguishing morphological characters of *novaehollandiae* and *fasciatus* compared with those of the hybrid. a. cere, beak, facial bristles and lips; b. tail, stance; c. wing shape. In each case l to r. — *fasciatus, novaehollandiae*, and hybrid (where shown).

two species co-exist in many areas, a general description of the potential for segregation of the two species according to the usual means of resource partitioning (e.g. MacArthur 1972) is warranted.

Partitioning by habitat

Novaehollandiae nests in temperate, sub-tropical and tropical rainforest, and tall-open forest, woodlands, wooded gorges, dense timber along water courses, and farmland, usually in the 760+ mm rainfall zone.

Fasciatus often nests in drier, more open forest and woodland, but nests wherever there are trees — along streams, in gardens, farmland city parks and towards the edge or in clearings of dense forests. It may be more tolerant of habitat disturbance than *novaehollandiae*, may have benefitted from the opening up of forests and

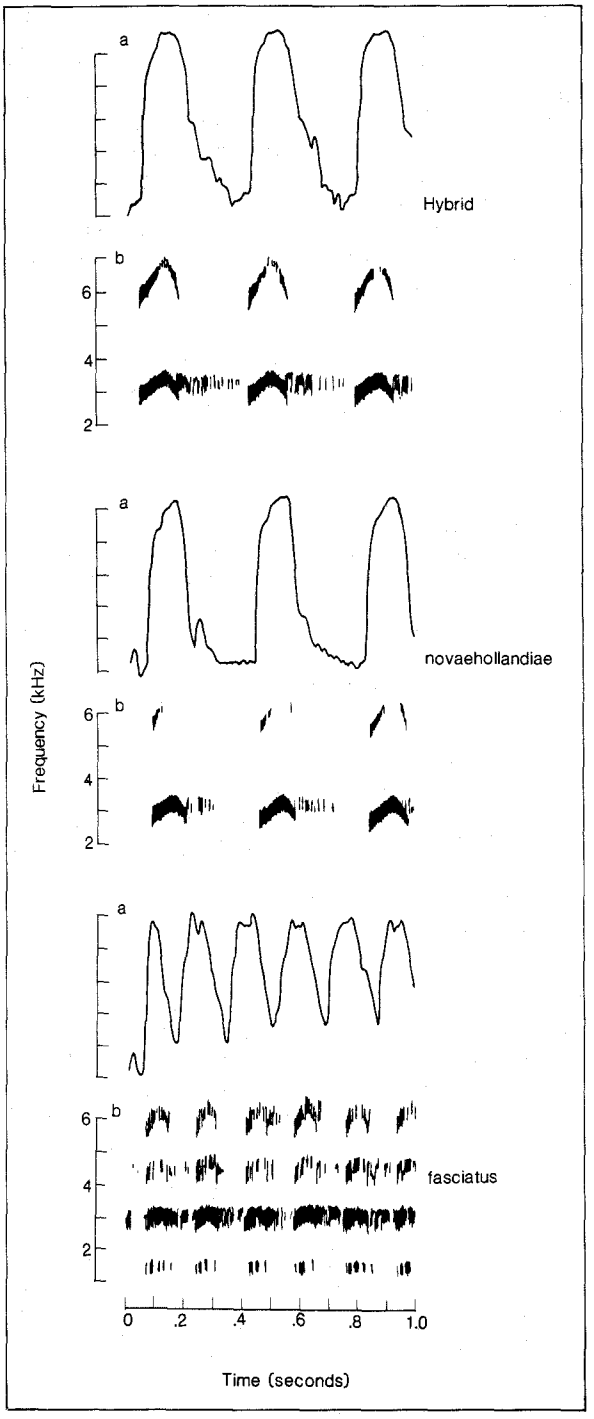

Figure 3. Alarm calls of *fasciatus, novaehollandiae* and the hybrid: a. average amplitude, each increment is equivalent to 6 decibels. b. Frequency (kHz), 300 Hz bandwidth filter.

has been found nesting in introduced trees (for example, introduced pines). However, extensive clearing precludes both species.

Partitioning by food type

Both species eat a wide range of live prey including insects and other invertebrates, reptiles, amphibians, birds and mammals, and, occasionally, carrion (Olsen & Olsen 1986). However, *novaehollandiae* takes larger birds and mammals than *fasciatus* (Table III). *Fasciatus* tends to take small, more aerial bird species that feed in the open whilst *novaehollandiae* takes large ground-feeding, or tree-feeding, less aerial, birds (especially pigeons).

TABLE III

Species reported as prey of fasciatus *and* novaehollandiae *(based on Olsen & Olsen 1986) as a percentage of total species.*

			fasciatus	*novaehollandiae*
			n = 70	n = 48
Arthropods			12	11
Fish, Amphibians and Reptiles			9	13
Birds:	small	< 100 g	40	17
	small-medium	102–249 g	16	13
	medium	250–500 g	12	22
	large	> 500 g	6	9
Mammals:	small	< 500 g	6	7
	medium	> 500 g	0	9

Indirect, although speculative, evidence of the main diet can be found in adaptive morphological characters. Relatively long tarsi, long middle toe and sharp talons (as in *fasciatus*) are found in aerial, bird-catching species, whereas relatively sturdy tarsi and massive talons (as in *novaehollandiae*, especially females) are found in larger species catching heavier prey (Wattel 1973).

Partitioning by foraging zone and foraging technique

In addition to the differences outlined in the previous section, the relatively long, pointed wing and tail of *fasciatus* are indicative of a faster flier, more suited to sustained, dextrous aerial pursuit of prey in the open than *novaehollandiae. Novaehollandiae's* short, wide, rounded, concave wing indicates that it makes relatively short, buoyant hunting (attack) flights, is more manouvrable at slow speeds, and spends less time on the wing than *fasciatus*; MacDonald (1973) describes its flight as owl-like. Habits of the various prey species

taken, indicative of foraging zone (Reynolds & Meslow 1984), are generally consistent with these differences (Olsen & Olsen 1986).

Partitioning according to seasonal movements

First year birds of both species appear to range more widely than adults. In *fasciatus* there is some evidence of movement of juveniles and adults northwards in late summer and autumn, and they can be found scattered throughout the north in the winter (Mason 1976). The relatively long wings of *fasciatus* may enable it to make longer range movements than *novaehollandiae*.

Partitioning by size

The Grey Goshawk and Brown Goshawk, together with the Collared Sparrowhawk *A. cirrhocephalus* and the Red Goshawk *Erythrotriorchis radiatus* form a series of accipitrid types. Due to sexual dimorphism in size and proportions they form an eight member group ranging in size from the male sparrowhawk (Baker-Gabb 1984).

GENERAL DISCUSSION

Morphological differentiation may take place without reproductive differentiation (Mayr 1976), particularly in geographically isolated populations. *Fasciatus* and *novaehollandiae* are thought to have shared a common ancestor, *fasciatus* evolving in Australia as an open-forest species and subsequently spreading to the islands to the north, geographically isolated from *novaehollandiae*, which underwent its main evolution as a specialised forest form in New Guinea and subsequently spread to Australia (Wattel 1973). Differring ecological (habitat) requirements may now be a major factor separating the two species.

There are few known nesting pairs of *novaehollandiae* in the Orbost area, and many *fasciatus*, although it was formerly typical Grey Goshawk habitat. The lone, male *novaehollandiae* was seen on several occasions in the two years before it was found (apparently) breeding with two female *fasciatus* in separate nests (Hollands 1984). Male *novaehollandiae* are larger, with relatively more massive talons and beak, than male *fasciatus* and therefore may be able to exclude them from a territory. A male *novaehollandiae* has been seen easily driving away a screaming male *fasciatus* (Macé pers. comm.).

In Tasmania and Victoria interspecific 'pairs' have been seen hunting together (Cupper & Cupper 1976; Mooney pers. comm.). Two other interspecific pairs have been found nesting: a Brown Goshawk female with a white morph Grey Goshawk male in Tasmania (Mooney, pers. comm.), and another with a grey morph male east of Melbourne (Aumann, per. comm.). In neither case was hybridization confirmed, although both members of each pair shared nest duties. At both nests the chicks most closely resembled those of *fasciatus*, and a male *fasciatus* was present early in the breeding season at the Melbourne nest. However, most of chicks produced by the confirmed hybridizing pair at Orbost each year between 1974 and 1980 also, in the field, most closely resembled *fasciatus* (Hollands 1984).

All three nesting interspecific pairs were in similar habitat — nesting in patches of timber remaining uncleared in farmland, in habitat that was formerly most suited to Grey Goshawks. If habitat disturbance is the precipitating factor, the potential for further hybridization exists.

Other possible causative factors in the hybridization are beyond the scope of this paper. The extent of hybridization, its cause and significance remain to be seen. It is tempting to speculate that the grey morph of *novaehollandiae* could be the result of introgression of *fasciatus* genes into the *novaehollandiae* gene complex. Several goshawk species on the islands around northern Australia resemble both the *fasciatus* and *novaehollandiae* groups in morphology and plumage, for example *A.n. griseogularis* (Brown & Amadon 1976; Wattel 1973) and *A.f. natalis*. Wattel (1981) suggests that hybridization of these oceanic goshawks may have occurred in the past, particularly during the Pleistocene.

However, polymorphism in colour of raptors is quite common and differences in pigmentation within each species do occur. The plumage of *novaehollandiae* has greatly reduced phaeomelanins compared with *fasciatus*, but a grey wash to the head and shoulders and slight barring on the tail is not uncommon in the white phase (e.g. NMV specimens R8108, B9760, B2264). Some *fasciatus*, on the other hand, are very pale and show 'some resemblance' to *novaehollandiae* (Ford & Stone 1957).

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JUVENILE PLUMAGE AND PLUMAGE VARIATION IN THE BROWN FALCON *FALCO BERIGORA*

The Brown Falcon *Falco berigora* is Australia's most widespread bird (Blakers *et al.* 1984), and one of its most abundant birds of prey. It is widely distributed throughout the continent and Tasmania, and extends to New Guinea. Its taxonomic position is inclear; initially it was placed in the genus *Hieracidea* and two species were recognised (North 1901). Cade (1982, p 180) considered it "an aberrant falcon, probably not closely related to any other species in the genus *Falco*", while Brown & Amadon (1968) thought of it as possibly a primitive or "degenerate" hobby. All authors reported many colour morphs in both juvenile and adult birds. Morris (1973) recorded no less than twenty-five plumage types.

Despite its importance in the study of taxonomy and geographical variation, no accurate juvenile plumage has been described. Condon (1951) listed the main juvenile characters as incomplete barring of rectrices, the presence of a buff or buffy-white nuchal collar, and dark underparts, with several subsequent subadult stages before the achievement of fully adult plumage. Cade (1982) however, repeated Brown & Amadon (1968) and described the first year birds as similar to adults in both pale and melanistic plumages.

METHODS

During 1982 and 1983, we visited forty-seven nests of Brown Falcons when the young were about to fledge and recorded their plumages. Where possible, details of the plumage of the parent birds were noted as well. The majority of nests (62%) visited were on the Melbourne and Metropolitan Board of Works Farm near Werribee (38°S, 144°35′E) in coastal Victoria, and at Pirlta (34°20′S, 141°55′E) in arid north-western Victoria.

Two nests were visited in central Australia. Additional observations from central Australia were received from D. Hollands.

Injured Brown Falcons of known age from Victoria and Tasmania were retained in captivity for up to six years to document yearly changes in plumage.

Skins of 432 Brown Falcons from areas throughout Australia and New Guinea were examined for geographical variation and comparison with field work. Plumages were examined for any variation that we could not explain as due to age.

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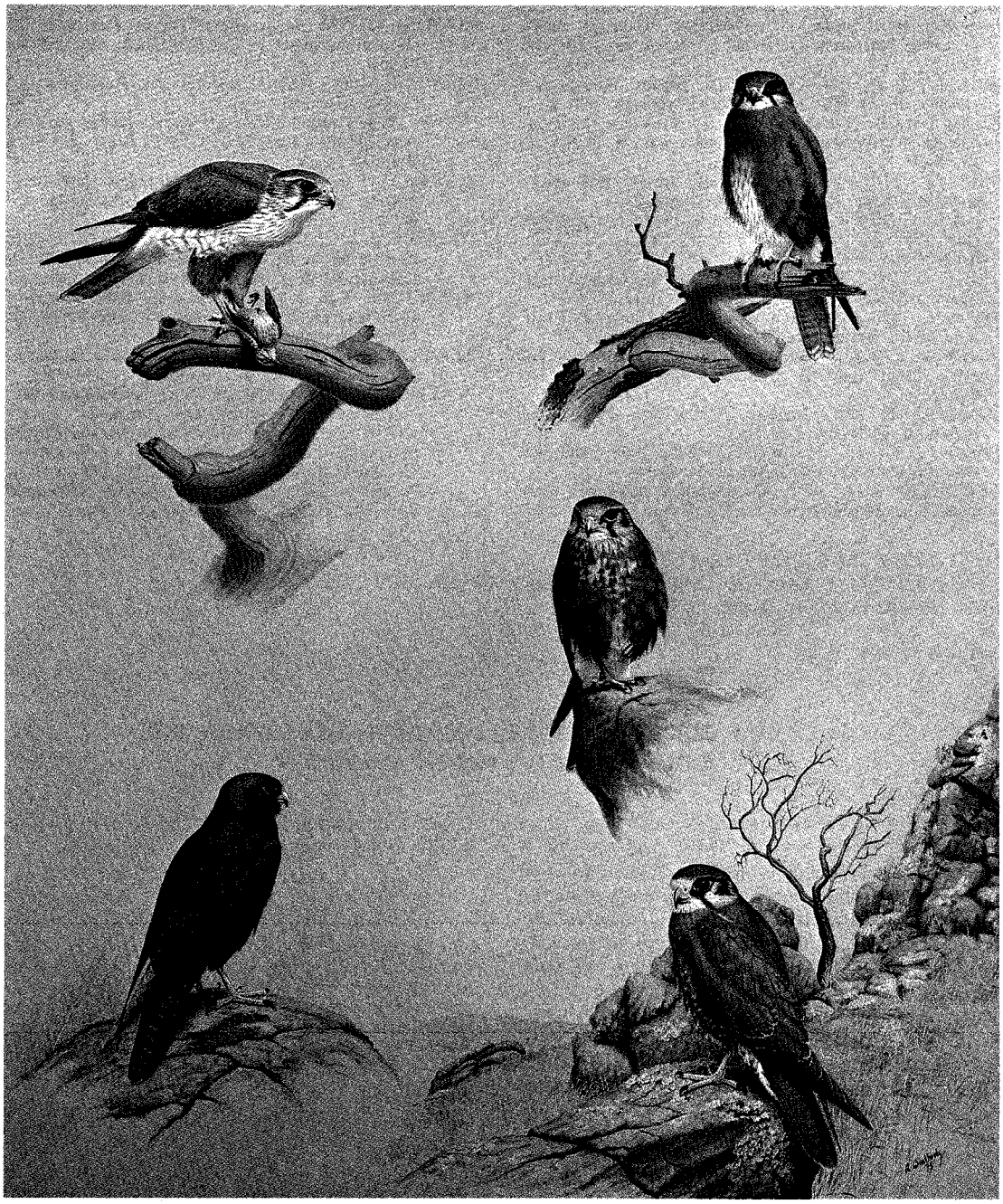

Plate 1. Juvenile Plumage and Plumage Variation in *Falco berigora*

Normal adult male, Mitiamo, Victoria (upper left).
Adult male, "red" variant, Rabbit Island, King George's Sound, Western Australia (upper right).
Normal juvenile, Loxton, South Australia (centre).
"Black" morph, South Alligator River, Arnhem Land, Northern Territory (lower left).
Normal adult female, Yunta, South Australia (lower right).