

Order FALCONIFORMES

Small to very large diurnal birds of prey. The terms 'diurnal birds of prey' and 'raptor' are used broadly to cover the convergent group of predatory and sometimes scavenging birds, much as 'seabirds' is used for the convergent assemblage of many sorts of marine birds, but not all are diurnal. About 280 species in 70 genera. Three families: Accipitridae, Sagittariidae and Falconidae. Monotypic Sagittariidae (Secretarybird *Sagittarius serpentarius*) extralimital in sub-Saharan Africa (Ethiopian region); other two cosmopolitan, except Antarctica, and represented in HANZAB region by 25 breeding species and one confirmed accidental (24 breeding and one accidental in Aust.; two breeding species and one non-breeding visitor in NZ). Traditionally (e.g. Amadon & Bull 1988; Peters) all diurnal birds of prey have been placed in a single order of four families (three above plus American Vultures Cathartidae). However, general uncertainty about the relationships of the higher taxa and recent studies of DNA-hybridization (Sibley *et al.* 1988; Sibley & Ahlquist 1990; Sibley & Monroe 1990) have led to the removal of the Cathartidae either into a separate order (Cathartiformes) or into a sub-family of the storks Ciconiidae, to which they are most closely related. Other arrangements of the higher taxa have been to put the Accipitridae into one order, with or without the genus *Pandion*, and the Falconidae into another or to put *Pandion* into its own monotypic family (BWP). Here we treat the Accipitridae, including *Pandion*, and the Falconidae as the two families of one Order. The Order may be of Gondwanan origin (Kemp & Crowe 1990).

As a whole, diurnal birds of prey have rather drab plumage in shades of brown, rufous, grey, white and black; patterns on underwings are sometimes important for identifying birds in flight. Field identification often depends more on general characters or jizz (structure, proportions, attitudes of wings in flight, and actions in flight) than on characteristics of plumage. These general characters are hard to describe succinctly and space does not allow us to discuss them exhaustively. Experience in the field with careful instruction from knowledgeable observers is really the only way to acquire skill in identification. However, Porter *et al.* (1986), though dealing specifically with European raptors, give useful information on fundamental differences between the various groups into which Accipitridae and Falconidae are divided.

Silhouettes and attitudes in flight being so important for identification, we have modified the section on Field Identification by adding a section on flight, in which these matters are described. It is as well to define standard terms for the sorts of flight that these birds use. Emarginations of inner and outer webs of primaries, leaves gaps between the feathers and gives a slotted or fingered appearance to wings; obvious and prominent in many Accipitridae, less so in Falconidae. **Gliding**: coasting forward on stiff wings without or between wing-beats; wings flexed according to angle of descent. **Soaring**: maintenance of height above ground or rising and circling up on stiff, fully spread wings and tail. **Hovering**: active flapping into wind to maintain position in relation to the ground. **Poising** (wind-hanging or kiting): facing into wind to maintain position but without flapping. **Stooping**: steep or shallow dive with wings folded close to the body; sometimes at great speed. The term **dihedral** (having two plane faces) describes the V-shaped attitude of the wings when raised above the plane of the body; qualified by **strong**, **medium** and **slight** to denote the degree to which the wings are raised to form a smaller or larger angle between their planes ($>15^\circ$, $5-15^\circ$, $0-5^\circ$ respectively); **modified dihedral** is when the innerwings are raised above the plane of the body but outerwing flat for the most part.

Members of the Order readily recognized by hooked, sharply pointed beaks with waxy membrane or cere at base through which nostrils open, strong powerful feet and sharp curved claws, otherwise found only in owls (Strigiformes), which resemble this order only by convergence. Palate imperfectly desmognathous with palatine processes of maxillae separated for much of their length and so grading into schizognathous type as found in some forms. Basipterygoid processes, absent in all except *Sagittarius*. Generally 14 cervical vertebrae but 15 in Falconidae and *Pandion*, 17 in some vultures (*Gyps*). Often no paired foramina or notches on sternum or else only one of pair. Holorhinal, nares impervious. Two carotids. Caeca, reduced except in *Pandion*. Crop, nearly always well developed; gizzard, poorly developed; fur, feathers, scales, insect chitin and many bones remain in crop and are later regurgitated as a compact pellet. Highly acid stomach for digesting all but chitinous or keratinous parts of prey. Syrinx, tracheo-bronchial. Ambians muscle present. Muscle formula, typically A (BXY in *Sagittarius*). No biceps slip; expensor secundariorum only in *Falco* and a few others. Ten functional primaries, eleventh vestigial or lacking; 11-25 secondaries; diastataxic. Tail with 12-14 rectrices. Feathers with aftershaft, except *Pandion*. Underdown present in varying amount; patches of powder-down in *Elanus*, *Circus*, *Gypaetus* and some others. Oil-gland, well developed, feathered except in *Microhierax*. Eyes, large with high density of cones in retina, giving high resolution; wide field of binocular vision. Hearing, acute. Sense of smell, poor; do not detect prey or carrion by smell, even in Old World vultures (cf. New World vultures [Cathartidae]).

Male nearly always smaller than, or same size as, female; thus different from most other birds; dimorphism greatest in bird-catching *Accipiter* and *Falco*. This reversed sexual dimorphism in size discussed by Reynolds (1972), Amadon (1975), Mendelsohn (1986a,b), Olsen & Olsen (1987), Pleasants & Pleasants (1988, 1989), Montgomerie & Lundberg (1989), J. Olsen (1989, 1990), P. Olsen (1991), Ydenberg & Forbes (1991) and Brown & Amadon¹ and others. Habits normally diurnal but sometimes crepuscular; a few nocturnal (e.g. Letter-winged Kite *Elanus scriptus*). Comfort behaviour includes bathing in water and dust; most adopt a characteristic posture for drying and sunning.

Raptors occur in all land faunas and a variety of climatic zones and habitats. Communities of raptors richest in Tropics and Subtropics and poorest in high latitudes. Patterns of movements vary: resident, migratory or dispersive; juveniles dispersive. In A'asia, small and medium-sized species breeding at high latitudes or altitudes or feeding on seasonally fluctuating prey tend to undertake seasonal movements, which are often towards coast, north (some to New Guinea) or to lower latitudes (Baker-Gabb & Fitzherbert 1989).

In A'asia, local threats to populations include illegal shooting, trapping and poisoning for supposed or real damage to livestock or poultry, or simply because they kill other birds. Egg-collecting, while illegal, is also a threat to some species. Some species have been or are used in falconry, an illegal activity in Aust. Secondary poisoning from pesticides is still a problem. Deforestation and other habitat degradation are the major threats. In consequence, some species are probably declining. Three endemic species are threatened: Square-tailed Kite *Lophoictinia isura*, Red Goshawk *Erythrotriorchis radiatus* and Grey Falcon *Falco hypoleucos* (Brouwer & Garnett 1990).

Further information on behaviour and biology of raptors in Newton (1979), Newton *et al.* (1990) and BWP.

(1) Because this reference and two others are so often used throughout the species accounts for the birds of prey, they are given in the texts without date and not listed in the references; they are Brown & Amadon (1968), Cupper & Cupper (1981) and Hollands (1984). For full details of these references, see the Introduction under Simplified References.

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Family ACCIPITRIDAE vultures, hawks, eagles and Osprey

Superficially diverse assemblage of small hawks to very large eagles and vultures; 200–225 species in more than 60 genera. Eighteen species, including five endemics, breed in Aust. and one is accidental; one species breeds NZ. Remarkably uniform as regards morphology. There is little agreement on subdivisions; up to 15 tribes or sub-families have been proposed by different authors (e.g. Wolters 1976; Amadon & Bull 1988; Kemp & Crowe 1990; Sibley & Monroe 1990; Holdaway 1991), some perhaps consisting of convergently similar species. Here we do not use formal subdivisions and arrange the species essentially in the same order as Peters and Amadon & Bull (1988). However, because the taxonomic affinities of three rather enigmatic endemic Aust. monotypic genera (*Erythrotriorchis*, *Hamirostra* and *Lophoictinia*) are uncertain they are extracted and placed at the end, followed by the somewhat aberrant and specialized *Pandion*, which others have regarded as forming a monotypic family. The following are useful groupings (sometimes considered sub-families):

(1) Honey-buzzards (*Pernis*) and cuckoo-hawks: 14 species in 5–7 genera; one species of *Aviceda* breeds in Aust. Small to medium-sized, without bony brow-ridges; with small weak feet; some crested; densely feathered lores or specialized bills. Plumage often boldly patterned or barred.

(2) Small (white-tailed) kites *Elanus* and others: six species in 3–4 genera; two endemic species of *Elanus* breed in Aust., one of which, Letter-winged Kite *E. scriptus*, fully nocturnal, uniquely so among raptors. Predominantly grey-and-white plumage; characterized by hovering with wings raised in strong dihedral; wings, long and pointed. *Elanus* are specialist predators of rodents. Inside of eggshell, buff, like *Pandion* and Falconidae (cf. green in other Accipitridae).

(3) Large kites (*Milvus*, *Haliastur*) and sea-eagles (*Haliaeetus*): 23 species in ten genera; four species in three genera breed in Aust.: one species of *Milvus*; two species of *Haliastur*, one of which endemic; and one species of *Haliaeetus*. Characterized by easy lazy soaring flight with tilting and twisting of tail, small feet; often of scavenging and piratical habits. The sea-eagles are larger than kites; soar on straighter wings, raised in moderate or strong dihedral, sometimes flat; and generally more predatory and aquatic than kites; tails, graduated or wedge-shaped.

(4) Harriers *Circus* and allies: 17 species in three genera; two species of *Circus* breed in Aust., one of which also breeds NZ. Spotted Harriers *C. assimilis* nest in trees, uniquely so for harriers. Characterized by owl-like facial ruff, large asymmetrical ears, slim body, long narrow wings, long tail and long legs. Fly buoyantly on raised wings, low over land or water; hunt by low-quartering in open country with wing often in strong dihedral. Only group in which polygyny common (Baker-Gabb 1982). For further discussion of this group, see Nieboer (1973), Baker-Gabb (1982, 1984).

(5) Goshawks and sparrowhawks: 53 species in five genera (see [7], Aust. endemic hawks, below); mostly in *Accipiter* (c. 40 species), which is the largest genus in the Family (see Wattel 1973). Three species of *Accipiter* breed in Aust.; another 19–20 species in New Guinea, Oceania and Wallacea. Typically in wooded lands; hunt from perches or by flying stealthily and dextrously through trees when hunting. Fierce expression caused by heavy brow-ridges; broad wings, rounded at tips; tail, long; legs and toes, long. For further discussion see Wattel (1973), Newton (1986).

(6) Buzzards (*Buteo*), hawks, eagles and allies: 91 species in 21 genera; two species in two genera (*Aquila*, *Hieraaetus*) breed in Aust. (both occurring New Guinea); another, Gurney's Eagle *Aquila gurneyi*, an accidental visitor from New Guinea. The most diverse group of the Family; predatory, soaring raptors with broad wings, bluntly rounded at end. Booted eagles and some other species have feathered tarsi.

(7) Aust. endemic hawks: three species in three monotypic genera in Aust.; perhaps related to other species that are extralimital in the A'sian zoogeographical region (*Henicopermis*, *Megatriorchis*); see Debus & Czechura (1989), Olsen & Olsen (1989), Debus (1991a), Schodde (in press). In general, affinities are quite uncertain (Kemp & Crowe 1990; Holdaway 1991); the resemblance of appearance and habits to typical kites, buzzards or goshawks may be a matter of convergence. Aust. species characterized by much rufous in plumage, especially in juvenile, and strongly patterned underwings.

(8) Osprey: monotypic, cosmopolitan; breeds Aust., not NZ. In several respects differs from rest of Family and stands out in appearance by the contrast of generally brownish upperparts and white head and underparts, distinctive silhouette, flight on long bowed wings, strictly aquatic and maritime habitat and diet predominantly of fish; dives into water to catch prey. Highly specialized and many characters adaptations to habitat and diet: dense plumage to avoid wetting, large feathered oil-gland, no aftershafts on feathers of head and underparts, closeable nostrils, long caecal sacs on intestine (as in other fish-eating birds), powerful feet with rough spicules on soles, long curved claws, reversible outer toe, bony ridges over tendons behind tarsus. Inside of eggshell, ochre, as in *Elanus* kites.

Two other groups, not represented in Aust. or NZ:

(9) Old-World vultures: 14 species in about eight genera. Perhaps the most distinct group in the Family.

(10) Snake-eagles (*Circaetus*) and allies: 14 species in five genera.

Some of the more salient characters shown by most members of the Family are as follows. Size of body varies from small and slender in small hawks to bulky and robust in eagles. Males are generally smaller than females, especially in *Accipiter*, but the reasons for such dimorphism, reversed from what is typical of birds in general, are a matter of debate (see Introduction to Order). Wings, broad, and shape correlated with mode of life and manner of hunting: short and rounded in *Accipiter* for dashing through woodland after prey; long broad and rounded in many other species that do much soaring; hardly ever pointed as in falcons. Similarly, tail varies: from long and square in some bird-catching hawks, kites and harriers, to enhance dexterity in pursuit of prey; to shorter, forked or wedge-shaped in others. Bills always with upper mandible curved down over shorter lower mandible: from slender in honey-buzzards to strong in goshawks and high and powerful in large eagles; not used to kill prey, which is always done by feet and claws, nor in defence and aggression. Long muscular tongue. Nostrils, opening in the cere, may be round, oval, elongated, or slit-like. Lores covered with hair-like feathers except in *Pernis*, which has small stiff scale-like feathers extending to base of bill as protection against attacks of insects. Often well-developed bony ridge over eye. Length and thickness of tarsi, and size and shape of feet and claws, also correlated with type of diet and predatory habits; tarsi and toes tend to be long with sharp claws in bird-hunters; legs long but toes shorter, with curved claws, in reptile-eaters; stout with heavy claws in species that take heavy prey on the ground: usually used for grasping and killing prey and in defence and aggression. Stance, upright or nearly horizontal; some species walk rapidly on flat ground and may even run and chase prey on ground. Right ovary and oviduct well developed, unlike most other birds. Squirt out droppings (cf. Falconidae) (Kemp & Crowe 1990; Newton *et al.* 1990).

Plumages vary greatly; no common features throughout Family but may be similarities within different groups, e.g. harriers, white-tailed kites and many accipiters. Brightest colours are rufous and chestnut; never reds, blues, greens, or yellows. Bare parts and iris often brightly coloured. Some groups tend to have white patches on rump; patterns on underwings, important for identifying soaring birds, often striking, even in otherwise uniformly plumaged species. Most predatory species have white triangular spot on upper nape, concealed unless feathers raised or disarrayed (Hafner & Hafner 1977); significance of this doubtful though it may serve as an appeasement signal. Some with elongation of feathers on head and neck, to form ruff-like or full plume-like crest, often differing in colour from rest of upperparts, often only ornamentation. Little difference in plumage between sexes, though females of some species more strongly patterned than males; considerable individual variation; pale and dark morphs occur, especially among eagles. Bare parts may be brightly coloured (e.g. red) and iris often strikingly yellow, orange, or red (cf. mostly brown in Falconidae). Single annual moult, often starting earlier in females than in males; complete in smaller species; primaries shed outwards, secondaries inwards

starting at two centres (s1 and s5); in larger species, full cycle often not completed within a year and birds in continuous moult, though may be halted during migration or breeding. Young, downy, semi-altricial and nidicolous; first down thick, silky and filamentous, rising from same papillae as later juvenile feathers; soon outgrown by long fluffy, usually white or grey second down, also originating from same papillae and covering whole body. Juveniles of smaller species often reach adult plumage by beginning of second year; those of larger species in third or later years after one or more immature plumages, gradually approaching adult plumage.

Almost world-wide distribution, except Antarctica; only one species in NZ. Found in all sorts of habitat from mountains and open moorlands to lowland forests, from deserts and arid lands to wetlands, both fresh and saline; occur along coasts but never going far to sea into truly marine conditions, where role of predators taken by groups in other Orders (Procellariiformes, Pelecaniformes, Charadriiformes); some species even found in urban environments. Many or most species in n. hemisphere migratory, at least in part; often concentrating in spectacular numbers at narrow sea-crossings or along narrow flyways; most migrating species make much use of soaring in thermals to gain height and gliding from one to another without use of flapping flight, but species of *Circus* feed *en route* and so sustain themselves fly low with flapping. In Aust., movements are poorly known; migration occurs in few species (e.g. *Milvus migrans*, *Circus approximans*, *Lophoictinia isura*); spectacular visible migration on a narrow front has not been noted. Letter-winged Kite *Elanus scriptus* is a species that erupts dramatically at the time of plagues of rodents, but many other species are attracted in large numbers to swarms of locusts, plagues of mice or to fire-fronts. Scavenging kites and vultures are useful in cleaning up man-made mess, perhaps more so in the past than now, and many species play some part in countering plagues of rodents and insects.

Most accipitrids are wholly predatory; some are wholly carrion-eaters; others both. Almost any prey taken: mammals, birds, reptiles, amphibia, fish and various invertebrates such as snails, grasshoppers, locusts and termites. Some species are highly specialized in diet, e.g. snail-eating kites, honey-buzzards. A very few even have a largely vegetable diet (Palm-nut Vulture *Gypohierax angolensis* in Africa). For the most part, hunting and catching methods are by pursuit in flight or by pouncing from a perch; white-tailed kites hover in very characteristic style and harriers quarter low above vegetation or water, both then dropping on prey on the ground. Hunting and feeding is typically diurnal but some (e.g. Bat-Hawk *Machaerhamphus* and *Elanus scriptus*) are crepuscular or nocturnal. Birds are plucked and eaten piecemeal, except very small ones, which may be swallowed whole; mammals are skinned and also torn in pieces but small rodents may be swallowed whole; indigestible matter (fur, feathers, chitin, etc.) regurgitated as pellets.

Displays commonly consist of stereotyped aerial manoeuvres such as undulating dives, slow flapping flight and lowering of legs, and ritualized attack and defence (cf. Falconidae) (Barnard & Simmons 1986; BWP). Outside breeding season, usually solitary except for scavenging species. Probably usually occupy rather large home-range and may maintain exclusive feeding territory within it. On migration in n. hemisphere often notably gregarious or loosely so. Most roost solitarily or in loose pairs in trees or on cliffs and similar high places; some, particularly harriers, roost on the ground, communally. See Newton (1976) for review of dispersion in diurnal birds of prey generally. Also typically solitary breeders, sometimes at traditional sites or in two or three traditional places in a territory, normally making a new nest each year. *Elanus scriptus* is exceptional because it is more or less gregarious throughout the year and breeds colonially or loosely so. Pairs are usually conspicuous at start of breeding season, defending vicinity of nest against conspecifics, other raptors and corvids; defence often done by female, which unlike males seem to stay near nests for entire breeding cycle. Pair-bond, typically monogamous, usually only for the season but in some species may be prolonged and even life-long. Polygyny occurs in some harriers. Activity over nesting territory often conspicuous: soaring or High-circling, singly or in pairs sometimes calling, which may develop into Flight-play in which birds grip each other's feet and spin downwards (Talon-presentation or -grappling and Cartwheeling); also Sky-dances when one of pair plunges and swoops in shallow or deep undulations, often calling and with wings partly closed and still (pothook type) or swinging to and fro (pendulum type) (Brown 1976; Brown & Amadon); Slow-flapping also part of aerial activity. Food-passing by males to females characteristic in many species; mostly during incubation and period of daytime brooding when male brings all food to female; also occurs as part of courtship well before laying. Copulation near or on nest or elsewhere in nesting territory, in some never or rarely on nest; may start well before laying and so probably also part of courtship. Some species bring sprays of green leaves to nest throughout or for part of nesting cycle; function not fully explained but probably for lining of nest, which may have some antiseptic properties, or for camouflage, or may have some social significance. Calls rather unspecialized; mostly loud harsh grating chattering, yelping, yapping, screaming, whistling, whining, or mewing; often resonant and tremulous. Often loaf during day for long periods on favoured perches in characteristic attitudes, e.g. with head drawn into shoulders or jutting forwards; some vultures squat on tarsi on ground or even lie down fully. Spend much time preening; allopreening reported in *Haliaeetus*, *Aquila*, *Lophoictinia*, *Hamirostra* and others. Commonly bathe and drink but some species seem not to drink, even in captivity. Dust- or sand-bathing also reported but incidence in Family as a whole not studied. Shield young in nest from sun or rain by standing and spreading wings; individually may also spread wings partly or fully on favoured perches probably for drying or sunning. Pant, gasp and gular-flutter to dissipate heat. Scratch head direct. Comfort movements (head-scratching, body-shaking) sometimes performed in flight. Some vultures, fish-eagles and *Hamirostra* use stones as tools to break open bones or eggs (Boswall 1977; Aumann 1990; Debus 1991b; Pepper-Edwards & Notley 1991).

Breeding season protracted, especially in large species and in warm latitudes. Nests placed in many situations in trees, on cliffs and even buildings, but on ground in thick cover in most harriers; usually rather or entirely inaccessible. Build own nest of sticks and branches; sometimes all sorts of rubbish in nests of typical kites, vultures and Osprey. Lining of fresh grass or green leaves in some; commonly decorated with sprays of green leaves. Nests of large species often huge by traditional use of same site. Building by both sexes, or entirely by female in *Circus*; material carried in bill or feet. Eggs usually broadly oval, mat, dull white or very faintly bluish and streaked and mottled with brown and red. Clutch-size, small to medium: invariably one in some large species (vultures, snake-eagles); 1–2 in some eagles; 1–3 in typical kites, some fish-eagles, eagles and typical buzzards; 2–6 in white-tailed kites, harriers, accipiters and some typical buzzards. Laying interval: 2 days in small species to 5 days in large. Generally single-brooded because full nesting cycle too long to allow more than one in time suitable for nesting; second broods occur only occasionally in species with a cycle of less than 6 months; yet *Elanus scriptus* apparently breeds almost continuously during plagues of rodents and may lay in second or later nests before young have fledged from first attempt. Clutches may be replaced if lost when fresh but period of replacement short (as early as c. 2 weeks in small species; 29 days in *Haliaeetus*). Nesting cycle of some large tropical eagles lasts longer than 12 months and, if successful, birds breed only every other year. Incubation period 4–8 weeks, depending on size of species, and to some extent on genus (e.g. 35–38 days in *Haliaeetus*, 42–44 days in *Haliaeetus vocifer*, 42–45 days in species of *Aquila* of similar or less weight than *Haliaeetus*, up to 47 days in *Circaetus*). Typically incubation starts with first egg and hatching asynchronous. Incubation mostly or entirely by female but male may cover eggs while she is away. Females have single median brood-patch; males often with none. Eggshells eaten by female or dropped out of nest or carried away. Female alone broods and actively feeds chicks, bill to bill. Usually male brings food for female and young but female may start to hunt again in latter part of nestling period. However, male known to brood young and even feed them in a few species, successfully rearing young when female died. Duties shared equally by sexes only in *Pernis*, snail kites and typical vultures and possibly others. Nestling period long, 4–31 weeks; the larger the species, the longer; difficult to determine accurately because young often clamber outside nest and stay away from it for several days before first flight. Smaller males tend to fledge sooner than larger females. In broods of two or more, youngest chick sometimes dies, being unable to compete for food with older and stronger siblings; may die through starvation, exposure or by being injured or thrown out of nest by siblings, which may eat them if they die in nest. In some eagles, second chick of two never survives even in favourable conditions but dies early in nestling period. In species with broods of two, fighting between siblings often fierce (Cain-and-Abel conflict), the larger persecuting the smaller, even when food plentiful. The adaptive significance of this behaviour much discussed and has led to theories on ecological significance of clutch- and brood-size, mortality in nest and evolutionary processes of its development (Brown *et al.* 1977; Gargett 1978; Simmons 1988; Brown & Amadon). Young of all species depend on parents for some time after fledging but, being difficult to observe and determine exactly, the length of the period is poorly known; certainly varies considerably depending on size and diet, from perhaps 2–3 weeks in small accipiters to a similar number of months in some large eagles and vultures. Age of first breeding 1–2 years in small accipiters and in harriers, 2–3 years in typical kites and buzzards, perhaps 4–9 in large eagles.

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Circus approximans **Swamp Harrier**

COLOUR PLATES FACING PAGES 193, 200 & 201

Circus approximans Peale, 1848, *US Explor. Exped.*, 1838–42, 8: 64 — Vanua Levu, Fiji.

Approximans is Latin for resembling or approximating (other harriers).

NZ Australasian Harrier

OTHER ENGLISH NAMES Allied, Gould's or Marsh Harrier, Swamphawk; Pacific Marsh Harrier.

So long as this bird is kept separate from *C. aeruginosus*, **Swamp Harrier**, the traditional name in Australia, can be used. If not, it becomes merely a subspecies of Marsh Harrier.

MONOTYPIC

Plate 6

Whistling Kite *Haliastur sphenurus* (page 71)

1 Adult; 2 Juvenile, fresh; 3 Juvenile, worn

Little Eagle *Hieraaetus morphnoides* (page 180)

4 Adult; 5 Juvenile

Black Kite *Milvus migrans* (page 53)

6 Adult; 7 Juvenile

Brahminy Kite *Haliastur indus* (page 63)

8 Adult; 9 Juvenile; 10 Immature

FIELD IDENTIFICATION Length 50–60 cm; wingspan 120–145 cm; weight: male 630 g, female 850 g. Large slim-bodied raptor, very similar in size and shape to Spotted Harrier *Circus assimilis* and similar in size to large kites *Milvus* and *Haliastur*. Owl-like face bordered by narrow ruff, long slender legs, and long tail gently rounded at tip. Wings, long and broad, with outerwing slightly narrower than innerwing and showing five free primary-fingers; wing-shape differs between sexes. When perched, wing-tips level with or just short of tip of tail. In adult, combination of prominent white patch on upper tail-coverts, barred underside of primary-fingers and slow sailing flight on upswept wings low to



Fig. 1a Soaring and slow gliding



Fig. 1b Fast gliding

ground or water, diagnostic. Sexes differ; female slightly larger; also distinguished by structure and plumage. No seasonal variation. Juvenile separable.

Flight Soar and glide slowly with wings raised in strong dihedral with tips of primary-fingers curled up (Fig. 1a). In **fast glide**, innerwings raised as when soaring but outerwings flattened to nearly horizontal, producing modified dihedral (Fig. 1b). When **soaring**, wings pushed slightly forward, leading-edge slightly angled, primary-fingers splayed; in males, innerwing little wider than outerwing, trailing-edge gently curved and roughly parallel with leading-edge; in females, innerwing noticeably broader, with longer more bulging secondaries between narrower outerwing and pinched-in effect at body, producing distinctly S-curved trailing-edge; head appears short and broad; well-spread tail rounded at tip though often soar with tail closed. When **gliding slowly**, shape of wing similar to that when soaring, but carpals pressed farther forward and outerwings angled slightly backwards; tail closed or held partly spread. In **fast glide**, wings strongly angled, with carpals in line with bill, primaries closed and strongly swept backwards; closed tail appears long and narrow, gently rounded to nearly square-cut at tip. Flight buoyant, noticeably heavier and faster than that of Spotted Harrier; combine bursts of smooth, rhythmic wing-beats with long glides on raised wings, low to ground or water, gently rocking or tilting; quarter with frequent wing-beats; hover with deep slow wing-beats then drop on to prey. In Aust., sometimes soar high; do so often in NZ. Long legs sometimes lowered during slow gliding flight and occasionally when soaring.

Description Adult male Marked variation related to age; older birds generally paler. **Darkest (younger) males** Facial disc, dark brown, bordered by narrow pale ruff. Forehead, creamy; crown, nape and hindneck, dark brown with blackish streaking, thickest and heaviest on nape and hindneck. Tricoloured pattern above: remiges, primary coverts and outermost greater coverts, light bluish-grey with blackish wing-tip (fingered portions of outer five primaries); rest of wing-coverts and saddle, dark brown; some show narrow pale-buff leading-edge to innerwing, conspicuous in head-on view, and narrow pale trailing-edge to secondaries and inner primaries; narrow dark barring on remiges and primary coverts becoming broken across inner primaries; and wider dark subterminal band on secondaries and outermost greater coverts. Upper tail-coverts, white with a few dark subterminal spots, forming prominent pale patch at base of tail. Tail, brownish-orange, tinged grey, with 4–5 narrow, evenly spaced blackish bands; central rectrices, light bluish-grey with indistinct broken dark bands. Underbody, buff to orange-buff heavily streaked blackish brown on breast, belly and flanks. Undertail, whitish with faint dark barring. From below, most wing-coverts, buff or whitish, heavily streaked and barred dark brown, as underbody; remiges and greater primary coverts, paler, buff-white with thin dark barring (more sparse and broken on bases of outer primaries);

narrow, even dark-grey subterminal band on secondaries; primary-fingers have thin dark bars inside small blackish tip. **Palest (older) males** Facial disc, dark brown. Grey areas of upperwing, paler silvery-grey, giving more striking tricoloured pattern; leading-edge of innerwing, paler creamy or white; dark subterminal band on secondaries reduced to thin bar on some. Tail, paler silvery-grey, narrowly tipped white and with indistinct broken dark bands on outer feathers; wholly grey in some. Underbody and under wing-coverts, white, with generally less streaking, mostly on breast, upper belly, flanks and hindmost coverts. In a few, facial disc and ventral streaking darker slate-coloured; when viewed in poor light or at distance, such birds can appear to have dark hood with dark ventral streaking running off hind-edge, contrasting strongly with white underbody (resembling immature and some adult Eastern Marsh Harriers *C. spilonotus spilothorax*). Bill, black with grey base. Cere, yellow; pale yellow in non-breeding season. Iris, pale yellow. Legs and feet, yellow-orange; lemon-yellow in non-breeding season. **Adult female** Plumage varies with age, older birds having greyer upperparts, more grey in tail and more pale streaking on underbody and under wing-coverts. Facial disc, head, neck, and upperbody, dark brown like darkest males, or reddish brown, with buff streaking on nape and hindneck; on some, upper tail-coverts washed brownish orange, resembling juvenile. Upperwing: lesser and median innerwing-coverts, dark to reddish brown, contrasting with darker-brown greater secondary coverts (which have paler-brown or creamy tips forming thin pale border to inner wing-coverts) and much darker blackish-brown secondaries, which show faint darker barring and wider dark trailing-edge in good light when close. Primary coverts, inner primaries and bases of outer five primaries, dull grey, traversed by broken blackish barring and with broken dark trailing-edge (blackish tips of inner five primaries); show as pale panel between dark secondaries and blackish wing-tip (fingered portions of outer five primaries). Uppertail, similar to dark adult male but central rectrices, dull grey, with 4–6 narrow blackish bars, often broken or reduced to spots. Underbody, uniform reddish brown or narrowly streaked buff. Undertail, silvery grey, with 3–5 narrow dark bands, subterminal one widest. Two-tone pattern to underwing: forewing-coverts, uniform reddish brown or sparsely streaked buff, as underbody; remiges and greater primary coverts, much paler, silvery grey, with narrow dark-grey barring, clearest on primary-fingers, which have small blackish tips; bases of primaries slightly paler buffish-white and contrasting slightly with darker, greyer secondaries; prominent dark trailing-edge to secondaries, broadening towards body (cf. narrower even subterminal band of male). Some, probably older, birds show more and paler grey in upperwing (extending on to outer secondaries and outer greater secondary coverts), resembling darkest males, though never quite matching their tricoloured appearance above; more and paler grey in tail but retaining obvious dark bands; reddish-brown underbody and under wing-coverts more heavily streaked buff, resembling that of darkest males. These best distinguished from male by different wing-shape, less coarsely dark-streaked nape and hindneck, broader dark ventral streaking and wider dark trailing-edge of secondaries below. Bill and cere, as male. Iris, light brown to pale yellow (older birds). Legs and feet, dark yellow; yellow in non-breeding season. **Juvenile** Head and neck, uniform blackish brown, with little or no pale ruff; broad creamy streaks on nape form prominent pale patch. Saddle and upperwing, blackish brown, with: darker blackish wing-tip, faint paler greyish panel on inner and bases of outer five primaries, thin pale chestnut or buff border to lining, and thin buff trailing-edge to secondaries and inner primaries. Upper tail-coverts and tail, rich brownish-orange with central rectrices tinged grey; tail has three

narrow dark grey-brown bands above broad dark grey-brown subterminal band (bands paler, broader and less clear-cut than on adults). Underbody, uniform dark chestnut. Undertail, silvery grey, with 2–3 narrow dark bands and wide dark subterminal band. From below, forewing-coverts, uniform dark chestnut, as underbody; remiges and greater primary coverts, unbarred dark grey (lacking two-tone underwing-pattern of adult); bases of primaries much paler silvery-grey, forming conspicuous pale patch in outerwing. During first winter, acquire adult-like white upper tail-coverts and central rectrices, grey barred blackish as other rectrices. Bill, as adult. Cere, pale yellow, becoming yellow in second year. Cere and base of bill much paler, contrasting more with darker blackish head than on adult. Iris, dark brown, changing to light brown by first winter in males, mid-brown by second winter in females. Legs and feet, pale yellow, becoming yellow or dark yellow (males) in second year.

Similar species Often confused with **Spotted Harrier**, which differs by: **all ages** show slightly broader, more clear-cut blackish tail-bands giving much more boldly banded appearance to tail, above and below; solid black (not barred) underside of primary-fingers, forming large black wing-tip; and structure and flight: slimmer, with broader and more deeply fingered wings (fingers more splayed), slightly longer tail distinctly wedge-shaped at tip and occasionally held in dihedral (never so in Swamp); flight slower and more buoyant, with slower, deeper wing-beats. Further distinctions: **Adult Spotted Harriers** differ from male Swamp Harrier (especially paler birds) by: barred (not white) upper tail-coverts; uniform light-grey upperparts with chestnut shoulder patch and finely white-spotted inner wing-coverts; chestnut underbody and under wing-coverts densely spotted with white (these areas buff or white with dark streaking on Swamp Harrier). **Juvenile Spotted Harrier** distinguished from adult Swamp (particularly males) by: richer, more orange-buff head and underparts (with shorter, finer dark streaking on breast, belly and flanks); prominent orange-buff tips of mantle, back and scapulars give scaly appearance to saddle when fresh (uniformly dark on Swamp); prominent orange-buff forewing-panel contrasting with dark saddle and remiges; in fresh plumage, narrower creamy patch on distal upper tail-coverts (larger white patch on Swamp). Juvenile Swamp Harrier much darker, with more uniform plumage than any Spotted, and should not cause confusion (note especially, prominent brownish-orange upper tail-covert patch, white patch on nape, and almost uniformly dark underwing, with dark grey and unbarred remiges hardly contrasting with dark lining and relieved by paler silvery bull's-eye on bases of primaries). Swamp Harriers with reddish-brown underparts and barred underwings and tail sometimes mistaken for **Red Goshawk** *Erythrotriorchis radiatus* (q.v.) or **Square-tailed Kite** *Lophoictinia isura*. Square-tailed Kite slimmer, with longer, more deeply fingered wings with six (not five) primary-fingers held more widely splayed; tail sharp-cornered and square-ended or gently notched and twisted in flight; short legs; some show creamy (though narrower) patch on upper tail-coverts resembling Swamp Harrier, but prominent pale bar across central upper wing-coverts and, from below, distinctive black crescent on primary coverts and much bolder blackish barring through primary-fingers distinctive. Ought not to be confused with **New Zealand Falcon** *Falco novaeseelandiae* (q.v.).

Solitary or loosely gregarious harrier of lakes, swamps, grassland, coastal heath and tall crops. Migrate in groups, roost communally on ground. Often harry swimming waterbirds. Perform undulating display-flight over breeding areas. Perch on ground or on low posts, stumps, swamp vegetation, less commonly in trees. Nest on ground. Usually silent; during breeding display birds utter high-pitched, far-carrying, descending whistle, which attracts

attention to high-flying bird; otherwise usually silent.

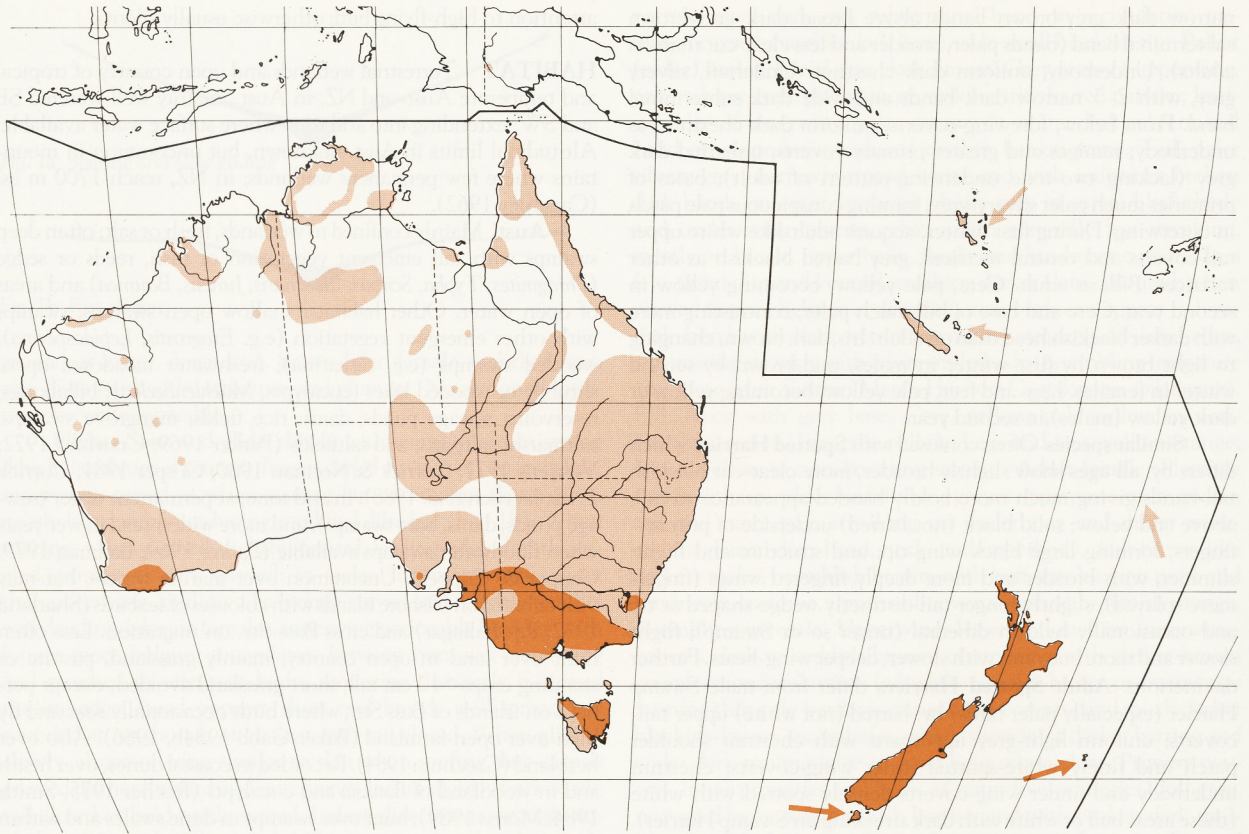
HABITAT Terrestrial wetlands and open country of tropical and temperate Aust. and NZ; in Aust., mainly well-watered SE and SW, extending into arid zone where surface water available. Altitudinal limits in Aust. unknown, but uncommon in mountains where few permanent wetlands; in NZ, reach 1700 m asl (Caughley 1962).

Aust. Mainly confined to wetlands, fresh or salt; often deep swamps with tall emergent vegetation of rush, reeds or sedge (*Phragmites*, *Typha*, *Scirpus*, *Eleocharis*, *Juncus*, *Baumea*) and areas of open water. Other habitats: shallow open swamps; swamps with other emergent vegetation (e.g. *Eragrostis*, *Lepidosperma*); wooded swamps (e.g. casuarina); freshwater meadows; open, shrubby or wooded lakes (eucalypts, *Muehlenbeckia*); billabongs; reservoirs; sewage ponds; dams; rice fields; mangrove swamps; saltmarsh; saltpans; and saltfields (Parker 1969; Crawford 1972; Vestjens 1977; Corrick & Norman 1980; Gosper 1981; Corrick 1982; Jaensch *et al.* 1988). In arid zone, at permanent water (sewage ponds, dams, bore swamps), and more widespread in wet years when floodwater swamps available (Parker 1969; Badman 1979; Cupper & Cupper). Uncommon over marine waters, but may visit or breed on offshore islands with colonies of seabirds (Sharland 1932; P.J. Fullagar) and cross Bass Str. on migration. Less often hunt over land in open country; mainly grassland, pasture or standing crops >10 cm tall; short grassland avoided, except perhaps on islands of Bass Str., where birds occasionally soar and fly high over open farmland (Baker-Gabb 1984b, 1986). Also over hermland (Czechura 1984). Recorded in coastal dunes, over heath and in woodland of *Banksia* and eucalypts (Recher 1975; Smith 1984; Morris 1989); hunt over swamps in dune swales and within vegetation where it is sparse or patchy (Corrick & Norman 1980). Dense wooded habitats unsuitable, but fly over woodland and forest near water (Jones 1952; Smith 1984; Henle 1989).

NZ Not confined to wetlands as in Aust.; often over farmland with short grass, where abundant supply of live prey and carrion (Baker-Gabb 1986). Also high-country slopes, terraces, plateaux and river valleys covered with tussock grassland and scrub (*Chionochloa*, *Festuca*) (Child 1975; Pierce & Maloney 1989). Less restricted to wetlands than in Aust.; mainly freshwater swamps with tall growth of *Typha* (Raupo), rush or sedge (Baker-Gabb 1981a; Ogle & Cheyne 1981); in Whangamarino wetlands, hunted mainly over dense beds of wirerush *Empodisma minus* growing in peat swamp (Ogle & Cheyne 1981). Regular over marine habitats: hunt over coastal dunes and beaches; mangroves and associated mudflats; tidal shores and inlets fringed with rush or saltmarsh; and ocean off mainland and islands, sometimes fly over deep water up to 1 km from land (Hodgkins 1949; Gibb 1970; Jukes 1981; Cunningham & Moors 1985; Owen & Sell 1985; CSN 20). On Campbell I., several records; on beach and in tussock grassland (Bailey & Sorensen 1962).

On mainland Aust., nest in deep swamps with extensive beds of tall reed or rush, particularly *Phragmites* or *Typha*, in which nests are built; rarely on land in standing cereal or hay crops. In NZ, Tas. and islands of Bass Str., more often nest in non-reed and dry-land vegetation (crops, tall grass, bracken, blackberry, fern, shrubs). Also in wetlands; as on mainland Aust., mainly swamps with dense rush or sedge (e.g. *Typha*, *Leptocarpus*, *Carex*) (Sharland 1932; Sutton 1967; Baker-Gabb 1981a, 1983, 1986; Pierce & Maloney 1989).

In Aust., usually hunt by low slow-quartering <9 m above water surface or ground; soaring unusual. In NZ, fly high and soar often, searching for carrion (Baker-Gabb 1986); recorded at height of 900 m (Black 1957). Use thermals for lift, and fly high transects



along road verges and rows of trees. On migration in Bass Str., fly over sea at heights of 15–100 m; gain lift from thermals over islands (Hobbs 1959; Brothers & Davis 1985). Take prey from water surface, do not fully submerge. Active on ground; sometimes wade into shallow water, and scavenge, capture prey, feed, rest and roost on land. Usually perch low, on posts, stumps, low vegetation; trees little used. Roost in vegetation in wetlands, tall dense grass, or crops.

In Aust., many deep vegetated freshwater swamps lost or altered by drainage, increased salinity, clearing, grazing and burning (Riggert 1966; Goodrick 1970; Corrick & Norman 1980; Corrick 1981, 1982). Loss of wetland breeding habitat forces nesting in crops, where mortality high during harvesting (Mooney 1983b). Artificial wetlands used for feeding and nesting; even nest in dams down to 10 m diameter if reeds present (Mooney 1985). In NZ, clearing and establishment of farmland and roads since European settlement have provided new feeding habitat and ample supply of carrion (Gurr 1968); but species possibly adversely affected in some areas by drainage of wetlands. In Aust. and NZ, recorded over young plantations of *Pinus radiata* (Friend 1982; Baker-Gabb 1986).

DISTRIBUTION AND POPULATION Widespread A'asia and sw. Pacific.

Aust. Mostly in SE and SW, S of line from Fraser I., Qld, to Streaky Bay, SA, and from Israelite Bay to near Perth, WA (Aust. Atlas). Regular winter visitor to n. regions (Bravery 1970; Garnett & Bredl 1985; Draffan *et al.* 1983), augmenting small local populations (Gill 1970; Crawford 1972). Sporadic inland records (w. and sw. Qld, ne. SA, s. NT and Goldfields of WA); apparent influxes after unusually high rainfall and flooding, or represent birds on passage to wintering areas (McGilp 1934; Hobbs 1959;

Badman 1981; Gibson & Cole 1988; Cupper & Cupper; Aust. Atlas).

NZ Widespread and common throughout mainland and offshore islands except forested parts of ranges of NI and Westland, S. Alps and Fiordland, SI (CSN 33; NZ Atlas).

Norfolk I. Irregular visitor in winter (Schodde *et al.* 1983; Wakelin 1968; Hermes 1985; Hermes *et al.* 1986).

Lord Howe I. Irregular visitor in autumn and winter (Hindwood 1940; Hindwood & Cunningham 1950).

Cocos-Keeling Is One record, single, Home I., 6 July 1941 (Gibson-Hill 1950).

Macquarie I. Singles, 29 Oct. 1949 (Gwynn 1953); single, 26 June–7 July and 16 Sept. 1960 (Warham 1969); singles, Oct. 1969; two other occasions (Green 1989).

Kermadec Is Non-breeding visitor (Iredale 1910a; Merton 1970; Oliver).

Chatham Is Common and widespread (CSN 33; Fleming 1939).

Campbell I. Rare visitor (Westerskov 1960).

Snares Is Single 28 Sept. 1972 (Horning & Horning 1974).

Auckland I. Straggler (Falla *et al.* 1981; Oliver).

Breeding Aust. In SE, generally S of 33°S, from near Ulladulla, NSW, to Eyre Pen., SA, though circumstantial evidence of breeding in ne. NSW; active nest Wallis L. (Debus 1992); Tas. and Bass Str. islands (Hobbs 1961; Aust. Atlas; Aust. NRS); in SW, S of 31°S, from Albany to near Perth (Aust. Atlas; Aust. NRS). **NZ** Throughout range, though not Kermadec and subantarctic islands.

Populations, secure; most common NZ raptor. Population on Hunter Grp, Bass Str., 20–30 breeding pairs; Furneaux Grp, 25–50 breeding pairs; other islands 3–5 breeding pairs (Mooney 1984). In sw. WA, estimated at ≥22 breeding birds (Jaensch &

McNee 1984). NZ At Pukepuke, NI, densities estimated at 1 harrier/50 ha during breeding season and 1/80 ha during non-breeding, and 1 breeding pair/120 ha (Baker-Gabb 1981a). On Bellarine Pen., Vic., 18 pairs bred in 1200 ha (1 pair/67 ha) with nests 525 m (275–800) apart (Baker-Gabb 1983). Roadside counts between Christchurch and Little R. gave density of 0.5 birds/km; between Christchurch and L. Pearson, 0.08/km (CSN 34). Numbers have increased following clearing of forests for grassland and pasture, especially in NZ, and introduction of animals suitable as prey (see Food), especially rabbits *Oryctolagus cuniculus* (Wodzicki 1946; Gurr 1968; Redhead 1969; Baker-Gabb 1986). Control of rabbits, mainly with 1080 poisoning, has markedly reduced numbers of Harriers in some areas since 1950s (Secker 1965; Redhead 1969; McKenzie 1979). Often killed on roads, probably while eating carrion. In Tas., of 28 found dead, 21 were road-kills (Mooney & Hunt 1983). In Mackenzie Basin, SI, 46 road-kills in 33 km between June 1985 and Oct. 1986 (Pierce & Maloney 1989). Often shot because supposedly a threat to sheep, domestic fowl and game animals (e.g. ducks) or damage pelts of trapped rabbits (Gurr 1968). In NZ, between 1923 and 1938, bounties were paid for feet of Harriers; Auckland Acclimatisation Society paid bounties for 200,000 Harriers (Oliver 1938) and in 1930s and 1940s, Otago Acclimatisation Society paid bounties for 26,184 harriers in 7 years (Baker-Gabb 1981b). By 1922, most Harriers resident on Little Barrier I. had been shot; only visitors from mainland recorded subsequently (Oliver 1922). Fully protected in all Aust. States and Territories; partially protected in 1985 in NZ (Baker-Gabb 1985; Bell 1985). Sometimes trapped or poisoned (Hobbs 1959; Mollison & Green 1959; Baker-Gabb 1981b; Mooney & Hunt 1983). Observed feeding on dead rabbits along poison-lines (Watson 1954), but no evidence of secondary poisoning (Pierce & Maloney 1989). When nesting in crops, eggs may be smashed or young decapitated by harvesting machinery (Sharland 1947) or trampled by sheep (Bourke 1948). Nests readily deserted, especially after eggs already laid, after even minor human disturbance (Sharland 1932, 1947; Cupper & Cupper; N.J. Mooney). Occasionally injured by hitting power lines (Fox 1977a). Introduced to Society Is, sw. Pacific, in about 1885 to exterminate rats (Mayr 1945; Long 1981).

MOVEMENTS **Aust.** Partly migratory. Large spring and summer breeding population Tas.; smaller breeding population se. Aust.; birds from both populations migrate N late summer and autumn, returning late winter and spring (Sullivan 1929; Sharland 1958; Hobbs 1959; Bedggood 1972, 1973; Baker-Gabb 1984b). Some birds resident: n. Aust. (Barnett 1980); e. and sw. Aust. (Hobbs 1961; Gill 1970; Cooper 1974; Gosper 1981; Baker-Gabb 1984a,b; Debus 1992; Cupper & Cupper; Aust. Atlas; Vic. Atlas). Very few stay Tas. where first return July, numbers increasing Aug. to peak in Oct.; first birds leave Jan., most in Feb.–Mar. (Sharland 1958); influxes in Feb.–Mar. recorded Bass Str. islands (Templeton 1974; Brothers & Davis 1985; Patterson 1985) and s. Vic. (Cooper 1974; Baker-Gabb 1984b; Peake 1989). Influxes during Apr. recorded sw. NSW (Hobbs 1959) and Sydney region (Debus 1982), some birds remaining through winter, departing spring (Hobbs 1959; Debus 1982). Mostly winter or dry-season visitor to n. NSW, but resident n. coast (Gosper 1981; Debus 1985, 1992), Lord Howe I. (Hindwood 1940), Norfolk I. (Hermes 1985), coastal s. Qld (Czechura 1984), coastal lowlands of ne. Qld (Gill 1970), Atherton Tablelands (Bravery 1970), Torres Str. islands (Druffan *et al.* 1983), w. C. York Pen. (Garnett & Bredl 1985), Mt Isa district (Horton 1975), Darwin region (Crawford 1972) and nw. Aust. (Storr 1980; Aumann 1991). Some records in all

months or during summer from se. Qld (Czechura 1985), highlands near Innisfail (Gill 1970), Darwin (Crawford 1972) and Victoria R. Downs, NT (Boekel 1980). Dispersal patterns of sw. Aust. birds little known; migrants to Torres Str. islands possibly mingle with birds from PNG (D.J. Baker-Gabb). In se. Aust., migrations of mainland and Tas. birds overlap, e.g. at Werribee, some breeding residents and offspring leave Feb.–Mar.; local numbers then increase Mar.–Apr. with influx and passage of migrants from Tas.; numbers remain low during winter, increase again late July–Oct. as birds migrate S (D.J. Baker-Gabb). Similar pattern recorded from Wilson's Prom. (Cooper 1974), where influxes noted late summer and Aug.–Sept. In sw. NSW, most local breeding birds leave Feb.–Mar.; influx recorded Apr., with arrival and passage of birds from Tas. and Vic.; lower numbers recorded winter; influx late July–Oct. as birds migrate S (Hobbs 1959). Though many birds appear to migrate N for winter, some birds migrate short distances only; three banded adults and one juvenile wintered at Werribee in successive years; sighted during breeding season over w. Vic. or SA lakes, an average of 170 km W (Baker-Gabb 1982a).

Large numbers appear to migrate in groups; Hobbs (1959) recorded 200 birds in 3 h in Bass Str., birds travelling in small groups of up to six birds; Templeton (1974) noted loose groups of up to ten birds passing over King I., late Feb. to early Mar.; nine first-year birds in loose group (birds not more than 500 m apart) observed flying from c. 1 km into shore, C. Otway, Vic., Feb. 15 (Peake 1989); Sharland (1958) calculated that many hundreds, perhaps thousands leave Tas. for winter. Adults leave Tas. as soon as young are independent; young leave 1–2 weeks later (N.J. Mooney), *contra* Sharland (1958) who recorded first-year birds leaving Tas. Jan., c. 1 month earlier than adults. Most first-year birds may remain on mainland during first summer; only adults known to return to Tas. (D.J. Baker-Gabb). One banded first-year male resident at Werribee, winter 1979; moved 25 km to summer site; returned to Werribee, winter 1980; subsequently recovered Tas., Oct. 1980; six other birds banded at Werribee and recovered Tas. have also been 2 years or older; however, all have been recovered within 30 km of banding place in Tas., except one juvenile that travelled 360 km W (Baker-Gabb 1982a). Of birds banded Tas. or King I., three long-distance recoveries: one from King I. 640 km NW to near Adelaide; one to near Geelong (540 km); and one to NSW–Qld border, 1520 km NNE (Mollison & Green 1959; Purchase 1973).

To some extent faithful to winter and summer grounds; 18 of 34 marked birds returned to Werribee in successive winters; most returning to hunt at same locality as previous season. Of these birds, significantly more females than males returned. On King I., Templeton (1974) considered that at least two pairs returned to previously held breeding territories; other breeding territories have been used in every year for 6–13 years (Baker-Gabb 1982a; Hollands), though individual identities of birds unknown.

Irregular movements recorded in some near-coastal areas in e. Aust. (Gibson 1977; Longmore 1978); may disperse inland following heavy rains (McGilp 1923). May move locally in response to fluctuations in food. At Werribee, numbers fluctuated according to abundance of waterfowl; decreased in autumn 1982 and winter 1981 when waterfowl numbers declined; showed atypical increase, summer 1982, when many waterfowl present (Baker-Gabb 1984b). Recorded from mallee areas in nw. Vic. during plague of House Mice *Mus musculus*; not recorded there previously (Hayward & MacFarlane 1971).

NZ Not generally migratory, though most birds with established summer ranges disperse from breeding areas during

non-breeding season, return late winter, spring (Baker-Gabb 1978); some post-breeding dispersal; some local movements in response to food (Gurr 1968). Post-breeding dispersal begins Feb., birds usually travelling N or S (Watson 1954; Baker-Gabb 1978), some crossing between NI and SI (D.J. Baker-Gabb). At Pukepuke Lagoon, NI, juveniles dispersed Feb., adults Feb–Mar. During autumn, early winter, additional birds passed through, most of which not seen again: for adult males, juvenile males, adult females and juvenile females caught in autumn, 100%, 82.3%, 100% and 72.2% respectively were seen only once (Baker-Gabb 1978). Dispersing birds may travel long distances; one adult banded Apr. 1952 was recovered May 1952, 740 km SW of banding site (Watson 1954). Juvenile males and females may travel 100 km or more from natal territories; rarely become permanent residents; some continuing to disperse through late winter, spring and summer (D.J. Baker-Gabb). However, juvenile males trapped in seasons other than autumn were more likely to establish home-ranges than those trapped in autumn; juvenile males trapped in spring, summer, or winter also showed much higher rate of return to former home-ranges (40.4%) than juveniles trapped during dispersal phase in autumn (11.8%). Adults usually disperse 15 km or less (Watson 1954; Baker-Gabb 1978). In 2 years on w. coast of NI, 13 of 15 and 10 of 15 adults left breeding grounds Feb.–Mar. and moved to nearby farmland areas for autumn and early winter (Baker-Gabb 1978); some birds returned to same farmland areas in successive years (D.J. Baker-Gabb). Most adult males returned to breeding areas mid-May; some females also returned then, but c. 50% of marked females did not return till late winter or early spring, c. 3 months after return of males (Baker-Gabb 1978). Juvenile and adult females appeared to be more dispersive than males: a greater percentage of females being trapped only once, and not seen again, e.g. 56.5% of females trapped late winter to early spring were seen once only. Some evidence of migratory movements: birds annually visit Kermadec Is, 1500 km NE of NZ, late Mar. to Sept.–Oct. (Iredale 1910a; Oliver); feed on young Sooty Terns *Sterna fuscata* and petrels. Jukes (1981) recorded group of more than 30 birds flying near coastline at s. tip of SI in autumn, with more birds arriving from out to sea; possibly from Stewart I., perhaps migrating to mainland for winter (D.J. Baker-Gabb). Birds sometimes congregate at temporary sources of food; up to 70 preying on Kiore *Rattus exulans* on White I., 50 km from mainland (Buller 1888); also congregate at sites where fish, rabbits or carcasses of rabbits abundant (Stead 1932; Gurr 1968; Baker-Gabb 1978). Local movements of 5–8 km observed between communal roosting sites and feeding grounds (Watson 1954; Gurr 1968).

FOOD Take small mammals, up to size of adult hare, rabbits, birds and eggs, large insects, frogs, fish and reptiles. In NZ, often take carrion; less so in Aust. Study of prey in coastal Vic. (n=777, Baker-Gabb 1984b, 1985) found mammals 43% no., 36% wt.; birds 49% no., 62% wt.; insects, fish, frogs and lizards taken in small numbers; in Tas. (n=151, Mooney 1983b) mammalian s. Reptiles: lizards: Scincidae –, 1.1, 0.9, –. Birds: Z (n=477, Baker-Gabb 1978) mammals 46.4%, birds 35.7%, eggs of birds 4.8%, insects 7.6%, aquatic prey 4.6%. **Behaviour** All hunting diurnal (Baker-Gabb 1984b). Exploit plagues of mice (Hayward & MacFarlane 1971; Hobbs 1971) and rabbits (McKenzie 1979). Usually search for prey by slow-quarterming (Table 1) (Baker-Gabb 1984b; 1986). At Werribee, Vic., most common method of attack hover-and-drop; at Pukepuke, NZ, most common method dive-attack (Table 2) (Baker-Gabb 1986). In light wind, flap and glide from 3–5 m high to edges of vegetation to surprise prey. Hang in air in strong to gale-force winds, drifting sideways (D.J.

Baker-Gabb). In NZ, three approaches to carrion recorded (Robertson)

Table 1. Observed methods of searching (% obs).

	1	2	3
Low slow-quarterming and transects	88	85	81
Flushing by stooping	8	6	2
Fast contour-hunting	1	3	7
Ground-hunting	2	6	7
Soaring and high transects	1	0	8

(1) Werribee, Vic.; methods observed with or without subsequent attack (n=273; Baker-Gabb 1984b); (2) Werribee, Vic.; methods before observed attacks (n=65; Baker-Gabb 1986); (3) Pukepuke, NZ; methods before observed attacks (n=100; Baker-Gabb 1986).

Table 2. Observed methods of attack (% obs).

	1	2
Hover-and-drop	40	38
Dive-attack	39	51
Direct-flying attack	15	4
Pounce-and-scratch	6	5
Tail-chase	0	2

(1) Werribee, Vic. (n=65; Baker-Gabb 1986); (2) Pukepuke, NZ (n=100; Baker-Gabb 1986).

1978): straight glide from 50 m to few metres from item; high circling >20 m above item, with spiral descent; low circling, flapping and gliding round item, landing up to 20 m away.

Occasionally attack from perch (Fox 1977b; Baker-Gabb 1978), e.g. quail *Coturnix* (Czechura 1979). Hover-and-pounce usually directed at mice and grasshoppers, more active attacks at live birds and rabbits (Baker-Gabb 1984b). Observed using direct-flying attack to strike and kill sprinting Brown Hare *Lepus europeus* (estimated weight 3 kg; S. Pellis), also stooping and striking down flying Rufous Night Heron *Nycticorax caledonicus* (North). Pounce-and-scratch attacks unusual, directed at small ground prey such as crickets and locusts (Stead 1932; Baker-Gabb 1982a). Catch prey on ground or water, rarely on wing (D.J. Baker-Gabb). When taking Eurasian Coots *Fulica atra* from water may remain above until Coot too exhausted to dive, sometimes plunging into water (Hollands). Also tired out Dusky Moorhen *Gallinula tenebrosa* by holding under water, trying either to move or drown prey (Coventry 1989). Attend fires that flush prey (Fiji: Holyoak 1979). Occasionally pursue birds in flight, dropping on them when landing (Gibb 1970). Stoop to catch fish, grasping them in feet under water (Habraken 1979); sometimes half-submerge when attacking swimming duck (Potter 1950); wade in shallow water to catch fish and tadpoles (Stead 1932). Once observed snatching small live fish from surface of water (H. Naarding). Recorded recovering dead duck from water by dragging slowly through water to shore; once on shore easily flew holding prey (McLennan 1976). Corner prey on ground, confine it by spreading wings and kill with jabs from feet (Redhead 1969). In a comparison of hunting behaviour, Baker-Gabb (1978) found adult males more manoeuvrable and less conspicuous than females and juveniles, flying lower and faster, and hunting in habitats with generally more agile prey. Unmated juveniles and adult females occasionally hunt in pairs, but not adult males (Baker-Gabb 1982a). Members of pairs hunt separate areas, one joining

other only when prey attacked (D.J. Baker-Gabb). Males prey on smaller prey (Pierce & Maloney 1989). Recorded stealing food from Whistling Kite *Haliastur sphenurus*, Peregrine Falcon *Falco peregrinus* (Hindwood 1933; Baker-Gabb 1980), and Kelp Gull *Larus dominicanus* (Robertson 1978). When eating carrion, stand on carcass, feet c. 10 cm apart. Feeding sequence: pluck prey, tear portion from carcass, while folded wings lowered and spread slightly from body with tail depressed to maintain balance. Captive adult female completed this sequence up to 32 times/min in first 2 min of feeding, rate dropping to steady 17–21 feeds/min for next 9 min, tailing off sharply; 240 g of meat was consumed (Robertson 1978). To eat large prey, eat large areas of muscle on fore and hindquarters of carcass, flesh off ribs and backbone, and liver and heart (Robertson 1978). Difficult prey like European Hedgehogs *Erinaceus europeus* entered from belly (Redhead 1969). Eggs carried for eating elsewhere (Mooney 1988; Whiter 1991), or possibly broken in nest (Gardner & Gardner 1984). Appear to select food by colour and ease of handling: in experiments, white and blue baits preferred to red, green or brown; Brown Rats *Rattus norvegicus* and Domestic Chicken pullets *Gallus gallus* preferred to rabbits; Brush-tailed Possum *Trichosurus vulpecula*, Short-finned Eel *Anguilla australis* and skinned rabbits preferred to unskinned rabbit carcasses (Robertson 1980). Brown Hare preferred to Rabbit preferred to Brush-tailed Possum (Fennell 1980). Orientation of carcass unimportant (Robertson 1980). Low wing-loading allows high manoeuvrability and sustained low flights (Brown 1976). Long legs help to catch prey in tall vegetation (D.J. Baker-Gabb). Seasonal variations: House Mice, rabbits and four species of rat most frequent mammalian prey throughout year (Baker-Gabb 1982a). Greatest numbers of House Mice and rats taken autumn and winter in Aust. and NZ, reflecting seasonal population changes of rodents (Newsome 1969a,b; Braithwaite & Gullan 1978; Baker-Gabb 1981b). In Aust., greatest number rabbits eaten spring and summer when immature rabbits most abundant (Shepherd *et al.* 1981); however, greatest amount consumed autumn and winter in NZ but possibly as carrion (Baker-Gabb 1981b). At Werribee, three times as many waterbirds as land birds taken (Baker-Gabb 1982a; Mooney 1983b), Eurasian Coots most numerous (16%) throughout year, with most taken autumn and winter. Live Coots and smaller waterbirds regularly taken; larger birds, e.g. ibis *Threskiornis*, always eaten as carrion. Land birds generally taken in breeding season, spring and summer (D.J. Baker-Gabb). In NZ, rely much upon eggs and nestlings in spring and summer (Redhead 1969; Baker-Gabb 1981b); road-kills, sheep and adult birds staple diet in autumn and winter (Redhead 1969). All land birds were open-country species. Birds greatest proportion of prey biomass (56%, Baker-Gabb 1978), though mammals greater in spring and summer. Carrion important autumn and winter. In Mackenzie Basin, more scavenging in winter (Pierce & Maloney 1989). No secondary poisoning noted in areas poisoned for rabbits (Pierce & Maloney 1989).

Adult Tas. (two nest-sites, 151 food items; Mooney 1983b) Amphibians: frogs: Green and Golden Bell Frog *Litoria aurea* 2.0% no. Reptiles: lizards: *Tiliqua nigrolutea* 4.0, *Leiopisma metallica* 6.6, *L. ocellata* 2.6; snake *Drysdalia coronoides* 2.0. Birds: Australasian Grebe *Tachybaptus novaehollandiae* 2.0; Little Black Cormorant *Phalacrocorax sulcirostris* 0.7; Pacific Black Duck *Anas superciliosa* 1.3; Brown Quail *Coturnix ypsilophora* 0.7; Tasmanian Native-hen *Gallinula mortierii* juv. 6.6; Purple Swamphen 2.0; Masked Lapwing *Vanellus miles* juv. 7.9; Laughing Kookaburra *Dacelo novaeguineae* 0.7; White-throated Needletail *Hirundapus caudacutus* 0.7; Skylark *Alauda arvensis* nestling 1.3; Common Starling *Sturnus vulgaris* 7.3; European Goldfinch *Carduelis carduelis* nest 2.6; other nests 4.0; Mammals: Rabbit *Oryctolagus cuniculus*

38.4; Brown Hare *Lepus europeus* 0.7; Rodents: Black Rat *Rattus rattus* 2.6; House Mouse *Mus musculus* 2.6. Carrion 1.

At Werribee, Vic. (n=227 prey items autumn; 270 winter; 106 spring; 174 summer; total n=777; Baker-Gabb 1984b, 1985): Insects: Orthoptera 15.4% no. autumn, 2.6% no. winter, 0.9% no. spring, –% no. summer; Coleoptera –, –, –, 1.7. Fish: Anguillidae: eel –, –, –, 0.6; carp *Cyprinus* –, –, –, 5.2. Amphibians: frogs: Hylidae –, –, 1.9, 1.1: Growling Bell Frog *Litoria raniformis*. Reptiles: lizards: Scincidae –, 1.1, 0.9, –. Birds: grebes 4.4, 3.0, 4.7, 0.6; ibis *Threskiornis* 2.6, 2.2, –, 0.6; Anseriformes indet. 3.9, 3.0, –, 1.1; Black Swan *Cygnus atratus* 0.9, 1.5, 0.9, 1.7; Grey Teal *Anas gracilis* 0.4, 0.7, –, 2.3; Chestnut Teal *A. castanea* 0.4, –, –, 0.6; Australasian Shoveler *A. rhynchos* –, 0.4, –, 1.1; Pink-eared Duck *Malacorhynchus membranaceus* 3.9, 1.1, 1.9, 0.6; Hardhead *Aythya australis* 1.3, 0.4, –, –; Stubble Quail *Coturnix pectoralis* –, –, 1.9, 3.4; Buff-banded Rail *Gallirallus philippensis* –, 0.7, –, 1.7; Australian Crane *Porzana fluminea* 0.4, –, 0.9, 0.6; Dusky Moorhen 0.9, 1.8, –, 0.6; Purple Swamphen *Porphyrio porphyrio* –, –, 1.1; Eurasian Coot 23.3, 27.8, 17.0, 3.4; Red-necked Avocet *Recurvirostra novaehollandiae* –, 0.4, –, –; Scolopacidae: sandpipers 0.4, 0.4, 1.9, 2.3; Latham's Snipe *Gallinago hardwickii* –, 0.9, –; Silver Gull *Larus novaehollandiae* –, –, 0.9, –; Feral Pigeon *Columba livia* –, –, 0.9, 0.6; Red-rumped Parrot *Psephotus haematonotus* –, –, 0.6; unident. passerines 3.1, 3.3, 5.7, 8.0; Richard's Pipit *Anthus novaeseelandiae* or Skylark –, –, –, 3.4; Blackbird *Turdus merula* –, –, 1.9, 1.7; Clamorous Reed-Warbler *Acrocephalus stentoreus* –, –, 1.9, 2.9; grassbird *Megalurus* or calamanthus *Sericornis* 0.4, 0.4, –, 6.9; Brown Thornbill *Acanthiza pusilla* –, –, –, 0.6; Golden-headed Cisticola *Cisticola exilis* –, –, 0.9, 0.6; White-fronted Chat *Ephthianura albifrons* –, –, –, 0.6; Common Starling –, –, 3.8, 1.1; European Goldfinch –, –, –, 0.6; House Sparrow *Passer domesticus* –, –, 3.8, 3.4. Mammals: Rabbit 4.4, 8.9, 30.2, 24.1; Brown Rat 3.9, 4.4, 1.9, 5.1; Swamp Rat *R. lutreolus* –, –, –, 1.1; Black Rat 1.8, 3.0, –, –; Water Rat *Hydromys chrysogaster* 1.3, 0.4, 0.9, –; House Mouse 26.0, 32.2, 13.2, 8.0. Live prey and carrion analysis of same data: summer: 88% no., 72% wt. live prey; 12% no., 28% wt. carrion; autumn: 82, 66, 18, 34; winter: 76, 64, 21, 36; spring: 88, 80, 12, 20; total: 83, 69, 17, 31.

NZ Breeding N. Canterbury, SI (Douglas 1970): remains of European Hedgehog and juvenile Brown Hares found at three nests, Australian Magpie *Gymnorhina tibicen* imm. at one, Yellowhammer *Emberiza citrinella* at one. **Throughout NZ** (124 stomachs; Carroll 1968): vegetation 41.9% no. Arachnids: Araneae: spider 2.4. Insects: Orthoptera: Gryllidae: crickets 11.3; Acrididae/Tettigoniidae: grasshoppers 10.5; Acrididae: locusts 5.6; Hemiptera: Cicadidae: cicadas 6.5; Coleoptera 0.8; Lepidoptera: moth 4.0. Fish unident. 0.8. Amphibians: frogs 4.8. Birds unident. 12.1; eggs 5.6; duck 2.4% no.; Skylark 4.8; Blackbird 11.3; Song Thrush *Turdus philomelos* 5.6; Tomtit *Petroica macrocephala* 0.8; Silveryeye *Zosterops lateralis* 2.4; Common Starling 1.6; House Sparrow 12.9; European Goldfinch 0.8; Chaffinch *Fringilla coelebs* 1.6; Yellowhammer 0.8. Mammals: Rabbit 12.1; Brown Hare 6.5; European Hedgehog 5.6; House Mouse 1.6; Brush-tailed Possum *Trichosurus vulpecula* 8.1; Sheep *Ovis aries* (wool only) 12.9. Seasonal data (no. stomachs in which foods occurred; 34 stomachs collected autumn, 21 winter, 11 spring, 58 summer): remains of birds found in 29.4% stomachs autumn, 42.9% winter, 63.6% spring, 53.4% summer; mammals 64.7, 90.5, 45.5, 25.9; frogs and fish 8.8, 4.8, 9.0, 3.4; invertebrates 52.9, 9.5, 9.0, 37.9; plants 32.4, 61.9, –, 48.3. Vegetation probably incidental, from gut contents of prey. **At Pukepuke Lagoon, sw. NI** (477 prey items: summer n=243; autumn 85; winter 92; spring 57; Baker-Gabb 1981b): Mammals 46% no., 71% biomass; birds (including eggs) 41, 25; fish and frogs 5, 4; insects 8, <0.1. In

detail: Insects: Orthoptera 2.5% no. prey items summer, 29.4% autumn, -% winter, -% spring, 6.4% total prey items; Hemiptera 1.2, 1.2, 1.1, -, 1.0; Coleoptera 0.4, -, -, -, 0.2. Amphibians: frogs: 2.5, -, -, 5.3, 1.9. Fish: carp 0.8, -, 1.1, -, 0.6; eels 1.7, -, 6.5, -, 2.1. Birds: eggs 6.2, -, 2.2, 10.5, 4.8; prion *Pachyptila* (probably carrion) 1.7, -, -, 0.9; duck *Anas* 2.0, 5.9, 2.2, 5.3, 3.1; Common Pheasant *Phasianus colchicus* 2.0, 2.4, -, 5.3, 2.1; Purple Swamphen 2.5, -, 1.7, 1.5; unident. passerines 17.8, 7.0, 5.3, 1.7, 11.2; Skylark or Richard's Pipit 2.0, -, -, 1.7, 1.3; Grey Warbler *Gerygone igata* 0.4, -, -, -, 0.2; Silvereye 0.4, -, 1.1, -, 0.4; Blackbird 2.5, 1.2, 2.2, 1.7, 2.1; Common Starling 0.8, -, -, -, 0.4; Yellowhammer 5.8, -, 3.3, 3.6, 4.0; Chaffinch 1.7, -, -, -, 0.8; European Greenfinch *Carduelis chloris* 2.5, -, -, 1.7, 1.5; European Goldfinch 0.8, -, 2.2, -, 0.8; Hedge Sparrow *Prunella modularis* 7.8, -, 1.1, 3.6, 4.6; House Sparrow 2.0, 1.2, 1.1, -, 1.5; Australian Magpie 0.4, -, -, -, 0.2. Mammals: Rabbit 12.7, 25.9, 23.9, 12.3, 17.2; Brown Hare 0.8, -, -, -, 0.4, European Hedgehog 8.2, 11.8, 13.0, 5.3, 9.4, Brush-tailed Possum (carrion) 1.7, 1.2, 2.2, 3.5, 1.9, Sheep (carrion) 2.0, 3.5, 12.0, 33.3, 8.0, Brown Rat -, 4.7, 4.3, -, 1.7, House Mouse 6.2, 7.0, 15.2, 3.5, 7.8. In s. **SI** (129 crops or stomachs; Redhead 1969): plant material 0.2% vol., -% no., -% vol. spring (12 crops/stomachs), 0.2% summer (9 crops/stomachs), 0.0% autumn (52 crops/stomachs), 0.0% winter (56 crops/stomachs). Insects -, 1.5, -, -, -, -. Vertebrates: unident. meat 6.2, -, 8.4, 6.5, 0.0, 0.0; bones <0.1, -, -, 0.0, 0.0, 0.4. Fish *Salmo trutta* 2.4, 1.1, 1.0, 1.4, 0.0, 19.0. Reptiles: lizards: Scincidae -, 1.5, -, -, -, -. Birds: unident. 1.0, 5.7, 2.5, 0.4, 0.0, 0.0; eggs -, 6.9 (no seasonal data); duck *Anas* -, -, -, 23.2, 0.0, 12.2; indet. 7.7; 2.5, 6.9, 0.7, 3.8, 0.0; Skylark 0.4, 1.5, 0.2, 0.0, 0.0, 5.4: eggs -, 0.8; Blackbird 4.0, 5.3, 1.2, 2.2, 40.2, 0.0: eggs -, 0.8; Song Thrush, 5.2, 3.4, 0.5, 5.1, 33.0, 0.3: eggs -, 1.1; Goldfinch 0.3, 1.9, 0.2, -, 0.0, 2.8; House Sparrow 2.7, 1.1, 0.0, 4.5, 0.0, 0.0. Mammals: Brush-tailed Possum 1.8, 4.2, 6.7, 0.0, 0.0, 0.0; Rabbit 10.4, 7.3, 24.8, 0.1, 10.7, 47.7; Brown Hare 2.4, 3.8, 8.6, 0.1, 0.0, 0.0; European Hedgehog 6.9, 9.2, 6.4, 8.3, 0.0, 2.1; rodents: unident. hair -, 1.1; House Mouse 1.1, 3.8, 1.2, 1.2, 0.0, 0.0; Brown Rat -, 0.4 (no seasonal data); Sheep 45.0, 17.9, 13.0, 64.8, 8.2, 19.7; detritus 1.0, -, 1.3, 0.8, 0.3, 2.3. In pellets collected from same area (20 pellets, 38 food items; Redhead 1968) Brush-tailed Possum 7.0% no. items, remains of Sheep 15.8, Rabbit 5.3, Brown Hare 5.3; duck *Anas* 13.2, Song Thrush 5.3, Yellowhammer 2.6, unident. passerines 26.4, Skylark eggs 2.6, Blackbird eggs 5.2, unident. eggs 5.2; lizards: Scincidae 5.2. In n. **Canterbury, SI** (n=99 cast pellets; probably mainly carrion; Douglas 1970) Insects: *Uropetala carovei* 1% freq.; Orthoptera: *Hemideina thoracica* 1; Hemiptera: *Melampusalta* 1; Coleoptera: Carabidae 7; Lepidoptera 1. Birds: Canada Goose gosling *Branta canadensis* 1; Paradise Shelduck *Tadorna variegata* 1; unident. passerines 7; Australian Magpie 1. Mammals: Brown Hare ads 78, juvs 9; Rabbit 1; European Hedgehog 15; Chamois *Rupicapra rupicapra* 3; Sheep *Ovis aries* 2; Red Deer *Cervus elephas* 1; indet. 1. No seasonal trends apparent. In ne. **SI** (n=18 pellets; Fox 1977b): birds: unident. in 2 pellets; egg-shell 1; California Quail *Lophortyx californica* 1; Skylark or Richard's Pipit 1; Blackbird 1; Hedge Sparrow 1, Chaffinch 1; Silvereye 1; Brush-tailed Possum 1; Brown Hare 2; Rabbit 2; Rodents: House Mouse 1; Sheep 3, lamb 1.

At **Tekapo R., SI, NZ** (779 pellets; Pierce & Maloney 1989): Insects: Orthoptera: *Sigauss australis*. Reptiles (incl. geckos *Heteropholis gemmeus*; skinks *Leiopisma*; *L. nigriplantare macanni*; *L. chloronoton*; *L. lineoocellatum*). Birds: unident. 0.3; Kelp Gull *Larus dominicanus*; 0.1; Black-fronted Tern *Sterna albobristata* egg 0.1; unident. passerine 0.3; Blackbird 0.1; Skylark 0.5; European Greenfinch 0.1; Chaffinch 0.1; Yellowhammer 0.1; lagomorphs (mainly Rabbit with a few Brown Hare) 98.5; European Hedge-

hog. In **Cass Valley, SI, NZ** (239 pellets; Pierce & Maloney 1989): Insects (incl. Orthoptera: *Sigauss australis*) 20.1% freq. Reptiles: lizards (incl. geckos *Heteropholis gemmeus*; skinks *Leiopisma nigriplantare macanni*) 9.2. Birds: unident. 5.0: duck *Anas* egg 0.8, duckling 0.4; Double-banded Plover *Charadrius bicinctus* chick 0.8; Black-fronted Tern chick 0.8; unident. passerine 1.7; Skylark 2.9; European Goldfinch 0.4; Redpoll *Carduelis flammea* 0.4; Yellowhammer 1.7; lagomorphs (mainly Rabbit with few Brown Hare) 77.0; rodents: House Mouse 0.4; European Hedgehog 1.7; Sheep 1.7.

Other records Aust. Plants: *Trifolium* sds; Animals: Molluscs: gastropods: fruit-tree slug. Insects: Orthoptera: Gryllidae: crickets; Acrididae: short-horned grasshoppers (Barker & Vestjens). Fish: Carp *Perca fluviatilis* (Vestjens 1977). Reptiles: snakes: Tiger Snake *Notechis scutatus* (Vestjens 1977). Birds: shearwaters or petrels *Puffinus* or *Pterodroma* (Lord Howe I., Iredale 1910b); Australasian Bittern *Botaurus poiciloptilus* (Sharland 1932); ducks (Sharland 1958; Hobbs 1959); Domestic Chicken (Legge 1908; Hollands); Dusky Moorhen (Coventry 1989); Purple Swamphen ads, juvs (Fletcher 1924; Sharland 1932, 1958); Tasmanian Native-hen; Masked Lapwing (Sharland 1958; Mooney 1988); Banded Stilt *Cladorhynchus leucocephalus* (Wheeler 1963); Marsh Tern *Chlidonias hybrida* nestling (Breen 1988); pigeons (Hindwood 1933); parrots; honeyeaters and smaller species (Sharland 1958); grassbird nestlings (Fletcher 1924; Sharland 1932, 1958); Skylark (van Tets *et al.* 1977). Eggs: quail *Coturnix* (Sharland 1932); Australian White Ibis *Threskiornis molucca* (Gardner & Gardner 1984); oystercatcher *Haematopus* (Hollands). Mammals: Brown Hare (Bedgood 1960); Rodents: Black Rat (van Tets *et al.* 1977); Carnivora: Fox cub (McNabb 1991). **NZ** Insects: Orthoptera: Acrididae/Tettigoniidae: grasshoppers (Child & Child 1982); Coleoptera: ladybirds *Coccinella*. (Baker-Gabb 1981b). Fish: trout *Salmo* (Pierce & Maloney 1989; CSN 21); Short-finned Eels carrion (Baker-Gabb 1978; Robertson 1978). Amphibians: frogs: Green and Golden Bell Frog (Robertson 1978; Baker-Gabb 1981b); Whistling Tree-Frog *Litoria ewingi* (Robertson 1978). Reptiles: lizards (Buddle 1941). Birds: Pied Cormorant *Phalacrocorax varius* eggs (Parkin 1950); White-faced Heron *Avdeca novaehollandiae* (Redhead 1969); duck (McLennan 1976; Messenger 1990); Purple Swamphen (Messenger 1990); Domestic Fowl (Baker-Gabb 1981b); Kelp Gulls (Carroll 1968); Sooty Tern *Sterna fuscata* (Kermadec Is, Iredale 1910b); Black-winged Stilt *Himantopus himantopus* (Stokes 1949); Blackbird (Cunningham & Moors 1985; Messenger 1990); House Sparrow nestlings (CSN 19); European Goldfinch; European Greenfinch; Yellowhammer (Robertson 1978); eggs: Common Pheasant (CSN 22); Turkey; Song Thrush (CSN 19). Mammals: Brush-tailed Possum (Robertson 1978); rabbits (Robertson 1978; Messenger 1990); rodents: Black Rat (Robertson 1978; Messenger 1990); House Mice (Robertson 1978; Cunningham & Moors 1985); Stoat *Mustela erminea* (Savill 1947); Sheep (Robertson 1978; Cunningham & Moors 1985).

Young Chicks sometimes eat smaller siblings (D'Ombrian 1905; Baker-Gabb 1982b; Cupper & Cupper).

Intake Av. daily intake of 722-g adult was 112 g; of a 635-g juvenile, 23-40 days after hatching, was 148 g; same bird after completion of feather-growth, 41-55 days after hatching, was 104 g (Redhead 1969). Single feed of adult, 240 g (Robertson 1978). Efficiency of assimilation of energy of captive birds varied with diet: mice 75.5%, 14-day chicks 70.2, fish 81.1, pellets were produced after eating mice and chickens but not fish (Tollan 1988). In captivity, on average 55% of diet metabolized, and gross energy intake varied from 246.2 kJ/day to 297.9 kJ/day depending on diet (Tollan 1984).

SOCIAL ORGANIZATION Based on information provided by D.J. Baker-Gabb; major studies: coastal NI, NZ, coastal Vic., Aust. (Baker-Gabb 1978, 1981a, 1982a, 1983). Usually seen singly. In non-breeding season, often roosts communally and, in past, sometimes in large numbers, e.g. in NZ up to 200–300 (Stead 1932); with decrease in rabbits, such large numbers no longer seen. Also in past, some records of large groups on other occasions (Sharland 1958); during winter in NZ, congregation of c. 100 hovering and calling for about 2 h (Wodzicki 1949). Rarely display in groups (Sharland 1932; Fox 1978), but several males may display at the same time near their territories early in breeding season (Baker-Gabb 1983). Loose groups may also assemble during migration: over King I., up to ten drifting overhead and 16 resting together (Templeton 1974); nine observed flying from sea over coastal Vic. (Peake 1989). Usually feed singly but unmated pairs or trios of juveniles and adult females may form hunting associations.

Bonds Mostly monogamous (Stead 1932; Soper 1957; Baker-Gabb 1983) but polygyny recorded twice in NZ (Baker-Gabb 1981a) and further studies may reveal it to be more widespread. If polygynous, males defended much of available nesting habitat: one male had two territories 1300 m apart, each defended by a female against the other female as well as intruders; second male had two females with nest-sites 350 m apart; females divided territory, interacting aggressively along their boundary; first female to arrive appeared dominant (Baker-Gabb 1981a). Little information on length of bond. In NZ, of 15 breeding adults tagged one year, ten re-established territories following year; of these, eight in their same territories and six pairing with mate of previous season (Baker-Gabb 1981a); possibly pairs returning to same nesting area each year also noted by Templeton (1974), Baker-Gabb (1982b) and Hollands. Sex-ratio 1:1 and, at one study site, all adults formed pairs (Baker-Gabb 1981a; D.J. Baker-Gabb). Most females pair and breed in second year and most males in second or third year; a few birds pair in first year but generally do not breed; rarely, females may breed in first year. Breeding displays begin from late May to mid-July in coastal NZ and from July or Aug. in coastal Vic. (Baker-Gabb 1981a; D.J. Baker-Gabb). Birds breeding for first time breed up to 5 weeks later than older birds nearby. **Parental care** Female builds nest, incubates, feeds young and guards nest; male hunts for female and young, and female may begin to hunt once nestlings more than 2 weeks old; after fledging, female alone may feed young but more usually both adults feed them.

Breeding dispersion Single pairs, territorial. Density: in coastal Vic., in 12 km² of reed bed and swamp, 1 nest/67 ha (n=18) with mean distance between nests 525 m (275–800) (Baker-Gabb 1983); in e. Tas., along three streams mean distance between nests 2.1 km (1.1–3; 12) (N.J. Mooney); in coastal NI, in 12 km², 1 breeding pair/120 ha with mean distance between nests 910 m (300–1600; 19) (Baker-Gabb 1981a); near Tekapo R., SI, nests 1180 m (380–3220) apart (Pierce & Maloney 1989). Boundaries of territories often follow ecotones, e.g. between reed beds and farmland. Territories clearly defined by Sept. in both Aust. and NZ. Size of territory round nest-site: c. 30 ha; diameter 300–600 m; defended to heights of 20–30 m above nest-site and 20 m at boundaries; may decrease in size after young hatch (Baker-Gabb 1981a, 1982a). Territory used for courtship, mating, nesting, feeding and rearing of young; some hunting within territory, but mostly outside it. All adult males and females appeared to defend territories; young males may establish small territories in inferior areas but abandon them after a few months; young birds breeding for first time also observed breeding at inferior sites (Baker-Gabb 1981a). **Home-range** During breed-

ing, favoured hunting areas may change as season progresses; adult male hunts up to 3 km from nest-site, in areas that overlap much with neighbouring pairs; in NZ, home-range estimated to be c. 900 ha overlapping c. 75% with those of neighbours, though neighbours seldom seen in same area at same time; within each 900 ha, pair favours and mainly hunts in an area of c. 300 ha (Baker-Gabb 1981a). Daily home-ranges of non-breeding birds similar in size to favourite hunting areas of breeding adults, but range much larger throughout breeding season. Outside breeding season, permanent residents occupied home-ranges of c. 3.7 km²; daily home-ranges of temporary residents similar in size to those of permanent residents but varied in location by 5–10 km from month to month or, more rarely, from week to week. Home-ranges of permanent residents varied little in location; similar in size for adults and juveniles, but home-range of males found to be 60 ha smaller than that of females. Home-ranges of permanent residents may be overlapped by those of six or more of their neighbours. Permanent and temporary residents occasionally visit communal roosts, different from roost normally used, up to 20 km outside their established home-ranges. Always return to habitual roost within 1 week (Baker-Gabb 1982a).

Roosting Nocturnal; on or near ground in reed beds, swamp, marsh, tall grass in grasslands, tall standing pastures (e.g. lucerne); along river beds, in estuaries and margins of lagoons, pools and lakes (Gurr 1968; Baker-Gabb 1978, 1982a); return to same areas each year if vegetation unchanged. Many apparently perch on sedges to keep feet out of water (Gurr 1968). During breeding season, adult females roost on nest, males usually within 100 m on fallen reeds or 'cock nests' concealed in tall reeds or grass; occasionally males use communal roost near nest-site. Communal roosts may be used throughout year by non-breeding birds; fledgelings, until at least 4 weeks old, return to nest-site (Gurr 1968; Baker-Gabb 1981a). In coastal Vic., communally roosting birds land in areas of c. 0.5 ha within fields >100 ha of tall grass (*Phalaris* and *Lolium*) growing in c. 10 cm of water (D.J. Baker-Gabb); c. 0.6 km² of a 5–8 km² swamp used for communal roost (Gurr 1968). Communal roosting areas identified by a cluster of trampled sites indicating where birds have spent night; probably each site only occupied by one bird (Gurr 1968). Numbers at roosts in past in NZ: 200–300 (Stead 1932), 45 (Middleditch 1949), maximum 50–150 (Gurr 1968); numbers may now be much lower with extermination of rabbits, e.g. 16 (Hedley 1976), maximum 20 (Baker-Gabb 1978) and large roost observed by Gurr (1968) now deserted (D.J. Baker-Gabb). In Aust., five communal roosts averaged 13 birds but as many as 40 recorded and numbers fluctuated from day to day, probably because birds of passage move through; some birds changing roosts; occasionally birds roost solitarily near communal roost but join it after one or two nights (Baker-Gabb 1982a, 1984b). Adult males evict juvenile males and maintain segregation within roost, juveniles roosting some 300 m from adult males with adult females in between. When number of roosting birds dwindles to about five, roost abandoned *en masse*; in Vic., abandoned by early Dec. and re-occupied early Mar. Two of five communal roosts re-used in 5 consecutive years; these had areas of especially long rank grass, which, unlike less permanent roosts, was never grazed. Single birds arrive at roosts at twilight (Gurr 1968). Return to roost with steady flapping flight 10–20 m above ground from as far as 7 km away; occasionally perch at staging points 0.5–2 km away; most early arrivals soar over roost or perch outside it, sometimes in groups, on grassy verges of freshwater pools, on grass or on fence posts, in leafless willow trees; perching birds may preen or bathe (Gurr 1968; Baker-Gabb 1982a). Leave roost at dawn and for up to 30 min afterwards; after leaving, some spend up to 30 min

preening and loafing on fence posts or ground near roost; or most preened before departing to hunting grounds (Gurr 1968); most flew straight from roost (Baker-Gabb 1982a).

SOCIAL BEHAVIOUR Based on information provided by D.J. Baker-Gabb; major studies coastal NI, NZ and Vic., Aust. (Baker-Gabb 1978, 1981a, 1982a, 1983). Very shy at nest and will desert eggs and young if disturbed by man (Sharland 1932, 1947; Soper 1957; Cupper & Cupper); less likely to desert if nest inspected while female off nest voluntarily. Spend much of day hunting with peaks in activity in mid-morning and mid-afternoon. Often wade belly-deep into water; may bathe daily, like captive birds (D.J. Baker-Gabb); before roosting some birds bathe or drink (Gurr 1968).

Aerial activity Following mainly relates to courtship; see Agonistic behaviour for other aerial displays. **DISPLAY SOARING:** pair flies above territory, with wings raised high and bent slightly back; male, often above, occasionally stoops at female, causing her to fly fast zigzag course away from him for c. 20 s; more often, flips over and thrusts tarsi at male, in manoeuvre reminiscent of aerial food-pass (Baker-Gabb 1981a; Stead 1932). Rarely, pairs may lock talons and swing in downward spiral (Cooper 1969); presentation of talons also observed during agonistic encounters, see below. Soaring usually followed by **DISPLAY-DIVING** during which Courtship Call given; early in season appears as shallow undulating flight but later more spectacular series of U-shaped dives at heights varying from 50–200 m; fly with deep exaggerated wing-beats, dive steeply for 25 m or more, and then shoot out of dive on upraised wings and perform a full- or half-barrel roll, or twist and turn at zenith (Baker-Gabb 1981a; Hollands). If female soars with male before he begins Display-diving, she descends slowly with her wings held high and lands in tall vegetation, or leaves area; if female lands, male continues diving and begins twisting and jinking like a falling leaf before eventually alighting near her (Stead 1932). Rarely, several birds perform Display-diving simultaneously (Sharland 1932; Fox 1978; Baker-Gabb 1983); each bird ends display over own territory; flight similar to birds performing Display-diving alone; up to eight males seen displaying early in breeding season (Baker-Gabb 1983); occur at a great height and birds call loudly on upward flights (Sharland 1932); function of group displays unknown. Another display ('switch-backs'), seen much less often, performed at heights of <50 m: while gliding in level flight above nest-site, bird suddenly reverses flight direction (Hamerstrom 1969).

Agonistic behaviour During breeding, non-breeding birds usually not evicted from breeding pair's favourite hunting area unless fly within 100 m of a hunting adult; all parts of nesting territory defended with equal vigour by both sexes. When hunting, solitary birds may stoop and try to displace conspecific feeding on large prey on ground: owner mantles food, crouching with wings spread and gives Threat Call (Redhead 1969) or leaps into air and thrusts talons at attacker; occasionally intruder may rush directly at mantling defender with wings and tail spread and lowered, body-feathers fluffed out, and feathers of nape erect; if this fails, may lash out with tarsi and lock talons with defender while throwing body back out of reach; displacement sometimes successful but often fails until owner of food satiated; when on ground, intruder usually perches some 20 m away and waits (Baker-Gabb 1978; Robertson 1978; Cook 1988). Occasionally flying bird, usually female, stoops at and tries to displace bird occupying roosting site or perched outside roost, sometimes resulting in aerial chase; however aggressor, as often as not, does not then land in vacated site (Gurr 1968; D.J. Baker-Gabb); 6–8 birds may join in chases (Gurr 1968); in morning, birds leaving roost

sometimes stoop at perched birds. **TERRITORIAL ADVERTISING:** territorial display-flights up to six times a day but decrease in frequency as breeding season progresses (Baker-Gabb 1981a). Diving displays (see Aerial activity) may have territorial function, specially if series of U-shaped dives are shallow ones of 5–15 m; such shallow dives often performed in company of several rivals (Sharland 1932; Baker-Gabb 1983). **TERRITORIAL BOUNDARY DISPLAY:** early in breeding season, rival adult males display by flying silently, c. 10 m apart and at height of c. 15 m, in same direction along each side of boundary of territory; wings held exaggeratedly high and bright orange-yellow tarsi thrust straight down (Fig. 2); fly slowly with few wing-beats and pale underparts and dark underwing bars conspicuous (Baker-Gabb 1981a). If each bird lands on prominent shrub or knoll in its territory, may call and remain perched for c. 5 min and then usually leave area and begin hunting. As season progresses, boundary display replaced by **BORDER PATROLLING**, characterized by male flying unaccompanied along territorial boundary but without adopting display postures. Females rarely make Territorial Display-flights or Border Patrols. Until nest built, adults usually evict only birds of their own sex, but after this usually indiscriminate in eviction and become increasingly intolerant of intruders. **Threat, Attack** Owner of territory evicts intruders by flying low, fast and directly, attacking or pursuing intruder until it crosses boundary of territory or climbs to height of at least 20 m; once intruder above this height, female pursuer usually returns to circle over centre of territory, whereas male escorts intruder to boundary, flying below and often ahead of it; male may thrust tarsi down on reaching territory boundary and fly along boundary for short (50 m) distance before returning to centre of territory or continuing hunting. Locking of talons and cartwheeling, between adult female neighbour intruding on resident male; talon-grappling with New Zealand Falcon when intruding on latter's territory (Fox 1978); do not usually nest within sight of or within 1 km of nest-site of New Zealand Falcon (Fox 1977b). Hunting Harriers may be

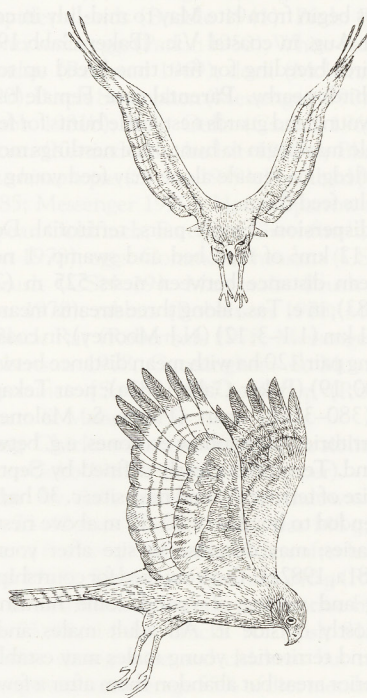


Fig. 2 Territorial Boundary Display

attacked by smaller raptors such as Black-shouldered Kites *Elanus axillaris* (D.J. Baker-Gabb), large passerines such as corvids and Australian Magpies *Gymnorhina tibicen* and large waders such as Masked Lapwings *Vanellus miles*; attacks cause little disruption and, although those of breeding Lapwings fierce, do not prevent Harriers from taking young Lapwings (see Food); to ward off attacker, Harrier may roll over and thrust long legs in direction of attacker; Australian Magpies occasionally kill Harrier that they have grounded (Buller 1888; Stead 1932). Flocks of Little Ravens *Corvus mellori* recorded chasing Harriers from carrion (Baker-Gabb 1986).

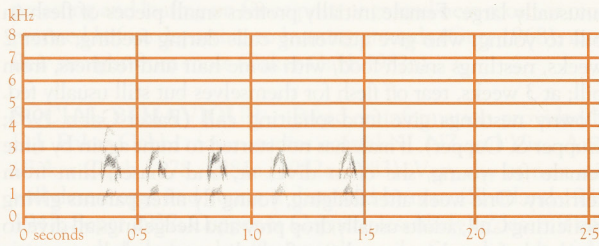
Sexual behaviour Displays described in aerial activity may incorporate aspects of courtship, maintenance of pair-bond and territorial advertising. Pairs SOAR and chase most often on warm sunny mornings and begin such activities in late winter in coastal Vic. Shallow undulating DISPLAY-DIVING performed by both sexes, but most often by male. When performing level gliding flight (see Aerial activity) above perched mate, female regularly gives loud *kee-oh* call, to which male answers with soft *kee-uck* (Baker-Gabb 1981a). **Courtship feeding** Probably occurs at least once a day for c. 6 weeks before laying; usually within territory out of sight in tall reeds; may occur at 'cock nest', which is unlined platform built by male c. 50 m from where female later builds nest in which eggs laid (Fletcher 1909; Baker-Gabb 1981a); other males may use an area of dry ground in territory for same purpose. Male flies to feeding site with prey, raises wings high and gives Courtship Call; female flies to him and takes prey; as she lands male leaves and perches nearby. Once incubation begins, most food-passes made in air; male calls female from nest then, flying c. 2 m above and ahead of calling female, drops prey 1–2 m to her as she flies beneath him; female flips forward and catches prey in one or both feet; less often, food-passes made from foot to foot (Baker-Gabb 1981a); after food-pass, female flies to eat prey at a plucking station, a regularly used area of dry ground c. 30 m from nest (Fletcher 1909; Soper 1957; Baker-Gabb 1981a); exchange of food continues after hatching (see Relations within family group). **Copulation** As with Courtship feeding, copulation may take place at cock-nest. Before copulation, soaring female twice seen to Display-Dive, with Soliciting Call, to mate that had prey; male left food for female, flew 3 m away and stood with wings raised side-on to her; female adopted crouched horizontal posture facing male and gave Soliciting Call again as she mock-pecked at food; male flew and alighted on her back for c. 10 s, flapping to maintain his balance; he then flew 30 m away and began preening while female completed her meal and then bathed nearby. Two similar copulations observed, except male flew in with and presented prey to female, but did not raise his wings in display before copulation (Baker-Gabb 1981a). Copulation also followed Display-diving, when no food was given to female (Hollands).

Relations within family groups When looking for nest-site, pair fly low over territory; when one bird lands, other continues to soar low and then roles reversed; when on ground male frequently gives short quickly repeated call. During 12 weeks between time pair begins searching for nest-site and young 2 weeks old, female seldom leaves territory; when not incubating, often perches in prominent positions near nest, soars overhead or makes short flights to collect nest material. About 1 week after hatching, female begins to spend long periods perched within 30 m of nest but returns to cover young when it rains; male no longer perches in territory after delivering prey but usually leaves area. Only female feeds young; male may land at nest and deposit food, once nestlings more than 2 weeks old, and female has begun to hunt, but does not stay to feed nestlings. After hatching, female flies directly to nest instead of using plucking station, unless prey

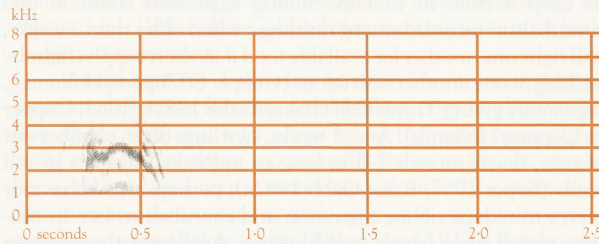
unusually large. Female initially proffers small pieces of flesh in bill to young, who give quavering calls during feeding; after 2 weeks, nestlings snatch food, with some hair and feathers, from bill; at 3 weeks, tear off flesh for themselves but still usually fed. Downy nestlings give food-soliciting call (Baker-Gabb 1983; Cupper & Cupper). If male has not started to hunt again by time female fed young, she often dives at, and chases, him from territory. One week after fledging, young fly after parents giving Soliciting Call; adults usually drop prey and fledgelings all dive to catch it before it hits ground; first fledgeling to see adult returning to territory usually secures food, mantles over it and Threat-calls to keep it from its siblings. Sibling aggression common and cannibalism recorded among nestlings; when older than 2 weeks, will fight one another for available food if in short supply; fight by striking at one another with talons (Cupper & Cupper; Hollands), repeatedly giving Threat Call (Baker-Gabb 1982b, 1983; Cupper & Cupper; Hollands). At c. 3 weeks, nestlings often clamber out of nest, down tunnels 1–5 m long to individual retreats in tall reeds (Soper 1957; Baker-Gabb 1982a); perhaps this behaviour serves to reduce sibling aggression and cannibalism late in nestling period when female away hunting. **Anti-predator response of young** Response of young more than 10 days old to intruders: spread wings, open bill and give hissing call; readily strike with talons by throwing themselves on backs and striking with both feet. Recently fledged young give same Threat Call when predators near nest-site. **Parental anti-predator strategies** Most interspecific disputes (see Agonistic behaviour) best interpreted as anti-predator behaviour. Some pairs soar overhead giving Threat Call when nest visited; others leave area immediately. One female with recently fledged young made shallow dives toward intruder, coming within 5 m, and making peregrine-like chatter. Potential nest-predators such as Australasian Bitterns attacked and chased from area; eat most other potential nest-predators, e.g. rats, snakes. For first week after fledgelings leave nest, stay within territory perched together on prominent bushes; males more precocial than females and leave nest-site and make first flight outside territory about a day earlier. Four weeks after leaving nest, fledgelings may travel up to 2 km from territory, but return to roost near nest-site; during this period of increasing independence, capture their first prey. Most young probably fully independent 6–8 weeks after leaving nest.

VOICE No detailed studies but well known from work of Baker-Gabb (1981a), who provided information. Calls of closely related Marsh Harrier *Circus aeruginosus* summarized, with sonagrams, in BWP. Generally silent outside breeding season, when threat and alarm calls occasional; soliciting call given, though rarely, by juveniles attending communal roosts. More vocal during breeding season; most calls from near nest or high above territory. Territorial displays usually silent. *Contra* McGilp (1934), rarely call when attacking prey. Calls of sexes differ (see below). Individual differences and regional variations not known.

Adult THREAT CALL: chattering *chit-chit-chit...* or *kit-kit-kit...* (sonagram A) given when one bird trying to displace another at food, or when intruder or potential predator (e.g. Australasian Bittern *Botaurus poiciloptilus*) near nest. One record of a female giving peregrine-like (but smoother) chatter, accompanied by shallow dives at intruder coming near nest with recently fledged young; called in groups of 5–6 calls, lasting 2 s per group. **ALARM CALL:** rattling *cheet* given when one bird struck by another's talons or flushed by human. **NEST-SITE INSPECTION CALL:** quickly repeated *see-oh*; given when perched at likely nest-site. **Adult male COURTSHIP CALL:** short far-carrying whistle *kee-u* (sonagram B) given during diving display. Commonly heard call; also used to



A. L. McPherson; near Invercargill, NZ, Dec. 1985; P103



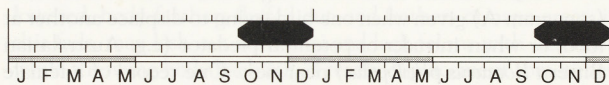
B. L. McPherson; near Invercargill, NZ, Dec. 1985; P103

call female for Courtship Feeding. **FOOD-PROVISIONING CALL:** quiet *chuck-chuck-chuck-chuck* given to call incubating female from nest to receive food, which is usually done via aerial pass. **KIRK CALL:** *kirk* given when perched after territorial boundary displays; rarely heard. **KEE-UK CALL:** soft *kee-uk* given when perched, in reply to mate giving *kee-oh* Courtship Call during display-flight. **Adult female SOLICITING CALL:** drawn out *see-u* given when soliciting for food or copulation. Commonly heard. **COURTSHIP CALL:** loud *kee-oh* during diving display.

Young FOOD CALL: downy young give quavering *see* when begging from female. Give reptile-like *sss* at intruders. At 14–18 days, give thin quavering squeals when fighting (Hollands). Feathered nestlings give **THREAT CALL** to siblings when squabbling over food. Recently fledged young give **THREAT CALL** when predators near nest-site and use **SOLICITING CALL** in flight to induce parent to drop food. Juveniles give **SOLICITING CALL**, rarely, when attending communal roost.

BREEDING Based on studies in NZ and se. Vic. (Baker-Gabb 1981a, 1982a,b, 1983); in Mackenzie Basin, SI, NZ (Pierce & Maloney 1989); 84 records in Aust. NRS to June 1991. Usually in simple pairs, solitarily, though two cases of polygyny in NZ. Information supplied by D.J. Baker-Gabb.

Season Vic.: laying, late Sept. to early Dec.; hatching, late Oct. to early Jan.; fledging, early Dec. to mid-Feb. (Baker-Gabb 1982a, 1983; Aust. NRS); Tas. generally 2–4 weeks later. NZ: laying, early Sept. to late Dec.; hatching, early Nov. to early Dec.; fledging, mid-Dec. to mid Feb. (Soper 1957; Baker-Gabb 1981a; Pierce & Maloney 1989; NZ NRS).



Site On ground, in swamps, near or on water; in crops, bracken, scrub, *Poa* tussocks, long grass, blackberry, stands of *Phragmites*, *Typha*, sedges, rushes; on abandoned nests of Black Swan *Cygnus atratus*, Purple Swamphen *Porphyrio porphyrio*; more nesting outside reed beds and on dry land in NZ than in Aust. For 25 nests in se. Aust.: 17 in *Phragmites*, seven in *Typha*, one in *Juncus* over water. For 19 nests in NZ: 11 in dune-hollow swamps with

Red Rushes *Leptocarpus simplex*, eight in Raupo *Typha orientalis* swamp, in sedges *Carex*; for 11 nests in Mackenzie Basin: six in tall grass or rushes, three in Matagouri *Discaria toumatou* bushes on terrace slopes, two on debris in river bed. Ten nests in NZ were surrounded by tall vegetation on three sides with opening to E, providing shelter from w. wind and rain. Several records of nesting in trees, e.g. among Supplejack *Rhipogonum scandens* growing in top of Mahoe *Meliclytus ramiflorus* 7 m high, in canopy where Barberry *Berberis vulgaris*, Mahoe and Wineberry *Aristotelia serrata* trees overlapped, 4.5 m high (Messenger 1990), in a Mahoe c. 6 m high (Hedley 1985), and at 2.5 and 15 m in Tawa *Beilschmiedia tawa* trees (Skinner 1979; G. Moon). One record of nesting on old drey of Ring-tailed Possum *Pseudochirus peregrinus* in top of tea-tree *Leptospermum* (Aust. NRS). May re-use old nest or alternate nests for many seasons, or new nest built annually, often close to previous year's site; rebuild nearby if first clutch disturbed or destroyed (Soper 1957).

Nest, Materials Raised mound of sticks, grass, reed stems, hay, thistles, blackberry, bracken, bark, hedge clippings, leaves of *Typha*, *Phragmites*; inner bowl lined with grass; vary much in construction (Sharland 1932; Messenger 1990; North; Aust. NRS). Relined old Purple Swamphen nest (Aust. NRS). **MEASUREMENTS:** nest diameter: 60 cm (16; 40–100; 21); thickness, 45 cm (27; 10–120; 34) (Aust. NRS); in NZ: ten nests averaged 50 x 80 cm across, oval in shape; base of cup, 40 cm deep. Built by female only. Grass added to lining throughout occupation (Cupper & Cupper). Collect material by landing and carrying it off in talons or bill; build mostly in mid-morning; nest built in 2–4 weeks. Males sometimes build unlined cock's nest (Hollands).

Eggs Rounded oval; rough or finely granulate shell, slight, or no gloss; uniform dull or faintly bluish white (North). **MEASUREMENTS:** in Aust., 50.3 (1.9; 47.5–53.1; 10) x 38.9 (0.7; 37.8–40.1) (Campbell; North); from Aust. museum egg collections: 50.4 (4.25; 37.3–57.4) x 38.9 (3.09; 28.4–43.2) (n=373; P.D. Olsen); in NZ: 52 x 39, 52.5 x 39.5 (Oliver).

Clutch-size In se. Aust.: 3.6 (3–4; 5); Tas.: 2–7 (n=9) (Baker-Gabb 1982a); from Aust. NRS: 3.6 (2–5; 14); C/2 x 1, C/3 x 4, C/4 x 8, C/5 x 1; from Aust. museum egg collections: 3.6 (0.9; 1–6; 110) (P.D. Olsen); in NZ: 4.2 (2–7; 50); C/2 x 1, C/3 x 14, C/4 x 15, C/5 x 17, C/6 x 2, C/7 x 1 (NZ NRS; Baker-Gabb 1981a). Single-brooded; replacements laid after loss of eggs (Soper 1957; Baker-Gabb 1982b).

Laying At intervals of 48–72 h; irregular, usually alternate days for C/5 (Soper 1957).

Incubation By female only; starting with first to third egg (Soper 1957); hatching markedly asynchronous; in one nest: E1 and E2 hatched on same day; E3 and E4, 3 and 5 days later. Usually stops after hatching of third chick, further eggs usually fail to hatch although fertile (Soper 1957); unhatched eggs may remain in nest up to 6 weeks (Aust. NRS). Female fed via aerial transfer. **INCUBATION PERIOD:** 31–34 days (Soper 1957); 33 days (Cupper & Cupper).

Young Semi-altricial, nidicolous. Hatch in white down; eyes open in first two days. Down, off-white at c. 10 days. Wing-feathers show at 7 days; primaries emerge at 2 weeks; partially feathered, primaries, axillaries, rectrices burst sheaths at c. 3 weeks; almost full grown with little down left at 4 weeks (Soper 1957; Cupper & Cupper). May scramble out of nest to individual shady retreats during second half of nestling period. **Growth** In se. Vic., four chicks, weighed on same day and aged 15, 15, 12 and 10 days, weighed 660, 410, 380 and 95 g; at 34 and 31 days, first and third chick weighed 920 and 700 g. At fledging, young approximately adult weight (see Weights) but primaries and rectrices continue to grow for about another month. **Parental care, Role of sexes**

Brooded by female for first 4–7 days, thereafter only in bad weather. Fed by female only, male bringing food to or near nest, usually transferring it to female in air. Young fed piecemeal, bill to bill, at first female putting morsels in gapes of chicks; about every 4 h for first 2 weeks, usually in early morning, midday, about 16:00 and dusk; at c. 2 weeks, some hair, feathers included in offering, which young then grab from female's bill and may begin to tear at prey; at about 3 weeks fed in early morning, midday and dusk, capable of feeding themselves at times, liable to clamber out of nest to 1–5 m distance but return to nest to be fed; able to feed themselves at 4 weeks (Hollands); from 4 weeks to fledging, often fed in morning and evening only (Soper 1957). Rate of feeding varies greatly, depending on size of item brought (mouse to rabbit). Young defecate over rim of nest. Dead nestlings fed to surviving brood (Baker-Gabb 1982b; Cupper & Cupper; Aust. NRS). **NESTLING PERIOD:** two males, c. 43 days; two females, 45, 46 days.

Fledging to maturity Young clamber out of nest to individual shady retreats during second half of nestling period. Remain with parents 1 week after fledging; venture up to 2 km from territory at 4 weeks, roost on or near nest in evenings. Independent at 4–6 weeks, disperse at c. 7 weeks.

Success In se. Aust. (n=5): 18 eggs laid, 15 hatched, ten fledged; for 25 nests: 37 young fledged from 18 nests, which is 1.48 per nest and 2.06 per successful nest. In Tas., from 16 nests: 28 young fledged from 13, which is 1.75 per nest and 2.15 per successful nest (Baker-Gabb 1982a). From Aust. NRS, where clutch-size, number hatched and fledged determined (n=5): 19 eggs laid, 13 hatched, eight fledged; equal to 1.6 young per nest and 2.0 per successful nest. In NZ, for 19 nests over two seasons: 20 young fledged from 11, equalling 1.05 per nest and 1.82 per successful nest; in Mackenzie Basin: 2.25 (2–3; 4) young fledged in 1985, five pairs fledged three young each in 1986. Easily desert if disturbed during incubation or nestling periods, yet nests with young in fields can be ploughed round, even moved, without causing desertion. Female may break eggs early in incubation; eggs may fall through nest; several records of Forest Ravens *Corvus tasmanicus* taking eggs from disturbed nests (Mooney 1983a); fratricide recorded on occasions but may be caused by human disturbance (Soper 1957; Baker-Gabb 1982b; Cupper & Cupper; Hollands; Aust. NRS).

PLUMAGES Prepared by D.I. Rogers. Imperfectly understood. All birds that have completed post-juvenile moult are termed adults. With age, adults (particularly males) paler on underparts and under wing-coverts, and more grey on upperwing. Precise ages at which changes occur not known; further work may permit a more refined ageing system, though variation between darkest and lightest birds appears continuous.

Palest adult males Age attained unknown, but not until at least third winter (Baker-Gabb 1982a). **Head and neck** Hindneck and top of head, dark brown streaked rufous-brown to cream; cream streaks often restricted to nape. Feathers, lanceolate; black-brown (c20–c119) with rufous-buff (39 to pale 38) edges that broaden and grade to cream (54) at bases. With much wear, distal parts of pale edges lost and ground-colour of webs fades to dark brown (119A); top of head then appears dark brown with white streaking on nape. Lores, sparsely covered by wavy black (89) bristles, sometimes with minute tuft of white down at base; eyelashes, black (89). Chin and throat, white (sometimes with cream (54) tinge restricted to tips of feathers), broadly streaked by dark-brown (121) shaft-streaks. Ear-coverts, cream (54) with dark-brown (121) shafts; they look uniform brown at a distance. Facial ruff of stiff white feathers with dark-brown (121) shaft-

streaks looks white speckled brown; most distinct behind ear-coverts and peters out at back of neck. **Upperparts** Mostly dark brown (21–121), speckled when fresh by light-brown (c119C) or light rufous-brown (c38) distal corners to web of each feather. Feathers have black-brown (119) shafts; scapulars also have broad black-brown (c119) bars, all but distal bar usually being concealed. Upper tail-coverts, white with narrow incomplete rufous-brown (340) to dark-brown (121) bar near tip. **Underparts** Breast, cream (54) to cream-white, with broad dark-brown (121–119A) shaft-streaks forming bold tapering streaks on 15–30% of breast. Rest of underparts, whiter with narrower shaft-streaks; in some, can be white with inconspicuous dark-brown (121–37) shaft-streaks on belly, flanks and top of thighs; feathers at top of thighs often grade to cream (54) to buff (124) at tips, appearing slightly darker than belly and flanks. **Upptail** Light grey (85), becoming darker and browner with wear; tips and concealed bases of feathers, white; inner webs grade through concealed light-brown (223C) area to white inner edges. Basal thirds of feathers often have incomplete dark-brown (c20–121) bars, broadest on outer rectrices; outer web of t6, barred dark brown (c20) along length. **Undertail** Looks whitish with pale-grey wash to tips and outer webs. In extremely worn individual: tail, white grading to light-brown (c223C) distally; tips of t5 and t6 brown (119B); feathers have 3–4 evenly spaced dark-brown (c119A) bars. **Upperwing** Lesser, median and most marginal coverts, dark brown (c121) grading to black-brown (119) towards end; distal corners (and sometimes, all of tips) light rufous-brown (c37) to light brown (39). Median coverts (and sometimes longest lesser coverts) also have narrow white tips. Smallest marginal coverts, white with narrow dark brown (121) shaft-streaks. Primary-fingers, blackish brown (c20) with slightly darker (119) bars visible in perfect light. Rest of primaries, primary coverts, alula and most secondaries, light grey (85), becoming slightly darker and browner with wear, with black-brown (119) bars of 4–7 mm width spaced at intervals of c. 20 mm. Inner greater secondary coverts have narrow white tips in some. Inner webs grade through concealed light rufous-brown (223C) to white inner edges. Tertiaries and most tertial coverts, dark brown (c121), broadly barred black-brown (119); sometimes narrowly tipped light rufous-brown (c38) to light brown (119C). **Underwing** Coverts, white; marginal, lesser and median coverts have tapering brown (119B) to black brown (119) central wedges that are often narrower or absent outside carpal. Greater coverts similar but also barred rufous-brown (c38) to dark brown (121). Remiges, off-white to pale pinkish-buff (c121D), grading to pale-(86) or light grey (85) ends. All have black-brown (119) bars, broadest at shafts and often petering out before inner edges, especially on inner primaries in which barring can be inconspicuous, forming subdued pale panel. Primary-fingers have black-brown (119) tips, 35–40 mm wide.

Darkest adult males Includes all first-basic birds; not known how long darker plumages retained. Some males not readily placed in 'dark' or 'light' categories, pale ventral markings being intermediate in size and ranging from cream to white (tending to be palest towards tail). Transition thus likely to be gradual. **Head and neck** Facial disc, ear-coverts and hindneck, similar to older males but pale streaking narrower and often rufous-brown (c38) on top of head. Chin and throat, as breast. **Upperparts** Similar to older males, but upper tail-coverts can have varying dark-brown (121) shaft-streaks. Pale tips to other feathers narrower than in palest birds, often absent. **Underparts** Breast, dark brown streaked cream; feathers, dark brown (121–223B) with black-brown (119) shafts and broad cream (54) edges or streaks near edges. With wear, ground-colour becomes slightly paler and greyer (119A) and in some, cream edges are lost. Flanks and belly similar, but

more pale streaking; cream (54) edges broader and not lost with wear. Under tail-coverts and feathers of thighs often similar but broad rufous-brown (340) tips often make these look uniform rufous-brown. In some, under tail-coverts and longest feathers of thighs have tapering dark-brown (121) central wedges and rufous-brown (c38) or brown (119B) tips grading through cream (54) to white bases; these form heavy pale mottling on dark background. **Uppertail** Grey ground-colour generally darker and browner and usually grades to brown on outer feathers; feathers have 4–5 dark-brown bands, petering out on central feathers. **Undertail** Whitish, sometimes with traces of dark barring visible. **Upperwing** Pale tips to forewing-coverts narrower than in palest males, often absent. Grey ground-colour of remiges and greater coverts generally darker and browner than in pale males. **Underwing** Dark central wedges of coverts broader than in palest males; median and lesser coverts variously barred dark brown (121–223A). Remiges as lightest males, including dark subterminal bar on secondaries.

Adult female Like males, females become paler with age but separation to different immature plumages not possible. First-basic plumage varies; though never as pale as in old females, some second-year females can have some pale ventral streaking. **Head and neck** Lightest birds, similar to darkest adult males. Darkest birds lack pale streaking on chin and throat and look similar to juveniles, sometimes (perhaps always) differing by: rufous-brown areas on feathers of top of head restricted to edges; and less pale marking on feathers of nape. **Upperparts** Similar to darkest males; subterminal bars of upper tail-coverts average broader and variously bordered light rufous-brown (c39). **Underparts** Palest females closely similar to darkest males; pale ventral streaking never paler than cream (54). In darkest females, cream (54) edges restricted to basal parts of feathers of underparts, and are variously to completely hidden; when hidden, underparts similar to juvenile, but tend to have stronger reddish-brown tinge caused by indistinct dark-brown (223A–223B) fringes to feathers. **Tail** Light rufous-brown (39, c38) grading to dark-brown (119A–119B) tips, with 3–5 evenly spaced black-brown (c119) bars; on central feathers, ground-colour has greyish tinge, and dark bars often broken or reduced to spots. **Upperwing** Ground-colour of remiges darker and browner than in most males; generally dark brown (119A), with light-grey (c85) wash on inner primary coverts and primaries. Marginal and smaller lesser coverts can look paler than rest of upperwing because they have slightly broader rufous-brown fringes; otherwise upperwing as darkest adult males. **Underwing** Marginal, lesser and median under wing-coverts, as breast. Greater coverts, grey (rather glossy) with light rufous-brown (c38) fringes; in lighter females they are also variously barred light rufous-brown (c38). Remiges, similar to males but in darkest birds subterminal band of secondaries broadens from c. 15 mm at s1 to c. 40 mm on s12; in lightest birds it broadens from c. 10 mm on s1 to c. 25 mm on s12. Secondaries have 2–3 grey-black or black-brown bands, well defined in lightest birds, broken in darkest birds (sometimes so sparse and irregular that they form mottling rather than dark bars). Outer secondaries of darker birds sometimes have some pink-buff mottling on inner edges.

Downy young First down, light pink-brown (light 219D), becoming whiter with age, with pure white nape and hindcrown. Initially, neat facial mask of short white down, becoming bare before juvenile plumage emerges. Second down, white to greyish white; described as 'grey' by Hollands.

Juvenile Sexes similar. **Head and neck** Forehead and crown, dark brown (21) to black-brown (119) with rufous-brown (340) to light-brown (39) tips (sometimes fringes). Nape and hindneck, black-brown with varying cream-buff streaking. Feathers have

large black-brown (119) rosethorns; rest, orange-buff (118) grading through cream (54) to concealed white bases. Ruff of short stiff feathers, black-brown with lighter streaking; feathers dark brown (121) to blackish brown (119), with pale edges that grade from light brown (119C) on sides of neck to whitish in centre of throat. Ear-coverts, chin and rest of throat, dark brown (223) with black-brown (119) shaft-streaks, often with reddish brown (223A) tinge on edges on feathers. **Upperparts** Mostly dark brown (c121) to blackish brown. Feathers, dark brown (c121) with black-brown (119) tinge to distal ends; in some fresh individuals, scapulars, and occasionally feathers of mantle, narrowly fringed rufous-brown (340). Subscapulars, black-brown (c119). Rump, dark greyish-brown (c121), lacking blackish-brown tips of back and thus looking paler. Upper tail-coverts, rufous-brown (340, 38) to warm buff (c124), with concealed white bases and varying dark-brown (121) subterminal markings; when latter largest, they form broad dark-brown (121) subterminal band (and patch at base of tail is not contrastingly pale); when least, extreme feathers only have incomplete dark-brown (121) shaft-streak. **Underparts** Dark brown (121) to blackish brown (119), with varying reddish-brown tinge strongest on thighs and towards tail. Feathers, dark brown (121) with black-brown (119) shafts and indistinctly defined reddish-brown (c223A) fringes that are most extensive towards tail; they cover whole of feathers of thighs except black-brown (119) shafts. **Tail** Above, barred by black-brown (119) subterminal band c. 40 mm wide and 4–5 black-brown bars c. 15 mm wide; barring breaks up on outer feathers and t6 has black-brown (119) blotches forming no coherent pattern. Tips, light rufous-brown (c38–39) when fresh, light brown (119C) when worn. Ground-colour varies; in some, it is light rufous-brown (39, c38) grading to brown (119A–119B) towards tips; brown most extensive on inner webs. Other birds have concealed light rufous-brown (c39) bases to inner webs; ground-colour elsewhere usually light grey (c85) to greyish brown, tending to be paler and browner (c119D) on outer feathers. **Upperwing** Most coverts, as scapulars. All greater coverts and alula, dark brown (121) to blackish brown (119), with light rufous-brown (38) to light-brown (39) tips that form neat narrow line along centre of upperwing. Remiges, dark brown (121) grading to black-brown (119) at shafts and tips; all except p6–p10 have narrow pale-brown (c119) to off-white tips. Primary-fingers, black-brown (119). **Underwing** Most coverts, as breast. Greater coverts, glossy grey with rufous-brown tips, broadest on inner feathers. Secondaries, dark glossy grey (83–84) with narrow pale brownish-grey tips; they are more glossy towards bases and this, with pale tips, can give appearance of faint subterminal band. Primaries, glossy light-grey (85–86) with grey-black (82) primary-fingers. All primaries have off-white basal half to inner web, grading to pink-buff (121D) inner edge. This forms large pale panel, sometimes broken by narrow zones of dark grey-brown (c121) speckling along inner edges of p6–p9. Size of panel varies; sometimes extends on to bases of primary-fingers (even extending down longest primary-fingers as white streak) and sometimes it is small.

Aberrant plumages Partial to complete albinism has been described by Hedley (1983) and Klapste (1984); see Hedley (1983) for review.

BARE PARTS From photos (Baker-Gabb 1978; Robertson 1978; Tollan 1984; Moon 1988; Cupper & Cupper; Hollands) except where stated.

Adult male Basal half of bill, gape, lores, and brow-ridge, grey-blue (dark 88) or grey (84) to pale grey (86); base of bill and gape tend to be paler than rest. Distal half of bill, black (82–89). Cere, orange-buff (153) to cream-yellow (54). Orbital ring, light

yellow (157) or light grey (85–80) with yellow tinge. Cere and orbital ring palest in non-breeding season (Baker-Gabb 1978). Iris becomes light yellow (157) to cream (c54) soon after completion of post-juvenile moult; many have orange-yellow (18) iris at time of post-juvenile primary-moult but, in some, iris is still light brown (–) at start of second winter (Baker-Gabb 1982a). Inner rim of eyelids, black (82–89). Tarsus and toes, buff-yellow (53) to cream (92); more orange in breeding season (Baker-Gabb 1978). Claws, black (82–89). **Adult female** Gape, pale cream (c92) in some, as male in others. Iris, cream (c92) to pale yellow (157) in oldest birds; takes longer to attain this colour than in males; many females in adult plumage have brown (–), rufous-brown (136) or reddish-brown (32) irides, becoming orange-yellow (c18) or buffish yellow (c53) with rufous-brown (136) flecking before adult colour attained. Time taken to attain adult colour not well known, probably varies; two captive birds in NZ still had dark-brown (–) irides when 4.5 years old (Fox 1977c), as did a wild bird at least 5 years old, which had survived for some time with only one wing (Fox 1977a). Tarsus and toes, buff-yellow (c153) or straw-yellow (57) to pale yellow (157) or cream (c92); darkest in non-breeding season (Baker-Gabb 1978). Rest of bare parts as adult male. **Downy young** Bill, black (89) with bluish-green (164) basally in small chicks, pale grey-blue (c168D) basally in large chicks. Cere, cream (54) to pinkish white; gape similar in smaller chicks, like base of bill in large chicks. Bare facial mask, dark grey (83) to greyish blue (c168A) or light blue-grey (88). Iris, black-brown (119). Inner rim of eyelids, grey-black (83–82). Tarsus and toes, off-white to pale yellow (157). Claws, dark grey (83). **Juvenile male** Iris, usually black-brown (119) at fledging, sometimes lighter brown; becomes brown (121C) to light olive-brown (c52), sometimes with grey-brown (119B) tinge above pupil; some develop yellow flecking before post-juvenile primary-moult. Rest, similar to adult female. **Juvenile female** Iris, black-brown (119), becoming brown (223B) in some before post-juvenile primary-moult. Rest of bare parts similar to juvenile male, although tarsus and toes average paler (Baker-Gabb 1978).

MOULTS From skins (AM, ANWC, HLW, MV, SAM, WAM) and unpublished data from banded birds at Werribee, Vic. (D.J. Baker-Gabb) except where stated. Amadon (1941) gives some information from Polynesia. **Adult post-breeding** Primaries outwards; 1–3 primaries grow concurrently. Sequence of secondary-moult unknown; there can be three moult-centres. Tail centrifugal in one skin, with all feathers but t1 and t2 growing, but usually irregular, e.g. in three skins t5 was the last rectrix to be replaced and in two it was the first. One or two moult-waves occur on each side of tail; moult-induced gaps generally involve one feather. Interrupted moult of primaries and tail recorded in two females, one without collection date, the other collected in Apr. In study in NZ, adult females began moult in Dec. when nestlings about 1 week old, and continued moulting for c. 6 months until end of May; duration similar in males but moult began and finished a month later, beginning when chicks were nearly fledged (Baker-Gabb 1978). Further information on timing in NZ given by Fox (1977c) and Robertson (1978). Timing similar in se. Aust. (Baker-Gabb 1982a); adult female with fresh primaries collected in Tas. in early Nov. (ANWC) is exceptional. **Post-juvenile** In NZ, partial, beginning with moult of body from Apr. to Aug. of first year, with central rectrices being replaced between Aug. and Nov. (Baker-Gabb 1978); subsequent moult described as 'first post-nuptial' (i.e. second pre-basic), including remiges and central rectrices, latter being the last rectrices replaced, in Mar.–Apr. when slightly over 1 year old; in females 'first post-nuptial' lasted from Nov. to Mar.; in males it

began in Dec. and finished at end of Apr. In one male and two female skins from Aust., timing of post-juvenile moult of primaries was consistent with that in NZ; a male with primary-moult N⁶⁴3¹O¹ on 29 Apr. and a female with primary-moult N⁸⁴4¹O¹ on 25 Dec. suggest timing perhaps varies more than in NZ. However, five Aust. skins examined in post-juvenile moult inconsistent with this model of post-juvenile moult; all were replacing primaries and worn juvenile body-feathers, as was a female photographed in NZ (Moon 1988). An alternative model is that there may be a single protracted post-juvenile moult, beginning with body-feathers as early as Mar. of first year, ending with primary-moult when just over 1 year old. In NZ, central rectrices replaced in Aug.–Nov. of first year and again c. 6 months later in Mar.–Apr. (Baker-Gabb 1978). Records of post-juvenile tail-moult in 44 individuals from se. Aust. showed gradual moult from May until Jan.; sequence was irregular in 20, roughly centrifugal in 24.

MEASUREMENTS (1) Aust., skins (AM, ANWC, HLW, MV, SAM, WAM). (2) Werribee, Vic., live birds (Baker-Gabb 1982a). (3) Pukepuke Lagoon, NI, NZ, live birds (Baker-Gabb 1982a). BILL C = bill from cere; BILL W = width of bill (at gape) where cere meets feathers; M TOE, I TOE, M CLAW and H CLAW = lengths of middle and inner toes, middle and hind claws respectively. Additional measurements from NZ in Carroll (1970), Fox (1977c) and Robertson (1978).

ADULTS

	MALES	FEMALES	
WING	(1) 413 (7.03; 399–426; 17)	433.2 (7.10; 419–444; 10)	**
	(2) 413 (7.2; 406–425; 16)	431 (8.3; 421–455; 10)	**
	(3) 408 (9.3; 391–425; 16)	427 (9.2; 415–440; 33)	**
8TH P	(1) 311 (6.74; 298–323; 17)	321 (9.31; 304–336; 11)	**
TAIL	(1) 236 (8.64; 210–246; 16)	248 (6.97; 237–263; 11)	**
	(2) 231 (10.6; 219–250; 8)	249 (6.5; 241–261; 10)	**
	(3) 226 (10.0; 207–245; 16)	239 (8.9; 215–257; 33)	**
BILL	(1) 32.1 (1.53; 29.1–35.6; 15)	34.9 (1.14; 32.5–36.2; 10)	**
	(2) 33.8 (1.3; 31.5–35.2; 8)	36.6 (1.3; 34.0–38.8; 10)	**
	(3) 32.8 (1.3; 31.5–35.2; 17)	37.2 (1.9; 34.9–40.4; 34)	**
BILL C	(1) 22.8 (0.88; 20.8–24.8; 14)	24.1 (0.85; 22.1–24.9; 10)	**
	(2) 22.9 (1.0; 21.2–24.4; 8)	25.6 (0.8; 24.3–26.4; 10)	**
	(3) 22.2 (0.8; 21.5–23.8; 17)	25.2 (1.1; 22.9–28.2; 34)	**
BILL W	(2) 29.6 (1.5; 27.6–32.0; 8)	31.3 (2.0; 27.9–34.2; 10)	**
	(3) 28.7 (1.1; 26.6–30.1; 17)	32.0 (1.2; 30.4–34.2; 34)	**
TARSUS	(1) 95.5 (3.52; 86.8–102.8; 16)	100.1 (3.52; 95.4–104.7; 10)	**
	(2) 93.8 (1.9; 91.1–95.7; 8)	99.5 (3.5; 93.6–104.5; 10)	**
	(3) 91.0 (2.0; 88.1–94.5; 17)	97.9 (2.4; 94.2–103.9; 34)	**
M TOE	(1) 40.3 (1.71; 37.9–42.7; 6)	43.8, 44.6, 49.2	**
	(2) 42.4 (1.5; 40.3–45.0; 8)	47.7 (1.5; 44.7–49.7; 10)	**
	(3) 42.0 (1.4; 39.5–44.5; 13)	47.6 (1.7; 44.0–50.1; 17)	**
I TOE	(2) 24.3 (1.9; 22.0–27.0; 8)	28.8 (1.3; 25.2–30.3; 10)	**
	(3) 28.3 (1.7; 27.7–31.0; 14)	33.2 (1.9; 29.8–36.0; 26)	**
M CLAW	(1) 20.3 (0.81; 19.5–22.0; 7)	21.4, 21.7, 22.4	**
	(2) 20.0 (0.7; 18.8–20.7; 8)	22.6 (1.0; 21.0–23.9; 10)	**
	(3) 18.9 (0.8; 17.6–20.6; 17)	21.1 (0.9; 19.4–22.8; 34)	**
H CLAW	(2) 21.4 (1.1; 19.6–23.0; 18)	24.3 (0.9; 22.7–26.5; 34)	**
	(3) 22.0 (0.6; 21.0–22.7; 8)	25.0 (0.6; 23.9–25.8; 10)	**

JUVENILES

	MALES	FEMALES	
WING	(1) 399 (10.46; 380–417; 11)	423 (9.51; 402–440; 11)	**
	(2) 394 (8.7; 378–414; 23)	416 (7.6; 400–431; 37)	**
	(3) 403 (7.4; 385–421; 19)	422 (8.8; 400–440; 74)	**
8TH P	(1) 301 (9.28; 282–318; 10)	316 (7.37; 305–329; 11)	**
TAIL	(1) 233 (6.49; 217–242; 11)	242 (7.20; 232–259; 13)	**

	(2) 225 (4.9; 216–236; 23)	234 (7.8; 209–250; 37)	**
	(3) 224 (8.6; 195–240; 79)	235 (6.9; 214–247; 74)	**
BILL	(1) 32.4 (1.06; 30.7–34.4; 10)	33.8 (1.86; 29.0–36.0; 11)	
	(2) 32.5 (1.1; 30.7–35.2; 23)	35.2 (1.2; 33.6–38.8; 37)	**
	(3) 33.1 (1.6; 29.8–35.9; 79)	36.0 (1.1; 34.0–39.1; 74)	**
BILL C	(1) 22.5 (1.21; 20.9–24.8; 11)	23.8 (1.14; 21.9–25.5; 11)	
	(2) 22.4 (0.7; 21.1–23.8; 23)	24.9 (0.8; 22.9–26.5; 37)	**
	(3) 22.1 (0.9; 20.0–25.1; 79)	24.4 (1.3; 22.0–27.3; 74)	**
BILL W	(2) 29.2 (1.3; 26.4–31.8; 23)	32.2 (1.3; 28.6–34.2; 37)	**
	(3) 29.2 (1.5; 27.0–32.0; 79)	32.1 (1.6; 28.8–35.0; 74)	**
TARSUS	(1) 93.6 (3.36; 87.2–101.6; 11)	97.7 (1.17; 95.6–99.3; 12)	**
	(2) 94.3 (2.1; 90.4–99.0; 23)	98.6 (3.2; 90.5–103.8; 37)	**
	(3) 90.8 (2.9; 85.3–95.7; 79)	96.7 (3.1; 90.0–102.9; 74)	**
M TOE	(1) 42.7 (2.18; 40.2–46.1; 4)	44.7, 45.3, 47.5	**
	(2) 43.0 (1.8; 39.5–45.5; 23)	47.8 (1.7; 42.5–52.4; 37)	**
	(3) 42.0 (1.9; 38.3–45.3; 61)	46.0 (1.4; 42.6–49.5; 56)	**
I TOE	(2) 25.1 (1.8; 20.7–28.9; 23)	28.8 (2.2; 25.4–32.5; 37)	**
	(3) 27.7 (1.3; 24.5–31.0; 78)	30.9 (2.3; 28.6–36.0; 66)	**
M CLAW	(1) 19.8 (1.39; 18.8–22.5; 5)	21.3 (1.17; 20.1–22.9; 4)	**
	(2) 20.1 (0.7; 18.6–21.4; 23)	24.4 (0.7; 21.4–23.6; 37)	**
	(3) 19.2 (0.7; 17.9–20.9; 71)	21.2 (1.0; 18.9–23.2; 78)	**
H CLAW	(2) 21.5 (0.8; 19.5–23.0; 77)	24.1 (0.9; 22.7–26.4; 78)	**
	(3) 22.1 (0.7; 20.4–23.6; 23)	24.6 (0.7; 23.0–26.0; 37)	**

WEIGHTS (1) Pukepuke Lagoon, NI, NZ (Baker-Gabb 1978). Juveniles were significantly lighter than adults. Robertson (1978) also presents weights from Pukepuke Lagoon. (2) N. Canterbury, SI, NZ (Fox 1977c). (3) SE. SI, NZ (Redhead 1969). (4) Werribee, Vic. (Baker-Gabb 1982a). Pre-migratory gain of mass in Aust. populations not known. In NZ, 'falconry flying weight' with little or no fat is regarded as 580–650 g in males, 700–750 g in females (Tollan 1984). A starving juvenile male in NZ weighed 378 g (Fox 1977c).

ADULTS

	MALES	FEMALES	
TOTAL	(1) 640 (50.7; 520–720; 54)	870 (64.9; 700–1035; 66)	**
SUMMER	(1) 600 (n=9)	865 (n=13)	
AUTUMN	(1) 640 (n=22)	875 (n=13)	
WINTER	(1) 660 (n=19)	880 (n=23)	
SPRING	(1) 610 (n=4)	850 (n=17)	
	(2) 612 (47.8; 525–697; 17)	830 (68.7; 700–1016; 23)	**
	(3) 649 (542–726; 42)	839 (745–1044; 29)	**
	(4) 647 (36.4; 590–710; 40)	890 (97.6; 750–1080; 64)	**

JUVENILES

	MALES	FEMALES	
TOTAL	(1) 615 (51.4; 505–710; 111)	810 (55.5; 680–995; 113)	**
SUMMER	(1) 605 (n=12)	800 (n=25)	
AUTUMN	(1) 615 (n=34)	805 (n=42)	
WINTER	(1) 630 (n=44)	850 (n=29)	
SPRING	(1) 595 (n=21)	795 (n=17)	
	(2) 598 (78.4; 568–665; 4)	785 (55.9; 724–880; 6)	**
	(3) 617 (392–720; 32)	806 (622–1001; 21)	**
	(4) 617 (50.8; 530–740; 43)	845 (53.6; 740–1000; 75)	**

STRUCTURE Wing, long and rather pointed. Eleven primaries; p8 longest, p10 88–89 shorter, p9 13–20, p7 2–3, p6 24–34, p5 89–96, p4 115–124, p3 136–147, p2 153–167, p1 164–184; p11 minute. Outer web of p10 narrow along length, of p6–p9 emarginated, of p5 slightly so; inner webs of p7–p10 emarginated, of p6 slightly so. Tips of p6–p10 form short primary-fingers in flight. Fifteen to 16 secondaries, including 3–4 tertials. Tail rather long, narrow; 12 feathers; rounded to strongly rounded at tip, t1

10–24 mm longer than t6. Inner toe c. 60% of middle, outer toe c. 74%, hind toe c. 52%. Middle claw, c. 92% length of hind and inner; outer claw c. 83% length of middle. Rest of structure similar to *C. assimilis*.

SEXING Although darkest adult males and palest adult females closely similar in body-plumage, adults can be sexed reliably on underwing (D.W. Eades); in males, subterminal band on secondaries is evenly narrow along length; in females, it broadens considerably towards body. Females larger than males; juveniles and adults can be sexed fairly reliably on various measurements of bill and feet. Tarsus and toes more massive in females; with experience, possible to sex birds in hand by visual inspection only (Fox 1977c; Baker-Gabb 1978).

GEOGRAPHICAL VARIATION Monotypic; no geographical variation in plumage known. Previously, two subspecies recognized; *gouldi* from Aust., NZ, and s. New Guinea (where probably a winter visitor; Mees 1982), and nominate *approximans* from smaller islands in sw. Pacific, which was said to be longer-winged (Amadon 1941, 1978; Brown & Amadon). Nieboer (1973) and Baker-Gabb (1979) showed size differences between *approximans* and *gouldi* to be negligible. Baker-Gabb (1986) found some slight but significant differences in measurements between birds from Aust. and NZ; at Werribee, Vic., juveniles and adults of both sexes had longer tarsi, inner, middle and outer claws than birds of same age and sex from Pukepuke Lagoon, NI; Vic. birds had shorter inner and outer toes. Lengths of culmen and tail did not differ in Aust. and NZ; wings of juveniles seemed shorter in Aust. but this may have been because NZ birds were trapped at a time when wings were fresher.

Circus approximans forms superspecies with *Circus aeruginosus*, *splonotus*, *maillardi* and *ranivorus* (Amadon 1978, Peters). Often referred to as the Marsh Harrier complex, the group differs from other harriers in shorter tail, occurrence of predominantly dark-brown subadult and adult plumages and preference for reed marshes (Nieboer 1973). Vaurie (1965) reported interbreeding of *C. aeruginosus* and nominate *splonotus*, prompting later workers to combine all members of Marsh Harrier complex, except *ranivorus* of Africa, as single species *aeruginosus*. Amadon (1978) pointed out that not enough is known of interbreeding in Asia and that occasional hybridization between two species, rather than full intergradation, may occur. Until more data are available, conservative treatment is to separate *aeruginosus*, *splonotus* and *approximans* as full species (Amadon 1978, Baker-Gabb 1979, Mees 1982). For more information on plumages and geographical variation, see above references, Stresemann (1924), BWP and Porter *et al.* (1986).

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Sponsors: Dr DJ Baker-Gabb & Dr K Fitzherbert



Volume 2, Plate 14

Swamp Harrier *Circus approximans* (page 105)
1 Adult male, pale; 2 Adult male, dark; 3 Adult female; 4 Juvenile

Spotted Harrier *Circus assimilis* (page 94)
5 Adult female; 6 Juvenile



Volume 2, Plate 15

Spotted Harrier *Circus assimilis* (page 94)

1 Adult female; 2 Juvenile fresh plumage; 3 'Dark-hooded' first immature (in post-juvenile moult); 4 First immature

Swamp Harrier *Circus approximans* (page 105)

5 Adult male, pale; 6 Adult male, dark; 7 Adult female; 8 Juvenile



Volume 2, Plate 16

Spotted Harrier *Circus assimilis* (page 94)

1 Adult female; 2 Juvenile, fresh plumage; 3 'Dark-hooded' first immature (in post-juvenile moult); 4 First immature; 5 Second immature

Swamp Harrier *Circus approximans* (page 105)

6 Adult male, pale; 7 Adult male, dark; 8 Adult female; 9 Juvenile