

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 *Erythroriorchis 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 FALCONIDAE falcons

Small to medium-sized diurnal birds of prey; about 60 species in ten genera. Four subdivisions or sub-families recognized: (1) about nine species of caracaras (Polyborinae), extralimital in the Americas; (2) monotypic *Herpetotherinae*, extralimital in Neotropics; (3) forest falcons (Micrasturinae), five species extralimital, also in Neotropics; (4) falconets, pygmy falcons and typical falcons (Falconinae), 44 species in four genera, widespread in all continents except Antarctica. Seven of c. 37 species of *Falco* (Falconinae) breeding in HANZAB region, of which one endemic in NZ. These divisions would be treated as full families if whole assemblage treated as separate Order from other Falconiformes. Here we need to consider only Falconinae, and of that sub-family only the genus *Falco*, which has been analysed by Cade (1982), and tentatively revised by Olsen *et al.* (1989) on the basis of study of feather-proteins. Further discussion in Amadon & Bull (1988), Sibley *et al.* (1988), Kemp & Crowe (1990) and Sibley & Monroe (1990).

Falco has been divided informally (Olsen *et al.* 1989) into adaptive groups: (i) typical kestrels; (ii) desert falcons and gyrfalcons; (iii) merlins; (iv) peregrines; (v) aberrant kestrels; (vi) typical hobbies and similar species. In HANZAB region, *longipennis* (Australian Hobby), *subniger* (Black Falcon), *hypoleucos* (Grey Falcon), *berigora* (Brown Falcon), and *novaeseelandiae* (New Zealand Falcon) thought to belong to the hobbies. Merlins and desert falcons not represented. Strongly resemble other families of Falconiformes, having sharp talons and hooked bills; very acute sight; powerful flight; furcula free of sternum; similar moult of secondaries; and some common feather-lice. Differ in some important details of skull; in having bony tubercle in nostrils surrounded by almost completely ossified nasal bones; in details of sternum; in moult of primaries; in chemical and other characters of egg-shell; in chemical composition of feathers; in extra bones at base of pygostyle for insertion of powerful muscles; and in having projections, or tomial teeth, on upper cutting edges of upper mandible on either side correspond with notches on lower mandible. Usually, droppings let fall, not squirted out as in Accipitridae (Kemp & Crowe 1990; Newton *et al.* 1990). Some (e.g. Starck & Barnikol 1954; Starck 1959; Sibley *et al.* 1988) have considered that the Family is related to owls Strigiformes but now generally considered close to Accipitridae (Sibley *et al.* 1988; Sibley & Monroe 1990).

Falcons have strong rigid bodies, thoracic vertebrae being ankylosed, not free as in other Falconiformes; necks, short; wings, long and pointed in contrast to short and rounded in *Accipiter*. Ten functional primaries, p1 minute; 11 secondaries; diastataxic. Wing-beats strong; hunting action characterized by diving or stooping at prey but species such as kestrels hover and drop on prey, and hobbies and merlins tail-chase. Tails, narrow, of medium length; 12 rectrices. Bills, short, strongly hooked with single tomial teeth; in some, if prey not killed by strike, killed by bite to neck. Short fleshy tongue. Cere found in all groups. Nostrils, typically rounded, opening in cere. Syrinx, large with tympaniform membrane. Lores, feathered; many species have dark malar stripe. Orbital skin bare. No marked brow-ridge. Tarsi, fairly long in most; usually reticulate (except Brown Falcon); toes, powerful with long claws; strike down prey with open feet. Stand erect or diagonally when perched or settled; can walk and even run surprisingly fast. Oil-gland, feathered. Feathers with aftershaft. Thin-walled, large, distensible ventriculus of stomach. Caeca minute. Eyes, usually brown; large with acute vision.

Plumages vary considerably; generally rather drab in greys, black and rufous; some species have colour morphs. Often various shades of grey above and rufous below; black moustachial stripe characteristic of many species; kestrels typically rufous above. Sexes alike except in size. Iris dark as are bills and claws. Cere, eye-ring and legs usually brightly coloured. Complete annual moult. Moult of primaries inwards and outwards from p4; similarly, of secondaries from s5 (centrifugal). Young semi-altricial, nidicolous; hatched with eyes closed and ears open; down, white; first down soon overgrown by dense second down. Juveniles often darker and streaked, with dull bare parts; usually acquire adult plumage after moult at end of first year.

Distributed almost world-wide and adapted to nearly every zone of latitude and climate in a great many habitats; some individuals range far in aerial search and pursuit of prey. Species vary greatly from fully migratory to resident or even sedentary, but in Aust. and NZ apparently mostly non-migratory, or dispersive or nomadic, perhaps moving to some extent according to climatic condition, though some species apparently undertake regular migrations (e.g. Australian Kestrel to PNG). Migrations, diurnal, typically with flapping flight, when rarely gregarious and rarely soaring. Generally suffer from persecution and other human pressures such as degradation of habitat, persistent pesticides, collection of eggs and young for falconry and direct slaughter but Aust. species may be less affected than those in Europe and Middle East.

Highly predatory; seldom eat carrion. Large falcons specialized to take large birds such as pigeons, ducks and grouse, typically attacking by stooping at great speed and striking down prey with feet, usually at no great height and even taking prey that is much larger than themselves on the ground; thus much exploited by falconers. Hobbies specialize on chasing smaller birds and insects, often high above ground or at level of canopy in Aust.; Brown Falcon takes insects and ground-dwelling and aerial prey (and even carrion). Merlins hunt at lower levels and persist in chasing small birds like larks and pipits till they catch them or become tired out. Kestrels (and Brown Falcon) typically adapted to take insects, small rodents and reptiles on the ground by hovering and dropping on them. Most species hunt solitarily but many species may

congregate at swarms of insects and fires. Aerial hunters may eat prey on wing; larger species usually take prey to perch or plucking station where typically kill victim with bill if not already dead, pluck or skin it and then break it up. Indigestible matter regurgitated as pellets. Food may be cached.

Generally, displays consist of aerobatics and ritualized attack and defence with stereotyped postures on perches or nest (cf. Accipitridae) (see BWP; Cade 1982). Usually solitary outside breeding season, frequenting home-range or exclusive feeding territory. Roost at night alone or loosely as a pair; some insectivorous species (kestrels particularly) may form loose communal roosts near swarms of locusts or termites. For the most part also breed solitarily but some, e.g. kestrels, form loose colonies. Pair-bond normally monogamous, probably usually long-term; bigamy by males occasionally reported but no regular polyandry or polygyny. Nesting territories advertised by aerial displays and calling. Flight-play often spectacular with high-circling, talon-grappling and cartwheeling; high-speed chasing with complicated manoeuvres occurs. Nest-sites shown by males to females by ledge-displays accompanied by calling and even scraping out depressions to form potential nests, and by ritualized inspection of holes. Courtship feeding starts well before laying; male provides food for female, often using spectacular aerial food-passing. Males generally continue to bring food to female and young until young well feathered; typically, females become active in defending eyrie and in hunting when young no longer need brooding. Copulation occurs well before it is necessary, to fertilize the eggs and far more often than is necessary so is part of courtship; accompanied by special calls and displays. Frequent copulation probably a behaviour to avoid cuckoldry. Contact behaviour includes billing and allopreening but more usually avoid close contact. Nest-relief without ceremony, male simply replacing female if she leaves nest for feeding, loafing or preening. Voice unspecialized and usually consists of monosyllabic *keks* or *kiks* in series, chattering, chittering, trilling or cackling; shrill, piercing, loud, harsh; may differ in pitch between sexes. Loaf with head drawn in to shoulders, typically standing on one foot with other drawn up into feathers; may doze or sleep with bill under scapulars in middle back. Clean feet with bill after feeding and wipe bill on perch. Some bathe in shallow water, perhaps daily; sometimes dry themselves with wings partly spread; drink even when cold. Dusting widespread in Family. Sunbathing with fully spread wings occurs in hobbies; shield young from sun or rain by mantling over them. Comfort behaviour may be performed in flight as in Accipitridae. For fuller information on behaviour see Cade (1960, 1982), Glutz *et al.* (1971), Village (1990), BWP.

Timing of breeding season varies, perhaps with latitude. Nest-sites on ledges and in holes on cliffs, even on buildings, in holes and hollows in trees, in old stick-nests of other species and sometimes on ground. In spite of claims to contrary, no true building by any species, though hollows may be scraped out with feet and small pieces of material added or removed, e.g. sprays of leaves, bits of bark. Eggs, broad or rounded ovals; mat; white or whitish ground-colour, intensely or entirely blotched with reds and browns. No vacuoles in outer layer of egg-shell; inside of egg-shell, ochre. Usual clutch-size: 2–3 in hobbies; 3–6 in kestrels and other small falcons; 3–5 in large species. Annual variations at times of plagues of rodents less marked than in some accipitrids. Laying interval usually 2 days in all species but 3 days has been recorded for all species, including kestrels. Typically females show period of lethargy before laying. Single-brooded but losses of eggs replaced in 11–16 days (Newton 1977). Incubation mostly or entirely by female. Period: 25–31 days in kestrels; 28–35 days in merlins and hobbies; 32–35 in large falcons. Usually starts with second egg. Egg-shells often eaten by females (P.D. Olsen) (cf. Accipitridae). Parental duties divided much as in predatory Accipitridae; male may feed young bill to bill but often only in absence of female; can rear young alone if mate lost soon after hatching. Nestling period: 25–32 days in most small and medium-sized species; 35–49 days in large. No siblicide in nest. Depend on parents after fledging for 1–3 weeks in kestrel-like species; 2–3 weeks in hobbies; 4–6 weeks in larger falcons. Age of first breeding usually 2 years or older; earlier in small species.

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Falco Cenchroides Vigors and Horsfield, 1827, *Trans. Linn. Soc. Lond.* 15: 183 — Australia = New South Wales, *vide* Mathews, 1912, *Novit. zool.* 18: 253.

The Greek word for 'kestrel' was κέρχινη, because it has a hoarse voice (κέρχινειν, to be hoarse of voice). This has clearly been used in a generic synonym. The Greeks also had a word, κέγχρος for 'millet' or any small grain and also the spawn of fish; κέγγρις (not in Liddell and Scott's abridged lexicon) is said to be the Greek for small hawk but it seems more likely that *cenchr.* of the specific name has been derived from *cerchn.* by metathesis of the n and r. Thus we should get the specific name meaning 'somewhat like a kestrel'.

NZ Nankeen Kestrel.

OTHER ENGLISH NAMES Hoverer, Mosquito Hawk, Sparrowhawk, Windhover.

For the unsuitability of 'nankeen', see Rufous Night Heron (HANZAB 1). Species of kestrel replace each other geographically round the world and geographical epithets are thus best for differentiation.

POLYTYPIC Nominate *cenchroides*, A'asia, Indonesia, Christmas I. (Ind.); *baru* Rand, 1940, Oranje Mts, central New Guinea.

FIELD IDENTIFICATION Length 30–35 cm; wingspan 60–80 cm; weight: male 165 g, female 185 g. Smallest Aust. falcon; small, delicate; slightly smaller, noticeably slimmer-bodied and with longer tail than Australian Hobby *Falco longipennis*. Wings, long and narrow, usually rather blunt-tipped in flight; rather long narrow tail, rounded to gently wedge-shaped at tip. When perched, wing-tips level with tip of tail. Plumage distinctive: saddle and wing-coverts, chestnut contrasting with black outerwing; in male, rest of upperparts, blue-grey; in female, head, neck and tail, chestnut; both sexes mostly white below. Distinctive winnowing and hovering flight; often noticed hovering over paddocks and roadsides. Sexes differ in plumage and female larger than male. No seasonal variation. Juvenile closely resembles adult female, may be separable at close range if with parents.

Flight Soar and glide with wings held flat or slightly lowered, carpals below level of body, wing-tips curving up till held level (Fig. 1). When **soaring**, wings stretched out fully, carpals pushed slightly forward, trailing-edge smoothly curved forward, outer primaries slightly spread giving noticeably blunt wing-tip; well-spread tail rounded at tip. When gliding, wings curved back in smooth sickle shape: carpals pressed forward nearly in line with bill, primaries closed and swept back, tapering to narrow though blunt tip; trailing-edge straight to distinctly recurved adding to sickle shape of outerwing; folded tail, long, narrow, gently wedge-shaped at tip. Direct flight, rapid and winnowing, with sweeping



Fig. 1 Soaring and gliding

glides on flat or slightly lowered wings. Persistently hover into wind on outspread wings with rapid shallow wing-beats, tail depressed and fully fanned, body horizontal or sloping; or hang motionless into wind, with flexed wings held steady and above back; dive steeply on closed wings from hovering position or perch on to prey; from hovering position, usually drop steeply on to prey, often checking descent and again hovering.

Description Adult male Crown, nape and hindneck, blue-grey, finely streaked black. Forehead, narrow supercilium, and cheeks, white, with usually distinct blackish moustachial stripe and narrow blackish stripe behind eye. Saddle and inner wing-coverts, chestnut with sparse thin black streaks and drop-shaped spots mainly on scapulars, tips of greater coverts and tertials. Primaries and primary coverts, black; secondaries, black grading to chestnut with black barring towards body; thin creamy trailing-edge to remiges in fresh plumage. Rump, upper tail-coverts and tail, blue-grey, with broad black subterminal band and narrow white tip to tail. Underbody, white, with faint buff-brown wash

across foreneck and breast overlaid with fine dark streaks extending on to belly, flanks and wing-pit. Undertail, white, with bold black subterminal band. Underwing, white with indistinct grey barring on remiges and small dusky wing-tip. Bill, blue-grey with dark tip. Cere and orbital ring, yellow. Iris, brown. Legs and feet, yellow. **Adult female** Like male but differs by: crown, nape and hindneck, chestnut, finely streaked blackish; blackish eye-stripe and moustachial stripe generally less distinct; saddle and wing-coverts tend to be more heavily marked with thin black streaks, arrowheads and bars; rump, usually chestnut but pale blue-grey in some; upper tail-coverts, usually pale blue-grey or whitish, though sometimes chestnut, as back; tail, chestnut with narrow white tip, black subterminal band and fine black barring, though often no barring on central feathers or, in some, barring may be entirely absent; barring visible from below when tail spread; head, neck and tail may be lightly washed pale grey, mainly in those with unbarred rectrices and pale rump and upper tail-coverts; underparts tend to be more heavily streaked and washed buff. **Juvenile** Like adult female and difficult to recognize unless with parents. Black bars and marks on upperparts tend to be heavier and more numerous; males tend to be less heavily marked than females but much individual variation and overlap. Many acquire pale blue-grey rump and upper tail-coverts with post-juvenile body-moult. Slightly wider, more conspicuous creamy trailing-edge to wing when fresh. Cere, pale yellow. Orbital ring, pale grey-green. Legs, yellow.

Similar species Ought not to be mistaken for any other raptor by reason of small size and slender build, chestnut on upperparts with black outerwing, whitish underparts, conspicuous black subterminal tail band, and, importantly, persistent hovering habit and winnowing flight. **Elanus kites** only other raptors to hover persistently but have larger head, fuller body, broader wings and shorter tail and quite different hovering action with wings held in V high above body; wings raised when soaring and gliding. In poor light and especially when flying rapidly can be mistaken for **Australian Hobby** *Falco longipennis* or **Collared Sparrowhawk** *Accipiter cirrocephalus* (q.v. for differences). **Brown Falcons** *F. berigora* also hover but much less persistently and with slower, deeper wing-beats; are much larger and bulkier, with distinctive double cheek-stripe, and long legs.

Common diurnal raptor in Aust.; recorded NZ; solitary or in pairs and family parties in most open habitats, characteristic of farmland with scattered trees. Common in urban areas, roosting and even breeding on buildings. Perch conspicuously; when perched, appear slim and long-tailed, with upright stance. Hunt mostly from hovering position or perch but also pursue birds in flight. Most commonly heard call a strident rapid shrill chatter; also short single note repeated and upslurred chittering.

HABITAT Over open country and wooded lands, tropical and temperate. In Aust., widespread in all rainfall and altitudinal zones, but at high altitudes mainly in summer (Gall & Longmore 1978). Most common in open country with low, rather sparse cover of vegetation; in well-watered areas, particularly lands cleared for pasture or crops; in drier parts, natural grasslands and low shrublands (e.g. spinifex, Mitchell Grass *Astrelba*, wallaby grass *Danthonia*, saltbush, bluebush). Other habitats: sedge-covered floodplains; alpine herbfields and shrublands; heath; vineyards; mallee; acacia scrub (Mulga *Acacia aneura*, Myall *A. soudenii*); woodland (e.g. *Eucalyptus*, *Casuarina*, pine *Callitris*, Brigalow *Acacia harpophylla*); open forest; and young plantations of exotic pines (Sedgwick 1964; Crawford 1972; Longmore 1973; Brooker *et al.* 1979; Sonter 1981; Friend 1982; Czechura 1984). Occurs in forest, mallee or acacia scrub only if open, particularly forest on

dry ridges or along roads or clearings; avoid dense forest (rainforest, wet gully forest), unless opened up by clearing, logging or roads (Loyn 1980; Smith 1984; Czechura 1985; P. Maher). Marine and coastal habitats include: beaches; dunes; mangroves; saltmarsh; saltworks; offshore islands, often where there are cliffs for perching and nesting; and cays (Paton 1973; Abbott 1982; Gosper 1983; Smith & Johnstone 1985). On Nullarbor Plain, birds inhabit entrances to caves, and hunt, roost and nest there (Hamilton-Smith 1965; Lewis 1987). Common in urban areas and settlements, not only in parks, gardens and vacant land, but also in built-up and industrial areas (Wheeler 1973; Digan 1982). Observed sheltering under eaves of building in rain; also hunting on flat roof-top 12 storeys up, hovering above and dropping to roof-top (M. Hewish). Hunt where prey freshly exposed or disturbed, near farm machinery and vehicles and on recently burnt ground (Boehm 1961; Nielsen 1962; Sonter 1981; Garnett & Bredl 1985).

Few descriptions of habitats used in NZ, and on Christmas, Lord Howe and Norfolk Is, but apparently similar to those in Aust.: grassy open country, towns and openings in forests (van Tets & van Tets 1967; Fullagar *et al.* 1974; Edgar & Grant 1969).

Nest on ledges of coastal and inland cliffs; also in stick-nests and hollows in trees in or beside open habitats. On treeless plains, may nest in entrances to caves (Hamilton-Smith 1965). On Norfolk I., nest in open areas, on coastal cliffs, and near edges of clearings (Schodde *et al.* 1983; P.D. Olsen). Search for prey from elevated perch, especially in calm conditions, or on wing; hover expertly and effortlessly, head to wind, usually at heights of 2–50 m (Genelly 1978). Travel and soar higher; recorded at 1100 m (Meggs 1988). Take prey in open; on ground, in air or from exposed foliage. Active on ground: preen and loaf there, and walk, run or hop to pursue prey (Genelly 1978).

Clearing for pasture, crops and timber production since European settlement has provided new feeding grounds; however, in intensively farmed areas, diversity and possibly abundance of prey reduced, except during plagues of mice or locusts, which may have reduced numbers. May move to new areas when conditions become favourable, e.g. move into Nullarbor following good rains (Brooker *et al.* 1979). Possibly declined in some farmlands, where improved pasture too dense for hunting, but heavy grazing maintains preferred short open vegetation (Masters & Milhinch 1974); in Riverina, occur in high numbers where native grasslands lightly grazed, as seeding grasses encourage prey, including House Mice and insects (P. Maher). Clearing removes nesting trees, which may be detrimental where no cliff-sites (McEvey 1965). Recent arrival on Christmas I. (Ind.), using new niches created in forest by road-building and clearing (van Tets & van Tets 1967). Common in towns and cities, nesting on ledges of tall buildings, which structurally resemble natural cliff-sites (Digan 1982). Also nest on and in any artificial structure with suitable ledges or cavities: buildings, industrial machinery, water tanks, towers, windmills; even underground in mine shafts and gun-pits. Telegraph poles and buildings often used for perching and roosting (Genelly 1978).

DISTRIBUTION AND POPULATION Widespread on Aust. mainland; uncommon visitor to Tas., but recorded on most Bass Str. islands; resident Christmas (Ind.), Norfolk and Lord Howe Is; scarce non-breeding visitor to NZ; recorded New Guinea, Java and Moluccas (Coates 1985; White & Bruce 1986).

Aust. Widespread and common throughout mainland, though patchily distributed in n. Kimberley Division, Arnhem Land and Gulf of Carpentaria; seasonally infrequent in true sandy deserts of e. WA and w. SA (Aust. Atlas). **Tas.** Uncommon on

mainland; sporadic records, mainly in N, E and S (Thomas 1979; Patterson 1990; Tas. Bird Reps 4–18; Aust. Atlas); common and widespread Bass Str. islands, including Flinders and King (Green & McGarvie 1971; Cooper 1974; McGarvie & Templeton 1974; Thomas 1979; Green 1989; Tas. Bird Reps 9, 13).

Christmas I. (Ind.). Common breeding resident (van Tets & van Tets 1967; van Tets 1975). Self-introduced between 1940 and 1950 (Stokes 1988).

Norfolk I. Breeding resident; first recorded 1969 (Smithers & Disney 1969); occasional vagrant till 1978, resident thereafter (Moore 1981; Tarburton 1984). Widespread on Norfolk I., occasionally on Nepean and Philip Is (Moore 1981; Schodde *et al.* 1983; Hermes 1985; Hermes *et al.* 1986).

Lord Howe I. Breeding resident; first recorded early 1940s (Hindwood & Cunningham 1950; Fullagar *et al.* 1974; Fullagar & Disney 1975). A few pairs in 1952 (B.D. Heather).

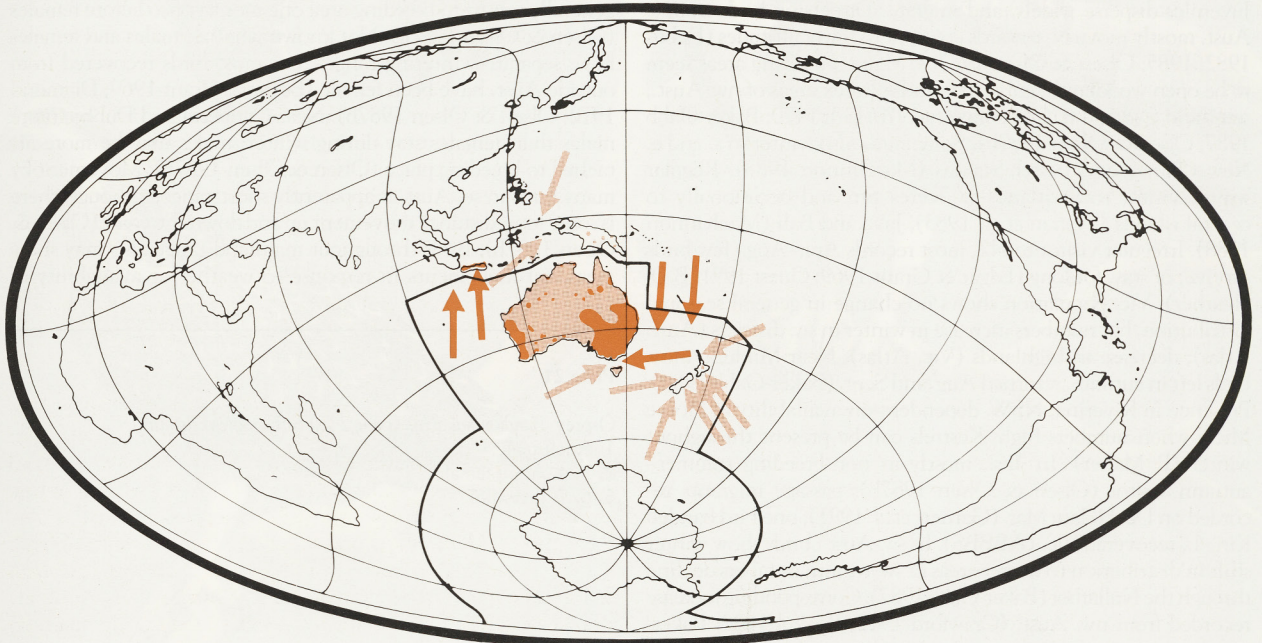
NZ Scarce non-breeding visitor; recorded most regions. **NI** Most from Northland; scattered records from Kaipara, South Auckland, Waikato, Volcanic Plateau, East Coast and Hawke's Bay; several in Manawatu, Wellington and Wairarapa. **SI** Few records Nelson and Marlborough; scattered records from West Coast, from Westport, S to Okarito; at least eight birds in May 1990 (B.D. Heather); several in central and s. Canterbury; coastal Southland (Edgar & Grant 1969; Powell 1975a,b, 1978; Pierce 1980; Guest 1991; CSN 19, 29–38).

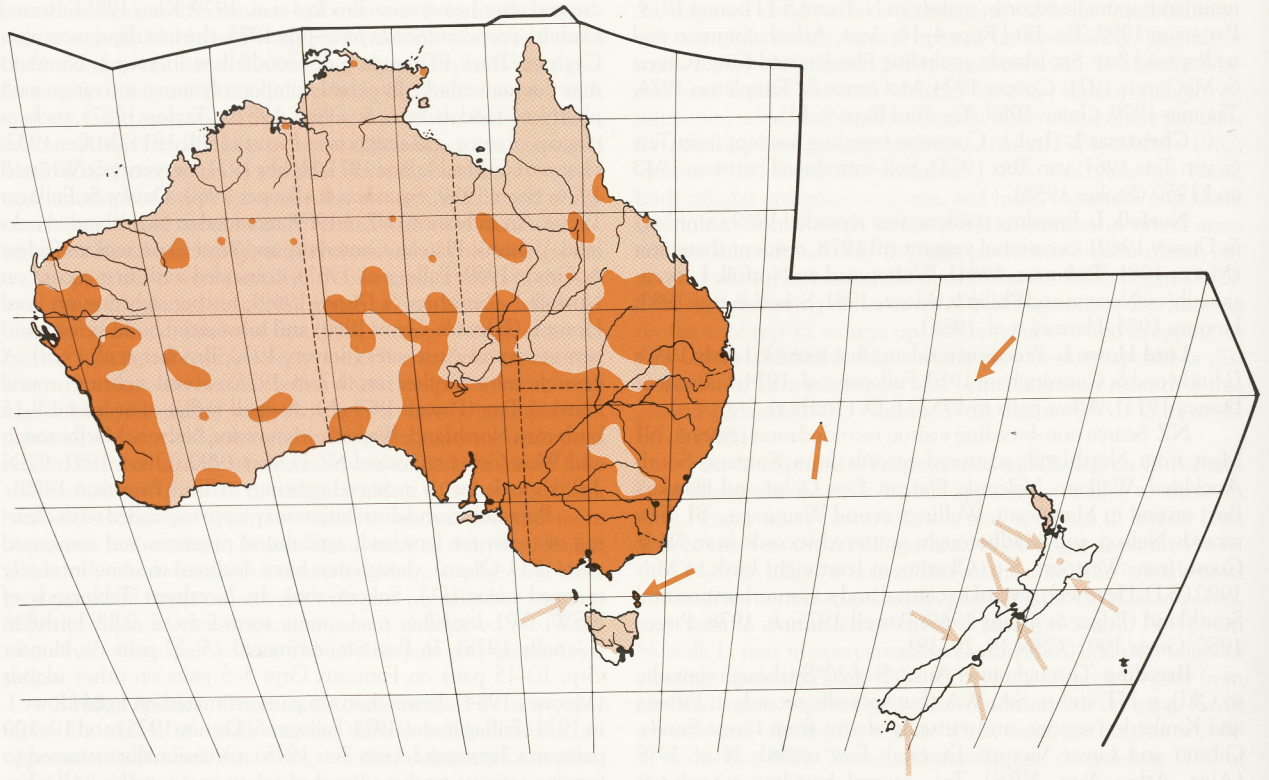
Breeding Throughout e. Aust., S of 20°S (though sporadic in Qld); s. NT and n. SA; WA (but sporadic records in Pilbara and Kimberley regions, and virtually absent from Great Sandy, Gibson and Great Victoria Deserts). Few records N of 20°S (Aust. Atlas; Aust. NRS). Tas., several breeding records on mainland including one pair in Hobart area (N.J. Mooney); also recorded on several Bass Str. islands (including Hunter and Furneaux Grps; Tas. Bird Reps 5, 10). Breeds Christmas (Ind.), Lord Howe and Norfolk Is (Fullagar *et al.* 1974; van Tets 1975; Schodde *et al.* 1983; Fullagar & Disney 1975; Hermes *et al.* 1986).

Subject to irruptions (Favaloro 1983). Dry weather may cause birds to leave an area (Debus 1985); drought in central Aust. in 1964 caused birds to move into n. districts (Rix 1970); numbers round Meandarra, Qld, declined during drought (Whitmore *et al.* 1983). Numbers in nw. and e. Nullarbor in-

creased after heavy rain (Brooker *et al.* 1979; Klau 1985). Round Darwin, very common in June–July 1975, the first dry season after Cyclone Tracy (Thompson & Goodfellow in prep.). Numbers may fluctuate markedly as birds temporarily move into areas with plenty of food (Olsen & Olsen 1987b; Taylor 1987) such as plagues of mice, grasshoppers or locusts (Hill 1911; Miller 1932; Hayward & MacFarlane 1971; Hobbs 1971; Serventy & Whittell 1976; Storr 1980; Saunders & Cooper 1982; Davey & Fullagar 1986). An influx into NZ in 1969, recorded in Northland, Auckland, Volcanic Plateau, Canterbury and West Coast regions (Edgar & Grant 1969; Falla *et al.* 1987), coincided with first record on Norfolk I. (Smithers & Disney 1969), further sightings on Lord Howe I. (Edgar & Grant 1969) and substantial build-up of numbers at several Aust. sites (Bravery 1970; Brooker *et al.* 1979). A possible minor influx into NZ in 1975; several sightings round Hawke's Bay (Powell 1975a,b). A small influx of at least 13–15 birds into Northland, Waikato, Manawatu, Nelson, Marlborough and West Coast regions of NZ in May 1990 (Guest 1991; CSN 38) coincided with increased sightings in Tas. (Patterson 1990).

Population and distribution may have expanded with clearing of forest for farmland, agricultural practices and associated pests (P.D. Olsen), though may have declined in some intensely cropped areas (D.J. Baker-Gabb). In Northern Tablelands of NSW, 0.01 birds/ha; road-counts recorded 0.2–0.32 birds/km (Genelly 1978). In Bass Str., estimated 15–20 pairs on Hunter Grp; 10–15 pairs on Furneaux Grp; 3–5 pairs on other islands (Mooney 1984). Fewer than ten pairs estimated on Lord Howe I. in 1971 (Fullagar *et al.* 1974; Fullagar & Disney 1975) and 10–100 pairs on Christmas I. (van Tets 1975). Occasionally attracted to farming activity, catching disturbed insects, mice and birds (Boehm 1961; Nielsen 1962). Often take introduced passerines and mice. Occasionally struck by vehicles (Mooney & Hunt 1983). Recorded eating bodies of poisoned mice (Saunders & Cooper 1982); up to 33% thinning of egg-shells through ingestion of DDT-based pesticides (Olsen & Olsen 1985b). In SA and Vic., maximum pesticide concentrations levels of 3.9 and 160 mg/kg recorded respectively (Birks & Olsen 1987). Occasionally persecuted as thought to threaten young Domestic Fowl (Passmore 1982; van Tets 1983). Unprotected on Norfolk and Christmas (Ind.) Is (Robinson & Brouwer 1989). Probably colonized





Christmas I. by ship-assisted passage during World War II (D.L. Serventy; P.D. Olsen).

MOVEMENTS Partly migratory. Resident populations through mainland range, particularly se. and sw. Aust. Widespread S–N migratory movements; some altitudinal migration (Olsen & Olsen 1987b). In s. Aust., many established pairs resident through year (Vic. Atlas; Genelly 1978; Olsen & Olsen 1987b), except at higher altitudes (Aust. Atlas; Gall & Longmore 1978; Olsen & Olsen 1987b), or in times of drought (Hobbs 1961; Debus 1985). Juveniles disperse widely, and migrate. Dispersing birds from s. Aust. mostly move N, towards coast, or to lower altitudes (Debus 1982, 1985; Olsen & Olsen 1987b). Major wintering areas seem to be open woodlands, grasslands and spinifex areas of nw. Aust., semi-arid Qld and n. Qld (Bravery 1970; Gill 1970; Baker-Gabb 1987; Olsen & Olsen 1987b). Some birds also winter in s. and e. New Guinea and Lesser Sundas (MacKinnon 1988). Regular winter visitor to w. islands of Torres Str. and occasionally to central islands (Draffan *et al.* 1983), Java and Bali (MacKinnon 1988). Irregular visitor to NZ, most records Apr.–Aug.; few birds survive, or stay, for long (Edgar & Grant 1969; Guest 1991; B.D. Heather). Vic. population shows no change in general seasonal distribution, but numbers increase in winter in sw. districts (Aust. Atlas); decrease in highlands (Vic. Atlas). Near Mildura, most birds left in autumn, returned Aug. and Sept. (Baker-Gabb 1984). Presence in Riverina, NSW, dependent on availability of House Mice; when numbers high, Kestrels can be present throughout winter (P. Maher). In Tas., mostly as non-breeding summer–autumn visitor (Olsen & Olsen 1987b); passage migrants recorded on Deal I. late Mar. (Garnett *et al.* 1991); one bird banded King I., recovered Vic. (ABBBS). In sw. Aust., birds show winter shift in distribution to wetter areas of sw. region; numbers decline through the Nullarbor (Baker-Gabb 1987). Corresponding increase recorded from nw. Aust. (Crawford 1972; Boekel 1980; Baker-

Gabb 1987). May migrate to nw. Aust. from sw. Aust. (Baker-Gabb 1987), and from central Aust. (Olsen & Olsen 1987b). Most central Aust. birds then may migrate to s. Aust. for summer (Olsen & Olsen 1987b). S. Aust. birds leave breeding area Mar.–Apr. (Genelly 1978; Baker-Gabb 1987), return Aug.–Sept. During non-breeding season, recorded from Innisfail district mostly Apr.–Oct.; from Atherton Tablelands, Feb.–Dec., but some birds resident (Bravery 1970; Gill 1970); Darwin district May–Oct. (Crawford 1972). Juveniles first to leave natal territories and adult females before adult males if they are leaving. Adult males generally return to breeding area one month or so before females (Olsen & Olsen 1987b). Not known whether males and females have separate wintering ranges, but most birds recovered from outside Aust. have been female (Edgar & Grant 1969; Diamond 1972; Olsen & Olsen 1987b). Near Canberra and Dubbo, more males than females stay during winter; males may be more attached to breeding place (Olsen & Olsen 1987b). Movement by many birds in se. Aust. is apparently short-range, although there is some long-distance movement up and down the coast (Olsen & Olsen 1987b). Birds throughout mainland range also may show aseasonal movements in response to weather or availability of

Plate 21

- Osprey *Pandion haliaetus* (page 225) Subspecies *cristatus*
 1 Adult male;
 2, 3, 4 Adult females;
 5, 6, 7 Juveniles

food; large influxes reported where mice abundant (Hayward & MacFarlane 1971; Davey & Fullagar 1986); on Nullarbor Plain, numbers increased after autumn rains (Brooker *et al.* 1979); near Hay and Armidale numbers decreased during drought (Hobbs 1961; Debus 1985); increased n. Aust. during inland drought (Hertog 1986). Influx in winter 1969 to NZ and Norfolk I. may have been stimulated by summer bushfires in Aust. (Edgar & Grant 1969).

Banding recoveries show strong philopatry. Over 80% of birds recovered within 6 months of banding were within 10 km of banding place (though most banding has been in s. Aust.); 62% of all birds recovered (n=118) have been recovered at the banding place. Adult females appear to move more often than males (14 of 26 adult females were recovered at their banding place, compared with 21 of 30 adult males), but may move shorter distances (Olsen & Olsen 1987b).

FOOD Terrestrial vertebrates, particularly mice, small birds and reptiles, and insects and other terrestrial invertebrates. **Behaviour** Normally diurnal, but nocturnal feeding recorded in PNG on moths attracted to artificial light (Warne 1990); also recorded feeding on mice by moonlight (Carter 1903; Boehm 1961). Most often hunt from concealed and unconcealed perches (82% success, n=364) and, particularly in windy conditions, by high-quarterming and hovering (Czechura 1979). Also recorded soaring and prospecting, hunting on ground (Genelly 1978), flushing by zigzagging low over vegetation alone or in pairs (Czechura 1971, 1979), hawking (McGilp 1934; Nielsen 1962) and hunting prey flushed by fires (Heron 1970) and vehicles (Boehm 1961; Nielsen 1962); observed hunting over flat roof-tops of 12-storey building, hovering and dropping to roof-top (M. Hewish). Attracted to, and exploit, plagues of mice (Hayward & MacFarlane 1971; Hobbs 1971; Saunders & Cooper 1982; Davey & Fullagar 1986), grasshoppers and locusts (Hill 1911; Storr 1980). Birds recorded soaring up to 1100 m (Meggs 1988). Methods of attack: drop-attack, direct flying attack, dive-attack, tail-chasing, particularly of insects, glide-attack (Genelly 1978) and snatching prey from canopy (Veerman 1985). When effort required to kill prey, dive heavily instead of dropping lightly (Czechura 1971). Insects often stripped of wings and legs before eating, often on wing (Veerman 1988); larger prey eaten at perch (Genelly 1978). Small mammals skinned before eating, entrails and bones left (Hayward & MacFarlane 1971). Take carrion (McLaughlin 1989; Smith 1989; P. Scofield). Males fed at one place for shorter time than females (38 min: 59 min; n=1480, 1357 min observation); males move between foraging stations by circling flight more often than females (Genelly 1978). During breeding season, male foraged by hovering, female by hunting from perch. Male succeeded on 103 (76%) of 135 attacks, female on 71 (78%) of 91 attacks (Paull 1991). Male attacked successfully every 21 min (3.8 attacks/h), female every 30 min (2.5 attacks/h). Usually feed alone but

sometimes in groups, up to 20 birds (Whelan 1983; Roe 1988). Steal food from other raptors: mouse from Black-shouldered Kite *Elanus axillaris*; flew in from above and behind Kite, turned 180° and grabbed mouse with talons (McKellar 1975); food also stolen from Kestrels: mice, by Brown Falcon (Roberts 1944) and Australian Hobby (S.J.S. Debus). In stomachs, lepidopterans occur mostly in spring and summer, orthopterans all year, mice generally in autumn and winter, reptiles in spring and summer (Olsen *et al.* 1979b); at Griffith, insects in summer and autumn, reptiles in spring and summer, mice in autumn and winter (P.D. Olsen). Partitioning of prey between sexes during nestling period (17 observations of male at nest, ten of female; Bollen 1991): grasshoppers 6% no. taken by male, 40% taken by female; lizards 6%, 20%; parrot 6%, -; sparrow *Passer* 76%, 20%; House Mice: 6%, 20%.

Table 1 Diet of the Australian Kestrel (% wt.)

	1	2	3	4	5	6
Mammals	35	3	97	5	18	11
Birds	45	67	2	74	-	16
Reptiles	7	<1	-	14	14	4
Invertebrates	13	31	1	6	68	69

(1) NW. Vic. (Baker-Gabb 1984); (2) s. NSW, ACT (Olsen *et al.* 1979b); (3) L. Cowal, NSW (Olsen *et al.* 1979b); (4) Goulburn, NSW (Bollen 1991); (5) Armidale, NSW (Paull 1991); (6) Aust. generally (Olsen *et al.* 1979b).

Table 2 Diet of the Australian Kestrel (% no.)

	1	2	3	4	5	6	7	8
Mammals	13.6	0.5	82.1	2	<1	0.9	1.0	58
Birds	9.5	3.2	0.4	19	0	0.3	0.0	5
Reptiles	4.5	0.5	0.0	53	17	5.8	0.3	3
Invertebrates	72.3	95.8	17.5	26	83	92.8	98.7	34
No. items	177	405	285	129	212	584	309	116

(1-6) As Table 1; (7) ne. NSW (Genelly 1978); (8) Griffith, NSW (P.D. Olsen).

Adult Detailed analyses of diet summarized in Tables 1 and 2. **Breeding In nw. Vic.** (38 pellets, four prey remains, at nests; Baker-Gabb 1984): Arachnids: Araneae: spiders 27.9% no.; Orthoptera 29.4; Coleoptera 3.3; Lepidoptera: larv. 11.7. Reptiles: Scincidae 4.5. Birds: Stubble Quail *Coturnix pectoralis* 5.0% wt., 0.6% no.; unident. passerines 3.9; Southern Whiteface *Aphelocephala leucopsis* 1.1; House Sparrow *Passer domesticus* 0.6; Common Starling *Sturnus vulgaris* 24.4, 3.3. Mammals: rabbit 15.5, 0.6; rodents: House Mouse *Mus musculus* 13.0. At **Armidale, NSW** (observations at nest, 212 items; Paull 1991): invertebrates (mainly Orthoptera) 83% no. Reptiles: lizards: *Lampropholis* 17. Mammals: Black Rat *Rattus rattus* imm. <1. At **Goulburn, NSW** (obs. at nest, 129 items; Bollen 1991): Arthropods: unident. 11.6% no.; Arachnids: Araneae: spiders 1.6; Insects: Orthoptera: Acrididae/Tettigoniidae: grasshoppers 13.2. Reptiles: lizards: *Lampropholis guichenoti* 5.3. Birds: unident. small birds 2.3; Red-rumped Parrot *Psephotus haematonotus* 0.7; Richard's Pipit *Anthus novaeseelandiae* 0.7; House Sparrow 11.6; Common Starling juv. 3.1.

Non-breeding At Griffith, NSW (pellets, 116 items; P.D. Olsen): Crustaceans: yabbie *Cherax destructor* 4% no. Insects 30.

Plate 22

Peregrine Falcon *Falco peregrinus* (subspecies *macropterus*) (page 307)
1 Adult; 2 Juvenile

Grey Falcon *Falco hypoleucos* (page 291)
3 Adult; 4 Juvenile

Australian Hobby *Falco longipennis* (page 268)
5 Adult, nominate *longipennis*; 6 Juvenile, nominate *longipennis*;
7 Adult, subspecies *murchisonianus*

Australian Kestrel *Falco cenchroides* (nominate *cenchroides*) (page 253)
8 Adult male; 9 Adult female; 10 Juvenile; 11 Immature male

Amphibians: frogs 1. Reptiles: snakes 1; lizards: Scincidae 1. Birds: small passerines 2; Common Starling 3. Mammals: Fat-tailed Dunnart *Sminthopsis crassicauda* 1; rodents: House Mouse 57. Near **Armidales, NSW** (obs., 309 items; Genelly 1978): unident. 78.6. Insects: Orthoptera 20.1; Coleoptera, poss. Chrysomelidae. Reptiles: lizard 0.3. Mammals: rodents: Muridae 1.0. On **Norfolk I.** (12 pellets; P.D. Olsen): three pellets: Coleoptera 10%; Birds: House Sparrow 90%. Nine pellets: Coleoptera 4%; House Mouse 72%; Polynesian Rat *Rattus exulans* 24%.

Breeding and non-breeding At **L. Cowal, NSW** (109 pellets collected during plague of mice; Olsen *et al.* 1979b): Arachnids: Araneae: spiders 2.8% no. Myriapods: Chilopoda 1.4. Insects: Gryllidae 2.1; Acrididae 1.1; Coleoptera: Dytiscidae 0.4; Staphylinidae 0.4; Scarabaeidae 1.1 (incl. water beetle *Eretus sticticus*); Tenebrionidae 1.4; Curculionidae 5.3; Diptera 0.4; Lepidoptera: ads 1.1; Hymenoptera 0.4. Birds: 0.4 (incl. Richard's Pipit). Mammals: 82.1.

In s. NSW and ACT (49 pellets; three nests: Sutton, s. NSW, Booligal, NSW, and Canberra, ACT; Olsen *et al.* 1979b): Arachnids: Araneida: spiders 16.0% no. Myriapods: Chilopoda: 2.2; Blattodea: cockroaches 2.5; Mantodea 0.2; Orthoptera: Tettigoniidae 6.9; Gryllidae 2.7 (incl. Gryllotalpidae); Acrididae 33.8; Hemiptera: Pentatomidae 0.2; Coleoptera: Carabidae 1.2; Lucanidae: 0.2 (incl. *Lampyris aurata*); Trogidae: 0.5 (incl. *Trox*); Scarabaeidae (incl. chafers *Aphodius howitti*, *Diphucephala*, christmas beetles *Anopognathus pindarus*, *A. palidicollis*, beetles *Adoryphorus couloni*, *Halaeus*, and dung beetle *Onthophagus*): 0.7 unident.; Aphodiinae 6.4; Melolonthinae 0.7; Rutelinae 9.4; Dynastinae 1.0; Buprestidae 0.2; Elateridae 1.0; Tenebrionidae 1.2; Chrysomelidae 0.2; Curculionidae 1.5; Diptera: Muscidae 0.2; Lepidoptera: ads 0.2; larv. 2.7; Hymenoptera: Formicidae 3.3 (incl. ants *Myrmecia*, *Rhithidoponera*); unident. beetle 0.2. Reptiles (incl. lizard *Morethia boulengeri*) 0.2. Birds 3.2 (incl. Richard's Pipit, Common Starling ads, juvs, Blackbird *Turdus merula*). Mammals: 0.5 (incl. House Mouse).

On Boullanger, Escape and Whitlock Is, near Jurien, WA (n=58 pellets; Dickman *et al.* 1991): Insects 79.3% freq., 39.2% vol., incl. Tettigoniidae, Acrididae, Coleoptera, Dermaptera, Blattodea, Phasmatodea. Reptiles 82.8, 37.7 incl. *Egernia*, *Ctenotus*. Birds 15.5, 6.6. Mammals: Dibbler *Parantechinus apicalis* 17.2, 9.2; *Sminthopsis griseoventer* 6.9, 2.1; House Mouse 13.8, 5.1.

In Aust. (37 digestive tracts from birds hit by aircraft; Olsen *et al.* 1979b): Arachnids: spiders 6.2% no. (incl. Pisauridae, Lycosidae). Myriapods: Chilopoda centipedes 4.1; Odonata: damselflies 0.2; Blattodea: cockroaches 0.3; Mantodea 0.7; Dermaptera: earwigs 2.2; Orthoptera: Tettigoniidae 2.6; Gryllidae 14.6 (incl. *Gryllotalpa australis*, *Telegryllus commodus*); Acrididae 27.7 (incl. *Nomadacris guttulosa*); Hemiptera: Pentatomidae 0.5; Coleoptera: Carabidae 1.2; Scarabaeidae 2.4; Elateridae 0.2; Tenebrionidae 3.4; Curculionidae 0.7; Lepidoptera: ads. 2.2; larv. 4.3; Hymenoptera: Formicidae 19.3 (incl. *Iridomyrmex*). Reptiles: 5.8 (incl. lizards: *Amphibolurus pictus*, *A. minimus*, *Diplodactylus elderi*, *Lampropholis guichenoti*, *Leiopisma trilineatum*, *Ctenotus taeniolatus*). Birds: 0.3. Mammals: 0.9; Carrion 0.2.

In Aust. (19 stomachs from birds hit by aircraft; van Tets *et al.* 1977): Arachnids: Araneae 26.3% freq.; Chilopoda: centipedes 5.3. Insects: Odonata: Zygoptera: damselflies 5.3; Mantidae 5.3; Orthoptera: Gryllacrididae 5.3; Tettigoniidae 5.3; Gryllidae: *Telegryllus commodus* 31.6; Gryllotalpidae: *Gryllotalpa australis* 10.5; Acrididae 52.6; *Austracris guttulosa* 5.3; Coleoptera: Carabidae 5.3; Scarabaeidae: ads. 21.1; Scarabaeinae 5.3; Dynastinae 5.3; Elateridae 5.3; Lepidoptera: Noctuidae: ads. 10.5; Hymenoptera: Formicidae: *Iridomyrmex* 15.8. Reptiles: lizards: Scincidae 21.1; *Leiopisma g. guichenoti* 10.5. Birds: Alaudidae: Singing Bushlark

5.3. Mammals 10.5; rodents: House Mouse 5.3. Grit 5.3.

Other records Annelids: Oligochaeta: Lumbricidae earthworms (Sharland 1931; P.D. Olsen). Chilopoda (Vestjens 1977; Barker & Vestjens): centipedes *Scolopendra morsitans*. Arachnids: Araneae: spiders (Lea & Gray; Rose 1973; Vestjens 1977) huntsman spiders *Isopoda* (McKeown 1934); Lycosidae (Rose 1973; Barker & Vestjens). Insects (Salter 1958; Wheeler 1973; Debus 1981; North): Odonata: Anisoptera: dragonflies (North); Blattodea: cockroaches; Mantodea (Barker & Vestjens): *Sphodropoda viridis* (Lea & Gray); Orthoptera (Rose 1973): Gryllotalpidae: mole-crickets (North); Acrididae/Tettigoniidae: grasshoppers (McIlwraith 1905; Barnard 1914; Le Souëf 1918; Norton 1922; McGilp 1923; Miller 1932; Chandler 1936; Lord 1956; Wheeler 1963; Czechura 1971; Bedggood 1972; Hall 1974; Debus 1981; Veerman 1985; North; Mathews; Lea & Gray); Acrididae (Vestjens 1977; Cleland; Lea & Gray; Barker & Vestjens): *Chortoicetes terminifera* (McKeown 1934; Veerman 1985; Lea & Gray); *Gastrimargus musicus* (Lavery 1969; Rose 1973); *Valanga irregularis* (Czechura 1985); Gryllidae: crickets (McKeown 1934; Bedggood 1972; Vestjens 1977; North; Barker & Vestjens); *Telegryllus commodus* (Stephen 1907; Lea & Gray); eggs (Lea & Gray); Tettigoniidae (Barker & Vestjens); Phasmatodea (Lea & Gray); Hemiptera: plant bugs (Lea & Gray); Cicadidae: cicada (Le Souëf 1918; Veerman 1985); Pentatomidae; Neuroptera: Myrmeleontidae (Barker & Vestjens); Coleoptera (Le Souëf 1918; Jarvis 1929; Sharland 1931; Rose 1973; Wheeler 1973; Hall 1974; Debus 1981; Veerman 1985; Mathews; Lea & Gray): Carabidae (Lea & Gray); Scarabaeidae (Wheeler 1973); Melolonthinae; *Anoplognathus*; *Melanastes vulgivagus* (Lea & Gray); Tenebrionidae; Curculionidae (Barker & Vestjens); Lepidoptera ads, larv. (Bedggood 1972; Czechura 1971; Rose 1973; Wheeler 1973; Lea & Gray; Barker & Vestjens); Noctuidae (Lea & Gray; Barker & Vestjens); Hymenoptera: Ichneumonidae (Lea & Gray); Formicidae: ants (Barker & Vestjens). Fish (Lea & Gray). Amphibians: unident. frogs (Wheeler 1973; P.D. Olsen). Reptiles (Chisholm 1944; North); turtles: Loggerhead Turtle *Caretta caretta* and other turtle *Chelonia* hatchlings (Limpus 1973); lizards: Gekkonidae: jewelled gecko (Barker & Vestjens); *Lialis burtonis* (Storr 1965); Agamidae: dragons (Barker & Vestjens); Bearded Dragon *Amphibolurus barbatus* (Czechura 1971); *A. minimus*; *A. pictus* (Barker & Vestjens); Scincidae (Le Souëf 1918; Chisholm 1924; Sharland 1931; Chisholm 1944; Warham 1955; Lord 1956; Czechura 1971; Rose 1973; Hall 1974; Debus 1981; Veerman 1985; Mooney 1988; Anson 1990; Howden 1990; North): *Morethia lineocollata* (Storr 1965); *Leiopisma trilineatum* (Rose 1973; Barker & Vestjens); *L. entrecasteauxii*; *Ctenotus leonhardii* (Barker & Vestjens); *C. australis* (Storr 1965); snakes (Chalmers 1985; Campbell; North): Red-bellied Black Snake *Pseudechis porphyriacus* (Czechura 1971). Birds (Lea & Gray; Chisholm 1944; Wheeler 1963; Debus 1981; North; Mathews); ground-breeding birds (North); young (Le Souëf 1918); Phasianidae: young quail (Czechura 1971); Brown Quail *Coturnix ypsilophora*; King Quail *C. chinensis* (Czechura 1979; P.D. Olsen); Stubble Quail (Olsen *et al.* 1979b); Domestic Chicken *Gallus gallus* (P.D. Olsen); Little Button-quail *Turnix velox* (Le Souëf 1918; Pedler 1975; Taylor 1987); Red-chested Button-quail *T. pyrrothorax* (P.D. Olsen); Little Tern *Sterna albifrons* eggs (Hill 1989); Fairy Tern *S. nereis* nestlings; Feral Pigeon *Columba livia* nestlings (P.D. Olsen); Red-rumped Parrot (Debus 1989; S.J.S. Debus); Brown Songlark *Cinclorhamphus cruralis* (Hollands); Welcome Swallow *Hirundo neoxena* ad., nestlings (Bywater 1966; Robertson 1990); Brown Treecreeper *Climacteris picumnus* (Baldwin 1975); Red Wattlebird *Anthochaera carunculata* (P.D. Olsen); Noisy Friarbird *Philemon corniculatus* nestlings (Baldwin 1975); White-fronted Chat

Ephthianura albifrons (S. Marchant); Silvereye *Zosterops lateralis* (P.D. Olsen); Starling ad., nestlings (Howe 1928; Salter 1958; Wheeler 1973; Baldwin 1975); sparrows *Passer* (Wheeler 1973); Red-browed Firetail *Emblema temporalis* (Czechura 1971); Richard's Pipit nestlings (Sharland 1931); European Goldfinch *Carduelis carduelis* (Lea & Gray); Redpoll *C. flammea* (Powell 1978); White-breasted Woodswallow *Artamus leucorhynchus* ad., nestlings (Batey 1907; Simson 1920; P.D. Olsen). Mammals (North): Chiroptera: Lesser Long-eared Bat *Nyctophilus geoffroyi* (Lewis 1987); rodents (Wheeler 1973): Muridae (Rose 1973): rats (McGilp 1923; Richards 1962); mice (McIlwraith 1905; Cheney 1915; Simson 1920; McGilp 1923; Chisholm 1929, 1938; Chandler 1936; Roberts 1944; Lord 1956; Richards 1962; Wheeler 1963; Czechura 1971; Hayward & MacFarlane 1971; Hobbs 1971; Bedggood 1972; Vestjens 1973; Olsen & Olsen 1987b; Anson 1990; Campbell; Mathews; Lea & Gray); Dusky Rat *Rattus colletti*; Long-haired Rat *R. villosissimus* (P.D. Olsen); House Mouse (Vestjens 1977; Debus 1981; Chalmers 1985; North); rabbit kitten (Veerman 1985). Carrion: Spotted Turtle-Dove *Streptopelia chinensis* (P. Scofield); Red-rumped Parrot (possibly; McLaughlin 1989); Galah *Cacatua roseicapilla* (Smith 1989). Sand (Lea & Gray).

Young Immatures appear to take fewer vertebrates than adults (Olsen *et al.* 1979b).

SOCIAL ORGANIZATION Not well known; information supplied by P.D. and J. Olsen, to whom unreferenced statements may be attributed; study during post-breeding period by Genelly (1978) and observations of single pairs (Bollen 1991; Paull 1991). Typically solitary, occupying established home-ranges defending core area, less often in pairs and sometimes in small groups. After breeding, pairs move or remain resident (Olsen & Olsen 1987b; see Movements); pair may separate for winter, males often remaining in breeding area (Olsen & Olsen 1987b; Olsen 1990); or pair may remain together throughout year (Heron 1970) sometimes roosting and maintaining contact throughout day but usually hunting separately (Genelly 1978). After breeding, young at first disperse short distances only (Olsen & Olsen 1987b). May form groups of up to 17 individuals (Genelly 1978; Whelan 1983; P.D. Olsen; J. Olsen); in late summer–autumn–winter groups may consist of immatures, or family groups of siblings, or siblings and adult female, usually no adult males (Genelly 1978; P.D. Olsen); may hunt or roost together (groups of 7–8; Genelly 1978); occasionally gather in loose groups where food abundant, e.g. at plagues of House Mice (Hayward & MacFarlane 1971), at grass-fires (Heron 1970); during plague of grasshoppers, 34 along 3 km of railway line (Miller 1932); in Riverina, NSW, 180 along 70 km of road during plague of House Mice (P. Maher).

Bonds Monogamous, though some promiscuous matings with neighbours; same pair may use same area for several years (Daw 1984; P.D. Olsen; J. Olsen). Often pair first before 1 year old; both sexes can breed in first-year plumage (Olsen & Olsen 1980a). **Parental care** Both sexes prepare nest, but mainly female; both incubate but mainly female; only female broods; male provides all, or most, food for family until last half of nestling period; only female feeds young nestlings but, if killed, male may take over; both sexes feed older nestlings (Sharland 1931; Bollen 1991; Paull 1991; Cupper & Cupper; Hollands); care for fledglings for several weeks.

Breeding dispersion Solitary. Nests usually well spaced, several kilometres apart, but near Deniliquin, NSW, in isolated woodlands surrounded by vast grasslands 0.2 ha/pair ($n=4$ active nests) in c. 0.75 ha woodland, two nests, with young, only 12 m apart; in woodland of 2.5 ha, 0.8 ha/pair ($n=3$ active nests) closest

being 100 m apart; in trees surrounding homestead 4–5 pairs in 3 ha or 0.6–0.8 ha/pair, two nests being 120 m apart (Baker-Gabb 1985a). Near Armidale, NSW, one pair occupied at least 200 ha (Genelly 1978) and active nests recorded c. 1 km apart (Baker-Gabb 1985a). Near Mildura, Vic., 12 pairs in 10 km radius, and 25 nests averaging 1–3.6 km apart or 1 pair/5.4 km² (Baker-Gabb 1984). At Millewa, Vic., averaged 1 active pair/5.3 km² (Campbell 1986). At Port Augusta, SA, ten nests on 7 km of power line, three being on adjacent pylons 450 m apart; seven pairs nested in <60 km² of Strzelecki Ck floodplain (Mace 1981), about 8 km²/pair. **Territories** Little known. Breeding territories established Aug.–Sept., generally adult male returning a month or so before mate; pairs court, mate, transfer food, and nest in territory (Olsen & Olsen 1987b; P.D. Olsen; J. Olsen). Vigorously defend area round nest-tree only, about 50 m diameter; less actively defend wider areas. After breeding, some adult pairs appear to continue occupying and defending fixed territories; at any time of day, pair likely to be within 800 m of roost-site, each bird feeding in different part of territory (Genelly 1978). **Home-range** Used for hunting, some courting and nest-site selection. At Armidale, home-range estimated 1.6 km², though occasionally birds ranged farther from nest. Non-breeding birds in NZ recorded defending hunting areas from other raptors (Edgar & Grant 1969).

Roosting Usually solitary (P.D. Olsen; J. Olsen) or in pairs, sometimes small groups (Genelly 1978). Sites high and sheltered from prevailing weather (Genelly 1978) and typically near, or within, hunting grounds; recorded returning to same roosts nightly (Genelly 1978; Wheeler 1963) and, at Armidale, sites at least 2 km apart (Genelly 1978). Sites: eucalypt groves, telephone poles, sheds, holes in trees (Genelly 1978), cliffs (Powell 1975b), caves, cave entrances (Hamilton-Smith 1965), on bolt above pump-house door (Wheeler 1963); well-sheltered ledge of house (Marchant *et al.* 1986); ledge on rectangular tower of cathedral, and a ledge near top of boiler chimney (Debus 1990b); in treeless areas, on low rock piles or ground (Baker-Gabb 1985b; P.D. Olsen; J. Olsen). During breeding, usually on favoured branches or ledges, near to nest-site with clear view of nest. Just after fledging, young roost in or nearby nest and later move higher up nest-tree (Hollands). Time of arrival at roost varies depending on weather: averaged 5.6 min after sunset ($n=50$; Genelly 1978); in May, between 17:26 and 18:00 (Stokes 1979); at Hawke's Bay, NZ, in June, between 16:30 and 17:00; about 1 h before sunset (Debus 1990b). Behaviour before roosting varies; commonly perform fast flights at canopy level round roosting tree (Stokes 1979); rapid winnowing flights round building, and gliding with lowered wings and chattering loudly (Debus 1990b). Depart about 3 min before sunrise (but later if raining) and locate sunny place to stretch wings and preen (Genelly 1978). Rest on and off throughout day at roost or convenient perch; on hot days, seek shade of trees or cross-arms of power poles; also seek shelter in heavy rain (Genelly 1978); under eaves of buildings (M. Hewish). When resting may tuck up one leg; preen often, but no apparent routine sequence in preening; most preening sessions short (Genelly 1978).

SOCIAL BEHAVIOUR Not well known. Studies at nests by Cupper & Cupper, Hollands, and observations of single nests at Goulburn, NSW (Bollen 1991) and Armidale, NSW (Paull 1991); additional information supplied by P.D. Olsen and J. Olsen, to whom unreferenced statements may be attributed. Conspicuous throughout day; perch conspicuously. Feed little within first hour after leaving roost, then feed throughout day, though slightly less so in hour before sunset; daily schedule varies with weather; less active in heat of warm days (Genelly 1978).

Bathe in shallow water; dry in sun with wings open and drooping. During early nestling period, female observed dust-bathing beneath nest-tree, shuffling round in soil for c. 3 min before flying up to tree (Bollen 1991).

Aerial activity Two males, in Sept., chasing and screaming after one another, swooping and weaving round trees; lasted about 20 min; occurred in presence of female, which sat and watched and inspected hollows nearby (Hollands). Males observed flying high, in possible territorial or advertising display, with bursts of rapid, short-amplitude wing-beats and glides on lowered wings, giving loud excited chattering calls; sometimes rotating axis of body between each series of wing-beats, creating a flash-pattern of alternating dorsal and pale ventral surfaces. Pair in apparent courtship-flight flew together, circling; male then stooped at female, which evaded him (Debus 1991).

Agonistic behaviour Pairs often hunt up to 1600 m apart and out of sight (Genelly 1978). Roosting sites defended (Marchant *et al.* 1986). Both sexes defend small area round nest. **Territorial behaviour** Some aspects of aerial displays seen in courtship may also serve to advertise occupation to neighbours. At Armidale, male made high circling flights above nest; also spent up to 1 h perched in a tall tree near nest, surveying territory (Paull 1991).

Threat Both sexes, specially male, drive conspecifics from territory by pursuing, swooping and diving at intruder (e.g. Brown Falcon) while chattering excitedly. Sometimes MANTLE over food: lower head and belly, spread wings, and raise feathers on back and head. Similar threat display against intruder perched nearby.

Attack Usually by diving, steeply or shallowly, with talons thrust forward when near intruder, repeatedly chattering; usually attack aerially. **Fight** On ground, face to face with necks stretched upwards, grabbing at each other with talons. At one nest, two Kestrels fighting fluttering and tumbling round dead tree and on to ground below (Debus 1991). **Escape** In aerial attack, roll or slip sideways to escape a dive and flee from attacker. When large raptors fly overhead, crouch or slip behind tops of poles to hide (Genelly 1978). **Submissive behaviour** Usually seen in courtship or by nestlings; associated with feeding: body, and particularly head, lowered, feathers sleeked, eyes averted. **Mobbing** During and outside breeding season attack other raptors: Peregrine *F. peregrinus* and Brown Falcons, Black-shouldered Kite, Little Eagle *Hieraetus morphnoides* and Wedge-tailed Eagle *Aquila audax* (Genelly 1978), Collared Sparrowhawk (Czechura 1987); also attack Australian Magpie *Gymnorhina tibicen*, Pied Currawong *Strepera graculina* (Genelly 1978) and humans (see Relations within family group). Kestrels attacked by Australian Magpies, crows and ravens, nesting lapwings and smaller birds such as Willie Wagtails *Rhipidura leucophrys*, Tree Martins *Cecropis nigricans*, and Common Starlings; usually when these species defending nests (e.g. Genelly 1978; Smith 1988; Paull 1991; P.D. Olsen; J. Olsen).

Sexual behaviour **Courtship and pair-formation** Pairs remaining together already have loose bond; in others, male usually arrives first, establishes territory and reoccupies home-range; mate from previous year, or another female, arrives later; usually much excitement on meeting. Courtship may begin months before laying. Pair spend much time soaring and playing together; male pursues female, often with rapid flight or soaring upward, followed by mock attacks; she dodges or rolls to present talons. Male also flies with undulating flight, in high wide circles; or flies with rapid wing-beats, interspersed with glides, where body tilts one way then other, with light flashing on white underwing as it tilts; often chatter. **Greeting** Sometimes perch near mate and call (see Voice), and give submissive head-bow or both. After breeding, one pair hunted apart but maintained contact every hour or so by

high circular flights (mainly by male, less often by female); communication varied from simple fly-over with exchange of calls, to perching closely together for a few minutes; in one case perched side by side in shade for 2 h (Genelly 1978). **Allopreening** Some nibbling of feathers round bill and legs, not pronounced. **Courtship feeding** Male often feeds female; she rarely offers food to him; exchange may be on perch or, less often, aerially. Deliveries of prey accompanied by loud chittering from female and occasionally slow clicking calls from male. At Goulburn, from at least 10 days before laying to laying; male brought food to nest-tree; close to laying, transfer took place at entrance to nest-hollow; male fed female 1.4 times/h (0.8–2.3; 36 h during 6 days; Bollen 1991). During incubation, male, flying in with food, calls, and female leaves nest; twice, after receiving food, female landed on limb and adopted submissive posture, lying along branch with head and tail depressed, and wings lowered and spread either side of branch; suggested invitation to mount (Hollands). One record of female perching near nest when male flew in with short-amplitude winnowing flight and prey in bill; female begged with fluffed feathers and lowered wings; after food-presentation, mating occurred. Throughout exchange pair gave upslored chittering calls, and single Ticking notes (Debus 1991). Male continues to supply food to female throughout incubation and during early nestling periods. **Copulation** Occurs several months before laying, increasing in frequency as laying approaches (0.3 times/h), peaking during laying (0.8 times/h), and declining once incubation starts; last seen 3 days after clutch complete (Bollen 1991). Occurs several times a day usually following courtship display or transfer of food, though not preceded by feeding on three occasions at Armidale. Female perched in front of male, calling gently and flapping her wings; took 4–5 s with much calling by both birds (Paull 1991); male delivered prey, flying to nest with winnowing flight; female begged with fluffed feathers and drooped wings and, after presentation of food, copulation took place (Debus 1991). Courting, calling and territorial behaviour seen round old nesting tree in autumn (Olsen 1990); nest-site inspection, attempted copulations seen Apr.–May (Czechura 1987). Once young independent, apparent increase in aggression, at least between females and males; probably related to autumn dispersal.

Relations within family group Both sexes choose nest-site; inspect suitable sites together or separately; male may attract female to site by landing with wings held in high V and making soft call, shuffling body, and making other scraping movements; may perch on edge of selected site and jump in together and begin to make scrape. After hatching, nestlings brooded almost constantly by female for first few days but thereafter female stopped brooding by day and began hunting and proportion of time spent at nest decreased. When nestlings young (during first week at Armidale), fed by adult female alone, supplying food caught by male or herself; female calls to elicit food-begging response; at hatching, young hold head up briefly in response to call. Female with young may call to encourage male to hunt (Cupper & Cupper); at this stage, when male approached calling, female perched nearby and called; male did not fly directly to her but landed nearby; she then flew to him and took food from his bill or talons, wings quivering, throat vibrating and calling (Sharland 1931). Male brings food to transfer-perch, giving shrill chattering call, and female flies out to collect it at perch, both adults and nestlings calling; female takes prey to nest (Bollen 1991). After female starts to hunt, male feeds young if female not present; when nestlings about 1 month old, scream when adults seen returning with food (Hollands). After fledging, fly out to meet parents returning with food, and after 10 days, already taking prey

from parents in flight and competing with siblings to do so (Hollands). Just before hatching and during early nestling stage, young may give soft comfort call. **Anti-predator responses of young** When approached by intruders or handled, call (Olsen & Olsen 1980b); just after fledging, may try to run away on ground, though move awkwardly; later said to stand still with head bobbing, before flying away (Hollands). Live nestling taken to nest of Black-breasted Buzzard, lay on its back chattering as soon as released by Buzzard in Buzzard's nest; Kestrel lashed out at adult Buzzard with talons, striking it repeatedly as the Buzzard tried to kill the Kestrel, which it eventually did (Hollands). **Parental anti-predator strategies** Response apparently varies throughout breeding cycle (Cupper & Cupper). When disturbed by intruders may: perch nearby, sometimes calling (Sharland 1931; Olsen & Olsen 1980b); circle or hover overhead, calling; stoop silently, or while calling, sometimes striking, see Fig. 2 (Sharland 1931; Genelly 1978; Olsen & Olsen 1980b; Cupper & Cupper; Hollands). Female may continue stooping when intruder 50 m away from nest. At one nest, male appeared less aggressive than female (Hollands) but level of aggression between individuals and seasons varies (Olsen & Olsen 1980b). One fledged young spent first day out of nest on fence post and was defended by adults when intruders approached (Paull 1991); female continually flew round above intruder calling (Bollen 1991). Stay with and fed by parents for up to 2 months; gradually learn to hunt for themselves, first from perch, later by hovering; though they benefit by following parents to hunting areas, they do not depend on them to learn to hunt. **Fostering** For remarkable case of young Kestrels being reared by Black-breasted Buzzard *Hamirostra melanosternon*, see that account. Black Falcon *Falco subniger* seen to feed Kestrel chicks at a Kestrel nest (P.D. Olsen).

VOICE No detailed studies, recordings of only two calls available (sonagrams below); some descriptions of calls in Hollands, Bollen (1991). Information supplied by P.D. and J. Olsen, except

where stated. Calls described as chatters, twitters, screams, trills, whines, tickings and cluckings; repeated highly pitched chattering *kee-kee-kee...* most commonly heard call. Most vocal before and during breeding season, otherwise fairly silent, although calling associated with territorialism in autumn (Olsen 1990); female called much when young fledged (Bollen 1991). Most calling near nest. Generally, do not defend nest against human intrusion (Olsen & Olsen 1980b) but may call from nearby perch (Sharland 1931); if birds defend, stoop silently (Olsen & Olsen 1980b). Similar vocabulary for each sex, calls of males more highly pitched, possibly less harsh. Female said to be more vocal than male during breeding season (Bollen 1991); however, male can be more vocal than female, especially early in breeding season when establishing territory (P.D. Olsen). Individual differences not significant. Regional variations not known nor suspected. Calls typical for falcons; more highly pitched because smaller than other species.

Adult (1) CHATTER: repeated highly pitched staccato chattering *kee-kee-kee...*, *kik-kik-kik...*, or *ki-ki-ki...* Most commonly heard call. Used in variety of circumstances: territorial defence against own and other species; during apparent territorial displays (Debus 1991); fighting over food; by female in response to intruder approaching fledged young; by male during copulation; by male approaching nest with food. Bollen (1991) and Debus (1991) described loud upslurred chattering or tremulous screaming *keek...keek...keek...*, about 1 syllable/s; given by both adults and nestlings during transfer of prey, especially by female; faster and more strident version given by both birds during copulation (Bollen 1991; Debus 1991). Twittering reported during high-circling flight to regain contact between members of pair that had hunted out of sight of each other (Genelly 1978). Chatter said to become a tremulous SCREAM when highly excited, that of female being lower and harsher (Hollands; P.D. Olsen; J. Olsen); Hollands reported use: in alarm; by displaying male; by two males chasing each other; and by either sex returning to nest with food. (2)

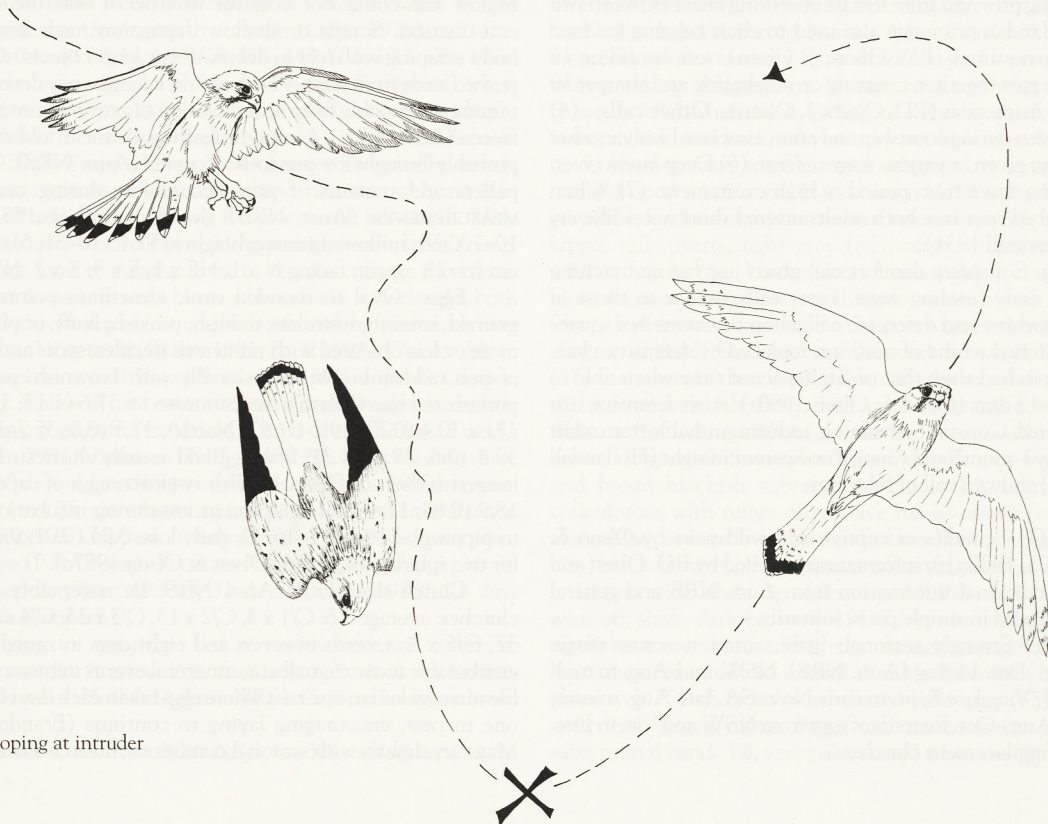
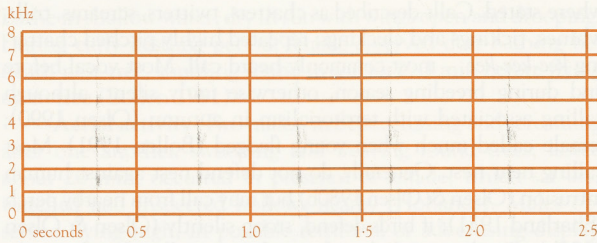
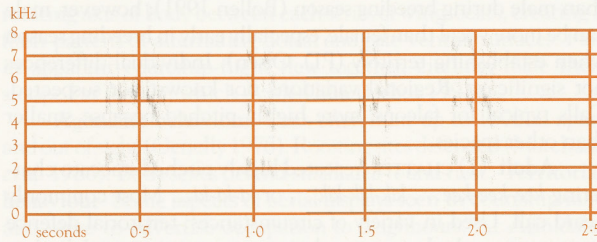


Fig. 2 Stooping at intruder



A J. Hutchinson; Carnarvon, WA, Sept. 1963; P35, P101



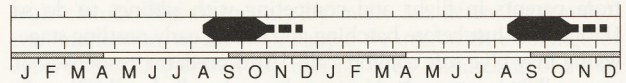
B ABC Nat. Hist. Unit; Murchison Ras, WA, Nov. 1974; P35

TRILLING: *vrii* or more whining *weeee-weeee*, varying in pitch and timbre; used as greeting between mates, during courtship displays or during food-pass; a whining call also given at various stages of fear (P.D. Olsen; J. Olsen). (3) **TICKING:** (sonagram A) described as *chip* or *tic* (P.D. Olsen; J. Olsen) or clicking *tic-tic-tic*, repeated three or four times only, at about 2 syllables/s (Hollands); given by female in nest or waiting nearby with food (Hollands); by female apparently urging male to hunt; by female arriving alone at nest to brood chicks; single ticking notes given by one or both birds when male delivered prey before copulation and during copulation (Debus 1991); by male when delivering prey, though slower (1 syllable/s) (Bollen 1991); soft or low clucking *toc-toc* reported from male bringing prey and from female observing chase between two males (Hollands); *tic* or *chip* also used to elicit begging for food from young nestlings (P.D. Olsen; J. Olsen); soft confiding *kit* given when pair together, courting or incubating and sharper *kit* during nest inspection (P.D. Olsen; J. Olsen). **Other calls** (4) Soft *peep*; given during courtship and often associated with another call. (5) Hiss; given at various stages of fear. (6) Deep *kwerk* given while settling down from period of high excitement. (7) When person climbed nest-tree both adults uttered short notes like cry of a cat (Sharland 1931).

Young Soft *peep* comfort call given just before hatching and during early nestling stage. Later calls similar to those of adults: food whine and defensive call when threatened or squabbling. Frightened whine of nestlings replaced by defensive chatter, higher pitched than that of adults, about time when able to stand at 12–13 days (Olsen & Olsen 1980a). Also defensive hiss when cornered. Constant screaming, indistinguishable from adult call, given by 1-month-old young if one parent in sight (Hollands). Sonagram B shows a call of nestlings.

BREEDING Studies of captive and wild pairs by Olsen & Olsen (1980a, 1987a,b); information supplied by P.D. Olsen and J. Olsen. Additional information from Aust. NRS and general references. Breed in simple pairs, solitarily.

Season Strongly seasonal; little variation across range; usually Aug.–Dec. Laying (Aust. NRS): NSW, mid-Aug. to mid-Oct. (Nov.); Vic., late Sept. to early Nov.; SA, late Aug. to early Oct.; WA, Aug.–Oct. Records of eggs from NSW and Vic. in Dec. probably of replacement clutches.



Site In holes in tree, old nests of other birds, cliffs, broken tops of ant-hills, nest-boxes, occasionally on ground; underground in sink-holes and mine shafts, up to 3 m below surface (Carter 1903; Whitlock 1910; Le Souëf 1928; Sharland 1931; Baker-Gabb 1985a; Olsen & Olsen 1985a; Campbell; Aust. NRS). Use old nests of White-winged Chough *Corcorax melanorhamphos*, Australian Magpie, Whistling Kite *Haliastur sphenurus*, crows and ravens, upper chamber of Chestnut-crowned Babbler *Pomatostomus ruficeps* (Hobbs 1979). Recorded nesting on quarrying machinery, structures in oil refineries, lighthouses, city buildings; enclosed rather than open sites preferred, with good view of surrounding area (Wheeler 1973; Fletcher 1980; Aust. NRS). Nest height: hollows, 6 m (5; 2–30; 67); old nests, 6 m (3; 3–15; 59); cliffs, 13 m (11; 3–31; 8). Depth below vegetation: hollows, 7 m (3; 1–14; 31); stick-nests, 1.7 m (1.6; 0.25–2.4; 33); below top of cliffs, 3 m (2; 0.9–6; 5). Sites used traditionally; one site in coastal cave used since 1930 (Daw 1984). Three pairs nested within 30 m of Peregrine Falcon on sea-cliffs (Olsen *et al.* 1979a); two nests on cliff 68 m apart (Aust. NRS).

Nest, Materials Nil, though preparation of site can take about 3 weeks and definite saucer-like nest or scrape made, of decayed wood, bark, twigs, beetle and pellet remains; material brought about every 30 min (Sharland 1931). Grass, twigs, and leaves occasionally placed in hollows (Bollen 1991; Aust. NRS); camel dung in one hole (Campbell); one nest in long (c. 6 m) hollow branch where a small retaining wall of small pieces of charcoal and horse manure had been built, in an enlarged area c. 90 cm from entrance, which prevented eggs rolling down hollow (McGill 1934). Paull (1991) describes both birds carrying small twigs, bark and what appeared to be bits of fur and feathers into a hollow but could not confirm whether it was used in nest-construction. Scrape or shallow depression made by shuffling body, scraping with feet in debris, if any; large objects removed or pushed aside from scrape. Nests on rock ledges may develop slight raised cup, possibly from accumulation of prey remains, pellets or faeces (Aust. NRS). Lining of feathers or fur in old stick-nests probably brought by previous occupier (Aust. NRS). Debris of pellets and remains of prey accumulate during occupation. **MEASUREMENTS:** (Aust. NRS): depth of hollows, 55 cm (32; 10–100; 9); hollow entrance: height, 25 cm (10–31; 6); width, 34 cm (n=2); aspect: facing N x 1, NE x 1, E x 3, S x 2, NW x 1.

Eggs Oval to rounded oval, sometimes pointed; close-grained, smooth, lustreless; reddish, pinkish, buffy, or pure white, more or less obscured with numerous freckles, spots and blotches of rich reddish-brown, occasionally with brownish, pale red or pinkish-red hue (North). **MEASUREMENTS:** 37.6 (1.13; 35.6–39.4; 17) x 30.4 (0.73; 29.2–31.9) (North); 37.5 (0.8; 35.7–38.6; 9) x 30.4 (0.6; 29.6–31.3); first egg laid usually shortest, last often longest (Olsen & Olsen 1987b). **WEIGHT:** eggs of captive pairs: 18.9 (0.84; 17.4–20.1; 9); percent loss during incubation (laying to pipping): 11 (3.2; 7–16; 7); daily loss, 0.05 (0.01; 0.04–0.07); for two infertile eggs, 6% (Olsen & Olsen 1987c).

Clutch-size From Aust. NRS, for acceptably complete clutches: average 3.8: C/1 x 3, C/2 x 13, C/3 x 23, C/4 x 39, C/5 x 32, C/6 x 4; records of seven and eight eggs in nests, probably attributable to two females or unnatural events in history of nests. Eleven eggs laid in one nest where eggs taken each day but leaving one in nest, encouraging laying to continue (Brandon 1938). May vary slightly with seasonal conditions; mean 3.1 in a dry year,

4.5 in exceptionally good year (from about ten clutches per year; Olsen & Olsen 1980a).

Laying Usually intervals of 1–3 days between laying; five eggs laid in 7 days (Sharland 1931). In captivity: four eggs in 7 days, or one every second day. Correlation between delayed laying and disturbance near nest: five eggs laid in 13 days, interval between consecutive eggs being 3, 4, 2 and 3 days. In wild, unusual record of 7-day interval between laying of E2 and E3 (Olsen & Olsen 1980a). First egg in clutch laid between 13:30 and 16:00 (Aust. NRS). May rarely rear two broods in a season, re-laying immediately after first brood fledged (Cupper & Cupper).

Incubation By both sexes, mostly by female; sometimes by female only. One female spent 91% of observation time in hollow; male incubated for up to 5 min when female off nest feeding, for c. 2 h on a rainy day when female absent (Bollen 1991). In captivity, male incubating on five of 16 occasions, female on ten, both on one. Incubation began with E3 of C/5, E2 of C/4 and C/3. Male provides most food for female during incubation; female fed 0.4–0.9 times/h, throughout day (Bollen 1991; Paull 1991). **INCUBATION PERIOD:** marked eggs, in captivity: 28 days (n=5), 29 days (n=2). In wild: 28 and 29 days (Olsen & Olsen 1980). Hatching asynchronous, on consecutive days or same day to 3 days apart for some clutches. In captivity, adults ate eggshells; no shells found in nests in wild.

Nestling Semi-altricial, nidicolous. Hatched in sparse white down; bill and claws, pink; eyes closed; cere and orbit, pink; feet, pale pink-yellow to rich orange-yellow. Down replaced by thicker, longer creamy-white down at 4–9 days; eyes begin to open c. 2 days, fully open at 5–6 days; remiges appear c. 8 days, rectrices by 9 days. Can stand for short periods by 12–13 days. Claws and bill darken to dark grey during first 2 weeks; orbit, yellowish-white by 8–16 days, yellow at c. 3 weeks (Olsen & Olsen 1980a). **Growth** Weight at hatching: captive-bred young averaged 15 g (n=4; P.D. Olsen); greatest rate growth, 48% on day 3; rate decreased after 15–17 days, most rapid in first week at 22%/day, 8% in second week, 2% in third week. For one male chick in wild: weight increase with age (from growth curve in Bodley 1978) at 2, 4, 8, 12, 16, 20, 24 and 28 days: 44, 75, 115, 140, 155, 190, 179, 170 g respectively; maximum weight at 20–21 days. For growth information of wing, tail, middle toe, radius-ulna, and tarsus length, and breadth of tarsus, and of captive-bred young, see Olsen & Olsen (1980a). **Parental care, Role of sexes** Brooded by female only, almost continuously up to 10 days, thereafter only at night (Bollen 1991; Hollands). Young fed piecemeal, bill to bill. Male brings all food for first half of nestling period; female feeds young; male brings food to nearby branch, female collects food from male, takes to nest. Female hunts when chicks 2 weeks old; both sexes feed chicks during second half of nestling period; deliver average 0.6–0.9 items/h (Bollen 1991; Paull 1991). Chicks able to feed themselves at c. 18 days (Sharland 1931; Cupper & Cupper; Hollands). Male will take over if female killed; female successfully fledged three young after male disappeared when chicks c. 2 weeks old (Bollen 1991). Between 08:45 and 12:00, a pair feeding three young c. 18 days old made 74 visits to nest with one 30-min pause, or 74 visits in 195 min of activity, female visiting twice as often as male (Cupper & Cupper). Young defecate outwards, away from nest-scrape (P.D. Olsen). **FLEDGING PERIOD:** young fledge, 31–35 days (Olsen & Olsen 1980a); 31 days (Bodley 1978); 26 days (Cupper & Cupper).

Fledging to maturity Fed at nest-hollow and return to hollow to roost for first few days after fledging; remain in nest-area for up to 3 weeks (Hollands; Aust. NRS). Captive birds can breed at 1 year.

Success Data from Aust. NRS, for 50 nests where clutch-

size and outcome determined: 201 eggs laid, 133 hatched (66%), 95 young fledged (45%); 16 (32%) nests failed, 10 (20%) at egg-stage. Number of nests from which number of young fledged for different clutch sizes in Table 3. In nw. Vic., mean number

Table 3

	Number of young fledged					
	5	4	3	2	1	0
Clutch-size						
6 (n=2)	2	0	0	0	0	0
5 (n=17)	0	4	6	0	1	6
4 (n=17)		5	2	4	2	4
3 (n=9)			2	2	1	4
2 (n=4)				1	1	2
1 (n=1)					0	1

fledged per nest started, 1.6; per territorial pair, 1.3 (Baker-Gabb 1984). Infections causing blindness probably contribute to mortality of chicks (Cupper & Cupper). Lace Monitors *Varanus varius* take young from hollows (Debus 1990a); young taken by Black-breasted Buzzards *Hamirostra melanostemon* (Cupper 1977).

PLUMAGES Prepared by D.J. James. At all ages mostly white below and rufous-brown above; adult females and juveniles of both sexes quite similar but adult males usually distinguished by greyish head and tail.

Adult male Attained with first complete moult at end of first year. First 'adult' plumage may not be definitive (climactic) and gradual change may take place over several successive plumages (Cam & Cam 1975; Clancy 1976; Smedley 1976); neither confirmed nor disproved by skins. **Head and neck** Crown, nape, hindneck and side of neck, light grey (85), uniform or with narrow to very broad rufous-brown (c340) fringes; feathers have thin black-brown (119) shaft-streaks; usually contrastingly greyer than dorsum. Narrow, often fairly faint, black moustachial stripe; short faint blackish line behind eye; and very thin ring of black feathers round orbital ring. Narrow supercilium, rest of head and foreneck, white; feathers have blackish shafts producing very faint streaking. **Upperparts** Mantle, back and scapulars, rufous-brown (c340) when fresh, fading to light brown (c139) when worn; mantle and back, may or may not have thin black-brown (119) shaft-streaks; scapulars and subscapulars have small diamond-shaped subterminal black-brown (119) spots. Rump, light grey (85); feathers may have narrow rufous-brown (c340) fringes. Upper tail-coverts, light grey (85), often with very restricted rufous tinge at tip. **Underparts** Feathers have concealed grey plumulaceous bases. Breast and flanks, whitish with varying rufous to buff-brown tinge (tend to be pure white in birds with clean grey top of head); feathers have thin dark-brown (121) to brown (37) shaft-streaks that, especially on flanks, expand slightly near tip on outer web only. Belly, thighs and under tail-coverts, usually white or buff-white without streaks but occasionally belly is like breast. **Uppertail** Somewhat varied; usually grey with white tip and broad blackish subterminal band. T1, light grey (85) concolorous with rump; often have rufous-brown (c38) dusting along edges in narrow (occasionally broad) strip; broad (c. 20–30 mm) black-brown (119) subterminal band (broadest along shaft); c. 10 mm wide white tip often tinged rufous, which is prone to wear off; shaft, dark-brown (219). T2–t3 similar but inner webs rarely have any rufous along edge though may grade to whitish here; sometimes, one to several thin black-brown (119) bars on inner web. T4–t5 often paler, dusted light-grey (85)-and-white with less, if any, rufous tinge, and narrower (c. 15–20 mm) subterminal band. T6, very pale, dusted white and pale grey (86)

grading to white along edges; subterminal band on inner web only and narrow (<10 mm), just a small spot or absent; shaft, white. **Undertail** Whitish with dark-brown (121) subterminal band and (when present) faint discontinuous bars. **Upperwing** Remiges, mostly black-brown (119) with barred inner webs; barring sometimes visible on wing when well spread. Primaries have thin whitish fringe at tip when fresh; inner webs have broad whitish spots or bars on basal three-quarters (in saw-tooth pattern); bars, tinged salmon (6), incomplete next to shaft, and coalesce into white panel along edge. Outer three or four secondaries, as primaries with about five bars on inner web; central secondaries (s4 or s5 to s7 or s8) have increasing amount of rufous tinging to bars on inner web and small rufous-brown (340) spots on outer web. Inner 2–3 secondaries, rufous-brown (340) barred black-brown (119). Tertiaries, as scapulars. Greater primary coverts and alula, black-brown (119), greater coverts with 1–2 and alula with 2–3 rufous-brown spots on inner web. Greater secondary coverts, rufous-brown (c340) with a black-brown (119) subterminal bar or spot and, on outer coverts only, black-brown (119) bars on bases. Lesser and median coverts, as back. Marginals inside carpal joint, white, but those outside carpal are white on outer webs and rufous-brown (340) on inner webs. **Underwing** Coverts and subhumeral, white, the latter with dark-brown (119) shaft-streaks. Remiges appear white with brown-grey (brown 80) barring; primaries have fairly broad but not distinct brown-grey (brown 80) trailing-edge (distal fifth of inner webs).

Adult female Similar to adult male but with less grey on head, rump, upper tail-coverts and tail, and with slightly bolder markings above and below. **Head and neck** Rufous-brown (340) to light rufous-brown (139) on top with black-brown (119) shaft-streaks giving profusely streaked appearance; occasionally feathers have greyish centres but rarely, if ever, have appearance of cap contrastingly greyer than upperparts. Rest of head as male. **Upperparts** Mantle, back and scapulars, as male except diamond-shaped spots larger on average. Rump, usually mostly rufous-brown (340) but may be light grey (85) with rufous-brown (340) margins of feathers. Upper tail-coverts may be rufous-brown as back, but usually paler, pale grey (86) to buff-white or whitish. **Underparts** Similar to male but with slightly stronger rufous-brown wash and slightly more prominent dark streaks. **Tail** Shows great variation, probably becoming paler and less patterned with age. Darkest tails are light rufous-brown (139) to light brown (39) with 8–10 narrow black-brown (119) bars that are usually incomplete next to shaft, a broad (c. 20–30 mm) black-brown (119) to black subterminal band and a whitish to light-brown (c39) tip. However the narrow bars may be absent from central, central and outer, or all rectrices. A few have considerable light-grey (85) dusting next to shafts, giving greyish cast to tail (see also Ageing and Sexing). **Upperwing** Mostly as male except greater secondary coverts have three black-brown (119) bars; median and lesser coverts have larger diamond-shaped spots; inner secondaries are more heavily barred. **Underwing** As male.

Juvenile Similar to adult female. However top of head and upperparts have no traces of grey feathering. Most have larger dark spots on upperparts. Most have black-brown (119) bars on subscapulars (may be diagnostic when present; needs confirming). The underparts are more heavily streaked on average. Probably always some barring (additional to subterminal band) on rectrices; probably never any grey in tail. Body-moult begins early in first year often producing grey feathers on rump, upper tail-coverts and head and complicating ageing (see Ageing and Sexing for details).

Aberrant plumages Carins *et al.* (1973) reported 'leucistic' bird at Narrabundah, ACT: top of head, upperparts and upper

wing-coverts, silver-grey; primaries appeared dark from above; prominent subterminal tail-band; moustachial stripe, present; legs, yellow. More precise details lacking but apparently bird had deficiency only in rufous-brown pigment.

BARE PARTS Nominate *cenchroides*. Based on photos (Aust. RD; NZRD; Cupper & Cupper; Hollands) and museum labels (AM, ANWC, HLW, MV, QM, SAM, WAM).

Adult Bill, black, grading to pale grey or pale blue-grey at base. Orbital skin and cere, yellow, dull yellow or greenish yellow. Iris, dark brown or black-brown. Legs and feet, yellow to orange-yellow. **Downy young** Bill, grey, paler at base. Cere, white to pale grey. Orbital skin, white to yellowish white. Iris, black-brown. Legs and feet, pale yellow. **Juvenile** Bill, dark grey or grey-black with smaller grey base than on adult. Iris, dark brown to black-brown. Orbital skin and cere pale grey with greenish or yellowish tinge; become yellow soon after fledging. Legs and feet, pale yellow. Mouth, 'pale greyish to purplish' on specimens of unspecified age (Hall 1974).

MOULTS Based on skins (AM, ANWC, HLW, MV, SAM, WAM); about 180 specimens examined.

Adult post-breeding (Pre-basic). Complete. Adult population begins moult of primaries from Oct. to Dec. finishing by Feb.–Apr.; moult of an individual probably spans 4–5 months. Other tracts moult before, during, or after primaries. Moult of primaries centrifugal, usually beginning p4; typically sequence p4–5–6–3–7–2–8–1–9–10, but variations occur; p5 sometimes precedes p4, p1 sometimes follows p10; others often moulted simultaneously or in reversed order. Up to three primaries may be growing at once, particularly in latter stages, but varies; may begin with one primary only or two almost simultaneously. Secondaries centrifugal from about s5. Tail essentially replaced outwards from t1, though t6 usually precedes t2. Body-moult begins with head and rump, followed by mantle, scapulars and upper breast, proceeding posteriorly. **Post-juvenile** (First pre-basic). Not well understood. Usually partial but possibly sometimes complete. Body-moult protracted, beginning in first few months after fledging and continuing for most of first year. Primary-moult begins in spring (Sept.–Dec.) and finishes by late summer or early autumn. Whether third generation of body-feathers always acquired simultaneously with second-generation primaries (as consistent with a partial post-juvenile strategy) or whether replacement of body-feathers during the first primary-moult is sometimes a continued protracted replacement of juvenile feathers is uncertain. Otherwise, sequence of moult similar to adult post-breeding.

MEASUREMENTS Nominate *cenchroides*. Aust. mainland, skins (AM, ANWC, HLW, MV, SAM, WAM); sexing based on unambiguous plumage traits or drawings or descriptions of gonads on labels: (1) adults; (2) juveniles. (3–4) Aust. mainland,

Plate 23

Grey Falcon *Falco hypoleucos* (page 291)
1 Adult; 2 Juvenile

Peregrine Falcon *Falco peregrinus* (subspecies *macropterus*) (page 307)
3 Adult; 4 Juvenile

Australian Hobby *Falco longipennis* (page 268)
5 Adult, nominate *longipennis*; 6 Juvenile, subspecies *murchisonianus*

Australian Kestrel *Falco cenchroides* (page 253)
7 Adult male; 8 Adult female; 9 Juvenile

live (Olsen & Olsen 1987b): (3) adults; (4) juveniles

	MALES	FEMALES	
WING	(1) 247 (5.57; 235–260; 58)	258 (6.43; 248–273; 36)	**
	(2) 245 (7.59; 233–259; 22)	256 (6.79; 244–268; 21)	**
	(3) 250 (6.4; 257)	259 (6.6; 174)	
	(4) 250 (7.4; 154)	262 (8.0; 80)	
STH P	(1) 185 (6.04; 172–198; 57)	192 (7.13; 173–208; 36)	**
	(2) 184 (6.20; 174–197; 19)	190 (1.29; 173–203; 14)	ns
TAIL	(1) 157 (5.22; 146–168; 60)	162 (6.08; 151–176; 36)	**
	(2) 156.7 (7.71; 142–168; 18)	161 (7.73; 151–178; 18)	ns
	(3) 156.1 (1.4; 49)	162 (3.0; 58)	
	(4) 158.4 (1.6; 27)	165 (0.9; 9)	
BILL C	(1) 13.7 (0.60; 12.6–15.3; 59)	14.7 (0.76; 13.0–16.2; 35)	**
	(2) 13.7 (0.86; 12.5–16.6; 22)	14.0 (0.94; 12–15.8; 26)	ns
BILL F	(1) 17.1 (0.93; 14.1–19.4; 59)	18.0 (0.79; 16.6–19.7; 34)	**
	(2) 17.0 (0.68; 15.9–18.9; 22)	17.3 (1.13; 15.3–19.2; 26)	ns
TARSUS	(1) 35.9 (1.41; 33.1–38.0; 10)	36.0 (1.70; 32.0–38.1; 11)	ns
	(2) 35.5 (1.99; 31.9–37.2; 6)	35.7 (1.99; 31.3–38.4; 12)	ns
TOE	(1) 24.8 (1.01; 23.5–27.0; 16)	25.2 (0.96; 23.1–27.5; 18)	ns
	(2) 24.6 (1.35; 23.0–26.3; 16)	25.6 (1.09; 24.2–27.3; 12)	ns

Differences between sexes significant for adults except tarsus and toe; for juveniles, in wing only. A slight increase in wing and tail with longitude detected; on average, smaller in WA (Olsen & Olsen 1987b).

WEIGHTS Nominate *cenchroides*. (1–2) Aust., skins (AM, ANWC, HLW, MV, SAM, WAM): (1) adults; (2) juveniles. (3–4) Aust., live (Olsen & Olsen 1987b): (3) adults; (4) juveniles.

	MALES	FEMALES	
(1)	156 (16.6; 121–195; 33)	179 (30.3; 115–255; 19)	*
(2)	133, 158, 186	144.6 (30.8; 118–185; 5)	
(3)	163 (8.0; 180)	182 (12.8; 135)	
(4)	170 (6.5; 66)	186 (60; 36)	

Olsen & Olsen (1987b) found that weight increased with longitude; males from NSW averaged c. 10 g heavier than those from WA; females c. 20 g. There was also a slight increase with latitude for females. In NSW, adults were heaviest in autumn, lightest in spring (mean spring weight of males c. 96% of autumn, females c. 95%) (Olsen & Olsen 1987b).

STRUCTURE Small, slim-bodied falcon. Wing, narrow; outerwing, pointed. Eleven primaries; p9 longest, p10 17–25 shorter, p8 2–5, p7 20–31, p6 37–45, p5 57–66, p4 74–86, p3 90–103, p2 105–119, p1 118–131, p11 minute. Emargination on outer web p9 56–70, p8 28–36. Emargination on inner web p10

Plate 24

Peregrine Falcon *Falco peregrinus* (subspecies *macropterus*) (page 307)
 1 Adult male, rufous; 2 Adult female; 3 Juvenile

Grey Falcon *Falco hypoleucos* (page 291)
 4 Adult female; 5 Juvenile

Australian Hobby *Falco longipennis* (page 268)
 6 Adult male, nominate *longipennis*; 7 Adult female, subspecies *murchisonianus*; 8 Juvenile male, nominate *longipennis*

Australian Kestrel *Falco cenchroides* (page 253)
 9 Adult male; 10 Adult female; 11 Juvenile

32–42, p9 30–35. Thirteen to 14 secondaries, including 3–4 tertials; longest tertial falls between p2 and p4 on folded wing. Tail long, (57–71% of wing), narrow, rounded; 12 rectrices; t6 c. 15–30 mm shorter than t1. Bill, rather small; tomial tooth, fine; cere, narrow. Tarsus, thin, moderately long; scales, reticulate. Toes, slender; outer toe without claw, c. 63% of middle, inner c. 66%, hind c. 44%. Claws, curved, sharp.

AGEING AND SEXING Plumage varies continuously; ages and sexes overlap and differ only in degree. Plumage probably changes slightly over several moults after post-juvenile moult. Smedley (1976) presented a brief, tentative scheme for ageing up to third year based on study of skins but impossible to confirm a link between age and variation beyond juvenile and post-juvenile in such a study. Females average slightly larger than males but there is also considerable overlap so most measurements are of small value in sexing.

Combination of grey, or mostly grey, crown and solid-grey rump, upper tail-coverts and tail characterizes adult males. However, some males have little grey on crown and broad rufous-brown edges to rectrices; further, some females have considerable grey on crown, rump, upper tail-coverts and down the centre of their unbarred rectrices (*contra* Cam & Cam 1975); the amount of grey in different tracts is correlated. Pattern of tail essentially varies continuously from grey to rufous-brown; males have mostly grey tails, often with rufous-brown dusting along edges of rectrices; females have rufous-brown tails, often with grey dusting down centre of rectrices; barring of rectrices correlates with amount of rufous; some overlap between sexes may occur.

Not always possible to distinguish browner females and juveniles. Use of structural features possibly often only reliable means, especially fault bars (see Ageing introduction; Smallwood 1989), and pattern of moult (but pattern of wear of primaries is of little use in ageing *Falco*). On average, juveniles much more heavily marked above than adult females; their larger blackish diamond-shaped spots on scapulars and secondary coverts can be distinctive, especially when fresh, but this characteristic also varies continuously and is difficult to quantify or apply consistently; barring on subscapulars may be characteristic of some juveniles but this requires further study. When fresh, juveniles have, on average, broader pale tips to remiges; best measured on p1 (adult females 1.5–4 mm, juveniles 2.5–6.5 mm) but this subject to wear and not reliable on worn primaries. Olsen & Olsen (1987b), following Village *et al.* (1980), suggested pattern of feathers of flanks could be used for ageing; in adults, dark shaft-streak symmetrical about shaft and pinched on both webs ('double waisted') but in juveniles, asymmetrical (outer web only) and pinched on one side ('single waisted'). Though this characteristic deserves further investigation it varies and is difficult to use reliably; it has been used successfully on Common Kestrel *F. tinnunculus* (Village *et al.* 1980) but appropriate markings considerably more developed in that species.

During post-juvenile moult, differences between old and new generations of feathers can help in ageing and sexing. In-growing rectrices much less patterned than older ones (allowing for both differences in pattern between different pairs of rectrices in same generation and the usually considerable fading of old rectrices) is characteristic of post-juvenile moult. In-growing rectrices that are predominantly grey indicate males; predominantly rufous-brown, most likely females (whether females ever show much grey in second-generation rectrices is unknown). In-growing feathers of upperparts with much smaller dark markings than old feathers also indicate post-juvenile moult, particularly that of males.

Sexing of juveniles rarely possible. Some males have grey upper tail-coverts and some feathers of rump (attained in earliest stages of post-juvenile moult) that strongly contrast with rufous-brown, distinctly barred tail; easily confused with some grey adult females but in latter the grey rump associated with reduced barring and greyish dusting on rectrices; females apparently do not attain grey upper tail-coverts during post-juvenile moult.

Morphometrics may help determine sex (see Measurements, Weights); wingspan suggested as most useful (Cam & Cam 1975; Olsen & Olsen 1987b) but use requires caution. Cam & Cam (1975) suggested birds with wingspans above 770 mm were female and those below 760, male, with overlap from 760 to 770. In summarizing banding data, Olsen & Olsen (1987b) presented the following wingspan data:

	MALES	FEMALES
(1)	737 (12.4; 240)	769 (14.4; 145)
(2)	739 (12.2; 124)	773 (9.6; 64)

Banders had sexed most birds over 770 as female (98%, n=172), most under 760 as male (94%, n=480), but only 59% of birds between 760 and 770 (Olsen & Olsen 1987b); this suggests that sexing was often based on wingspan (i.e. data biased). Wingspans of adults (AM) collected in NSW, 1972–78 and sexed by dissection are:

	MALES	FEMALES
	726 (35.3; 620–772; 24)	770 (14.4; 748–790; 12)

This smaller but unbiased sample shows a greater overlap than usually recognized; together with variation between measures in wingspan this emphasizes need for caution.

GEOGRAPHICAL VARIATION Two subspecies recognized: nominate *cenchroides* (described above) breeds Aust., Tas., Christmas (Ind.), Norfolk and Lord Howe Is; straggles to NZ, New Guinea, and Indonesia (see Distribution); birds from WA slightly smaller on average (Olsen & Olsen 1987b). Subspecies *baru*, resident New Guinea, reported to be slightly larger than *cenchroides* (wing-length of males 254–262, females 269; Brown & Amadon) and with greater differences between sexes in plumage; head of males, darker grey (grey extending to sides of throat), and tail, darker grey, less often barred; females and juveniles tend to have more grey on head and tail (Condon & Amadon 1954; Brown & Amadon).

Considered to form superspecies with up to six other kestrels (e.g. Cade 1982; Peters) and thought to be closely allied with Common Kestrel *F. tinnunculus* of Eurasia and Africa, and Moluccan Kestrel *F. moluccensis* of Indonesia (e.g. Village 1990; White & Bruce 1986); recent electrophoretic studies of feather proteins suggest Australian and Moluccan Kestrels form group slightly distinct from other rufous-backed kestrels (Olsen *et al.* 1989).

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Peregrine Falcon *Falco peregrinus* (subspecies *macropterus*) (page 307)
1 Adult; 2 Juvenile

Grey Falcon *Falco hypoleucos* (page 291)
3 Adult; 4 Juvenile

Australian Hobby *Falco longipennis* (page 268)
5 Adult, nominate *longipennis*; 6 Juvenile, nominate *longipennis*; 7 Adult, subspecies *murchisonianus*

Australian Kestrel *Falco cenchroides* (nominate *cenchroides*) (page 253)
8 Adult male; 9 Adult female; 10 Juvenile; 11 Immature male



Volume 2, Plate 23

Grey Falcon *Falco hypoleucos* (page 291)
 1 Adult; 2 Juvenile

Peregrine Falcon *Falco peregrinus* (subspecies *macropterus*) (page 307)
 3 Adult; 4 Juvenile

Australian Hobby *Falco longipennis* (page 268)
 5 Adult, nominate *longipennis*; 6 Juvenile, subspecies *murchisonianus*

Australian Kestrel *Falco cenchroides* (page 253)
 7 Adult male; 8 Adult female; 9 Juvenile



Volume 2, Plate 24

Peregrine Falcon *Falco peregrinus* (subspecies *macropterus*) (page 307)
1 Adult male, rufous; 2 Adult female; 3 Juvenile

Grey Falcon *Falco hypoleucos* (page 291)
4 Adult female; 5 Juvenile

Australian Hobby *Falco longipennis* (page 268)
6 Adult male, nominate *longipennis*; 7 Adult female, subspecies *murchisonianus*; 8 Juvenile male, nominate *longipennis*

Australian Kestrel *Falco cenchroides* (page 253)
9 Adult male; 10 Adult female; 11 Juvenile