

Order STRIGIFORMES

A rather homogeneous group of small to large, soft-plumaged birds with raptorial adaptations of feet and bill, and mainly nocturnal habits. Two families recognized: Strigidae (typical owls, including boobook or hawk-owls, scops-owls, eagle-owls, fish-owls, and pygmy-owls) and Tytonidae (barn or masked owls); between 133 and 178 species in 24–29 genera. On all continents except Antarctica, with centres of diversity in N. and S. America, Eurasia and Africa (Sibley & Ahlquist 1990; Schodde & Mason 1997). Most closely allied to Caprimulgiformes (nightjars and allies) (Burton 1973; Sibley & Ahlquist 1990; Christidis & Boles 1994; BWP). Based on DNA–DNA hybridization studies (Sibley *et al.* 1988; Sibley & Ahlquist 1990; Sibley & Monroe 1990) it has been suggested that the Caprimulgiformes should be placed within the Strigiformes (see Caprimulgiformes) but this view has been challenged (Christidis & Boles 1994) and not followed here. In the past, have also been placed with the Falconiformes (diurnal birds of prey), but this no longer accepted (Burton 1973; Christidis & Boles 1994).

Strigiformes characterized by (from Sibley & Ahlquist 1990; Schodde & Mason 1997; BWP): Palate schizognathous with desmognathous tendency, or desmognathous; vomer small and discrete. Basipterygoid processes functional. Nares holorrhinal and impervious. Syrinx bronchial with one pair of muscles. Fourteen cervical vertebrae. *Musculus expansor secundariorum* and biceps slip absent; *M. tensor patagium brevis* with wristward slip. Pelvic muscle formula A or AD. No *M. ambiens*. Two carotids. Coracoids connected. Flexor tendons Type 1. Hypotarsus simple. Tongue fleshy. Caeca large, long, with expanded ends. No crop. Oil gland (uropygial gland) well developed. Nostrils hidden by stiff bristles. Wings large, broad in proportion to length of body; 11 primaries, p11 much reduced; 12–18 secondaries; diastataxic. Tail short to moderate; 10–13 rectrices, usually 12. Hypotarsus with single deep furrow. Strong powerful feet with sharp curved claws (shared only with Falconiformes, which resemble Strigiformes only by convergence). Three toes forward and one hindtoe (anisodactylous); outer toe reversible; have strong talons for catching prey.

Appearance distinctive and familiar, with eyes facing forward and encircled by a facial disk or mask of modified feathers. See well by day but better by night, though said not to see in absolute darkness; hearing excellent, apparently most highly developed in Tytonidae (Thomson 1964; Fry *et al.* 1988; Schodde & Mason). Structure of facial disk aids in directing sound toward ears, at least in some species (see below). Ear-openings often placed asymmetrically on skull to aid in pinpointing origin of sounds. Eyeballs shaped like tapering cylinders; cannot rotate up, down or sideways; to focus on an object, must rotate whole head to bring it into view; neck can be moved through c. 270°. Bill hooked, with cere at base. Body plumage generally rather dense and soft, and edges of remiges frayed; these characters aid in silent flight. See introductions to Strigidae and Tytonidae for other general features, development of plumage, and moult strategies.

Occur in most habitats, from arid and semi-arid zones to tropical rainforest, alpine regions, and arctic moorland and tundra. Some species regularly in cultivated country, at least when foraging. Arboreal, terrestrial or both. Many require hollows, and therefore old trees, in which to nest, and are adversely affected by the removal of hollow-bearing trees (see below). Others nest in caves, in disused buildings, or on ground among rank vegetation (see below).

Worldwide, range from sedentary, to irruptive and dispersive, to migratory (mostly forms breeding in temperate zones); most Tytonidae considered sedentary or resident. In HANZAB region, *Ninox* mostly sedentary, with post-fledging dispersal poorly known; some of Tas. population of Southern Boobook *Ninox novaeseelandiae leucopsis* migrate N across Bass Str. in winter; Brown Hawk-Owl *Ninox scutulata* vagrant to HANZAB region and has resident tropical populations and migratory temperate populations. Three of five *Tyto* in HANZAB region sedentary or resident; Barn Owl *T. alba* and Grass Owl *T. capensis* irruptive and dispersive, with movements and breeding depending on abundance of their main prey, so that numbers in a region may follow a boom-and-bust cycle; coastal populations of Grass Owl, however, appear more stable perhaps because supply of food more consistent.

Raptorial predators. Some species occasionally take carrion (e.g. Powerful Owl *Ninox strenua*). Mainly nocturnal or crepuscular, though some diurnal or partly so (BWP). Use highly developed night vision, acute hearing, and silent flight to locate and catch prey, sometimes in complete darkness. Carnivorous; feed exclusively on animals: from earthworms, snails and insects, to frogs and reptiles and small and medium-sized birds and mammals; many species feed on small mammals, especially irruptive species; many Aust. forest-dwelling species feed on arboreal marsupials. Methods of hunting vary, both methods of searching and methods of attack; individual species will use variety of methods depending on type of prey being hunted. SEARCH METHODS include: (1) LOW SLOW QUARTERING, in silent flights (e.g. Masked Owl *Tyto novaehollandiae*, Grass Owl in HANZAB region); and (2) CONCEALED AND UNCONCEALED PERCH-HUNTING, birds perching on fence posts, low branches and the like, scanning for prey using sight and hearing; long-stay, short-stay or both (e.g. Barking Owl *Ninox connivens*, Southern Boobook, Sooty Owl *Tyto tenebricosa*, Masked Owl); and (3) SUSTAINED HOVERING (e.g. Barn Owl). KLEPTOPARASITISM, or attempted kleptoparasitism, also observed

(see Southern Boobook). ATTACK METHODS include: *SALLY-STRIKING*, taking prey directly from foliage, branches or trunks of trees (e.g. Sooty Owl), or from air (e.g. Powerful Owl); *SALLY-POUNCING* from perches to catch prey on ground (e.g. Barn Owl); and *HOVER-DROP* from aerial searches (e.g. Barn Owl). Occasionally attack in direct *TAIL-CHASES* (e.g. Powerful Owl); *FLUSH-PURSUIT*, crashing into foliage to disturb prey (e.g. Rufous Owl *Ninox rufa*); or *GROUND-HUNTING AND STALKING*, running after prey on ground (e.g. Little Owl *Athene noctua*). Use any method singly or in combination depending on type of prey being hunted. In Barn Owl in ne. Vic., use of different search and attack methods varied seasonally; success also varied between methods (McLaughlin 1994). DETECTION OF PREY: By both sight and sound; Tytonidae highly adapted for detection by sound, probably more so than Strigidae. Adaptations well known in Barn Owl, which relies largely on hearing for detection of prey (e.g. Glue 1974; Knudsen 1981; Bunn *et al.* 1988). The facial disk of the Barn Owl is composed of modified feathers (see Tytonidae) and acts as a reflector of high-frequency sounds; two troughs running through the facial disk, from the forehead to below the bill, funnel sounds to the ears, which are long slits positioned asymmetrically near the eyes; the left ear is oriented downward and more sensitive to sounds from below, and the right is oriented upward and more sensitive to sounds from above; the asymmetry of the ears and differences in loudness between the ears used to determine elevation of sounds; horizontal location determined by using minute differences in loudness and timing of sound waves reaching each of the ears. Direction of movement of prey can also be determined by using sound. To increase the likelihood of a successful attack, the Barn Owl spreads its talons and aligns them with long axis of the body of prey; experimental studies showed that even in complete darkness alignment of strike changed with changes in the axis of the body of the prey. Claimed that can locate prey to within 1–2° in both horizontal and vertical planes (Knudsen 1981).

Capture prey with hawk-like talons; tear and eat prey using short hooked bill, often holding food with feet. Usually eat food soon after capture, though sometimes cache prey (e.g. Little Owl); *Ninox* often roost during day with remains of prey held in talons (e.g. see Powerful Owl). If flying with prey, often carry small prey in bill, large prey in talons. Small prey usually swallowed whole; large to medium-sized prey eaten piecemeal, often from head down (e.g. Glue 1967, 1974; Morton 1975; Schodde & Mason). Indigestible matter, such as arthropod exoskeleton and vertebrate bones, hair and feathers, regurgitated as pellets, which are roughly cylindrical, with rounded ends, and varyingly compressed. Fresh pellets of Aust. *Tyto* have dark glazed appearance, a result of the drying of the mucous coating secreted on the pellet before egestion; those of more insectivorous species, for example Southern Boobook, generally smaller, rounder and of looser composition (Morton 1975; Smith 1983). Suggested that pellets formed by muscular action in the gizzard during digestion; it is then passed to the proventriculus where it is stored till the stimulus for egestion received (Smith & Richmond 1972). Regurgitated pellets usually contain a good skeletal record of all vertebrate prey consumed, plus the hair of mammals; it is possible to recover evidence of each prey item consumed that forms a pellet (e.g. Ticehurst 1935; Wallace 1948; Glue 1967; Raczyński & Ruprecht 1974); such pellets often used in studies of diet of owls (see species accounts). Owls have acidic stomachs, with pH of 2.35, which digest 20–50% of skeletal material swallowed (see Schodde & Mason).

Owls characteristically nocturnal or crepuscular; roost during daylight, often in dark holes, such as tree-hollows or among dense foliage; some diurnal or partly diurnal (Thomson 1964; Fry *et al.* 1988; BWP); some normally crepuscular or nocturnal species known to hunt during daylight, probably when food in short supply (e.g. Grass Owl). In HANZAB region, all basically nocturnal or crepuscular or both, though Barking Owl sometimes vocal and active by day (Schodde & Mason). Cryptically patterned and coloured plumage camouflages birds when roosting during day (Thomson 1964; Campbell & Lack 1985; Schodde & Mason). Sleep with head erect and eyes closed by twin eyelids (Schodde & Mason). Roosting owls often harassed by smaller species of birds (e.g. McNabb 1994; Fleay; Schodde & Mason). Food often taken to habitual roosts to be eaten, and such sites often marked by pellets, remains of prey and excreta (e.g. Fleay; Schodde & Mason). Some species seem to sunbathe, e.g. Little Owl (Thomson 1964).

Social organization, behaviour and breeding best known for the cosmopolitan Barn Owl (Tytonidae) (e.g. Bunn & Warburton 1977; Bunn *et al.* 1982; Fry *et al.* 1988; Taylor 1994; BWP). Strigiformes usually monogamous, nesting in individual pairs which are apparently permanent. Outside HANZAB region, some males of some species known to be polygynous (e.g. Tawny *Strix aluco*, Snowy *Nyctea scandiaca*, Short-eared *Asio flammeus* and Boreal *Aegolius funereus* Owls). Some species of Tytonidae show some flexibility in social organization, usually breeding as solitary pairs but sometimes forming loose colonies (e.g. Grass Owl, Barn Owl), and such species may not form permanent pairs (includes Barn and Grass Owls in Aust.); others both permanently paired and territorial, with some such species also having ritualized evening duets by males and females during courtship (includes Lesser Sooty *Tyto multipunctata*, Sooty and Masked Owls in Aust.; see Schodde & Mason). Said that young owls can breed when c. 1 year old (Campbell & Lack 1985); in HANZAB region, some may breed at 10–11 months (e.g. Barking Owl, Barn Owl), and others may pair when 1 year old but not breed till 2 years old (e.g. Boobook Owl, Powerful Owl) (Fleay). During breeding, parents partition labour: usually only female incubates while male hunts and brings food to female; both sexes care for young (Thomson 1964; Campbell & Lack 1985; Fry *et al.* 1988; BWP) but usually only female broods and feeds young nestlings (Schodde & Mason). Most appear to be territorial (Campbell & Lack 1985), though some within HANZAB region can form loose colonies (see above). Few quantitative studies of territories or of home-ranges within HANZAB

region, and most claims of use and defence of territories and, especially, size of territories or home-ranges speculative and unsubstantiated, with few claims supported by studies of individually marked birds. Territorial owls can be very aggressive towards other birds of prey, especially during the breeding season; birds of prey and smaller owls form as much as 3–5% of the total food of the Eurasian Eagle-Owl *Bubo bubo* (Campbell & Lack 1985). In circumstances of aggression or threat, often respond with loud bill-snapping or clicking sounds (Thomson 1964; Fleay). Many species perform threat displays with head lowered, eyes wide open, feathers of back raised and wings held out; some also lower wings when feigning injury (Fry *et al.* 1988; Fleay). In defence, masked-owls often hiss, churr and snap bills, while crouching and swaying from side to side with wings outstretched and head thrust forward (Fleay; Schodde & Mason; Hollands). Calls probably important in social behaviour of all nightbirds; in owls, they are diagnostic of species and announce existence of occupied areas or territories and presence of individuals (Campbell & Lack 1985). Strigidae often call monotonously in territories and, during incubation, males seem to call brooding females away from the nest to feed them (Schodde & Mason). Compared with Strigidae, Tytonidae show some very different behaviour: do not call monotonously and, in Aust., only the Sooty Owl seems to call territorially from perches; have more ritualistic defence displays; males feed incubating females at and in nests, apparently never calling females off nest to be fed outside (Schodde & Mason). All *Ninox* breeding in HANZAB region utter double-noted call for advertisement or contact; in Aust. Tytonidae, advertising or contact calls are screeches, except in Sooty and Lesser Sooty Owls, which utter long siren-like descending whistles. Use of playback of calls commonly used to locate owls and is a standard procedure in survey work (e.g. Debus 1995). However, unnecessary use of playback, particularly during breeding season, can disturb and stress owls (McNabb 1994; Debus 1994, 1995).

Some species breed seasonally, others when conditions favourable, especially when food abundant (Thomson 1964; Campbell & Lack 1985); in HANZAB region, *Ninox* strictly seasonal (Fleay; Schodde & Mason); some species of *Tyto* breed opportunistically at any time of year (Debus 1994; Hollands). Most nest in holes in trees, rocks, cliffs or buildings, or sometimes in old nests of other species of birds, such as corvids and hollows of woodpeckers; the most well-known tytonid, the Barn Owl, often nests in hay-lofts, as well as other structures. Usually do not construct nests (Thomson 1964; Campbell & Lack 1985; Fry *et al.* 1988; Schodde & Mason); eagle-owls *Bubo* sometimes dig nest cavities into uninhabited anthills; some, such as Snowy Owl and Grass Owl, nest on ground or in low vegetation, and they may make a shallow scrape and even add some nest-material (Campbell & Lack 1985). Eggs white (Campbell & Lack 1985; Fry *et al.* 1988; Schodde & Mason); rounded in *Ninox*, oval in Tytonidae (Fleay; Schodde & Mason). Clutch-size varies, from one to 14; size of clutch sometimes related to availability of food (Thomson 1964; Campbell & Lack 1985). Olsen & Marples (1993) summarize breeding season, clutch-size and dimensions, shape and volume of eggs for all Aust. breeding species except Lesser Sooty Owl and Christmas Island Hawk-Owl *Ninox natalis*. Lay at intervals of 48 h (Schodde & Mason) or several days (Campbell & Lack 1985). Incubation begins with laying of first egg, resulting in asynchronic hatching, which enables stronger young to survive if food becomes short (Thomson 1964; Campbell & Lack 1985; Fry *et al.* 1988; Schodde & Mason). Usually female incubates (always in *Tyto*). Incubation period often >30 days (Thomson 1964); it is for all Aust. species. Little nest-hygiene in Tytonidae; said to be somewhat better in *Ninox* (Fleay; Hollands). Adult strigids seem to enter nesting hollows feet first; most tytonids head first, at least in Aust. species (Hollands). Young semi-altricial and nidicolous; hatch with eyes and ears closed, and a sparse covering of white natal down; unable to regulate temperature independently (Thomson 1964; Campbell & Lack 1985; Fry *et al.* 1988; Schodde & Mason). Nestlings either then begin pre-juvenile moult to juvenile plumage (Strigidae) or develop a second (mesoptile) down (Tytonidae), usually within c. 2 weeks of hatching (see Family accounts). In Aust., *Tyto* have longer fledging period and, size for size, are slower to develop than species of *Ninox* (Hollands).

Worldwide, 26 species of owls considered threatened. Overall, the major threatening process is extensive clearance and fragmentation of habitat, particularly in tropical zones (Collar *et al.* 1994). In HANZAB region, the only extinct taxa are Laughing Owl *Sceloglaux albifacies* of NZ and the Lord Howe I. and Norfolk I. subspecies of the Southern Boobook (*Ninox novaeseelandiae albaria* and *N.n. undulata* respectively); several other taxa threatened, either vulnerable (Christmas Island Hawk-Owl), rare (Powerful Owl, Rufous Owl *N. rufa queenslandica*, Masked Owl *Tyto novaehollandiae novaehollandiae*, Sooty Owl *T. tenebricosa tenebricosa*) or insufficiently known (Rufous Owl *N. rufa meesi*, Masked Owl *T. novaehollandiae kimberli*, *T.n. melvillensis*) (Garnett 1993). The impact of forestry on populations of forest-dwelling owls in Aust. contentious and not fully understood in HANZAB region. Several species of forest owls in Aust. thought to be threatened both by clearance of forests for agriculture and intensive forestry, which result in a shortage of large hollows suitable for nesting (see Milledge *et al.* 1991; Kavanagh & Peake 1993; Debus 1994; Kavanagh & Bamkin 1995; Kavanagh *et al.* 1995; Kavanagh 1997; also see accounts for Sooty, Masked, and Powerful Owls [Habitat, Distribution]). Fragmentation and degradation of forests by altered fire regimes, urbanization and clearance of habitat also threats; in n. Aust., changed fire regimes, in particular increased frequency of fires late in dry season, destroy nesting trees at edges of forests (Roberts 1977; Lundie-Jenkins 1993; Garnett 1993; Chafer & Anderson 1994). Use of rodenticides in canefields in n. Qld implicated in local declines of several species (Young & De Lai 1997).

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Family TYTONIDAE barn or masked owls

Medium-sized to large owls with speckled, streaked, spotted, barred or chevroned plumage and forward-facing eyes set within well-defined facial disk. Vary in size, but not to the extent of the Strigidae; largest is Masked Owl *Tyto novaehollandiae* of Aust. (up to 50 cm total length and weighing up to 1.2 kg), smallest is Oriental Bay-Owl *Phodilus badius* of s. Asia (23–28 cm total length). Distributed worldwide except NZ, Hawaii and Antarctica, with centre of diversity in se. Asia and A'asia. Between 10 and 17 species in two genera, cosmopolitan *Tyto* (masked or barn owls) and *Phodilus* (bay-owls) of Afro-Asia. *Phodilus* is of uncertain origin (Sibley & Ahlquist 1990); sometimes placed in its own subfamily (Phodilinae) within Tytonidae (e.g. BWP); in the past, has sometimes been placed with Strigidae (e.g. Ridgeway 1914). Five species of *Tyto*, all breeding, occur in HANZAB region.

Tytonidae distinguished from Strigidae by following (based on Sibley & Ahlquist 1990; Schodde & Mason 1997; BWP). Facial disk sharply defined and typically heart shaped, though shape varies with posture (see Field Identification of species accounts). Skull long and narrow. Ears long slits; usually have large flap (operculum) covering small orifice, but no flap in *Phodilus*. Sternum without manubrium. Metasternum entire or with one notch each side. Furcula ankylosed to carina. Oil gland (uropygial gland) tufted. No primaries emarginated; remiges frayed only on leading edge. Small aftershafts present. Rectrices emarginated. Tarsi long, with feathers on posterior side pointing upward. Tarsometatarsus lacks bony ring. Inner toe as long as long as middle toe; claw of middle toe pectinate.

Adult plumage varies greatly: from very dark brown (almost black) in Sooty Owl *Tyto tenebricosa* of Aust., to very pale in Barn Owl *T. alba*, but most species have contrasting spots or speckles covering plumage. All species have well-developed facial disk, composed of densely packed bristle-like feathers that radiate outwards from bill and eye. All contour feathers rather soft. Eyes rather small (cf. Strigidae). Iris usually very dark; other bare parts usually rather dull brown, yellow, grey or black. Sexes similar in plumage or differ only slightly. Sexes often dimorphic in size, with females larger. Post-breeding moults of adults complete and prolonged; often moult in slow staffelmauser; take at least 2 years to complete moult of primaries; sequence of moult of primaries often appears erratic and often suspended; each wave of primary-moult begins from p6 and proceeds inward and outward from that point.

Young hatch in natal down (ptilopaedic). Nestlings have two downy plumages (neossoptiles): hatch in short sparse and patchy first down (protoptile [also neoptile]); replaced by longer, denser second down (mesoptile), c. 2 weeks after hatching, at least in Barn Owl (BWP); second down completely downy, unlike second plumage of strigid owls (q.v.). Both sets of down arise from same papillae as later juvenile and adult feathers (BWP). Terminology for the 'second down' problematical. BWP confusingly termed the second down of *Tyto* owls both 'juvenile' and 'mesoptile'; this terminology inconsistent because standard definitions are that 'juvenile' is the first pennaceous feathering (first teleoptile) (Dwight 1900), whereas 'mesoptile' is the second natal down (second neossoptile) (Pycraft 1907). Schodde & Mason also termed the second down 'mesoptile' and, like BWP, assumed that its downy nature is a derived state evolved by 'regression' from the ancestral, more pennaceous, true juvenile plumage; and therefore that the second down of *Tyto* owls is homologous with the down-like juvenile plumage of strigid owls. Consequently, they termed the first pennaceous plumage of *Tyto* owls 'adult'. However, while evolution of the juvenile plumage of strigid owls to semi-plumulaceous (from an ancestral state of pennaceous) is plausible (semi-plumes like those of juvenile strigids have shafts and are much closer in structure to pennaceous feathers than to down) and evident (there is a continuum from pennaceous to semi-plumulaceous juvenile plumages among species of Strigidae), evolution to completely plumulaceous (with no intermediate states) in *Tyto* owls would be a much bigger step and highly unlikely. Furthermore, by definition the juvenile plumage of all birds is the first pennaceous plumage (Dwight 1900; Humphrey & Parkes 1959), and the second down of *Tyto* owls is not pennaceous. We therefore consider the second (downy) plumage of *Tyto* owls to be a true down, the mesoptile (presumably homologous with the mesoptile of, for example, diurnal raptors [Falconiformes] and others), and the third (first pennaceous) plumage, in which they leave the nest, to be the true juvenile plumage (homologous with the second or juvenile plumage of strigid owls). A series of photos in Bunn *et al.* (1982) illustrates the development of downy and juvenile plumages in European Barn Owl (*T.a. alba*). Mesoptile probably does not grow on mask. Otherwise appears to be well or completely developed before first pins of pennaceous (juvenile) feathers appear. Pins of juvenile plumage first appear on remiges and rectrices; then facial disk, ruff, leg, and upperwing-coverts; then scapulars and breast; lastly hindneck, sides of breast, belly and thighs (BWP; see photos in Fleay). Start to attain adult plumage at 2–3 months old, but post-juvenile (first pre-basic) moult may take 2 or more years to complete.

For details of general biology, see Introduction to Strigiformes.

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Tyto alba **Barn Owl**

COLOUR PLATE FACING PAGE 961

Strix alba Scopoli, 1796, *Annus 1*, *Hist.-Nat.*: p. 21 — 'Ex Foro Juli' = Friuli, Italy.

Specifically named with reference to the white face and underparts (Latin *albus*, white).

OTHER ENGLISH NAMES Delicate, Lesser Masked, Monkey-faced, Cave, Screech or White Owl; Ghost Bird.

POLYTYPIC One subspecies in HANZAB region: *delicatula* (Gould, 1837), restricted to Aust. About 30 extralimital subspecies, occurring all continents except Antarctica.

FIELD IDENTIFICATION Length 29–38 cm; wingspan 70–100 cm; weight: 310–360 g. Rather small slim and pale *Tyto* owl, with small eyes set in heart-shaped facial disk, and long slender legs and delicate feet. Smaller and slimmer than Masked Owl *Tyto novaehollandiae*, with shorter wings (much smaller wingspan), much slimmer and more finely feathered legs and

less massive feet, and proportionately smaller eyes. Similar in size and shape to Grass Owl *Tyto capensis* but with shorter, narrower and slightly more rounded wings, and shorter legs (with only tips of feet just projecting beyond tip of tail in flight). Characterized by white facial disk, with narrow dark teardrop below eye, and outlined with rather narrow dark ruff and

prominent buff brows; beautifully and delicately mottled light-grey and buff upperparts, overlain with many small white-tipped black markings; and white or cream underparts with varying fine dark spots and indistinct dark barring on underside of remiges. Sexes differ slightly in plumage, female averaging slightly darker, but much overlap and probably not reliably separable in field. No seasonal variation. Juvenile like adult and inseparable by plumage once last patches of down lost. **Adult male** Facial disk heart-shaped, but often appears more broadly rounded when bird alert and staring or narrower and more triangular when bird relaxed with head hunched into body. Disk, white except for narrow dark-brown teardrop on inner edge of, and below, each eye; and outlined with narrow, but varying dark, ruff, always with distinctive pattern of buff (or darker) brows across top of disk and narrower blackish rim round bottom half or so (but disk never completely encircled by blackish ruff). Top of head and neck, upperbody and all upperwing-coverts finely and densely vermiculated light grey and boldly blotched rich buff, with overlay of copious small white-tipped black drop-shaped markings (finest on head and neck). Rest of upperwing, and uppertail slightly paler buff, finely and densely vermiculated grey and with clear narrow blackish barring (not usually obvious on folded secondaries); cap to saddle appears more uniformly grey than more boldly buff-blotched upperwing-coverts. Grey of hindneck merges across sides of neck to white of underbody. Underbody, white, cream or buff with varying fine dark-brown spotting and streaking, from none to throughout, but typically not on midline of body, legs or undertail-coverts. Males tend to be paler than females, but complete overlap. Feathering on legs much sparser and hair-like on lower half or so, giving long and slender-legged appearance. Undertail, white with 3–4 narrow light-grey bars. Underwing, white except for: varying fine dark-brown spotting on coverts (as underbody), narrow dark carpal crescent across tips of greater primary coverts; diffuse dusky wing-tip; and several diffuse rows of narrow dark-grey bars across remiges (usually on outer primaries, but on primaries and secondaries of some); in palest birds, white except for vestigial dusky markings at tip. Bill and cere, white to pale pink. Iris, dark brown. Orbital ring, dirty pink. Lowermost tarsi and feet, cream, dirty pink or light brown. **Adult female** Very similar to male, with much overlap in plumage, and not reliably separable in field. Average differences from male, which may be useful when adult pair together, are: more and slightly brighter buff in upperparts; heavier dark spotting on underbody, and more and heavier flecking on underwing-coverts; and ground-colour of underbody and underwing usually darker than typical male. **Juvenile** Newly fledged birds easily distinguished by remnant patches of fluffy white or cream down, retained for several weeks after fledging, especially on head and neck, and typically retained longest on lower underbody. After down lost, inseparable from adult except by dependent behaviour and begging calls.

Similar species Palest *Tyto* in region and the only one in NZ. Often confused with pale and intermediate morph of **Masked Owl**, especially small, pale and slim-legged subspecies *kimberli* of n. Aust.; also confused with **Grass Owl** (see those texts for details).

Typically inhabit open country, such as open woodlands, grasslands and farmland; generally avoid wet closed forest but regularly forage at edges of such habitats. Usually seen singly, occasionally in pairs or family groups of adult pair and young; occasionally roost and forage in small loose groups, especially during plagues of rodents. Usually roost in tree-hollows, but also in dense foliage of trees and sometimes on ground or in

caves. Mainly nocturnal, though sometimes hunt by day in dull conditions. Commonly seen along roadsides at night, either perched on fence posts or gliding low across road in headlights. Hunt for terrestrial prey by gliding from perch or by dropping from low quartering flight or hovering position. In spotlight views, characteristically appear very pale grey above and ghostly white below, with no obvious contrasting dark markings. Foraging birds can often be attracted by imitating squeaking sounds of rodent. When perched, characteristically appear rather slender for a *Tyto*, with rather small head, slim neck and shoulders, and generally upright stance; long slender legs conspicuous, adding to generally gracile form. Roosting birds perch bolt upright, with facial disk appearing narrow and triangular and wings drawn forward to conceal pale ventral plumage. In flight, body tapers markedly from large head to short tail; tips of toes just project beyond tip of tail when legs held flush with underside of tail in travelling or quartering flight; long legs often dangle in short flights; compared with forest-dwelling *Tyto*, wings less rounded at tips, though more rounded than in Grass Owl. Flight buoyant, erratic and rather slow, with slow silent flapping interspersed with occasional brief harrier-like glides on wings held in shallow modified dihedral; travelling flight, such as when flushed, more direct and rhythmic than hunting flight. Commonest call a long hissing screech *shir-r*, *sk-air* or *skee-air*, delivered all on one note and uttered singly and infrequently, while perched or in flight; sounds high-pitched, falsetto and tinny compared with screech of Masked Owl. When begging for food, dependent fledged juveniles utter repeated plaintive rasping *air-sh*.

HABITAT Mostly in open areas, such as grassland and farmland; also in open woodland with grassy understorey, and along timbered watercourses. In farmland, often in cereal crops, pasture, cane fields, or near where grain or feed for stock stored, which often attract rodents (Bravery 1970; Hayward & MacFarlane 1971; Masters & Milhinch 1974; Leach 1988; McLaughlin 1994; Young & De Lai 1997; Vic. Atlas; Hollands); sometimes near homesteads (Morse 1918; Hyem 1936); also along roads (Hutton & Brickhill 1985; Campbell 1986; Hollands). In arid areas, often occur in and round rocky outcrops or ranges with many caves; or in riparian woodland of Coolibahs *Eucalyptus microtheca*, River Red Gums *E. camaldulensis* or Black Box *E. largiflorens* (Barnard 1914a; Cox 1973; Badman 1979; Gibson 1986; Gibson & Cole 1988; Henle 1989; McAllan 1997; Schodde & Mason; Storr 22); sometimes in mallee, or on plains vegetated with saltbush or spinifex (Ross 1926; Jones 1952; McLaughlin 1994; Aust. Atlas). Sometimes in scattered, grassy woodland, which may be intersected by gallery forest, especially in tropical areas (Leach 1988; Nielsen 1995; Hall; Storr 7, 11; Schodde & Mason). Generally avoid wet closed *Eucalyptus* forests or rainforests (Condon 1969; Morris *et al.* 1981; Schodde & Mason; Aust. Atlas), but in Tropics, recorded in patches of monsoon rainforest (White 1917; Woinarski 1993). Sometimes in plantations of pines (Watson 1955; Morton 1975); or in swampy areas; among lightly scattered timber, saltmarsh, clumps of lignum *Muehlenbeckia*, or reeds and rushes (Tarr 1950; Wheeler 1950; Roberts 1975; Cox 1976; Johnstone *et al.* 1979; Schodde & Mason; Storr 26; Hollands). In coastal areas, sometimes inhabit thickets of tea-tree *Leptospermum* or *Banksia* (Howe 1928; Cooper 1974; Parker 1977; Smith 1984a,b; Dickman *et al.* 1991); mangroves (White 1917; MacGillivray 1918; McGill 1943); or heathland (Hollands). Sometimes in gardens or street trees in towns or suburbs; more rarely in cities (Payne 1931;

Bryant 1938; Binns 1954; Sedgwick 1973, 1988; Templeton 1992; Storr 28; Qld Bird Rep. 1985; NSW Bird Rep. 1991; SA Bird Rep. 1969–70). May fly over sea: sometimes recorded on nearshore or offshore islands, platforms of oil-rigs, and rarely land on fishing boats at sea (Ford 1965; Booth 1970; Eckert 1971; Chilvers 1975; Parker & Cox 1978; Sedgwick 1978; Johnstone 1980; Dickman *et al.* 1991); one bird seen flying over sea but falling in and being washed back onto shore (NSW Bird Rep. 1994); sometimes beachcast (Green 1971, 1981; Leishman 1973; Holmes & Morris 1975; Wainer & Dann 1979).

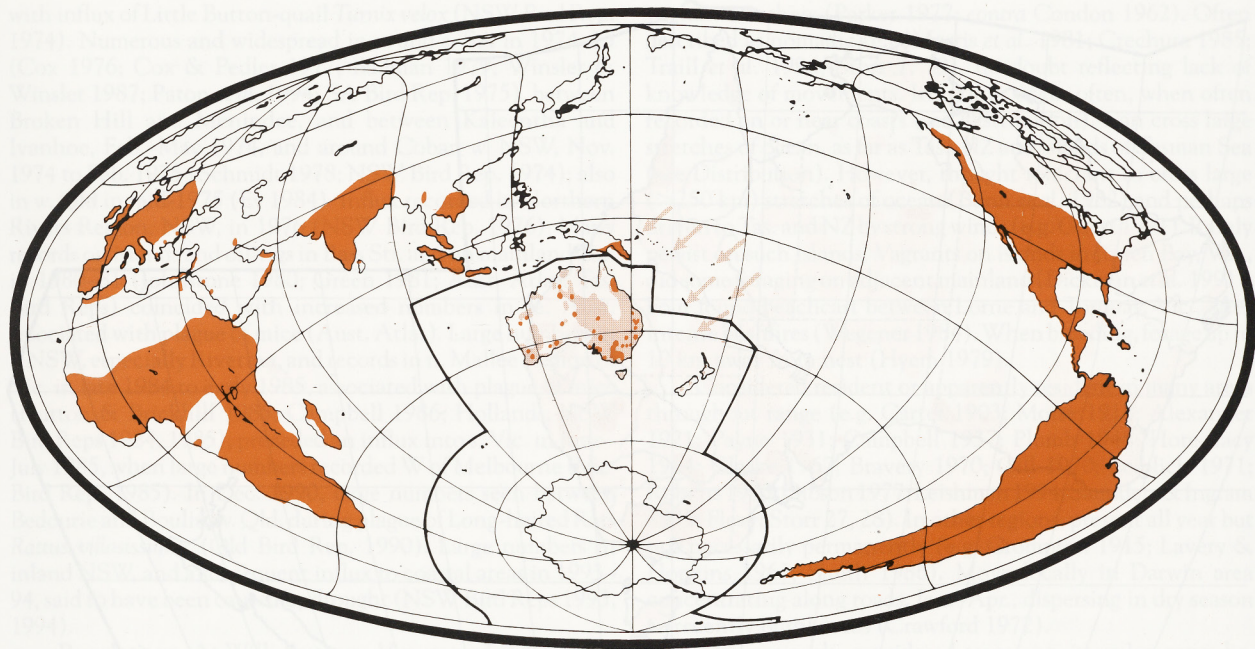
Usually nest in large hollows in trees, especially *Eucalyptus*, often in lightly timbered country, along creeklines or surrounded by farmland (Barrett 1916; Brandon 1948; Masters & Milhinch 1974; Hyem 1979; Close & Jaensch 1984; Hutton & Brickhill 1985; Gibson 1986; McLaughlin 1994; Campbell; North; Fleay; Hollands; NRS). In detailed study in nw. Vic., all tree-hollows used (both for breeding and roosting; see below) were ≤ 10 m from cleared land or clearing $>c.$ 800 m² in area (McLaughlin 1994). Also nest in holes and caves in limestone (Storr 27) and in cavities beneath boulders (Gibson 1986); mines, wells and disused buildings (Schodde & Mason; Hollands). Of 14 nests in nw. Vic., 13 in tree-hollows and one in hayshed (McLaughlin 1994). In areas with no suitable tree-hollows, said to have nested in clumps of lignum, grass tussocks and rabbit burrows (Ross 1926; Schodde & Mason). Once recorded breeding in cavity in side of disused nest of Wedge-tailed Eagle *Aquila audax* (Ey 1984). During irruption, once bred in temporarily vacated observation hide (Hollands).

Hunt in open areas, mainly for terrestrial prey (see Food). Often in grassland or farmland, in grassy paddocks or cropland, and sometimes round haystacks or barns; also in lightly timbered woodlands (Hyem 1936; Hayward & MacFarlane 1971; Boekel 1980; McLaughlin 1994; Fleay; Hall; Schodde & Mason; Hollands). Also in other cleared areas, such as along roadsides or in recently burnt areas (Crawford 1972; Hutton & Brickhill 1985; McLaughlin 1994). In arid Aust.: round Mt King, nw. NSW, most hunting concentrated along creeks, and less often on surrounding plains; near Coober Pedy, SA, much hunting occurred on open plains away from creeks; and at Sandringham Stn, sw. Qld, Owls did not restrict hunting to any specific habitat (Morton *et al.* 1977; Morton & Martin 1979). In detailed study in nw. Vic. (n=97 attacks), most hunting (65%) occurred along fencelines, roadsides and occasionally channels ('verge' habitat), and rest (35%) took place in paddocks under crop, stubble or pasture ('field' habitat). Use of habitats varied seasonally: during autumn–winter (n=53 attacks), 86.6% of attacks in 'verge' habitat, and 13.2% in 'field' habitat; during spring–summer (n=44 attacks), 61.4% in 'field' habitat, and 38.6% in 'verge' habitat (McLaughlin 1994). Sometimes hunt round grain silos (Hayward & MacFarlane 1971). In some areas, e.g. s. Vic., Tanami and Simpson Deserts, NT, appear to avoid hunting in rocky areas, such as rocky ridges or outcrops (Morton 1975; Smith 1983). Usually do not hunt within forests or woodlands, but may hunt near edges of timbered watercourses or forests (Schodde & Mason; Hollands); sometimes forage among mangroves (White 1917) or clumps of lignum (Cox 1976). Rarely, on islands, hunt in and round breeding colonies of petrels or terns (Chilvers 1975; Parker & Cox 1978; Brothers 1985; Schodde & Mason; Hollands; Vic. Bird Reps); possibly feed on small birds attracted to light of lighthouse (Ford 1916). Also said to snatch birds as they roost among foliage, and may catch bats or insects in flight (Johnstone *et al.* 1979; Hollands; NSW Bird Rep. 1991). Once seen catching moths at lighted window of house (Marchant 1992).

Mainly roost in deep hollows in trunks or limbs of trees, especially large *Eucalyptus* (Barnard 1914a; McGilp 1923; Leach 1928; Carnaby 1933; Brandon 1948; Lord 1956; Parker 1977; Whittle 1994; Fleay). In study in nw. Vic., hollow-roosting Owls only found in Oil Mallee *Eucalyptus oleosa* (n=46) and Belah *Casuarina pauper* (n=12) (McLaughlin 1994). Also roost in caves, blowholes, cavities and crevices among large boulders, and overhangs and ledges on cliffs (Troughton 1924; Kinghorn & Fletcher 1927; Finlayson 1946; Ford 1965; Eckert 1971; Paton 1973; Parker 1977; Parker & Cox 1978; Boekel 1980; Brothers 1985; Gibson 1986; Johnson & Rose 1994; Gee *et al.* 1996). Often also use similarly dark places within artificial structures, including old buildings, dry wells and mine shafts (Wheeler 1950; Hutchison 1972; Moriarty 1972; Paton 1973; Parker 1977; Sedgwick 1978; Morton & Martin 1979; Gibson 1986; Storr 24); also on ledges or parapets on buildings (Bryant 1938; Vic. Atlas); once seen trying to enter window on 11th floor of building in city centre (SA Bird Rep. 1969–70). May also roost among dense vegetation: among foliage in stands of *Eucalyptus*, including mallee trees and riparian Coolibahs, casuarina, Cattlebush *Alectryon oleifolius*, willows *Salix*, pines *Pinus*–*Araucaria* or cypress *Cupressus*, Peppercorn *Schinus molle*, boxthorn *Lycium* or among mangroves (White 1915; Edwards 1925; Tarr 1950; Watson 1955; Hirth 1976; Cox & Pedler 1977; Morton & Martin 1979; McLaughlin 1994; Fleay; Vic. Atlas; Hollands). Sometimes in trees in streets or gardens (Binns 1954; Sedgwick 1988). Less often in dense clumps of bushes, or tussocks of long grass or rushes (McGill 1943; Rix 1943; Tarr 1950; Wheeler 1950; McKean *et al.* 1969; Morton 1975; Smith 1984b; Chatto 1987; Saunders 1987; Dickman *et al.* 1991; Vic. Bird Rep. 1985). Rarely, roosts in open (Cohn 1934; Tarr 1950; Learmonth 1958); once on bare ground in shade of fence post (Maher 1988). Recently fledged birds may roost in open more often (McLaughlin 1994); once, immature found inside rubbish bin (Fleay). For further details of roosting sites, see Social Organization. At night, often perch on fence posts, roadside posts or tree-stumps, and sometimes overhead wires (Hyem 1936; Tarr 1950; Bravery 1970; Chinner 1977; Dawson *et al.* 1991; McLaughlin 1994; Griffin 1995; Fleay; Hollands).

Have benefited from creation of open rural habitats, both by creating open environment and by providing abundant food, especially rodents (Baxter 1989; Schodde & Mason). Adversely affected by burning or clearing, which may destroy hollow-bearing trees (Fleay; Hollands), though may hunt in recently burnt areas (Crawford 1972; Vic. Bird Rep. 1985). Often roost or perch on structures (see above).

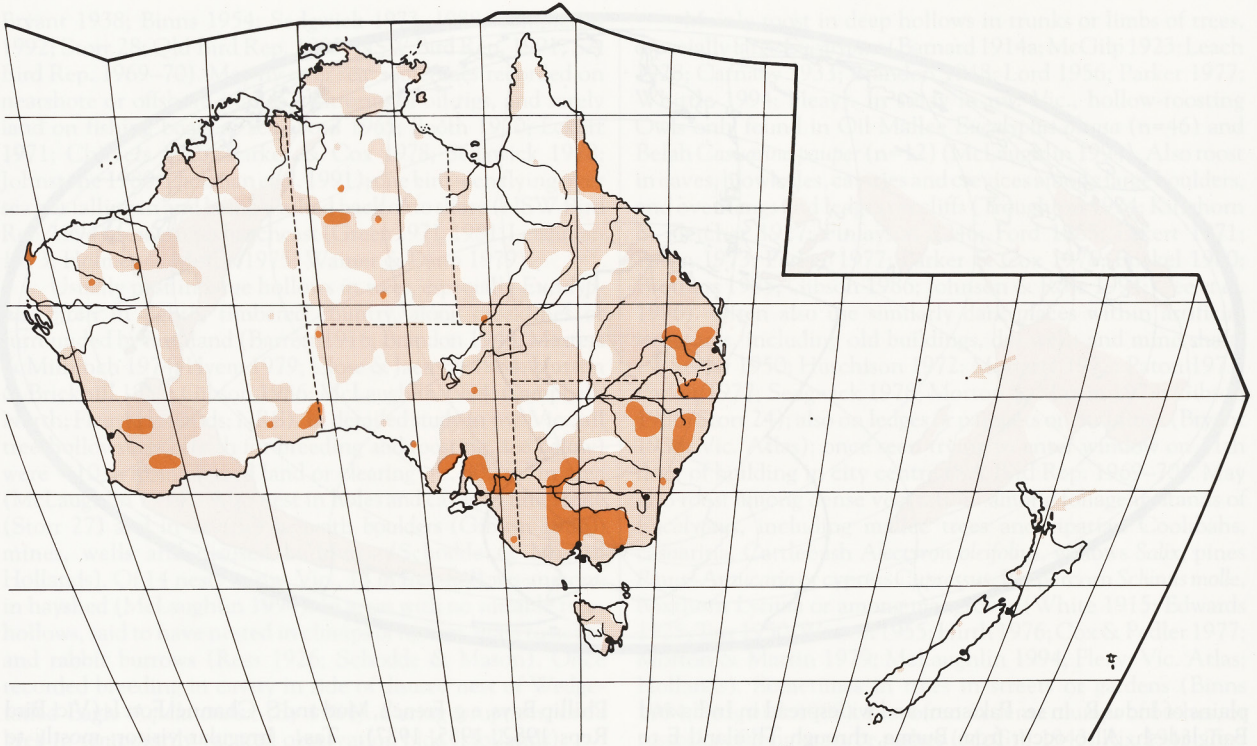
DISTRIBUTION AND POPULATION Cosmopolitan except for Antarctica. Widespread in N. America, from sw. British Columbia and s. Ontario, S through most of USA to Mexico and Central America; also in the Bahamas and Greater and Lesser Antilles. Widespread throughout S. America, from Panama S to Tierra del Fuego; also on Galapagos Is. In w. Europe, widespread in British Isles and in continental Europe, from coasts of North and Baltic Seas, including Denmark, E to central Ukraine around Kiev and nw. coast of Black Sea, and S to Iberian Pen., Italy and Balkans. Also in n. Africa, in Morocco, n. Algeria and Tunisia; also along Nile R. Valley and Mediterranean coast of Egypt. Distribution in Sahara Desert not clear, but widespread farther S, from w. Mauritania and Gulf of Guinea (as well as islands in e. Atlantic Ocean), S to South Africa, but absent from parts of Congo R. Basin, and E to Ethiopia and Madagascar. Scattered on Arabian Pen. and elsewhere in Middle East, especially Iraq and Iran. Recorded on



plains of Indus R. in se. Pakistan, and widespread in India and Bangladesh. Also occur from Burma, through Thailand E to Indochina and S along Malay Pen. to Sulawesi and Lesser Sundas in Indonesia. Widespread in sw. Pacific Ocean, from New Guinea, S to Aust. and E through Bismarck Arch., Solomon Is, New Caledonia, Vanuatu and Fiji to Tonga, Niue and Samoa; introduced to Hawaii. Also introduced to Seychelles and St Helena (Delacour 1966; Ali & Ripley 1969; de Schauensee 1970; Prestt & Wagstaffe 1973; King & Dickinson 1975; Stokes 1980; Long 1981; Bunn *et al.* 1982; AOU 1983; Coates 1985; Smythies 1986; White & Bruce 1986; Pratt *et al.* 1987; Fry *et al.* 1988; Lekagul & Round 1991; Roberts 1991; Bregulla 1992; BWP).

Aust. Widespread on mainland. **Qld** Scattered records on w. C. York Pen., but not recorded from islands in Torres Str. (Draffan *et al.* 1983; Garnett & Bredl 1985; Aust. Atlas). Said to be absent from e. C. York Pen., N of Cooktown (Storr 19), but Aust. Atlas has 11 records at Iron Ra. Widespread in e. and central Qld, E of line from Laura and Cooktown, S through Hughenden and Winton to near Dirranbandi. Farther W, many scattered records W of line joining Cunnamulla, Davenport Downs, and Mulligan R. Also in Gulf Country, round Mt Isa and N to Nicholson R. (Cornish & Ellis 1974; Storr 19; Aust. Atlas; Qld Bird Reps). Sometimes on nearshore or offshore islands, e.g. Fairfax, One Tree, Fraser, Stradbroke Is (Vernon & Barry 1972; Chilvers 1975; Vernon & Martin 1975; Kikkawa 1976; Sutton 1990; Storr 19). **NSW** Widespread in all regions. Mostly W to w. North-west Plains, Central-west Plains and Riverina Regions, E of line from near Mungindi to Tooleybuc. Farther W, widely scattered records in Upper and Lower Western Regions; possibly more widespread in W than records indicate (Costello 1981; Morris *et al.* 1981; Cooper & McAllan 1995; Aust. Atlas; NSW Bird Reps). Sometimes on nearshore islands, e.g. Muttonbird I. (NSW Bird Rep. 1983). **Vic.** Widespread in all regions (Vic. Atlas), though rare in E. Gippsland (D.G. Hollands). Sometimes on islands or oil-rigs in Bass Str. (Reilly 1978; Wainer & Dann 1979; Johnstone 1980; Vic. Atlas) and rarely on islands in Western Port and Port

Phillip Bays, e.g. French, Mud and S. Channel Fort Is (Vic. Bird Reps 1982, 1985, 1987). **Tas.** Irregular visitor; mostly to islands in Bass Str., e.g. King I., Hogan, Kent and Furneaux Grps (Green 1971, 1981; Green & McGarvie 1971; Green & Scarborough 1985; Gray *et al.* 1987; Garnett *et al.* 1991; Tas. Bird Reps). Records (singles unless stated) on mainland since 1970 include: specimen, Exeter, 28 June 1970 (Green 1981); specimen, Launceston, 27 Apr. 1976 (Green 1989; Tas. Bird Rep. 6); specimen, Mt Nicholas, St Marys, 2 Aug. 1980 (Green 1981); specimen, Triabunna, 4 or 5 Aug. 1980 (Green 1981; Tas. Bird Rep. 10); specimen, Burnie, Aug. 1980 (Green 1981); specimen, Warrane, Hobart, Aug. 1980 (Green 1981; Tas. Bird Rep. 10); Weymouth, 15 Nov. 1980 (Tas. Bird Rep. 10); specimen, Maria I., 12 Dec. 1980 (Green 1981; Tas. Bird Rep. 10); Longford, Jan. 1986 (Tas. Bird Rep. 16). **SA** Widespread in e. half (Parker 1977; Aust. Atlas); scattered records in e. L. Eyre Drainage Basin; widespread from n. Flinders Ras S to coastal areas from Vic. border to e. and s. Eyre Pen. In W, a few scattered records from round Streaky Bay W to near Fowlers Bay, and said to occur e. Nullarbor Plain, but no Aust. Atlas records there (see McAllan 1997). In NW, a few scattered records in e. Great Victoria Desert (*contra* Parker 1977); also many records from near Amata E to s. Simpson Desert, and S to s. and w. L. Eyre Drainage Basin, round Coober Pedy and near Marree (Cox & Pedler 1977; Parker 1977; Badman 1979, 1989; Close & Jaensch 1984; Jaensch & Jaensch 1987; Stove 1994; Aust. Atlas; SA Bird Reps). Sometimes on nearshore or offshore islands (Parker 1977; Parker & Cox 1978; Hornsby 1978; Baxter 1989). **WA** Formerly widespread on Nullarbor Plain, but current range not well known; many recent records around Eyre Bird Observatory, but few from other parts of the Plain (Brooker *et al.* 1979; Martindale 1980; Congreve & Congreve 1985; McAllan 1997; Aust. Atlas; Storr 27). Rarely in Arch. of the Recherche (Storr 27). Widespread S of line linking Esperance and Kalbarri, though in E of range also occur N to Leonora and Wanjarri (Moriarty 1972; Saunders & Ingram 1995; Aust. Atlas). Farther N, scattered records near Carnarvon, and also near Wiluna and L. Naberu. Widespread in Pilbara Region,



from Pt Cloates, E to L. Disappointment, and N to Port Hedland. Also widespread in sw. Kimberley Div., from Roebuck Plain and Dampier Pen. E to Fitzroy Crossing; isolated record on Mitchell Plateau; more often recorded near Wyndham and L. Argyle. Scattered records in n. and e. Great Sandy Desert, and rarely in Gibson or w. Great Victoria Deserts (Johnstone *et al.* 1979; Johnstone 1983; Jaensch 1989; Aumann 1991; Storr 11, 16, 26; Aust. Atlas). Sometimes recorded on nearshore or offshore islands (Sedgwick 1978; Saunders 1987; Dunlop *et al.* 1988; Dickman *et al.* 1991; Storr 16, 21, 24, 27, 28). NT Widespread but scattered throughout (Storr 7; Aust. Atlas). Many records in Top End from Darwin, N to Cobourg Pen. and E to Gove Pen. and Groote Eylandt, and S to near Katherine. Farther S, recorded from Victoria R. Downs and Borroloola, S through Tanami Desert to Simpson Desert and Petermann Ras (Deignan 1964; Crawford 1972; Frith & Calaby 1974; Schodde 1976; Boekel 1980; Smith 1983; Aust. Atlas; H.A.F. Thompson & D.K. Goodfellow).

NZ Vagrant. All records are of single birds; some recent records may have been transported by aircraft. Specimen, Barrytown, 16 Aug. 1947 (Oliver); near Haast, Oct. or Nov. 1955 (Falla & Riney 1958); specimen, Greymouth, 12 Aug. 1960 (Grant 1960); specimen, Flat Bush, near Papatoetoe, Auckland, 27 Mar. 1983 (possibly assisted passage) (Gill & Turbott 1984); mangled remains in undercarriage of aeroplane from USA via Hawaii, Auckland, 12 Mar. 1985 (Gill & Turbott 1985); specimen, New Plymouth, 17 Aug. 1990 (Guest 1991; CSN 39); Whenuapai RNZAF base, 21 Apr. 1992 (possibly assisted passage), but see next record (Smuts-Kennedy & Lovegrove 1996; CSN 41); Little Barrier I., 30 June to 18 Sept. 1992 (possibly Whenuapai bird) (Smuts-Kennedy & Lovegrove 1996). Subfossil remains found at Tom Bowling Bay, Northland, in Jan. 1966 and attributed to this species (Scarlett 1967) now known to be remains of Laughing Owl *Sceloglaux albifacies* (Millner 1983).

Lord Howe I. Unsuccessfully introduced in 1920s (see below) (Hindwood 1940; Disney & Smithers 1972). Recorded Nov. 1936 (Hindwood 1940); fresh skeleton collected in Feb. 1971 (Hutton 1991).

Norfolk I. Several records from late 1960s and early 1970s, till at least 1972 (Disney & Smithers 1972; Hermes *et al.* 1986); also recorded in Sept. 1977 (Hermes *et al.* 1986).

Breeding Probably throughout range in mainland Aust.; breeding recorded in most regions (Aust. Atlas; NRS). Single confirmed record in Tas., on Hogan I. (Tas. Bird Rep. 14), though said to have bred at Devonport and Forthside in 1940s (Elliott 1996; Aust. Atlas).

Introductions Unsuccessfully introduced to NZ: seven birds released at W. Taieri, Otago, in 1899 (Thomson 1922; Long 1981) but not recorded after 1900. Eight (though possibly as many as 30) unsuccessfully introduced to Lord Howe I. from NSW and Vic. in Oct. 1923 and later (Troughton 1924; Hindwood 1940; Disney & Smithers 1972; Hutton 1991); ten, from USA, unsuccessfully introduced in Mar. 1927 (Hindwood 1940; Hutton 1991); introduced to control rats (Recher & Clark 1974).

Irruptions Irruptions occur often, and usually depend on abundance of principal prey, mostly rodents. Irruptions usually follow general pattern of higher than average rains, abundant plant-growth, and abundant populations of rodents; Owls may breed continuously while numbers of rodents high, populations increasing rapidly; probably disperse when populations of rodents decline, irrupting in areas where previously rare or absent; drought or lack of food or both may start decline in population of rodents (Hayward & McFarlane 1971; Morton 1975; Morton *et al.* 1977; Morton & Martin 1979; Smith & Cole 1989; Fleay). Some examples since 1970: Influx in nw. Vic., round Strathalbyn, SA, and parts of NSW in 1970 (Hayward & MacFarlane 1971; Vestjens 1973; SA Bird Rep. 1970–71). Large numbers in Lower Western Region of NSW, Feb.–May 1974, coinciding

with influx of Little Button-quail *Turnix velox* (NSW Bird Rep. 1974). Numerous and widespread in e. and s. SA in 1974–75 (Cox 1976; Cox & Pedler 1977; Badman 1979; Winslet & Winslet 1987; Paton *et al.* 1994; SA Bird Rep. 1975), between Broken Hill and Menindee, and between Kaleentha and Ivanhoe, Feb.–May 1974, and around Cobar, w. NSW, Nov. 1974 to Feb. 1975 (Schmidt 1978; NSW Bird Rep. 1974); also in w. Qld in mid-1975 (Ey 1984). Influx recorded in Northern Rivers Region, NSW, in 1976 (NSW Bird Rep. 1976). Many records on islands and oil-rigs in Bass Str. and on mainland Tas. in 1980–81 (Johnstone 1980; Green 1981; Aust. Atlas; Tas. Bird Reps) coincided with increased numbers in se. Aust. associated with plague of mice (Aust. Atlas). Large numbers in s. NSW, especially Riverina, and records in n. Mallee Region of Vic. in late 1984 to early 1985, associated with plague of mice (Hutton & Brickhill 1985; Campbell 1986; Hollands; NSW Bird Reps 1984, 1985), preceded an influx into s. Vic. in June–July 1985, when large numbers recorded W of Melbourne (Vic. Bird Rep. 1985). In Dec. 1990, large numbers seen between Bedourie and Boulia, w. Qld, during plague of Long-haired Rats *Rattus villosissimus* (Qld Bird Rep. 1990). Large numbers in inland NSW, and a subsequent influx to coastal areas in 1993–94, said to have been caused by drought (NSW Bird Reps 1993, 1994).

Populations At Williamstown, Vic., recorded at density of 0.2 birds/ha (Smith 1986).

Often struck and killed by cars, sometimes in large numbers during irruptions: e.g. near Darlington Pt, NSW, 215 dead in 60 km of road, 16 Dec. 1984; 101 in 210 km between Leeton and Conargo, NSW, 6 Dec. 1984 (Hutton & Brickhill 1985); near Hay, NSW, 20 along 2 km of Sturt Hwy, 30 Aug. 1994; seven along 25 km of Cobb Hwy, 30 Aug. 1994 (NSW Bird Rep. 1994); and ten along 175 km of road between Camooweal and Barry Caves, 24 Oct. 1975 (Brooker 1976). Sometimes injured or killed by flying into wires (Sedgwick 1952; Tas. Bird Rep. 10) or windows (Stokes 1982). Formerly shot by settlers (White 1915). Occasionally caught in rabbit traps (Hyem 1936; Purchase 1972). Sometimes killed by secondary poisoning after eating rodents affected by anticoagulants (Smith 1986; Rose 1996). Populations of Owls in Herbert R. district, n. Qld, said to have declined since 1992, when rodenticides used in nearby cane fields (Young & De Lai 1997). Traces of pesticide endrine detected in liver of Owl road-killed during a plague of mice (Saunders & Cooper 1982).

MOVEMENTS True nature of movements poorly known, though considerable speculation in literature. No large-scale, regular seasonal movements (Aust. Atlas). Appear mainly dispersive or irruptive; in some areas, resident for months or years (Schodde 1976; McLaughlin 1994; Fleay; Schodde & Mason). Appear to be present year-round in many areas (partly sedentary) but with marked fluctuations in numbers, either as result of local increases through breeding or immigration, or decreases through emigration or mortality, all in response to fluctuating abundance of prey; emigration from areas can then result in influxes to other areas as birds search for prey (see Hutton & Brickhill 1985; Johnson & Rose 1994; McLaughlin 1994; Schodde & Mason; Hollands). Irruptions from local breeding appear to occur when high prey densities widespread rather than patchy (McLaughlin 1994). In Vic., said to be present throughout year but movements of part or all of population dictated by numbers of rodents, breeding during times of abundance and dispersing once numbers of rodents decline (Vic. Atlas). In SA, resident in some areas and irruptive

vagrant in others (Parker 1977; *contra* Condon 1962). Often described as nomadic (e.g. Morris *et al.* 1981; Czechura 1985; Traill *et al.* 1996; Storr 7, 19), no doubt reflecting lack of knowledge of movements. Irruptions occur often, when often recorded on or near coasts (see Distribution). Can cross large stretches of ocean, as far as Tas., NZ and islands of Tasman Sea (see Distribution). However, thought reluctant to cross large (>250 km) stretches of ocean (Bunn *et al.* 1982) and perhaps driven to Tas. and NZ by strong winds (e.g. Guest 1991). Rarely persist on such islands. Vagrants on islands in Jurien Bay, WA, did some foraging on adjacent mainland (Dickman *et al.* 1991). Four found beachcast between Lorne and Torquay, Vic., after intense bushfires (Wegener 1984). When breeding, forage up to 10 km away from nest (Hyem 1979).

Considered resident or apparently resident in many areas throughout range (e.g. Carter 1903; Morse 1918; Alexander 1921; Payne 1931; Campbell 1937; Plumb 1948; Hore-Lacy 1964; Clarke 1967; Bravery 1970; Gill 1970; Leiblich 1971; Roberts 1975; Gibson 1977; Leishman 1994; Saunders & Ingram 1995; Fleay; Storr 27, 28). In other regions, present all year but not necessarily permanently (e.g. Crompton 1915; Lavery & Hopkins 1963; Smith 1986). Move locally in Darwin area concentrating along roads, Jan.–Apr., dispersing in dry season to recently burnt areas (Crawford 1972).

Also variously considered transient, irregular, sporadic, casual or infrequent visitor (e.g. Sutton 1926, 1927; Carnaby 1933; Abbott 1974; Cooper 1974; Zann 1976; Longmore 1978; Paton & Paton 1980; Whitmore *et al.* 1983; Marchant 1992; Baxter & Berris 1995; ACT Atlas). Sometimes absent from areas where usually present (e.g. Cain 1934; Brandon 1948; Badman 1989); not found Sandringham Stn, sw. Qld, after 2 years of below-average rainfall (Morton *et al.* 1977) and exodus from nw. Vic. after collapse in populations of House Mice in cold winter (Aumann 1989; McLaughlin 1994). On Barkly Tableland, NT, concentrations noted during times of high densities of Long-haired Rat (Brooker 1976; Schodde 1976; Storr 7).

Some seasonal movements described but with little hard evidence of regularity. Said to be mainly winter visitor to coastal e. Qld (Storr 19). Round Sydney, marked decline suspected in summer (Aust. Atlas). Apparent seasonal winter movement away from Strathbogie Ra., Vic. (Bedgood 1972). In coastal s. Vic., emaciated and starved birds found, usually in late autumn or winter, e.g. round Orbost (Hollands). Seen mostly Apr.–Sept. on Lefevre Pen. near Adelaide, SA (Winslet & Winslet 1987). In WA, considered visitor round Perth, late Mar. to mid Oct. (Storr 28); thought to be dry-season visitor to Kimberley Div., and autumn–winter visitor to Pilbara area and mid-e. and se. interior (Storr 11, 16, 22; Aust. Atlas), but timing can vary, e.g. disappeared from Crossing Falls, Ord R., WA, in late dry season (Aug.–Nov.) in 1989, after being common May–July (Aumann 1991).

Young Some move far (see Banding). In HANZAB region, thought to disperse widely before breeding (McLaughlin 1994; Fleay). Most Tas. records are of young birds (Aust. Atlas). Extraliminally, first-year birds disperse more widely than adults (Bunn *et al.* 1982).

Banding Of 286 banded in Aust., New Guinea and sw. Pacific, 1953–96, 25 recoveries (8.7%): 12 (48%) <10 km from banding site; 8 (32%), 10–49 km; 1 (4%), 50–99 km; 4 (16%) ≥100 km. Long-distance recoveries: Pitt Town, NSW, to near Clare, SA (1149 km, 266°, 10 months^D, May; +1); Moolap, Vic., to Baroota, SA (840 km, 313°, 18 months, Jan.; P); Richmond to Taree, NSW (248 km, 42°, 55 days^D, May; P);

Narara to near Wollongong, NSW (120 km, 199°, 25 days^D, Oct.; +1). Longest lived, 92 months (ABBBS; Purchase 1972; Anon. 1988; Wilson 1988; Aust. Atlas).

FOOD Mainly small mammals, particularly small native and introduced rodents; also take birds, reptiles, amphibians and some insects. Many extralimital studies, mostly analysis of pellets; studies and reviews of feeding behaviour and diet in w. Palaearctic (Glue 1974; Bunn *et al.* 1982; BWP), Africa (Dean 1973; Fry *et al.* 1988), N. America (Pearson & Pearson 1947; Otteni *et al.* 1972) and S. America (Jaksic & Yenez 1979). For extralimital details on foraging behaviour and diet in Europe, see BWP. **Behaviour** Mainly nocturnal; occasionally crepuscular (Baker-Gabb 1984; Dickman *et al.* 1991; Schodde & Mason); often leave roost just on dusk (Dickison 1941); sometimes hunt well before dark (Hollands); often seen feeding during daylight (Chisholm 1934). Feed solitarily (White 1915; McLaughlin 1994). Hunt throughout night, with peaks in hunting at start and end of night (McLaughlin 1994). Most prey taken from ground (McLaughlin 1994; see details of prey below). **METHODS OF SEARCH AND ATTACK:** Mainly (1) low quartering, followed by hover-and-drop attack; or (2) stationary hunting from perches, making glide attacks (Baker-Gabb 1984); also sustained hovering (McLaughlin 1994). Extraliminally, cover many kilometres during single night; when hunting, rarely fly more than a few metres above ground, and seem to follow regular routes, particularly along sides of ditches, hedges or fencelines (Burton 1973). Hunt as far as 10 km from roosting or nesting sites (Hyem 1979). Said to forage over same areas that have proved productive night after night (Schodde & Mason). Seen to attack young rabbits by flying low over warrens and suddenly snatching them with talons (White 1915). In nw. Vic., used three search methods (n=97 obs.): (1) stationary perch-hunting (75.3% of all observations), looking for prey from perch, using successive perches for periods of 2–5 min; (2) low slow quartering, 1–3 m above ground (20.6%); and (3) sustained hovering (4.1%). In nw. Vic., attacks mainly by gliding from stationary perch (75.3%), and hover-drop (24.7%); perch-hunting 1.5 times more likely to result in capture of prey than slow quartering, and about twice as likely as hovering; overall capture rate 60.0%. Methods used varied seasonally, perch-hunting used significantly more and slow quartering significantly less during autumn–winter (Apr.–Aug.) than during spring–summer (Sept.–Mar.); of 53 observations during autumn–winter and 44 during spring–summer: perch-hunting 89.9% in autumn–winter, 63.3% in spring–summer; quartering 11.3%, 31.8%; and hovering 3.8%, 4.5% (McLaughlin 1994). See Habitat for discussion of foraging habitats. **FOOD SELECTION, SEASONAL CHANGES:** Opportunistic predator. Feed mainly on small rodents. Dominant prey in diet tends to be rodent species that undergo marked population fluctuations, such as House Mouse *Mus domesticus*, Long-haired Rat *Rattus villosissimus*, and Spinifex Hopping-mouse *Notomys alexis* (Morton *et al.* 1977; Smith 1983; Smith & Cole 1989; also see Detailed studies). Exploit plagues of rodents (e.g. Hayward & MacFarlane 1971; Morton *et al.* 1977; Morton & Martin 1979; Valente 1981; Saunders & Cooper 1982; Smith 1983; Hutton & Brickhill 1985; Fleay; see discussion of irruptions in Distribution and references therein). In Tanami and Simpson Deserts, dominant prey items in diet correlated with abundant prey density in field (Smith 1983; Smith & Cole 1989). At Fowlers Gap Stn, NSW, fed mainly on House Mouse for period of study, Oct. 1974 to June 1976; proportion of House Mouse in diet dropped in May 1976, while at same time other prey items such as frogs and birds increased

in proportion; also mean number of prey per pellet, and therefore number of House Mouse per pellet, increased from 4.2 in Oct. 1974 to 5.3 in Dec. 1974, coinciding with period of peak numbers of House Mouse in field; numbers of prey per pellet then gradually fell to original level over next 12 months as prey numbers declined (Morton & Martin 1979). **HANDLING OF PREY:** When prey located, hover silently above it; drop with head and ears in line with quarry, then throw back head and swing feet down, talons spread to grasp head of victim; snap neck of prey with bill and carry to perch to eat (Schodde & Mason). Extraliminally, captured prey often devoured at once, or carried only short distance to more sheltered position before being swallowed; swallow prey whole, only dismembering if prey too large (Burton 1973). **PELLETS:** Undigested portions of prey, such as bones, fur and feathers regurgitated in form of intact pellets; pellets usually firm, more or less oval in shape and varnished glossy black (Burton 1973; Smith 1983; see Intake). **ADAPTATIONS FOR FEEDING:** Sight and hearing extremely well-developed for catching prey in darkness; can see prey very efficiently under conditions of poor illumination. Ears highly specialized for locating prey; in complete darkness, hearing sufficient to enable location of prey well enough to make successful catch. Structure of facial disk and mode of flying also highly modified for nocturnal foraging (Burton 1973; see Bunn *et al.* 1982 for details of anatomy and physiology of sight and hearing specialization).

Detailed studies Table 1 summarizes food of adults from detailed studies in Aust. In all studies, small rodents form main part of diet (61–99%), the proportions of native and introduced rodents varying and usually reflecting availability of prey within a given locality, with no marked preference. House Mice the most common introduced prey, ranging in importance from >90% of rodent diet at certain localities (e.g. White 1915; Morton & Martin 1979; Baker-Gabb 1984; McLaughlin 1994; Rose 1996) to almost insignificant proportions in other locations, where diet then dominated by native murids such as Spinifex Hopping-mouse and Long-haired Rat (Morton *et al.* 1977; Valente 1981; Smith & Cole 1989). Dasyurids, birds, reptiles, amphibians and insects were less important items in diet and increased only in areas where rodents less abundant; e.g. Simpson Desert (Smith 1983); Planet Downs Stn, sw. Qld (Valente 1981).

At SANDRINGHAM STN (574 items in 165 complete and 210 incomplete pellets in 1969; 244 items in 137 complete pellets in 1970) and OLD ROSEBERTH STN, SW. QLD (163 items in undetermined number of incomplete pellets in 1966; biomass presented as percentage of total weight of prey; and measured for each species as prey units, one prey unit equalling a 15–20 g small mammal; Morton *et al.* 1977): **BIRDS:** Button-quails *Turnix* 0.7% no., 0.5% biomass at Sandringham in 1969; 1.2% no., 0.9% biomass at Sandringham in 1970, – % no., – % biomass at Roseberth. **MAMMALS:** Marsupials: Dasyuridae: Kultarr *Antechinomys laniger* 1.1, 0.5; 1.2, 0.7; –, –; Kowari *Dasyercus byrnei* –, –, 0.4, 0.8; –, –, dunnart *Sminthopsis* 1.4, 0.5; –, –, 0.6, 0.1; Fat-tailed Dunnart *S. crassicaudata* 2.6, 0.8; 2.9, 1.0; –, –, Stripe-faced Dunnart *S. macroura* 0.4, 0.1; 0.8, 0.3; –, –, Eutherians: Chiroptera: bats –, –, –, –, 0.6, 0.1; Rodents: Muridae: Forrest's Mouse *Leggadina forresti* 9.9, 4.8; 5.3, 2.9; 2.5, 0.8; House Mouse 0.7, 0.2; 0.4, 0.2; 1.2, 0.3; hopping-mouse *Notomys* 8.9, 5.7; 8.6, 6.4; 4.9, 2.2; Spinifex Hopping-mouse (may include some Dusky Hopping-mouse *N. fuscus*) 18.1, 11.7; 34.0, 25.1; 3.1, 1.3; Fawn Hopping-mouse *N. cervinus* 10.1, 6.5; 12.3; 9.1, 0.6, 0.3; Sandy Inland Mouse *Pseudomys hermannsburgensis* 4.5, 1.4; 5.3, 1.9; 0.6, 0.1; Long-haired Rat

41.6, 67.2; 27.6, 50.7; 85.9, 94.8. Sample from 1970 also contained 77 insects (Orthoptera: Acrididae: *Chortoicetes terminifera* 67 items; *Nomadacris guttulose* 4; Gryllacrididae 6) not included in above analysis.

At PLANET DOWNS STN, SW. QLD (478 items in 134 complete pellets, and 49 incomplete pellets and fragmented pellets; Valente 1981): AMPHIBIANS: Frogs 17.0% no. REPTILES: Gekkonidae 5.2; Agamidae 0.4. BIRDS: 2.3 (some were identified and are listed in Other records). MAMMALS: Marsupials: Dasyuridae: Narrow-nosed Planigale *Planigale tenuirostris* 4.0; Fat-tailed Dunnart 0.4; Stripe-faced Dunnart 2.7; Eutherians: Rodents: Muridae: unident. 4.0; Forrest's Mouse 1.3; House Mouse 5.4; Long-haired Rat 61.0 (including 44.0% young adults and 17 juveniles). Sample also included insects not included in above calculations (listed in Other records).

At FOWLERS GAP STN, W. NSW (1436 items in 303 pellets collected Oct. 1974 to June 1976; biomass presented as percentage of total weight of prey and measured for each species as prey units, one prey unit equalling 15–20 g small mammal; Morton & Martin 1979): AMPHIBIANS: Frogs (including Hylidae: *Cyclorana platycephalus*, Myobatrachidae: *Limnodynastes tasmaniensis*); 2.2% no., 1.1% biomass. BIRDS: Unident. 1.0, 2.0. MAMMALS: Marsupials: Dasyuridae: Paucident Planigale *Planigale gilesi* 1.0, 1.0; Narrow-nosed Planigale 0.1, 0.1; Fat-tailed Dunnart 0.6, 0.6; Stripe-faced Dunnart 0.3, 0.3; Eutherians: Chiroptera: bats 0.2, 0.2; Rodents: Muridae: Forrest's Mouse 0.1, 0.2; House Mouse 91.3, 91.3; unident. 3.2, 3.2.

At BEGA, NSW (37 vertebrate and a few insect items in 15 pellets; Smith 1984b): INSECTS: Coleoptera: Undetermined. MAMMALS: Marsupials: Dasyuridae: Brown Antechinus *Antechinus stuartii* 2.7% no.; Dusky Antechinus *A. swainsonii* 2.7; White-footed Dunnart *Sminthopsis leucopus* 5.4; Eutherians: Muridae: House Mouse 75.6; Bush Rat *Rattus fuscipes* 8.0; Swamp Rat *R. lutreolus* 5.4.

NSW (628 prey items in nine complete pellets and some fragments, from four sites; Rose 1996): SPIDERS: Deinopidae: *Deinopis* 0.1% no. INSECTS: Coleoptera: Elateridae 0.1; Orthoptera: Gryllotalpidae: *Gryllotalpa* 0.2. BIRDS: Eggshell 0.1; unident. 0.2; scrubwren *Sericornis* 0.1. MAMMALS: Marsupials: Dasyuridae: Common Planigale *Planigale maculata* 0.3; Paucident Planigale 0.8; Fat-tailed Dunnart 0.8; Stripe-faced Dunnart 0.1; Eutherians: Chiroptera: Vespertilionidae: Little Forest Bat *Vespardelus vulturinus* 0.1; Eutherians: Felidae: Cat *Felis catus* 0.1; Muridae: House Mouse 89.0; Swamp Rat 2.0; Black Rat *Rattus rattus* 5.2; Bush Rat 0.1. Also in NSW (18 items from ten stomachs at ten sites; Rose 1996): Orthoptera: grasshoppers 11% no. MAMMALS: Brown Antechinus 5; House Mouse 84.

In RIVERINA, NSW (57 items in 20 pellets; Hutton & Brickhill 1985): MAMMALS: 19 pellets contained only House Mice (56 individuals); other pellet contained only remains of European Rabbit *Oryctogalus cuniculus*.

In MALLEE DISTRICT, VIC. (867 items in 217 pellets; McLaughlin 1994): INSECTS (mainly Coleoptera) 3% no. AMPHIBIANS: Myobatrachidae: *Limnodynastes* <1.0. BIRDS: <1.0. MAMMALS: Muridae: House Mouse 96.0.

At WERRIBEE, VIC. (952 prey items in 275 pellets; Morton 1975): SPIDERS 0.1% no. INSECTS: Coleoptera: Carabidae 0.1; Silphidae 0.1; Lepidoptera: larv. 0.1. BIRDS: Richard's Pipit *Anthus novaeseelandiae* 0.1%. MAMMALS: Marsupials: Dasyuridae: Fat-tailed Dunnart 1.3; Eutherians: Muridae: House Mouse 96.0; Rat 1.5. At same site (291 prey items in autumn and 236 items in winter from unspecified no. of pellets and direct obs.; Baker-Gabb 1984): INSECTS: Orthoptera 11% no., 1.0% biomass in autumn; 1, – in winter. MAMMALS: Muridae: House Mouse 86, 83; 85, 44; other mammals (including fat-tailed Dunnart) 3, 16; 14, 56.

E OF L. EYRE, SA AND NSW (data from four sites amalgamated

Table 1. Main components in diet. (All throughout year, except Werribee, Vic. [Baker-Gabb 1984], which only autumn–winter; N = total number of items. Figures in brackets are % no. of House Mice in total diet.)

LOCALITY	% NUMBER						N	REF.
	RODENTS	DASYURIDS	BIRDS	REPTILES	AMPHIBIANS	INSECTS		
SW. QLD								
SANDRINGHAM STN								
1969	94.0 (0.7)	5.5	0.7	–	–	–	574	1
1970	93.0 (0.4)	5.7	1.2	–	–	–	244	1
OLD ROSEBERTH STN	99.0 (1.2)	1.0	–	–	–	–	163	1
PLANET DOWNS STN	68.0 (5.4)	7.1	2.3	5.6	17.0	–	478	2
NSW								
FOWLERS GAP STN								
BEGA	89.0 (75.6)	11.0	–	–	–	tr.	37	4
NSW	96.3 (89.0)	2.0	0.4	–	–	0.4	628	5
NW. VIC.								
MALLEE REGION								
	96.0 (96.0)	–	<1.0	–	<1.0	3.0	867	6
S. VIC.								
WERRIBEE (A)								
	97.5 (96.0)	1.3	0.1	–	–	1.1	942	7
WERRIBEE (B)								
	85.0 (85.0)	8.0	–	–	–	7.0	527	8
SA								
E OF L. EYRE								
	94.0 (79.0)	4.5	0.6	0.5	0.3	–	1416	3
W OF L. EYRE								
	97.0 (67.8)	2.6	–	tr.	tr.	–	775	3
ADELAIDE								
	61.0 (–)	–	29.2	–	7.3	–	655	9
NT								
THE GRANITES								
	80.0 (2.9)	5.0	1.0	8.0	–	6.0	1054	10
TANAMI DESERT								
	81.0 (12.5)	7.0	2.4	4.0	–	5.8	1171	10
SIMPSON DESERT								
	72.5 (32.7)	3.0	4.0	13.0	–	7.5	856	11

and recalculated, 1416 items from 454 pellets; Morton & Martin 1979): AMPHIBIANS: Frogs 0.3% no. REPTILES: Gekkonidae 0.2; Agamidae 0.3. BIRDS: 0.6. MAMMALS: Marsupials: Dasyuridae: Paucident Planigale 1.1; Narrow-nosed Planigale 0.8; Fat-tailed Dunnart 1.0; Striped-faced Dunnart 1.7; Eutherians: Rodents: Muridae: Unident. 2.0; Forrest's Mouse 3.9; House Mouse 79.0; Long-haired Rat 8.8. W OF L. EYRE, SA (data from six sites amalgamated and recalculated, 775 items from 269 pellets; Morton & Martin 1979): MAMMALS: Marsupials: Dasyuridae: Fat-tailed Dunnart 0.5% no.; Stripe-faced Dunnart 1.6; Ooldea Dunnart *Sminthopsis ooldea* 0.5; Eutherians: Chiroptera: bats 0.5; Rodents: Muridae: unident. 0.9; Forrest's Mouse 10.0; House Mouse 67.8; Spinifex Hopping-mouse (may include some Dusky Hopping-mouse) 7.0; Sandy Inland Mouse 4.7; Long-haired Rat 6.0.

Near ADELAIDE, SA (c. 655 vertebrate prey and thousands of insects from unstated number of pellets and loose collection of bones; White 1915): INSECTS: Blattodea: Blattidae; Coleoptera: Cerambycidae: *Phoracantha*; Curculionidae; Elateridae; Lucanidae: *Figulus*; *Lamprima*; Scarabaeidae: *Anoplognathus*; *Heteronyx*; *Onthophagus*; Tenebrionidae: *Pterohelaeus*; Dermaptera: Labiduridae: *Labidura truncata*; Formicidae: *Camponotus*; *Ectatomma*; *Myrmecia*; Orthoptera: Gryllacrididae; Gryllotalpidae: *Gryllotalpa*. AMPHIBIANS: Frogs 7.3% no. of total vertebrates. BIRDS: Musk Lorikeet *Glossopsitta concinna* 1.5; House Sparrow *Passer domesticus* 24.5; Common Starling *Sturnus vulgaris* 2.5; honeyeaters 0.7. MAMMALS: Chiroptera: bats 0.2; Rodents: Muridae: 61.0; Lagomorph: Leporidae: European Rabbit 2.3. At same site (33 prey items in 7 pellets): AMPHIBIANS: Frogs 27.3% no. REPTILES: Agamidae: *Amphibolurus barbatus* 3.0. BIRDS: House Sparrows 9.0. MAMMALS: House Mouse 54.5; European Rabbit 6.0.

THREE ISLANDS IN JURIE BAY, WA (151 pellets; Dickman *et al.* 1991): INSECTS (mainly Orthoptera): Tettigoniidae 8.6% freq., 0.2% vol. REPTILES: Scincidae: *Egernia* 1.3, 0.3. BIRDS (including White-faced Storm-Petrel *Pelagodroma marina*, Rock Parrot *Neophema petrophila*, Buff-banded Rail *Rallus philippensis*) 19.2, 11.7. MAMMALS: Marsupials: Dasyuridae: Dibbler *Parantechinus apicalis* 4.0, 1.1; White-tailed Dunnart *Sminthopsis granulipes* 12.6, 3.3; Eutherians: Rodents: Muridae: House Mouse 95.2, 82.9.

In KIMBERLEY DIV., WA (three whole pellets; Johnson & Rose 1994): Forrest's Mouse (Rodents: Muridae); and two dasyurid marsupials: Stripe-faced Dunnart and Long-tailed Planigale *Planigale ingrami*.

THE GRANITES, TANAMI DESERT, NT (1054 items from whole and partial pellets and fragments at ten sites, between June 1980 and Dec. 1985; Smith & Cole 1989): INSECTS: Unident. 1.0% no.; Coleoptera 2.5; Diptera 0.4; Orthoptera 2.2. REPTILES: Lizards: unident. 2.6; Agamidae <0.1; Gekkonidae 1.5; Scincidae 3.8. BIRDS: Unident. 0.5; button-quail <0.1; Zebra Finch *Taeniopygia guttata* <0.1. MAMMALS: Marsupials: Dasyuridae: unident. 1.2; Stripe-faced Dunnart 2.3; Lesser Hairy-footed Dunnart *Sminthopsis youngsoni* 1.2; Fat-tailed Antechinus *Parantechinus macdonnellensis* <0.1; Eutherians: Chiroptera: Vespertilionidae: *Vespertilio* 0.4; Rodents: Muridae: unident. 2.1; Forrest's Mouse 4.2; House Mouse 2.9; Spinifex Hopping-mouse 52.2; Desert Mouse *Pseudomys desertor* 2.8; Sandy Inland Mouse 15.2; Western Chestnut Mouse *P. nanus* 1.0; Short-tailed Hopping-mouse <0.1.

In TANAMI DESERT, NT (1171 items from 323 whole and partial pellets and fragments at seven sites; Smith & Cole 1989): INSECTS: Unident. 1.2% no.; Coleoptera 2.0; Orthoptera 2.6. REPTILES: Unident. lizards 1.7; Agamidae 0.3; Gekkonidae

1.3; Scincidae 0.7. BIRDS: Unident. 1.4; button-quail 1.0; Zebra Finch <0.1; woodswallow *Artamus* <0.1; unident. honeyeater <0.1. MAMMALS: Marsupials: Dasyuridae: unident. 1.6; Stripe-faced Dunnart 3.6; Lesser Hairy-footed Dunnart 1.6; Fat-tailed Antechinus 0.2; Wongai Ningau *Ningau ridei* <0.1; Eutherians: Chiroptera: Emballonuridae: *Saccolaimus flaviventris* <0.1; Rodents: Muridae: unident. 3.3; Forrest's Mouse 11.2; House Mouse 12.5; Spinifex Hopping-mouse 32.0; Desert Mouse 5.5; Sandy Inland Mouse 7.5; Western Chestnut Mouse 9.1.

N. SIMPSON DESERT (856 items from 44 whole and partial pellets and fragments at four sites; Smith 1983): ARTHROPODS: Scorpionids 0.4% no. INSECTS: Coleoptera: beetles 5.8; Scarabaeidae 0.5; Diptera: Calliphoridae 0.2; Orthoptera: grasshoppers 0.5; Acrididae 0.1. REPTILES: Lizards: Agamidae 1.5; Gekkonidae: unident. 4.9; *Nephrurus* 2.9; Scincidae 3.3. BIRDS: Unident. 1.5; Little Button-quail *Turdix velox* 0.7; Budgerigar *Melopsittacus undulatus* 1.1; woodswallow 0.1; Zebra Finch 0.2. MAMMALS: Marsupials: Dasyuridae: unident. 1.4; Stripe-faced Dunnart 0.9; Lesser Hairy-footed Dunnart 0.1; Fat-tailed Dunnart 0.1; Fat-tailed Antechinus 0.1; Mulgara *Dasyercus cristicauda* 0.1; ningau 0.1; Eutherians: Chiroptera: bats 0.4; Lagomorphs: Leporidae: European Rabbit 0.4; Rodents: Muridae: unident. 3.5; House Mouse 32.7; hopping-mouse 0.7; Spinifex Hopping-mouse 1.5; Short-tailed Hopping-mouse 0.4; Sandy Inland Mouse 25.0; Forrest's Mouse 0.6; rat 0.5; Long-haired Rat 7.7.

Other records INSECTS^{9,10,14,15,20,40}: Blattodea: Blattidae^{5,15}; Coleoptera: beetles^{12,15,23,25,35}; Buprestidae²⁷; Carabidae: *Clivina*³⁷; Curculionidae²⁷; Geotrupidae⁵; Scarabaeidae^{5,15,27}: *Blackburnium*⁵; *Onthophagus*⁵; Tenebrionidae^{27,30}; Hemiptera: Pentatomidae²⁷; Hymenoptera³⁵: Formicidae²⁷: *Camponotus*³⁷; Lepidoptera: Noctuidae⁵; Isoptera²⁷; Mantodea^{5,27}; Orthoptera: grasshoppers^{5,25}; Acrididae^{14,27}: *Acrida conica*¹⁵; Gryllacrididae^{5,16}; Gryllidae^{5,37}; Gryllotalpidae: *Gryllotalpa*⁵; Tetrigidae²⁷; Tettigoniidae^{5,37}. AMPHIBIANS: Frogs^{3,5}; Myobatrachidae: *Neobatrachus centralis*²⁵. REPTILES: Lizards: unident.^{5,37}; Agamidae: *Tympanocryptis cephalus*²³; Gekkonidae³⁵; Scincidae³⁷. BIRDS: Unident.^{2,5,8,16,20}; White-faced Storm-Petrel¹⁰; Baillon's Crake *Porzana pusilla*⁵; Red-chested Button-quail *T. pyrrhorostris*²⁷; Purple-crowned Lorikeet *Glossopsitta porphyrocephala*²⁵; New Holland Honeyeater *Phylidonyris novaehollandiae*⁵; Jacky Winter *Microeca fascians*⁵; Grey Shrike-thrush *Colluricincla harmonica*⁵; Richard's Pipit²⁷; House Sparrow^{5,19}; Zebra Finch *Taeniopygia guttata*⁵; European Goldfinch *Carduelis carduelis*⁵; Golden-headed Cisticola *Cisticola exilis*⁵; Brown Songlark *Cinclorhynchus cruralis*²⁷; Rufous Songlark *C. mathewi*²⁵; Common Blackbird *Turdus merula*⁵; Common Starling^{5,13,41}. MAMMALS: Unident.^{6,12}; Marsupials: Dasyurids: Antechinus³⁹; dunnart^{18,31}; Fat-tailed Dunnart⁴; Common Dunnart *Sminthopsis murina*³⁵; Diprotodontids: Acrobatidae: Feathertail Glider *Acrobates pygmaeus*²⁶; Petauridae: Sugar Glider *Petaurus breviceps*⁵; Peramelomorphs: Peramelidae: Southern Brown Bandicoot *Isoodon obesulus*¹⁶; Eutherians: Felidae: Juv. Cat³²; Chiroptera: bats⁵; long-eared bat *Nyctophilus*²⁵; Leporidae: European Rabbit^{1,5,25}; Rodents: Muridae: *Leggadina*³¹; Greater Stick-nest Rat *Leporillus conditor*¹⁶; Grassland Melomys *Melomys burtoni*³⁵; House Mouse^{5,10,11,17,20,22,24,28,31,34,35,36,37,38,39}; hopping-mouse³¹; mouse *Pseudomys*^{31,36}; Sandy Inland Mouse⁵; rat *Rattus*^{10,11,20,21,34,35,38}; Polynesian Rat *R. exulans*^{33,42}; Bush Rat^{7,29,30}; Swamp Rat³⁵; Brown Rat *R. norvegicus*³⁵; Black Rat^{5,35}; Canefield Rat *R. sordidus*¹⁸; Long-haired Rat^{31,38}.

REFERENCES: ¹ D'Ombain 1905; ² Hill 1911; ³ Barnard 1914b; Lea ⁴ 1917, ⁵ 1922; ⁶ White 1917; ⁷ Chisholm 1934; ⁸ Cohn 1934; ⁹ Thomson 1935;

¹⁰ Dickison 1941; ¹¹ Tarr 1950; ¹² Watson 1955; ¹³ Wheeler 1966; van Tets *et al.* ¹⁴ 1969, ¹⁵ 1977; ¹⁶ Eckert 1971; ¹⁷ Hayward & MacFarlane 1971; Parker ¹⁸ 1973, ¹⁹ 1977; Vestjens ²⁰ 1973, ²¹ 1977; ²² Hermes & Stokes 1976; ²³ Morton *et al.* 1977; ²⁴ Hyem 1979; ²⁵ Morton & Martin 1979; ²⁶ James 1980; ²⁷ Valente 1981; ²⁸ Saunders & Cooper 1982; ²⁹ O'Brien 1990; ³⁰ Dickman *et al.* 1991; ³¹ Gee *et al.* 1996; ³² Rose 1996; ³³ Smuts-Kennedy & Lovegrove 1996; ³⁴ Lea & Gray; ³⁵ Fleay; ³⁶ Hall; ³⁷ FAB; ³⁸ Hollands; NSW Bird Rep. ³⁹ 1971, ⁴⁰ 1991, ⁴¹ 1994; ⁴² CSN 41.

Young Poorly known. Thought to be fed similar food to diet of adults. In nw. Vic., fed on House Mice (McLaughlin 1994), which were only mammals eaten by adults. In Europe, food of young differed little from that of adults, though tended to be fed more of smaller species present (BWP).

Intake Size of prey varies greatly: from insects, to commonly small lizards or small mammals such as Ningauai and Lesser Hairy-footed Dunnart with an average adult weight of 10–15 g, to larger mammals, largest usually being Long-haired Rat, with average adult weight of 160 g (Morton *et al.* 1977; Morton & Martin 1979; Valente 1981; Smith 1983), though occasionally take juvenile rabbits weighing c. 300 g (D'Ombra 1905; Morton & Martin 1979). In Tanami Desert, prey items with maximum mean weight of 30 g were usual prey, though item of 100 g once recorded (Smith & Cole 1989). **PELLETS:** Characteristics of pellets summarized in Table 2. Usually produce one pellet per day, representing one night's hunting (Morton *et al.* 1977; Morton & Martin 1979); in captive Aust. birds, average of c. 0.7 pellets/day reported (Marshall 1986). Extralimitally, two pellets in 24 h reported; under exceptional circumstances captive birds can produce up to four pellets in 24 h, but one or two usual (Bunn *et al.* 1982). Throughout range, 1977 pellets were analysed; mean size and weight of pellets similar; mean number of prey per pellet varied between 1.8 in sw. Qld and 3.9 in nw. Vic., with estimated average of c. 3 prey/pellet. **DAILY INTAKE:** Estimated mean daily intake of food: in Tanami Desert, 63 g live prey weight (Smith & Cole 1989); in sw. Qld, 70–90 g (Morton *et al.* 1977); and in arid s. Aust., 50–100 g (Morton & Martin 1979). Owls throughout range take average of three prey per day.

SOCIAL ORGANIZATION Not well known in HANZAB region except for study of biology, including roosting, in nw. Vic. (McLaughlin 1994), and general observations by Fleay and Hollands. Better known extralimitally, e.g. Bunn & Warburton (1977), Bunn *et al.* (1982), Fry *et al.* (1988), Taylor (1994) and BWP, from which extralimital material below is taken. Biology reviewed by Schodde & Mason, but sources of observations (i.e. Aust. or extralimital) not clear; certainly some from extralimital sources. Extralimitally, solitary or in pairs outside breeding season. In Aust., patterns of movements not well known and appear to vary (see Movements), and social behaviour possibly

varies with movements undertaken. Generally said to be solitary and non-territorial (White 1915), but in some areas seem to behave as territorial pairs all year (McLaughlin 1994). Usually seen singly or in pairs (e.g. Longmore 1978; Badman 1979; Hall; Storr 26, 28). Sometimes gather in small loose groups to forage and roost, especially during irruptions (e.g. Dickison 1941; Hollands); larger groups include: c. 30 in a few dozen hectares of marginal habitat (Hollands); several hunting in c. 10 ha (Debus 1997); 12 (QOS Bird Rep. 1989); and c. 40 attracted to person calling up Foxes (NSW Bird Rep. 1985). High densities recorded along roads at times (see Distribution); also see Roosting (below).

Bonds In nw. Vic., monogamous, at least some remaining paired outside breeding season (McLaughlin 1994; *contra* Schodde & Mason). Extralimitally, apparently long-term monogamy but occasionally polygamous, with male attending two females at two nests; high fidelity to nesting site and mate; pair-bond often persists all year; outside breeding season, members of pair may maintain close contact or only loosely associate. In Aust., able to breed at 10–11 months old, possibly earlier (Fleay; Hollands). **Parental care** Only female incubates and broods and feeds young nestlings, during which time only male hunts; after female stops brooding, both sexes hunt and feed young (McLaughlin 1994; Hollands; NRS). Young independent 1–2 months after fledging (Fleay; Strahan). May be some aggression by adults toward young nearing independence (McLaughlin 1994).

Breeding dispersion Often as solitary pairs (e.g. McLaughlin 1994; Hollands; NRS); during irruptions, often loosely communal (Fleay; Schodde & Mason; Hollands). In nw. Vic., breeding density of 1 pair/500 ha, with 1.5–2 km between nests (McLaughlin 1994); in another area, two pairs within c. 300 m of each other (Fleay). During irruptions can be nests in every available hollow (Fleay). Sometimes territorial, apparently when at low breeding densities; and other times not, apparently when at high breeding densities (McLaughlin 1994; Schodde & Mason); may inhabit sites permanently (Hollands); see Agonistic behaviour. Home-range may cover large area; most hunt well away from roost or nest, sometimes as far as 6–10 km (Hyem 1979; Schodde & Mason). During nesting, activity centred on nest; after fledging, dependent young fed anywhere within c. 200 m of nest (McLaughlin 1994). Said to leave nesting area a few days or so after young fledged (Hollands). Independent young may disperse far (see Movements). One pair nested in same tree as nesting Barking Owl *Ninox connivens*, Pacific Black Duck *Anas superciliosa*, Laughing Kookaburra *Dacelo novaeguineae*, Eastern Rosella *Platycercus eximius*, and Red-rumped Parrot *Psephotus haematonotus* (North). Rarely respond to calls of other species of owls (Debus 1997). Extralimitally, breed as solitary pairs with overlapping home-ranges, but occasionally in loose colonies; defend nesting, and sometimes roosting, sites; possibly defend larger territories.

Table 2. Summary of pellet characteristics and number of prey per whole pellet throughout range of Barn Owls.

	NO. PELLETS	MEAN WEIGHT (G)	MEAN LENGTH × WIDTH (MM)	MEAN NO. PREY /PELLET	REFERENCE
SW. QLD	106	4.5 (2.1–8.4)	38.0 × 27.0	1.8	1
NW. NSW, NE. & N. SA	1026	4.05 (3.3–5.6)	–	2.9	2
NW. VIC.	217	3.9±1.7	37.1 × 26.4	3.9 (1–13)	3
SIMPSON DESERT	44	4.02 (1.34–10.21)	37.3 × 26.6	2.83 (1–10)	4
TANAMI DESERT	584	4.57±1.64	41.2 × 25.9	2.9±1.4	5

Roosting Diurnal. Often in hollows of living or dead trees, especially large eucalypts, where often seem to stay near entrance rather than going deep into hollows; also on rafters in barns and old dwellings; in caves and clefts in faces of cliffs and the like; and dense foliage of trees or shrubs; rarely, in open trees or under thick tussocks of grass (see Habitat). In nw. Vic. ($n=82$ roosts), 71% in hollows, 24% in foliage, and 4% in artificial structures; possibly roost in foliage more often in warm weather. In nw. Vic., roosts in HOLLOWs recorded only in Oil Mallee *Eucalyptus oleosa* and Belah *Casuarina pauper*, and usually no more than 10 m from cleared land or open woodland: height of trees used as roosts only (i.e. not nesting) 9.8 m (3.2; 3.4–18.4; 57) and diameter at breast-height 37.5 cm (9.8; 22–60; 56); entrance to hollow, 3.9 m above ground (1.0; 2.2–6.8; 58), 18.4 cm wide (3.9; 9.0–26.0; 57), angle from vertical 40° (24; 5–123; 55); percentage canopy cover directly over entrance, 13% (16; 0–63; 56); depth of hollow, 2.0 m (1.3; 0.2–6.5; 54); area of floor of hollow, 452 cm² (225; 132–1075; 46); distance to nearest other hollow apparently suitable for roosting or nesting, 58 m (46; 1–150; 57). Roosting in FOLIAGE recorded in Oil Mallee, Yorrell *E. gracilis*, Square-fruited Mallee *E. calyogona*, Belah, Cattlebush *Alectryon oleifolius*, African Boxthorn *Lycium ferocissimum*, and Peppercorn *Schinus molle*: height of tree, 4.2 m (0.8; 3.1–5.4; 12); height of roost, 2.4 m (0.5; 1.8–3.1; 10); percentage canopy cover directly over roost 64% (8; 53–80; 10) (McLaughlin 1994). Roosts often seem to be used only once, particularly roosts in foliage, though sometimes used more regularly (McLaughlin 1994). Some seem traditional, and used year after year; one hollow used for 3–4 years (Dickison 1941). Pellets often accumulate in or under regularly used roosts (e.g. White 1915; Morse 1918; Morton 1975; Valente 1981; Smith 1984b; McLaughlin 1994; Schodde & Mason), sometimes deposits almost 0.6 m thick (Brandon 1948). In some areas said to inhabit same hollow throughout year and use it for nesting (McGill 1923, 1932), though elsewhere nest-sites not used for roosting after young have fledged (McLaughlin 1994). Birds occasionally die after getting legs caught at entrances to hollows (Cooper 1965). During irruptions, several roost in different hollows in same tree (Schodde & Mason); in sw. NSW, not unusual to flush up to 30 from a stand of timber (Hobbs 1961); once six (most likely this species) flushed from ledge in rocks (Finlayson 1946). Occasionally both adults occupy nest-hollow before laying or when with eggs or young (Brandon 1948; Cooper 1965; McLaughlin 1994; NRS). After female finishes brooding, at some sites both adults roost away from nest-tree (Hollands), but not together. Newly fledged young may spend long periods (>30 min) dozing on ground; may choose poor roosting sites (McLaughlin 1994). Crepuscular hunting noted (Baker-Gabb 1984) and sometimes hunt well before dark (Hollands); also seen to move about in daylight, sometimes hunting (Chisholm 1934; Vic. Bird Rep. 1985). Also recorded emerging just on dusk (Dickison 1941). May return to roosts with prey and feed on it during daytime (D'Ombra 1905; North). When roosting, perch almost upright (Schodde & Mason), sometimes on one foot (Cohn 1934).

SOCIAL BEHAVIOUR Not well known in HANZAB region except for study in nw. Vic. (McLaughlin 1994) and general observations by Fleay and Hollands. Better known extralimitally, e.g. Bunn & Warburton (1977), Bunn *et al.* (1982), Fry *et al.* (1988), Taylor (1994) and BWP, from which extralimital material below taken. Biology reviewed by Schodde & Mason, but sources of observations (i.e. Aust. or extralimital) not clear; certainly some from extralimital sources. In Aust., breeding

behaviour said to be similar to that elsewhere in range (McLaughlin 1994). Can be hard to study because breed, and often roost, in hollows, but also noisy and not easily overlooked (Hyem 1979); often difficult to band young in deep hollows of nest (McLaughlin 1994). Quite tolerant of human activity (Fleay). When several birds were hunting in same area, each occasionally gave Screech (Debus 1997).

Agonistic behaviour Claimed to defend themselves as other species of masked owl: crouch, spread and drop wings, and swing head from side to side, hissing and bill-snapping (Schodde & Mason), but extralimitally this display not used by adults against conspecifics. **Territorial advertising** Extralimitally, males, and apparently some females, demarcate territories by calling and flights. In nw. Vic., early in evening throughout year, birds seen to call as they flew at heights of 10–30 m from and round roosts or nests; also, at onset of breeding, utter Incessant Stationary Screech (see below) from perch; these displays possibly analogous to displays recorded extralimitally (McLaughlin 1994). **Threat** In nw. Vic., in response to playback of taped calls in non-breeding season, both members of pair responded with Screeching, fly-overs and perching nearby. When Barn Owl intruded within 50 m of occupied nest, resident male chased and Screeched at it. One night, same male tumbled to ground with intruding Owl (the two possibly locked talons) and fought for c. 15 s, emitting rapid Screams; many body-feathers and some remiges lost (McLaughlin 1994). **Alarm** Claimed that when alarmed, roosting bird stands more erect, narrows facial disk and drapes wings about breast as if to hide pale underparts (Schodde & Mason). If further disturbed, will flush from hollows (e.g. Barnard 1914b); one flushed from tussocks of grass and flew to a hollow (Vic. Bird Rep. 1985). Once out in open, usually pursued by species of diurnal birds, e.g. Noisy Miners *Manorina melanocephala*, butcherbirds *Cracticus*, Magpie-larks *Grallina cyanoleuca*, Australian Magpies, hawks and smaller species including honeyeaters; can be forced to ground to hide (White 1915; Cohn 1934; Dickison 1941; Lord 1956; McLaughlin 1994; Fleay; S.J.S. Debus); observed to be killed or badly injured by Laughing Kookaburras (White 1915; North). When escape not possible, birds hold body horizontal and sway from side to side, moving head in circular fashion, crouching, spreading wings, snapping bill, glaring and hissing or sometimes making rasping noise; seen in response to people and some nocturnal mammals (Fleay) and once to mobbing by Magpie-larks and honeyeaters (Cohn 1934). Extralimitally, in response to human intruders, captive birds may strike at intruder and feign death.

Sexual behaviour Copulation and some courtship behaviours possibly function in maintenance of pair-bonds (McLaughlin 1994). **Courtship** Sometimes courtship period quite long (McLaughlin 1994) but can be brief, probably if pair has recently bred and pair-bond already established (McLaughlin 1994). Extralimitally, Advertising Call and Display Flight of male seems to attract females as well as repelling rivals; other behaviour seen before nesting includes: caching of food by male and presentation of food to attract female; Pursuit Flights, where male flies above and behind female; Moth Flight, where male hovers with legs dangling. In Aust., first sign of breeding up to 8–12 weeks before laying, when male, who is noisier than female, gives INCESSANT STATIONARY SCREECH: Male of pair perches prominently, at entrance to potential nest or in or near potential nest-tree, and screeches persistently, often for over 10 min; usually occurs 20–40 min after dark. Occurs when nest-site being chosen and prepared, and not after laying starts. Later, birds perform COURTSHIP FLIGHTS, including tail-chasing

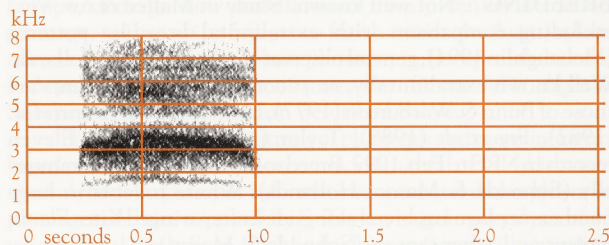
and pursuit flights, chattering and screeching excitedly as fly in circles near nest-tree. Usually ends with one or both birds entering nest-hollow. Sometimes only male flies, usually when female in nest. In nw. Vic., most flights <2 min duration, within c. 100 m of nest-tree, and 15–25 m above ground, but twice over c. 50 m; seen in 2–9 weeks before laying (McLaughlin 1994; Fleay; Schodde & Mason; Hollands). Birds also said to utter chirruping and wheezing calls during courtship (Hollands). Within c. 8 weeks of laying, female becomes sluggish and reluctant to fly at night or flush from hollow during day; 2–4 weeks before laying, spends much time in nest, or at entrance, though both birds active away from nest-tree in early evening (McLaughlin 1994). Before laying, may roost in nest-hollow for many weeks (Hollands); sometimes stay near nest-tree, calling occasionally (Fleay). After laying, call much less often, though calling seems to increase slightly at hatching (McLaughlin 1994). **Courtship feeding** In nw. Vic., within c. 8 weeks of laying, female starts to solicit food using Snore; 2–4 weeks before laying, male delivered food to female in hollow, male entering hollow briefly; food may be cached in hollow at this time. Male also feeds female during incubation, either at or in nest-hollow, sometimes 3–4 times a night. Female still fed in early stages of brooding of young but no longer Snore for food (McLaughlin 1994). **Allopreening** Seen before copulation (McLaughlin 1994). **Copulation** Seen up to 9 weeks before laying. Occurs in nest-tree, often within 2–4 m of hollow; probably also occurs inside hollow. May be preceded by courtship feeding, allopreening or Courtship Flights by male. Just before copulation, twittering by male increases as he solicits female; she responds with Snoring. Female may hold food in bill during copulation. Lasts 10–20 s, and accompanied by rapid calling. After copulation, calling quickly decreases and male usually flies to nearby branch, sometimes after short flight round nest-tree. At one nest, seen seven times in just over 3 h (McLaughlin 1994; Schodde & Mason). Extralimitally, occurs often and may continue till after hatching; apparently either sex may solicit, male sometimes crouching in front of female; usually female solicits with Snoring calls and lowers body; male mounts, balancing with spread wings and grasping female's nape with his bill; male gives Copulation Call.

Relations within family groups Young in nest beg for food with soft rasping, which turns into Snoring as birds get older and call more; female may give a squeaky Food-offering Call when feeding young. Adults carry food in bill to nest-hollow, sometimes calling with chatter or croak as they return. In early stages, male brings food to female who tears it up for young; at this stage, male may not be allowed into hollow or visits only briefly, to drop food. Later, when fed by both parents, turn-around at nest can be fast, and both adults may just drop food into hollow (Hyem 1979; McLaughlin 1994; Fleay). Near fledging, young use Snoring call to beg for food as well as a contact call. Young play and practise some behaviours, e.g. drop and pounce on dead prey brought by adults; preen, allopreen and apparently bill-fence or lock bills together (McLaughlin 1994). After fledging, at first inactive and beg with Snore. As become more active develop Screech; continue play and learning behaviour, and siblings remain close together. At this time, both parents very vocal and active (McLaughlin 1994; Hollands). Adults dived, chased and called after one fledgeling, 74–76 days old, which was no longer giving Snoring call, though not clear if fledgeling was their offspring (McLaughlin 1994). Said that younger and weaker siblings may be cannibalized in nest (Fleay). **Anti-predator responses of young** In response to people, nestlings may hiss (McLaughlin 1994); huddle together (McGilp

1932); sway and snap bills (but see Voice); if handled, attack with bill and talons (Fleay). Fledgelings do not flush easily; when approached to c. 2 m one adopted mantling posture with wings stretched out, down and forward, and hissed and snapped bill (McLaughlin 1994). Extralimitally, reported to crouch, hiss, lie prostrate with eyes closed, feign death, become silent when parents give warning call, and run or seek cover; rarely strike; fledgelings may seek cover, glare at intruder, give Mobbing Call or circle overhead. **Parental anti-predator strategies** Females do not flush readily from eggs (Dickison 1941). In response to people, female may leave nest and fly to another hollow (Fleay); male may attack with silent swooping from behind, then Screech when overhead (Hyem 1979). May sway, snap bill, hiss and glare as described in Agonistic behaviour (Fleay). Extralimitally, may also give Mobbing Call, stand over young in threat posture while Hissing, or swoop and scratch; seldom attack.

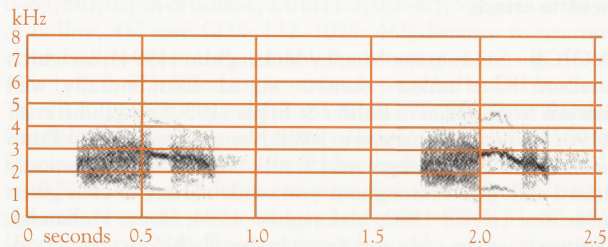
VOICE Study in nw. Vic., by McLaughlin (1994), on which account based unless otherwise stated. Extralimitally, well known from studies of Bühler & Eppe (1980) and Bunn *et al.* (1982), which summarized in BWP. Names of calls follow Bunn *et al.* (1982), who recognized 15 calls. Screech most commonly heard call, given throughout year; wide variety of calls given near nest (Debus 1990; McLaughlin 1994; Fleay; Hollands). Twitter given by male and Snore by female before copulation. Vocal activity reduced markedly after laying, though some calling continues in early evening and appears to increase slightly with hatching; very vocal when tending fledgelings. Male generally noisier than female. Extralimitally, Screech of female said to be generally more husky than that of male (Bunn *et al.* 1982), but in Aust. separation not possible with any confidence (McLaughlin 1994). Snore heard only from females, from 9 weeks before laying till hatching; similar call given by young (McLaughlin 1994); extralimitally, Snore heard only in spring and summer, usually from females and young, and only from males after end of breeding (Bunn *et al.* 1982). Differences in Screech occasionally permit identification of individuals. Screech high-pitched, falsetto and tinny in comparison with that of Masked Owl, which sounds richer, louder, deeper and harsher (Hyem 1979; Debus 1993, 1995; Fleay; Hollands). **NON-VOCAL SOUNDS:** Bill-snapping by adults and young said to accompany threat displays (D'Ombra 1905; Fleay). Clicks accompany hisses when fledgeling approached. Extralimitally, observations of nestlings suggest snapping or clicking produced not by closure of mandibles but by withdrawal of back of tongue from muscular pharynx (Bunn *et al.* 1982).

Adult SCREECH (sonagram A): Long hissing screech *shir-r-r*, *sk-air* or *skee-air*, delivered all on one note (Fleay; Hollands). Loud, but carries poorly and audible for only a few hundred metres (Hollands). Throughout year, birds give 5–15 brief Screeches, each lasting 0.5–1 s, over 30–60 s, during flight



A. J. Wiles; Julatten, Qld, July 1996; private

round roost or nest-site early in evening. In 8–12 weeks before laying, males perform Incessant Stationary Screech; perch on or near potential nest-tree, uttering persistent Screeches of c. 1 s duration every 2–5 s (see Social Behaviour). Similar but shorter bouts delivered from various positions >200 m from nest-tree, and occur with varying intensity throughout most of breeding period. Screeches frequent during courtship flights. Loud well-spaced Screeches given intermittently by several birds in loose congregations, all hunting over same area, as if to maintain contact or to advertise position (Debus 1997). Said to be uttered singly and infrequently, while perched or in flight. **SNORE:** Brief, but persistently repeated, raspy or wheezy call. Given by female only; similar to call of dependent young. **TWITTER:** Rapid high-pitched twitter; given by male before copulation. **FOOD-OFFERING CALL:** Squeaky e-e-e-e-e. **HISS:** Hissing; given by captive male, as threat (D’Ombain 1905;



B F. James; Mareeba, Qld, July 1981; P40

Fleay). **Other calls** Loud prolonged screeching when chasing intruding Barn Owl from near nest, and high-pitched and rapid screams when fighting on ground; may correspond to Warning Scream and Distress Call respectively of Bunn *et al.* (1982). Loud rapid explosive call from both members of pair when chasing fledgeling 74–76 days old. Variety of chirrups, wheezes, cries and wails during courtship (Fleay; Hollands). Low musical frog-like croak given by adult returning to nest with food (Hollands).

Young **BEGGING CALL:** Soft *gobble-gobble* from nestlings as young as 4–6 days old (McLaughlin 1994); repeated plaintive rasping *air-sh* from nestlings (Fleay; Hollands). Noise from feathered nestlings audible for considerable distance (Hyem 1979). From 15–30 days, nestlings noticeably more vocal, often uttering hiss or variety of twittering sounds; sustained hiss given in alarm when nest examined in daytime. From 30–45 days, even more vocal, with calls increasing in rapidity and intensity when adults return with food, most common call being a well-developed Snore (see above), uttered when begging for food. Thereafter, until fledging, Snores frequent and loud when begging, and may also be used as contact call. Immediately after fledging, Snore is main call; Screech develops gradually and raspy and imperfectly delivered at first.

BREEDING Not well known. Study in Mallee of nw. Vic., including comparison with extralimital breeding patterns (McLaughlin 1994); general observations by Fleay and Hollands. Well known extraliminally; most comprehensive accounts are those of Bunn & Warburton (1977), Lenton (1984), Bunn *et al.* (1982), Fry *et al.* (1988), Taylor (1994) and BWP. Eleven records in NRS to Feb. 1997. Breed solitarily or loosely communally (Schodde & Mason; Hollands). Where rodents in large numbers or plaguing, breed alongside Letter-winged Kites *Elanus scriptus* and other raptors (Schodde & Mason).

Season Often opportunistic, breeding at any time of year,

usually in response to abundant food (Fleay; Schodde & Mason; Hollands). Throughout range, eggs found in all months of year, though concentrated in spring: of 49 clutches, 8 (16.3%) in autumn, 13 (26.5%) winter, 22 (44.9%) spring, 6 (12%) summer (Olsen & Marples 1993; cf. Schodde & Mason). In nw. Vic., of 14 clutches, 12 (86%) laid June–Oct.; of nine clutches laid during irruption of House Mice, seven June–Sept. and two Feb.–Mar.; of five clutches laid after irruption, all Sept.–Oct. (McLaughlin 1994). When density of prey low, at least in some areas, breed seasonally (McLaughlin 1994; see Laying). Other published records include: QLD: Laying, Apr.–Aug.; eggs, Jan.–Feb., Aug.–Oct.; nestlings, Sept. (Lavery *et al.* 1968; Gill 1970; Purchase 1972; Lavery 1986; Campbell; NRS). NSW: Eggs, all months (Morris *et al.* 1981; North); nestlings, Apr. (NRS). VIC.: Breeding all months (McLaughlin 1994; Hollands; NRS; see above). SA: Eggs, May, July–Dec.; nestlings, Jan., May, Dec.; young, June; fledgelings, Nov. (Brandon 1948; Attiwill 1972; Purchase 1972; Parker 1977; Bransbury 1984; North; NRS). WA: Eggs, Sept.; nestlings, Sept.–Dec.; fledgelings, Dec. (Carter 1903; Masters & Milhinch 1974; Storr 16, 26, 27; NRS). NT: Laying, Apr.–June; eggs, Jan.–Feb., May, Oct.; nestlings, May, Aug., Oct.; large young, Aug. (Le Souëf 1902; Frith & Davies 1961; Purchase 1972; Gibson 1986; NRS).

Site Usually deep hollows of living or dead trees; in main trunk or large side limb; often in eucalypts. Also nest in caves, mines, holes in limestone, well shafts, shelves in roofs and walls of buildings; under granite boulders; and on ground under shrubs or grass tussocks; in photographic hide; on hay in hayshed (see Habitat). Often nest in roosting sites (McGilp 1923, 1932; Schodde & Mason), but not in all areas (McLaughlin 1994). Some sites appear traditional and used for generations, as in Europe (Hollands); other sites appear not to be re-used, though birds may nest nearby or in different hollows in same tree (McLaughlin 1994). **MEASUREMENTS:** In nw. Vic. mallee (McLaughlin 1994): Height of nest-tree, 11.5 m (1.5; 9.2–14.1; 14); diameter at breast-height, 43.3 cm (5.9; 31–56; 14); percentage canopy cover directly over entrance, 43% (16; 0–67; 14); height of entrance to hollow, 4.2 m (0.7; 3.4–5.7; 14); angle from vertical, 65° (18; 30–90; 14); depth to nest-chamber, 1.5 m (0.6; 0.5–2.7; 14). Few data from elsewhere: height of two nest-trees, 20 and 24 m (NRS); height of entrance, from just above ground to 20 m (Hyem 1979; Schodde & Mason; Hollands; NRS); depth of hollow usually 0.6–2 m (Hyem 1979; North; Schodde & Mason; NRS) but up to 8–10 m (Hollands). In nw. Vic., distance to nearest hollow that appears suitable for roosting or nesting, 42 m (34; 1–100; 14). In nw. Vic., compared with roosting hollows, nest-hollows have fewer splits or breaks in walls, larger floor areas, greater foliage cover directly over entrances, and with entrances at greater angles from vertical; usually no more than 10 m from cleared land. Compass orientation of entrance does not seem to matter (McLaughlin 1994). Also recorded nesting in wells, 4 and 9 m below ground (McGilp 1932; Hollands). When breeding at high densities, may use poorer nest-sites (McLaughlin 1994). May compete for use of hollows with other vertebrates; in nw. Vic., mainly with Galahs *Eolophus roseicapillus* (McLaughlin 1994). During irruptions, said that may compete with other pairs of Owls for sites (Fleay; Hollands).

Nest, Materials No real nest but eggs laid on rotten wood or accumulations of old pellets or food residues (Campbell; North; Hollands); said that occasionally grass and leaves added (Schodde & Mason), but not supported by primary sources. Little cleaning of nest (Fleay); floor of nest can get filthy with pellets and remains of prey (Fleay; North), especially by late in

nestling stage (McLaughlin 1994). Adults enter hollows head first and climb out of hole with claws (McLaughlin 1994; Hollands). **MEASUREMENTS:** Area of floor of hollow, 839 cm² (318; 433–1452; 14); width, 18.8 cm (5.3; 14.5–28.0; 14) (McLaughlin 1994); 20–25 cm (Schodde & Mason).

Eggs Oval to rounded oval; smooth and finely pitted; lustreless; dull white (North; Fleay; Schodde & Mason; Hollands). **MEASUREMENTS:** 41.9 (22.6; 38.2–46.0; 200) × 32.2 (12.7; 28.5–34.9) (Olsen & Marples 1993); 38–46 × 30–35 (n=38) (Schodde & Mason). Estimated volume, 22.2 cm³ (13.6; 16.9–26.5; 64) (Olsen & Marples 1993).

Clutch-size Often three to six, occasionally up to 12 (McGilp 1923; Olsen & Marples 1993; North; Fleay; Schodde & Mason; Storr 27; Hollands). Throughout range, mean 4.0 (12.0; 1–7; 64) (Olsen & Marples 1993); in nw. Vic., 4.7 (1.0; 3–6; 9) (McLaughlin 1994). Largest when food abundant (McLaughlin 1994; Fleay; Hollands). Clutch-size seems smaller in Aust. than elsewhere (McLaughlin 1994).

Laying Said to be at intervals of 2 days (Fleay; Schodde & Mason; Hollands); extraliminally, 2.5 days. In Aust., may breed twice a year, and often breed continuously during increases in number of rodents (McLaughlin 1994; Schodde & Mason; Hollands). One pair raised three broods in 18 months (Hollands); another laid c. 12 weeks after earlier brood fledged (McLaughlin 1994). Captive birds can lay continuously (Fleay). Said occasionally to lay second clutch when first brood still in nest (Strahan), but this not supported by primary Aust. sources and may refer to extralimital populations; said to do so in Wheatbelt during mouse irruptions (P. Olsen).

Incubation By female only; female fed by male during incubation (McLaughlin 1994). Normally begins with first egg (Fleay; Schodde & Mason). In captivity, eggs may become stained (Fleay). Do not flush readily from eggs (Dickison 1941). Male may occupy hollow at same time as incubating female (Brandon 1948; NRS); male also sometimes roosts in nest-hollow (see Roosting). **INCUBATION PERIOD:** 33±1.5 days (McLaughlin 1994); 33–35 days (Schodde & Mason); 34 days for each egg (Fleay); in captivity, 32–33 days (McLaughlin 1994). Extraliminally, 30–31 days.

Young Semi-altricial, nidicolous. Siblings hatch in staggered sequence. Hatch in sparse short white down; at 10–12 days, acquire denser, longer white to pale-grey second down (see Plumages). Said to be fully feathered by 8–9 weeks old (Schodde & Mason). Rate of increase in weight of nestlings, c. 22 g/day (n=5 nestlings) (McLaughlin 1994). In one brood of four, smallest nestling 17.1 g and heaviest 64.5 g (NRS). Recorded broods, 2–7 (Purchase 1972; Hutton & Brickhill 1985; Copley 1988; Fleay; Hollands; NRS). Just before fledging, may move nearer to entrance of hollow (Fleay; Hollands) and spend much time looking out, though when food delivered, descend hollow again; also begin wing-stretching and exercising flight muscles. From c. 45 days, nestlings climb or make short flights or hops out of nest, round nest-tree and adjacent trees, and onto ground within 6–8 m of nest-tree (McLaughlin 1994). Extraliminally, at 8–10 days, eyes begin to open; at 5–6 weeks, exercise wings vigorously and make walking excursions from nest; able to dismember food at c. 16 days (also see Scherzinger 1971; Lenton 1984; Wilson *et al.* 1987). **Parental care, Role of sexes** By female only; young brooded for c. 2 weeks. Female stays in hollow while male hunts, passing food to her to feed to young. After this, both sexes roost away from nest-tree and hunt for young (McLaughlin 1994; Schodde & Mason; Hollands). Feeding rates increase during nesting period, reaching maximum just before fledging: average number of prey

delivered: at three nests, when <15 days old, 1.2 prey/h (n=3 nests); when 15–45 days old, 2.3 prey/h (n=2 nests); when >45 days old, 3.3 prey/h (n=3 nests) (McLaughlin 1994). At other nests, one pair fed older nestlings four mice in 3 h (Hollands); another pair, with seven young, brought at least 30–40 mice or equivalent per night (Fleay). Defend young by attacking or giving defence postures (see Social Behaviour).

Fledging to independence **FLEDGING PERIOD:** 50–55 days (Hollands); said often to be 9–10 weeks (Schodde & Mason), but no details. In captivity, 40–45 days, if food provided *ad libitum*, otherwise 50 days (McLaughlin 1994); desert nest at 8 weeks (Fleay). Young first roost outside nest-hollow (often continue to roost inside hollow after first flight) at 46–52 days old (n=11) (McLaughlin 1994); extraliminally, 50–55 days. Fledge in plumage similar to that of adults, but retain some down on head, neck and body (see Plumages: Juvenile male). For first few days fed near nest by parents (Hollands). Independent c. 12 weeks after leaving nest (Schodde & Mason); have left nest-area by 90 days after hatching, and once at 74–76 days (McLaughlin 1994); in captivity, independent by at least 4 months old (Fleay). Extraliminally, dependent until 12–14 weeks old, rarely 16 weeks.

Success In nw. Vic., of ten nests with completed clutches, eight hatched young; of 42 eggs from nine clutches 38 (90.4%) hatched, giving mean brood-size of 4.2 young/nest; number of fledgelings/nest, 3.6 (1.5; 0–5; 13 nests); of 36 eggs, 28 (77.8%) produced fledgelings; of 36 nestlings, 32 (88.9%) fledged. Mortality of eggs and young lower during irruption of prey than after populations of prey had crashed (McLaughlin 1994). Can raise succession of large broods of up to 5–7 when food plentiful (Hollands). When food supply declines or fails, often left trying to raise large broods and many young may die, apparently of starvation, particularly with onset of winter; some die after dispersing to marginal habitat (e.g. D'Ombra 1905; Dickison 1941; Morton 1975; Morton & Martin 1979; Green 1981; Baker-Gabb 1984; Hutton & Brickhill 1985; North; Hollands; NSW Bird Rep. 1993). Those unable to disperse, such as nesting adults and many fledgelings, die from starvation, exhaustion and cold in winter (Fleay; Schodde & Mason). One nest with eggs deserted when floor of hollow partly collapsed (McLaughlin 1994). Nestlings possibly eaten by goannas (Hollands). Younger and weaker siblings may be cannibalized (Fleay; Schodde & Mason). Young roosting outside hollow noted being killed by Australian Magpies and kookaburras *Dacelo* (Fleay). In past, eggs said to be eaten by Aborigines (McGilp 1932).

PLUMAGES Prepared by K. Bartram. Hatch in short neoptile down; acquire longer mesoptile down after 10–12 days. Pre-juvenile moult to juvenile plumage begins at c. 6 weeks old, and finishes by 8–9 weeks old (Schodde & Mason). Juvenile like adult but separable. Moult in staffelmauser. No precise data on duration of post-juvenile (first pre-basic) moult in Aust.; in Europe, undergo slow staffelmauser from juvenile into adult plumage, taking up to 5 years to finish moult. In Aust., adults take at least 2 years to replace plumage; in Europe, adults take 2–3 years to finish moult of primaries. Sexes differ slightly. Subspecies *delicatula* of Aust. described below.

The following descriptions of plumages and measurements based on examination of museum skins (a total of 149 skins used in analyses). Additional information on sexual dimorphism in plumages and size supplied by S. Taylor, based on analysis of 43 whole, dead adult Barn Owls, which were frozen till examination, and dried wings of four adult male specimens. There are

some differences between the results of these two studies regarding both coloration of plumage and size. These differences probably in part a result of an unknown proportion of museum skins being mis-sexed, and possibly also fading of museum skins. The broad results of Taylor's work summarized in Sexing, but also noted in the plumages descriptions where they differ from the descriptions from museum skins.

Adult male (Definitive basic). Most feathers of top of head (centre of forehead, crown, nape and hindneck), upperparts and upperwings have drop-shaped markings in centres of tips, made up of white spots or flecks at very tips, surrounded basally by grey-black (82), with stem of drop tapering toward base of feather. **HEAD AND NECK:** Heart-shaped facial disk typically white, with dark-brown (121–121A) teardrop-shaped patches that extend narrowly from inner upper edge of eye, between eye and bill, to expand below eye (extending 10–15 mm below eye); in darkest birds, facial disk varyingly washed cream (54). Facial disk bordered by varying ruff of mottled grey-black (82), dark brown (21), pale yellow (157), cream (pale 54) and white; ruff never completely dark and always shows, at least, distinctive pattern of dark area across top of ruff (forming brows) and narrow blackish area round bottom half or so; typically, upper half or so of ruff, pale buff, thickest at top of disk, and merging to narrower blackish bottom half or so, and which usually narrowly broken below bill; in darker birds, top of ruff darker and more prominent, and bottom half or less of ruff reduced to finer dark flecking, often with intervening part of ruff appearing white or almost so. Centre of forehead, crown, nape and hindneck appear mostly pale grey, patchily mottled with cream, buff or yellow-brown (especially when feathers ruffled or parted), and finely spotted white; feathers, cream (54), buff (54) or, occasionally, yellow-brown (123C) centrally, with concealed pale grey to light grey (86–85) bases, and broad pale grey (pale 86) tips, thinly but heavily vermiculated dark brownish grey (ne) and with small (c. 2 mm wide) white and grey-black to dark grey (82–83) drop-shaped markings at centre of tip of each feather (see above). Throat and foreneck, white; rarely (in darkest birds), have a few small, faint dark grey (84) flecks on sides of foreneck. Sides of neck mostly white, merging to coloration of hindneck on upper sides of neck; rarely (in darkest birds), sides of neck mostly cream (54), not white. **UPPERPARTS:** Whole upperparts patterned and coloured much as hindneck, except: drop-shaped markings larger (c. 3 mm wide at widest); middle of feathers slightly brighter, orange-buff (153) to yellow-brown (123C) and more readily exposed; and vermiculations on distal part of feather more heavily marked and darker, grey (84). Concealed bases of scapulars and uppertail-coverts, white (ne) (not pale grey). **UNDERPARTS:** White, sometimes with faint cream (pale 54) tinge on sides of breast, vent and thighs and varying fine dark spotting and streaking. Typically have fine (<1 mm wide) dull brownish grey (ne) spot or streak at tip of feathers of sides of breast and flanks; in many, markings extend to centre of breast and down sides of belly. Palest have dark brownish-grey spots or streaks only on sides of breast. Darker birds have spots and streaks over whole underbody except for legs; in these males, spots can be as large as c. 2 mm wide on lower flanks and largest spots grey-brown (between 27 and 28) to dark olive-brown (129). In very few (3 of 62 skins sexed as males), underparts as darkest females (q.v.) but possibility of mis-sexing of these skins cannot be excluded. In Taylor's sample, underbody varied from wholly white to cream to wholly buff ('ochre') and dark markings could extend over whole underbody, including midline (see Sexing). **UPPERTAIL:** Barred. Ground-colour of central rectrices, cream (pale 54) to buff (53)

or yellow-brown (dull 123C) with light grey-brown (119C–27), brown (28), dark-brown (119A) or dark olive-brown (129) vermiculations and fine spots, overlain with tiny white (ne) spots in some; ground-colour becomes paler and vermiculations dissipate outward, so that t6 mostly dull white (ne) with slight orange-buff (153) tinge or cream (54) wash. Rectrices marked with 3–4 bars, broadest on t1 (c. 10 mm wide) and becoming narrower (c. 5 mm wide) outward, till reduced to blotches or very short bars, not reaching edges of feather, on t6; bars vary from brownish grey (dark 79), light grey-brown (119C), dark brown (119A), to brown (119B). Shafts, grey-brown (ne) to brown (37) on t1, becoming paler outward, to cream (pale 54) on t6. **UNDERTAIL:** Mostly white or cream (pale 54) with shadows of darker markings from uppertail showing through as pale-grey (86) markings. Shafts, pale cream (ne). **UPPERWING:** Marginal coverts, white or pale buff (ne), sometimes with a few small dark-brown (21) spots; forms pale stripe along leading edge. Rest of coverts appear mostly grey-brown to dark brown, spotted with white, and with patches or blotches of buff and white, and varying barring, most conspicuous on median and greater coverts. Coverts, yellow-brown (123C) to cream (54) centrally (which often partly exposed) with: white bases (which also sometimes partly exposed); vermiculated brownish grey (ne) to dark brown (119A) and white tips; and drop-shaped markings, 2–3 mm wide, in centre of tip (patterned as on hindneck). All lesser and median coverts and greater secondary coverts have single, narrow, brownish grey (ne) to dark brown (119A) bar in centre of feather, most conspicuous on median and greater coverts; greater primary coverts have two narrow (c. 3 mm wide) dark brown (119A) to greyish brown (ne) bars across centre. Some coverts more buff and white than others, particularly inner and central greater secondary coverts and central median secondary coverts. Inner 2–3 tertials (s16–s14) as coverts but drop-shaped markings slightly larger, c. 4 mm wide. Outer 3–4 tertials (s14–s11) like inner tertials but: most of centres of feathers, buff-yellow (dull 53) to pale cream (ne) vermiculated brownish-grey (ne), and with three brownish grey (ne) bands, 5–10 mm wide, extending from outer edge to about halfway across inner web (not reaching inner edge); inner edge broadly white; and drop-shaped markings at tips larger, 5–6 mm wide, and wholly white (no dark border basally). Secondaries and inner primaries (p1 to p4–p6) like outermost tertials but with: four, and broader (c. 10 mm wide) bands across each feather that extend slightly onto inner web; rest of inner web, white and, on inner primaries, drop-shaped markings at tips larger, c. 6 mm wide. Outer primaries (p4–p6 to p10) as inner primaries but with 4–5, and slightly broader (10–15 mm wide), bands that, except for outermost 2–3, extend just onto inner web, and on outermost 2–3 extend to inner edge; rest of inner web, white; and drop-shaped markings become smaller, from 5 mm to 2 mm wide; a few birds lack droplet markings on primaries and tips patterned with brownish grey, vermiculated with white. In Taylor's sample, primaries had 3–6 bars, typically five, and secondaries 2–5 bars, typically 3–4 (see Sexing). On folded wing, buff areas typically concentrated in three main areas: more-or-less solid band of colour through anterior lesser secondary coverts (bordered by narrower white leading edge to innerwing); irregular large buff patches on mainly basal parts of median and greater secondary coverts, which, with buff band on lesser coverts, often show as broad panel of alternating patchy grey and buff lines across secondary coverts; and obvious buff patch on leading edge of wing (on basal half of broadly grey-tipped greater primary coverts); folded primaries appear slightly paler buff with fine dark vermiculations and usually clear dark

barring but folded secondaries usually lack obvious barring. **UNDERWING:** Ground-colour of coverts and remiges, white; in darkest birds, washed with cream (pale 54). Coverts variously speckled with black-brown (19–119), formed by small spot or fleck at tip of each covert; in most, spotting or flecking confined to secondary coverts and central lesser primary coverts, but sometimes distributed over all except outermost greater primary coverts. Flecks usually <1 mm wide and c. 2.5 mm deep, but, in some birds, flecks larger on greater coverts (all except outermost) and become striations on rest of marked coverts. Outermost 2–4 greater primary coverts have broad, c. 15 mm wide, pale brownish grey (ne) tips. Remiges, patterned with darker tips and bands, like on upper surface, but most bands covered by overlapping remiges. Outer primaries have 4–5 narrow (c. 5 mm wide) pale grey-brown (ne) bands, most obvious on p10; inner primaries and secondaries have only 1–2 faint bars, near tip of feathers. Tips of primaries and all secondaries, pale grey-brown (ne) with grey-brown (ne) to brown (pale 28) vermiculations, and drop-shaped marks as on upper surface of remiges, though dark bases much paler grey-brown (ne).

Adult female (Definitive basic). Much overlap with adult male (see Sexing). Differences from adult male: **HEAD AND NECK:** Colour of facial disk varies: typically cream (54), paler cream (pale 54) or off-white (ne); disk usually darker than in male, but darkest males match darkest females; in palest females, disk white, like that of typical male. Teardrop-shaped patches round eyes slightly larger, and extend 15–20 mm from bottom of eyes. Ruff bordering facial disk averages darker, with little or no white, and more dark brown (21), grey-black (82), pale yellow (157) or cream (54); ruff more complete than in male, but never complete. Forehead, crown, nape and hindneck as in male, but centres of feathers more buff (dull 53) or yellow-brown (123C) (rarely cream as in adult male) and more exposed than in male; and drop-shaped markings larger, c. 3 mm wide. Foreneck and throat often washed cream (c54), and often have small grey-black (82) speckling in centre of foreneck and, in some, on all of foreneck and throat. Sides of neck like male, but usually more speckled and more often cream (pale 54). In nominate *alba* of Europe (Taylor 1993) and subspecies *stertens* of India (Kanakasabai *et al.* 1996), most males have white extending up sides of neck and females have light brown or buff in this area; this not seen to be as reliable in *delicatula*. **UPPERPARTS:** Like adult male but buff (124) or yellow-brown (123C) centres to feathers more obvious and often brighter. Drop-shaped marks slightly larger, 3–4 mm wide. **UNDERPARTS:** Ground-colour typically darker, and spotting, flecking and streaking heavier, but much overlap (see Sexing). Ground-colour typically pale cream (pale 54) throughout; in darker birds, ground-colour cream (54); rarely, in palest birds, white (as in male). In museum skins, spotting, flecking and streaking typically covers whole underparts, including centre of underbody, undertail-coverts and feathering of legs; in palest birds, spotting and flecking confined to flanks and breast, mostly at sides and just meeting in centre of breast. Dark markings usually larger than in male, and usually largest on base of thighs. In Taylor's sample, no significant differences between males and females in number of flecks on underbody, but flecks significantly larger in female; females also had significantly more flecks on legs (see Sexing). **UPPERTAIL:** Varies considerably and some females approach colour and pattern of adult males. Typically, ground-colour brighter, more often buff (124) to yellow-brown (123C); and bands on outer rectrices more complete, almost reaching edge of t6; edges of rectrices where not banded, white. **UNDERTAIL:**

Like male. **UPPERWING:** Very like male, but slightly brighter overall, with more yellow-brown (123C–123D). Drop-shaped marks better defined and slightly larger, 3–4 mm wide. Remiges tend to be brighter, yellow-brown (123C) to light brown (223D) in centres, and bands are slightly broader and better marked. **UNDERWING:** Patterned much as adult male. Ground-colour more often washed cream (pale 54), and is usually wholly brighter cream (54). Typically, all coverts have heavier dark spot, fleck or streak at tip: markings range from small, <1 mm wide, to quite large, c. 5 mm wide, and largest on outermost greater coverts (>5 mm wide); typically, all coverts marked but at palest, extent of markings similar to that of typical adult male. Bands on remiges, especially outermost primaries, usually slightly better marked and more complete.

Downy young Said to hatch in short white neoptile down (Schodde & Mason; Hollands). Then acquire longer, white or pale grey (pale 86) mesoptile down (photos in Fleay; Aust. RD; Hollands; Strahan) at 10–12 days old (Schodde & Mason); also claimed to be cream (Schodde & Mason), but possibly refers to extralimital taxa.

Juvenile male Like adult male, but tends to be orange-buff (153), buff-yellow (53) to yellow-brown (123C–123B) on upperparts and tail. In fresh plumage, 5–7 inner primaries have broad (2–5 mm wide) and neat, pale-grey (pale 86) fringes at tips. Down retained in patches on plumage after fledging: on head, neck and body, particularly crown, back and breast (Fleay; Schodde & Mason; Hollands); appeared to retain down on feathered legs when little down remained on rest of body (this study). In European populations, juveniles retain some down on hindneck, sides of breast, belly and thighs till 8–9 weeks old (BWP).

Juvenile female Like adult female; differs from adult female in same way juvenile and adult males differ.

BARE PARTS Based on photos (Wade 1975; Morcombe 1986; Trounson & Trounson 1987; Lindsey 1992; Flegg & Madge 1995; Fleay; Aust. RD; NZRD; Hollands; Strahan; unpubl.: D.J. James). Sexes similar. **Adult** Bill and cere vary from white or pinkish white (ne) to whitish pink (whitish 3). Iris, dark brown (221). Orbital ring and nictitating membrane, dirty pink (4). Lower tarsi and feet vary, from dull pink (dull 3), dirty pink (4), light brown (123A) to cream (54); claws, black (89) to dark grey (83) with black (89) tips. **Downy young** Naked skin of face, dull salmon (dull 106). **Juvenile** Orbital ring and nictitating membrane, pinkish grey (ne). Legs and feet, cream (92) to pale dirty pink (pale 4); extraliminally, legs and feet of juvenile duller than in adult (BWP) but differences not obvious in Aust. material. Rest as adult.

MOULTS Based on examination of 25 adult and 41 juvenile skins from Aust. (ANWC, HLW, MV), but little information available. Extraliminally, detailed studies in Europe (nominate *alba* and subspecies *guttata*) and Malaysia (subspecies *javanica*) (Piechocki 1974; Schonfeld & Piechocki 1974; Lenton 1984; Taylor 1993; BWP), partly summarized below. **Adult post-breeding** (Definitive pre-basic). Poorly known in HANZAB region; following mostly a summary from extralimital data (as above) unless otherwise stated. Slow staffelmauser. Moults prolonged, taking 2 or more years to finish. In a year, moult some primaries and secondaries, some or all rectrices, and probably all of body. Successive series of primary-moult start at p6, and progress inward and outward (centrifugally); duration 2 or more years. First-basic p6 replaced in fifth calendar year, while still replacing last juvenile primaries. In Europe, adults often have

2–3 series of primaries in active moult, producing complex patterns of different generations of feathers in wing. In Aust. very few adults in primary-moult; those that were moulting showed similar sequence to that of European birds and had complex patterns of moult (e.g. $O^14^13^1N^62^1$, $O^31^1N^33^1O^2$); and some had suspended or stopped moult after replacing 1 ($n=1$), 2 ($n=3$), 3 ($n=1$) or 4 ($n=1$) primaries. In Europe, secondaries moult from three loci: s12, s5 and s2. Moult of rectrices irregular, usually starting with t6, followed by t1, t2 or t3; rectrices usually replaced in 1 year, sometimes over 2. In Aust., no obvious pattern to moult of tail, and rectrices replaced asymmetrically. Few data on moult of body (and no extralimital information). Of Aust. skins, active moult of body recorded Feb. ($n=1$), Mar. ($n=1$), July ($n=3$) and Oct. ($n=1$); active primary-moult recorded July ($n=2$), Aug. ($n=1$), Oct. ($n=1$); skins with no moult recorded Jan. ($n=1$), Mar.–Sept. ($n=18$). **Post-juvenile** (First pre-basic). Staffelmauser. Virtually no information for Aust. Of 41 Aust. skins (from all months except Mar.), only one, from Apr., in moult: of primaries (starting at p6), rectrices (at t6), and body (with breast, throat and mantle actively moulting). Following extralimital data unless otherwise stated (as above). Similar to adult post-breeding, but takes longer to replace all feathers. Number of feathers moulted each year varies with age: none to several primaries, none to all rectrices, varying number of secondaries, and none to all of body. Do not begin moult till second or third calendar year. Primaries usually start with p6 (Lenton 1984; BWP), occasionally p7 (Schonfeld & Piechocki 1974). Moult of secondaries and tail similar to that of adult. Post-juvenile moult of primaries finished in fifth calendar year; secondaries in fourth calendar year; and rectrices over second or third calendar year; body often finished after second year, but sometimes takes till third year.

MEASUREMENTS Subspecies *delicatula*: (1–2) Throughout Aust., skins; Bill CB = Length of bill from tip to base of cere; Mid-Claw = Length of claw from tip to skin (ANWC, HLW, MV, QM): (1) Adults; (2) Juveniles. (3) Throughout Aust., adults, frozen and thawed specimens before preparation; Bill WB = Width of bill at base; Bill DN = Depth of bill immediately anterior to the nostril (S. Taylor).

	MALES	FEMALES	
WING	(1) 281.3 (6.79; 268–291; 23)	285.0 (5.28; 280–296; 23)	*
	(2) 276.9 (4.83; 265–288; 35)	283.0 (4.01; 274–294; 63)	**
	(3) 281 (6.0; 270–279; 22)	278 (6.0; 265–289; 21)	ns
TAIL	(1) 115.4 (4.24; 107–123; 23)	117.3 (3.27; 111–126; 23)	ns
	(2) 112.4 (2.88; 106–119; 34)	115.7 (3.57; 106–127; 63)	**
	(3) 120 (2.0; 115–125; 22)	121 (4.0; 115–125; 21)	ns
BILL S	(1) 33.6 (1.55; 30.5–36.8; 22)	34.5 (1.82; 30.2–37.9; 21)	ns
	(2) 33.1 (1.51; 29.9–37.1; 34)	33.6 (1.50; 31.4–38.3; 58)	ns
BILL C	(1) 21.0 (0.77; 20.1–23.2; 22)	21.8 (0.87; 20.2–23.3; 22)	**
	(2) 20.7 (0.73; 18.3–21.9; 34)	21.3 (0.82; 19.4–22.9; 62)	**
	(3) 20.9 (0.8; 18.5–22.4; 22)	21.4 (1.1; 18.4–22.9; 21)	ns
BILL DN	(3) 12.9 (0.5; 11.9–14.0; 22)	13.0 (0.6; 12.0–14.3; 19)	ns
BILL WB	(3) 10.4 (0.6; 9.6–11.9; 22)	10.8 (0.7; 10.0–12.9; 20)	ns
TARSUS	(1) 62.9 (1.42; 59.7–65.3; 23)	62.3 (1.75; 57.6–65.0; 23)	ns
	(2) 61.8 (1.70; 58.7–65.4; 34)	62.0 (2.35; 56.2–68.3; 61)	ns
TOE C	(1) 43.8 (2.31; 40.7–46.2; 4)	45.5, 46.5	
	(2) 44.5 (1.88; 41.1–47.2; 7)	44.2 (2.20; 41.2–48.4; 9)	ns
TOE	(3) 31.1 (1.1; 28.9–33.1; 22)	31.1 (2.1; 23.1–33.4; 21)	ns
MID-CLAW	(1) 18.2 (0.87; 16.0–19.9; 23)	18.3 (1.57; 16.4–22.6; 21)	ns
	(2) 17.5 (0.91; 15.5–19.5; 33)	17.5 (0.96; 15.7–20.2; 63)	ns
	(3) 17.6 (0.5; 16.8–18.8; 22)	17.1 (0.8; 15.1–18.4; 21)	ns

Comparing samples 1 and 2, adult males significantly larger than juvenile males in Wing, Tail, Mid-Claw ($P<0.01$)

and Tarsus ($P<0.05$); adult females larger than juvenile females in Bill S and Bill C ($P<0.05$) and in Mid-Claw ($P<0.01$).

Unlike results of measurements of museum skins, Taylor found no significant differences between sexes in any measure taken, including measurements in addition to those given above (and of both right and left sides of relevant measures).

WEIGHTS Subspecies *delicatula*: (1–2) Aust., from museum labels (ANWC, MV, QM): (1) Adults; (2) Juveniles.

	MALES	FEMALES	
(1)	350.3 (47.56; 250–418; 9)	359.0 (70.39; 258–470; 13)	ns
(2)	311.8 (52.23; 244.5–380; 13)	337.3 (65.16; 266–465; 11)	ns

No significant difference between adults and juveniles.

STRUCTURE Wings, broad and fairly long, with rounded tip. Feathers have soft texture. Ten primaries: p9 usually longest, sometimes p10; p10 0–5 mm shorter, p9 0–2, p8 3–7, p7 14–25, p6 32–45, p5 53–71, p4 70–86, p3 81–101, p2 92–116, p1 101–125. No emarginations. Outer web of p10 has small serrations along edge. Sixteen secondaries, including six tertials; tip of longest tertial falls between p3 and p5 on folded wing. Tail short and square; 12 rectrices; t2 usually longest, sometimes t1, t5 or t6. One bird collected Yarrowonga, Vic., had 13 rectrices (MV-R-4038); not previously noted for Barn Owl (see Parkes 1995). Head round. Skin of facial disk (beneath feathering), hardened; disk 57–69 mm wide to 42–47 mm deep; ratio of depth to width 0.64–0.79. Eyes small. Most of bill covered by bristles arising from base of bill. Orbital ring narrow. Bill laterally compressed and rather short; upper mandible, hooked. Cere well developed; nostrils open forward under front of cere. Legs long and slender; fully feathered; well feathered to about halfway along tarsus, feathering sparse and hair-like on lower half of tarsus. Toes have hair-like feathering on upper surface, reticulate scaling elsewhere. Inner toe longest; outer toe (with claw) 65–77% of inner toe, middle 94–98%, hind 59–62%. Claws moderately long; ridge or serrated flange on inner side of middle toe, serrated on distal half of ridge. Inner claw longest, outer claw 77–88% of inner, middle claw 82–93%, hindclaw 82–91%.

AGEING Tip of outermost primary very pointed in juvenile, slightly rounded in adults. In Europe, juvenile p10 retained for up to 5 years (BWP) and, if not too worn, can distinguish juveniles or birds undergoing post-juvenile moult. Young juveniles have narrower ridge on middle toe, without serration (Baker 1996), but ridge quickly becomes like that of adult. In this study, in juveniles ridge ≤ 1 mm wide; in adults, 1–2 mm wide, normally >1.5 mm. Juveniles also retain down for short time after fledging (see Juvenile male).

RECOGNITION Three *Tyto* owls with superficially similar pale plumage occur Aust.: Barn, Grass and Masked. Other than differences in plumages (which see individual accounts), differ by: (1) **FEATHERING OF LEGS**: In Barn Owl, legs well-feathered to about half way along tarsus, then feathering sparse and hair-like on lower half of tarsus; in Grass Owl, lower half to two-thirds of legs covered with sparse hair-like feathering. In Masked Owl, legs well-feathered, usually to bottom of tarsus, and most heavily feathered birds appear 'trousered'; n. subspecies *kimberli* of Masked tends to have less feathering on tarsi than other subspecies and, on some, up to c. 2 cm of base of tarsi can be nearly naked, with only sparse hair-like feathering, but still

much more feathered than Barn or Grass Owl. (2) **LENGTH OF LEGS AND FEET:** Legs of Barn much shorter than in Grass Owl, with tips of feet extending 2–4 cm past tip of tail when stretched out and held flush against tail; in Grass Owl, legs longer (and tarsi much more slender), extending 7–9 cm past tip of tail when held flush against tail. (3) **TOES AND CLAWS** of Barn Owl slightly larger and broader than in Grass Owl; shorter and more slender than in Masked Owl, which has much heavier and more powerful feet and claws (see Measurements in respective accounts). (4) **SIZE:** Barn Owl smallest *Tyto* in Aust., only smallest Masked Owls overlap with largest Barn (see Measurements). (5) **EYES:** Eyes of Masked larger than those of Barn, which are larger than of Grass Owl. Eyes of Sooty *Tyto tenebricosa* and Lesser Sooty *Tyto multipunctata* Owls larger than those of Masked, Barn or Grass (Schodde & Mason).

SEXING Detailed study of sexual differences in size and plumage characters by S. Taylor, based on examination of 43 whole, dead adult Barn Owls (frozen till examination) and dried wings of four male specimens. The frozen specimens were sexed by examination of gonads after measurements of size and plumage characters made. As stated above, there are differences between the results of Taylor's analyses and the examination of museum skins regarding both coloration of plumage and size. Plumages of males and females vary greatly, and while there are significant differences in many characters (see below), there is considerable overlap, and no one character can be used to determine sex with accuracy.

The following information based on S. Taylor's analyses (with much additional data to be included in published results). **MEASUREMENTS:** No significant differences between males and females in any measurement (q.v.). **COLOUR OF UNDERPARTS:** In both sexes, underparts varied from wholly white, to washed with cream and pale ochre, to strongly washed with ochre (=buff) over entire underbody. Males were more often at pale end of range of variation, females at darker. Numbers of birds with light, medium and dark wash to underbody: in males, 11 were classed as light, 6 as medium, and 4 as dark (n=20); in females, 6 were classed as light, 2 as medium, and 12 as dark (n=21). **FLECKING ON UNDERBODY:** In all specimens examined, including 22 males, flecking extended over entire underbody, including midline. No significant differences between males and females in number of flecks on underbody (excluding thighs and legs), though the size of flecks (both width and depth) significantly larger in females. Flecking extended to thighs of 13 males examined for this character, with no significant differences between males and females in number of flecks. However, males had significantly fewer flecks on legs and both some males (12 of 22) and females (3 of 20) had no flecks on feathered legs; mean for both legs combined: in males, 11 (16; 0–58; 21); in females, 46 (39; 0–113; 22) ($P < 0.001$). **FLECKING ON UNDERWING-COVERTS:** Males had significantly fewer flecks on primary and secondary coverts (and both combined) than females, though no males had no flecks on coverts. Mean number of flecks on primary and secondary underwing-coverts combined: males, 78 (44; 5–146; 24); females, 153 (24; 96–196; 21). Flecks also significantly larger in females, as on underbody. **BARRING ON TAIL:** Of 19 males and 17 females examined, all but one had four dark bars across both surfaces of tail; one female had three dark bars. **BARRING ON PRIMARIES AND SECONDARIES:** In 26 males and 21 females examined: most (19 males and 17 females) had five bars on primaries, with range of three to six; and three or four bars on secondaries, with range of two to four.

In large sample of museum skins, qualitative categoriza-

tion of skins (Table 3) shows that none of 87 females fell into palest categories (Types 1 and 2), and few males (5%) fell into darkest category (Type 5).

Table 3. Qualitative categorization of dark markings on underparts from museum skins (this study; birds sexed according to label.) **PLUMAGE TYPE 1:** Underparts wholly white or nearly so, with tiny dark-brown flecks confined to sides of breast. **TYPE 2:** Mostly white, with more flecking on sides of breast and flecking extending to upper flanks. **TYPE 3:** Flecks small but extensive, just meeting in centre of breast and extending down whole flanks; throat, foreneck, feathered legs, centre of belly and vent, white. **TYPE 4:** Most of underparts flecked, including a few flecks on foreneck, throat, centre of belly and base of tibia and with a few large flecks at base of flanks. Vent, undertail-coverts and most of feathered legs, unmarked. **TYPE 5:** Whole underparts heavily marked (often with large markings, especially on lower flanks), with many flecks on throat and tibia, and only tarsus unmarked.

PLUMAGE TYPE	NUMBER OF TOTAL MALES	PROPORTION OF MALES	NUMBER OF TOTAL FEMALES	PROPORTION OF FEMALES
TYPE 1	3	5%	0	0%
TYPE 2	16	26%	0	0%
TYPE 3	26	42%	5	6%
TYPE 4	14	22%	37	43%
TYPE 5	3	5%	45	51%
TOTAL #	62		87	

GEOGRAPHICAL VARIATION Cosmopolitan (except Antarctica) and many subspecies recognized, e.g. 35 (Bunn *et al.* 1982), 34 (Peters), or 33 (Prestit & Wagstaffe 1973). Worldwide, much variation in colour; darker subspecies include *guttata* from e. Europe and *javanica* from se. Asia; *pratinnicola* of N. America varies from pale to very dark; palest subspecies include nominate *alba* from w. Europe and *lulu* from islands of w. Pacific. For more information, see Prestit & Wagstaffe (1973), BWP, and references therein.

One subspecies, *delicatula* in Aust. (Mees 1964; Schodde & Mason 1997; Aust. CL). Much variation in colour and pattern of plumage in Aust., which mostly appears unrelated to geographical distribution; within an area, birds can vary from darkest to palest forms. Schodde & Mason noted slight difference between nw. WA and e. Aust. This study found no difference between n. and s. populations, in measurements or plumages.

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Barn Owl *Tyto alba* (page 930)

1 Adult male; 2 Adult female; 3 Juvenile; 4, 5 Adult

Grass Owl *Tyto capensis* (page 950)

6 Adult male; 7 Adult female; 8 Juvenile; 9, 10 Adult

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