

## 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 STRIGIDAE typical or hawk owls

Small to very large owls with forward-facing eyes within weakly developed facial disks. Vary considerably in size, from the Eurasian Eagle-Owl *Bubo bubo bubo* (66–75 cm total length and weighing 1.2–2.9 kg) to the tiny Least Pygmy-Owl *Glaucidium minutissimum* (12–14 cm total length). About 123–161 species in 22–27 genera; found on all continents except Antarctica, and on many islands. Ten species in five genera recorded HANZAB region: most in *Ninox* (five breeding species and one vagrant); monotypic Laughing Owl *Sceloglaux albifacies* of NZ extinct; one species of *Ketupu* recorded as early vagrant to Cocos-Keeling Is; one introduced species of *Athene* extant in NZ; and a species of *Strix* introduced to NZ but not established. Strigidae sometimes split into two subfamilies, Buboninae and Striginae, based on rather poorly defined differences in the structure of the ear (e.g. BWP).

The following characters differentiate Strigidae and Tytonidae (based on Sibley & Ahlquist 1990; Schodde & Mason 1997; BWP). Facial disk weakly developed (= mask) and more or less circular. Skull rather broad. Ears large, often positioned asymmetrically, with little covering or flap. Manubrium present in sternum. Metasternum deeply two-notched each side. Furcula free from carina. Oil gland (uropygial gland) naked. Emarginations on inner webs of 1–6 primaries; edges of remiges frayed. No aftershafts. Tail rounded. Feathers of tarsi point forward. Tarsometatarsus has bony ring on ventral surface of proximal end. Inner toe shorter than middle toe; claw of middle toe not pectinate.

Adults of most species have generally brown or reddish-brown plumage, often with paler barring, spotting or streaking. Face has modified feathers radiating out around eye forming small indistinct mask or facial disk. Many species (but not in HANZAB region) have flexible tufts of feathers above the eyes that are under muscular control; these possibly aid individual identification and communication (Burton 1973). All contour feathers rather soft. Iris usually rather bright, often yellow, red, or orange; other bare parts usually rather dull brown, yellow, grey or black. Sexes usually similar in plumage. Often sexually dimorphic in size, but which sex is larger varies between species. Post-breeding moult of adults complete. Primaries moult outward.

Nestlings hatch in sparse covering of natal (protopile) down. Natal down replaced in pre-juvenile moult to juvenile plumage, which on body appears very downy. This plumage often referred to as a second, mesoptile, down or a mesoptile plumage (e.g. BWP) but treated as a juvenile plumage in this work because (1) most body-feathers in this plumage are semi-pennaceous with distinct shafts and loosely knot projecting barbs and are not truly downy; and (2) the semi-pennaceous body-plumage grows at the same time as clearly pennaceous and undeniably juvenile remiges and rectrices. See Tytonidae for further discussion of pre-juvenile and juvenile plumages. Adult plumage attained at 2–15 months old (BWP). For discussion of general biology, see introduction to Strigiformes.

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*Strix novae Seelandiae* Gmelin, 1788, *Syst. Nat.* 1(1): 296 — Queen Charlotte Sound, South Island, New Zealand.

Specific epithet from Latham's (1781; *Gen. Synop. Birds* 1[1]), name 'New-Zealand Owl' for this bird (after the type-locality).

**OTHER ENGLISH NAMES** Boobook, Cuckoo, Mopoke or Morepork; Boobook, Red Boobook, Cuckoo, Fawn-bellied, Marbled, Spotted, New Zealand, Norfolk Island, Tasmanian, or Tasmanian Spotted Owl; Lord Howe, Norfolk Island, Northern, Jungle, or Red Boobook.

**POLYTYPIC** Nominate *novaeseelandiae*, NZ; subspecies *ocellata* (Bonaparte, 1850), NT, much of Qld, SA, WA and Sawoe I.; *boobook* (Latham, 1802), Vic., NSW, s. Qld, e. SA; *lurida*, De Vis, 1887, ne. Qld; *leucopsis* (Gould, 1838), Tas.; *albaria*, Ramsay, 1888, Lord Howe I.; *undulata* (Latham, 1802), Norfolk I. Extraliminally: *plesseni*, Stresemann, 1929, Alor; *fusca* (Vieillot, 1817), Timor; *moae*, Mayr, 1943, Moa, Romah and Leti; *cinnamomina*, Hartert, 1906, Babar; *remigialis*, Stresemann, 1930, Kai Is; *rotiensis*, Johnstone & Darnell, 1997, Roti I.; *pusilla*, Mayr & Rand, 1935, s. New Guinea.

**FIELD IDENTIFICATION** Length 30–35 cm; wingspan 56–82 cm; weight: male 250 g, female 315 g; size varies greatly between subspecies and also between sexes (see Measurements, Weights and Geographical Variation). Smallest hawk-owl of mainland Aust., and only *Ninox* in NZ. Small hawk-owl, with rather large head, short rounded wings and short tail, giving rather compact appearance. In Aust., much smaller and more compact than Barking Owl *Ninox connivens*; in NZ, similar in

size to Little Owl *Athene noctua*. Adults show distinctive combination of dark-brown to pale sandy-brown upperparts, with varying buff-white or white streaking or spotting or both; usually distinct dark mask, with characteristic spectacled appearance; white underbody with varying dark streaking and pale spotting or, in darkest birds, mainly dark underbody with much white spotting; and light greenish-grey to bright-yellow eyes. Familiar disyllabic *boobook* or *morepork* call diagnostic.

Sexes alike in plumage but differ slightly in size; not always reliably separable in field. No seasonal variation. Juvenile distinct, with downy, white or grey plumage of head, neck and underbody. Immature very similar to adult, and not reliably separable in field. **GEOGRAPHICAL VARIATION:** Marked variation in size, darkness and colour of plumage, extent and colour of pale spotting or streaking above and below, prominence of dark mask, and colour of iris and feet. Six extant subspecies in HANZAB region: **SUBSPECIES BOOBOOK** occurs se. mainland Aust.; large and dark, with varying pale streaking and spotting above, streaked or streaked and spotted below, obvious white X in face and pale border to mask, and greenish-grey to dull-yellow eyes. **SUBSPECIES OCELLATA** widespread throughout mainland Aust.; smaller than *boobook*, and much paler and more rufous-toned, usually with well-streaked underbody and prominent pale border to mask; plumage varies greatly with environment, with birds of humid forests of sw. Aust. generally dark (similar to *boobook*), those of arid woodlands much paler and more washed out, especially dorsally (and paler than palest *boobook*). **SUBSPECIES LURIDA** restricted to rainforests of ne. Qld; small, dark and usually reddish-toned, with little pale spotting above and often much spotting below. **SUBSPECIES LEUCOPSIS** breeds Tas., and some migrate to mainland se. Aust. in autumn–winter, distribution then overlapping with *boobook*; small and dark, with usually much white spotting above and below, and yellow to orange-yellow eyes (see below for detailed field differences between *leucopsis* and *boobook*). **NOMINATE NOVAESEELANDIAE** of NZ, small, with much spotting and streaking above and below, with rich-buff ground-colour to underbody, bright-yellow eyes, and pale to bright-yellow feet. **SUBSPECIES UNDULATA** of Norfolk I., small and dark, with much spotting. Pale and dark extremes of species described below. **Adult male** Ground-colour of head, neck and upperparts, brown (varying from pale sandy-brown to grey-brown, warmer dark reddish-brown or cold dark brown). Pattern of head, neck and face varies: all have dark facial mask (usually slightly darker than crown but concolorous in some), bordered by varyingly conspicuous pale spectacles, continuous with similarly pale X-shaped marking on face formed by whitish supercilia, patch on lower forehead, and through lores (X-shaped marking indistinct in NZ). Cap, nape and hindneck varyingly streaked and spotted paler: in palest birds, pale streaking of forehead grades into copious white to buff-white spotting over rest of cap, nape and hindneck and sometimes onto upper mantle, or, exceptionally, over entire mantle, back and rump; in others, hindneck heavily streaked or spotted buff-white, leaving rest of cap uniform dark brown; or pale markings confined to buffy streaking on forehead and a little buff-white streaking or spotting on hindneck; darkest have no pale streaking or spotting. Upperbody and secondary coverts of upperwing varyingly marked with white (in concert with head and neck): from large and prominent spots on outer scapulars, coverts and tertials to only a few white spots on outer scapulars and little or none on coverts, so that tracts appear rather uniformly dark; in NZ, rest of saddle liberally and finely spotted dull buff. Remiges narrowly barred light grey-brown. Uppertail varies from usually rather uniform dark brown to obviously, diffusely and narrowly barred light grey-brown. Underbody varies; typically white with bold thick dark-brown to dark red-brown streaking, heaviest on foreneck and upper breast, often grading to narrower streaking lower down, and with noticeably spotted pattern to lower breast, belly and flanks; in NZ, ground-colour of underbody, rich buff. Undertail, dark silvery-grey with faint narrow paler barring. Underwing-lining mostly buff with fine dark streaking, heavi-

est on primary coverts; rest of underwing (including greater coverts in some subspecies), dark brown with bold white barring. Bill and cere: in Aust., light blue-grey, grading to black on tip of upper mandible; in NZ, bill light bluish-grey, grading to off-white or pale yellow on tip of upper mandible (and some have grey-black cutting edges to mandibles) and cere mostly bright yellow, but light yellow-green or yellow-brown in some. Iris varies: light greenish-grey, dull straw-yellow, bright yellow, or orange-yellow in Aust. and NZ; much duller, cream, on Norfolk I. Orbital ring, dark grey. Legs fully feathered, buff. Feet: in Aust., light grey or pink-brown; in NZ, bright to pale yellow, with greenish tinge in some. **Adult female** In any subspecies, tend to have more pale streaking and spotting on cap to mantle, and to be more streaked below; also slightly bigger. However, much variation and overlap and not reliably separated in field. **Juvenile** Newly fledged young differ from adult by: soft and downy texture to otherwise adult-like upperbody; mostly white or brownish-white downy head and neck, except for adult-like plumage on crown and prominent large circular dark mask; downy white underbody marked with narrow dark-brown streaks and varying brown wash, both strongest on foreneck, breast and midline of belly; and pale pink to yellow feet. Downy texture of plumage retained longest on head and breast and lost fully 3–5 months after fledging. Calls also differ (see below).

In se. Aust., in autumn–winter, some non-breeding migrant subspecies *leucopsis* occur mainland se. Aust. (mainly Vic., but also recorded central coastal NSW) within range of widespread and abundant subspecies *boobook*. In field, adult *leucopsis* best distinguished from adult *boobook* by combination of: (1) **HEAD AND NECK:** Ground-colour of head, neck and facial mask very dark brown, as rest of upperparts, with faint or no contrast between mask and cap (usually obvious in *boobook*). Invariably have obvious white facial markings and supercilia as in *boobook*, and though always show obvious pale border to dark mask, border often has a more spotted pattern (cf. more streaked or solidly white in *boobook*), at least round top outer corner of dark mask. Extent and colour of pale spotting on cap, nape, hindneck and upper mantle vary: most have copious and rather fine clean white spotting over entire cap, nape and hindneck, extending onto upper mantle in some and, exceptionally, over entire mantle, back and rump; darkest birds have white spotting confined to narrow zone on upper forehead and sparse on hindneck, leaving rest of cap and nape uniformly dark brown; these extremes linked by range of intermediates with moderately dense spotting on upper forehead and in broad band across hindneck. Some *leucopsis* can be confused with those *boobook* with pale streaking or spotting or both on cap, nape and hindneck and upper mantle, though *leucopsis* invariably differ in having a spotted pattern (never a streaked or streaked-and-spotted one like *boobook*), and pale spots are usually clean white or, rarely, dull buff-white (pale markings on *boobook* always clearly duller, buff-white to buff); note that difference in colour of spots, though usually obvious in close views in daylight, may be impossible to discern in spotlight views at night. (2) **UPPERPARTS:** Ground-colour of upperbody and secondary upperwing-coverts very dark brown, appearing colder and less red-toned, and noticeably darker than *boobook* (but some overlap with darkest *boobook*); amount of white spotting on outer scapulars and secondary upperwing-coverts varies much as in *boobook*, but those birds with dense white spotting on cap to mantle typically appear more densely spotted white on scapulars and coverts than *boobook*. (3) **UNDERBODY:** Ventral pattern varies from streak-spotted to spotted as in *boobook*, but ground-

colour averages darker and 'colder' brown, with many appearing much more heavily and finely spotted below. (4) IRIDES: Much brighter yellow or orange-yellow (cf. duller light greenish-grey to dull straw-yellow or, rarely, orange-buff in *boobook*). (5) SIZE: Although difficult to judge without direct comparison (and especially so in spotlight views), markedly smaller size of *leucopsis* may sometimes be evident, particularly in males, some of which are tiny in comparison with average *boobook*.

**Similar species** In Aust. and NZ, should not be confused with other species, at least if seen well; distinctive *boobook* or *morepork* call diagnostic. In Aust., especially in N, could be confused with **Barking Owl** in brief or poor views; see that account. Could also be confused with **Brown Hawk-Owl** *N. scutulata* in poor views, but *Boobook* easily distinguished by: (1) squat appearance, with proportionately bigger head, shorter wings and tail; (2) always distinct and obviously pale border to mask (mask of Brown indistinct, never with pale border); (3) forehead, nape and hindneck and sometimes entire cap often streaked or spotted buff (always uniformly dark in Brown); (4) generally paler brown to reddish- or sandy-brown upperparts, liberally spotted white on outer scapulars and secondary coverts (Brown has much darker brown and more uniform dorsum, never with pale spotting on coverts); (4) generally narrower ventral streaking; (5) much duller yellowish or greenish-grey eyes; and (6) different call. Also see Little Owl.

Occur in almost any wooded habitat with trees containing hollows suitable for roosting and breeding, including rainforest, forest and woodland. Typically seen singly, in pairs, or family groups of adult pair and up to three young. Roost mainly in densely foliated trees but sometimes also on ledges and in caves, particularly in treeless areas; roost often betrayed by presence of whitish excreta and regurgitated pellets littering foliage or ground beneath or at site. Often allow close approach at night and during day, to within 1–3 m; though birds encountered by day sometimes shy, tending to flush at first sign of danger unless tending young, when generally sit tight. Mainly nocturnal, but sometimes active at dawn and dusk; in NZ, also active during day. Hunt mainly by perch-and-pounce method; also sally for insects. Flight-silhouette compact, with short, broad and rounded wings, and short tail. Flight goshawk-like, with strong snappy wing-beats; glide on slightly arched wings and swoop up to perch; very manoeuvrable in flight and can turn rapidly when hunting. Main call uttered by adult is diagnostic two-note hooting *boobook* or *morepork*; uttered repeatedly, sometimes for hours and often audible up to 1 km or more. Adult also utter variety of other growling, purring and chirruping calls (see Voice). Begging Call of dependent young a gentle high-pitched cricket-like trill, often uttered continuously at night.

**HABITAT** Most habitats with trees, from arid-zone woodland and shrubland to tropical rainforest; avoid treeless deserts of arid zone. Occur from coasts, including offshore islands, to treeline in alpine areas in Aust. and NZ (Challies 1966; Gall & Longmore 1978); once among boulders above treeline at top of Mt Wellington, Tas. (Tas. Bird Rep. 11); in temperate, subtropical, tropical, semi-arid and arid regions. In AUST., mostly in woodland and forest dominated by *Eucalyptus*; in semi-arid zone, also inhabit mallee woodland, Mulga *Acacia aneura* woodland-scrubland, or scrubland dominated by *Callitris*, *Acacia* or casuarina (Kinghorn & Fletcher 1927; Howe 1928; Beste 1970; Hollands); in arid zone, sometimes among *Acacia* shrubland on sandhills (Cox & Pedler 1977; Hollands), and often in woodlands dominated by *Coolibahs* *E. microtheca* associated with watercourses and other wetlands (White 1921; Cox & Pedler

1977; Badman 1979, 1989; North; Hall). Subspecies *lurida* of ne. Qld confined to tropical rainforest; subspecies *leucopsis* in Tas. also occurs in temperate rainforest (Schodde & Mason; Hollands; Tas. Bird Reps 4–6); elsewhere in range, usually avoid dense or continuous rainforest except along roads (Debus 1992; Hollands). In se. NSW, said to favour more open vegetation on tops of ridges rather than more densely vegetated gullies and slopes (Kavanagh & Peake 1993a,b); in ne. NSW, most common in mosaic of moist and dry forest (NSW NPWS 1994). Often in remnant patches of vegetation, including well-wooded farmland; in windbreaks; parks and gardens in urban areas; golf courses; orchards and plantations of pines *Pinus* (Morris 1975; Fielding 1979; Friend 1982; North; Schodde & Mason; Hollands; S.J.S. Debus). Sometimes recorded in scrubland dominated by *Banksia-Leptospermum-Melaleuca*; among casuarina in coastal sand-dunes; and mangrove forests (Agnew 1913; Le Souëf & McPherson 1920; Fletcher 1924; Kilpatrick 1934; Frith & Calaby 1974; North); once recorded on buttongrass plain (Tas. Bird Rep. 4). In NZ, mostly in native forests, such as those dominated by beech *Nothofagus*, or mixed podocarps *Podocarpus*, rata *Metrosideros* and hardwoods (Challies 1962; Williams & Harrison 1972; Guest 1975; Imboden 1975; St Paul 1977; Dawson *et al.* 1978; O'Donnell 1980; Fitzgerald *et al.* 1989; CSN 30); also at edges of forest or in remnant patches (St Paul 1977; CSN). Sometimes in scrub; farmland with shelterbelts; or plantations of exotic trees, such as pines (O'Donnell 1980; CSN 19 Suppl.); or in orchards (CSN 38). Often in urban areas with parks and gardens (O'Donnell 1980; Guest & Guest 1993; CSN). Once among mangroves (CSN 31). On NORFOLK I., mostly inhabit remnant rainforest with scattered tall emergent Norfolk Island Pines *Araucaria heterophylla* and open understorey (Schodde *et al.* 1983; Olsen 1996). Formerly inhabited forest on LORD HOWE I. (Garnett 1993). Occasionally land on boats well out to sea (North; CSN 19); often beachcast in NZ.

In Aust. and NZ, breed in most habitats in which recorded provided there are hollow-bearing trees. Usually in hollows in trees but sometimes among epiphytes in forest. In NZ, on some islands with few tree-hollows, recorded breeding on ground, beneath rocks, roots of plants, among tree-ferns or among fallen fronds, and in burrows of petrels (Ramsay & Watt 1971; Anderson 1992; Stephenson 1998). See Breeding for details.

Forage in most or all habitats in which recorded; possibly in more open habitats than used for roosting (Bravery 1970; Imboden 1975). Often forage in open near trees, including edges of forests or in clearings within forests, and often along roads (Hyem 1979; Hughes & Hughes 1984; Schodde & Mason; Hollands; CSN). Also forage at artificial sites where concentrations of prey available, such as mice round haystacks or insects attracted to lights (Wilkinson 1924; Schodde & Mason; Hollands; CSN). May occur on treeless plains during plagues of insects or rodents (Maher 1992; Hollands). Take prey aerially, sometimes flying up to several metres above tree-tops; from ground; and from crowns and foliage of trees and shrubs (Pizzey 1958; Sharland 1958; Sibson 1989; Ralph 1994; Debus 1996; Peter 1997; S.J.S. Debus; see Food). May perch on emergent branches above tree-tops between sallies for prey (Stephenson 1998).

In Aust., usually roost in tree-hollows or among dense foliage of trees and shrubs, including among epiphytes or tangles of vines in trees (M'Lean 1911; Lord 1956; Imboden 1975; Boekel 1980; Roe & Roe 1998; North; Hollands); in study in NZ, all roosted on branches (Stephenson 1998). Presence of overhead cover possibly most important feature of roost-site; roosting bird may be clearly visible from all sides but

not from above (Imboden 1975). Sometimes roost in top of treeferns, specially during rain (Stephenson 1998; Hollands; Tas. Bird Rep. 18). Sometimes roost in caves, crevices or on ledges; rarely, in animal burrows, holes in creek banks, or on exposed roots of trees (Moncrieff 1928; O'Brien 1990; Hoskin 1991; Gee *et al.* 1996; Rose 1996; North; Hollands). Once roosted among piles of felled trees in recently cleared country (M'Lean 1911). On some islands, roost on ground among grass tussocks (Sedgwick 1973; Morton & Braithwaite 1976). Sometimes roost in buildings (Fletcher 1903; Sedgwick 1974; Davies 1980; de Rebeira & Saunders 1983; Gibson 1989; Green *et al.* 1986; Schodde & Mason; Hollands; CSN). At night, often perch or loaf on elevated perches, including branches, stumps, fence posts, clotheslines and roofs. Sometimes sunbathe on ground at edge of forest (St Paul 1977; Fleay; CSN 6).

On Norfolk I., selective logging of large mature trees from remnant forest has reduced number of available nest-hollows, main cause of decline of that population (Olsen *et al.* 1989; Olsen 1996). In survey of 130 sites in Mountain Ash forests in s. central Vic., recorded at 16 sites, eight of which were in old-growth ( $\geq 165$  years old) forests, with rest in young (50 years old) stands (Milledge *et al.* 1991). Near Eden, NSW, more often recorded in mosaic of logged and unlogged areas of forest than in extensive areas of unlogged forest or regrowth (Kavanagh & Bamkin 1995); in some areas of NSW, appear not to be affected by logging (Kavanagh & Peake 1993b; NSW NPWS 1994) or only weak negative association with intensity of logging (Kavanagh *et al.* 1995). However, generally adversely affected by loss of habitat, particularly hollow-bearing trees (Stidolph 1977; McKenzie 1979; Saunders & Ingram 1995). In NZ, while said to have decreased in open parts of SI through competition with Little Owl (Turbott 1979), more likely caused by loss of habitat (B.M. Stephenson).

**DISTRIBUTION AND POPULATION** Widespread in Aust. and NZ, and Lesser Sundas; also occur s. New Guinea, where restricted to area from Bensbach R. E to Oriomo R. and N to Balimo; single record on Kai I. in s. Moluccas (Coates 1985; White & Bruce 1986).

**Aust.** Widespread throughout mainland and Tas. and on nearshore islands. **Qld** Widespread in most regions, though sparsely scattered in South-Western and Western-Central Regions, where mainly along watercourses in L. Eyre Drainage Basin (Storr 19; Aust. Atlas). Also inhabit nearshore islands, including Mornington I. in se. Gulf of Carpentaria, and islands off e. coast (Kikkawa 1976; Storr 19). **NSW** Widespread, but in Upper and Lower Western Regions mostly confined to major watercourses, including Darling and Paroo Rs (Morris *et al.* 1981; Cooper & McAllan 1995; Aust. Atlas). **Vic.** Widespread (Vic. Atlas). **Tas.** In Bass Str., recorded on King I., Furneaux Grp and some other islands (Green 1969; Whinray 1970; Green & McGarvie 1971; Pinner & Bird 1974; Thomas 1979; Aust. Atlas). Widespread on Tas. mainland (Thomas 1979; Aust. Atlas; Tas. Bird Reps). **SA** Widespread from North-East Region S to coast, and W to w. Eyre Pen. Farther W, probably absent on e. Nullarbor Plain, and sparsely scattered from Great Victoria Desert to s. Simpson Desert (Close & Jaensch 1984; Black & Badman 1986; Aust. Atlas). **WA** Widespread in most regions (Aust. Atlas); sparsely scattered records in area from Great Sandy Desert, S through Gibson and Great Victoria Deserts to Nullarbor Plain, and W to near Mt Magnet (Start & Fuller 1983; Congreve & Congreve 1985; Storr 8, 22, 26, 27; Aust. Atlas). **NT** Widespread, including nearshore islands, including Melville I. and Groote Eylandt (Haselgrove 1975;

Storr 7; Aust. Atlas); said to be absent in sandy deserts (Storr 7), but recorded in both Tanami and Simpson Deserts (Gibson 1986; Gibson & Cole 1988; Aust. Atlas).

**NZ** Widespread. **NI** Scattered records from C. Maria Van Diemen S to Karikari Pen. Widespread from 35°S, from s. Rangaunu Harbour S to s. Taranaki and E to line linking Tauranga, L. Taupo and Wanganui. More sparsely scattered farther E and S, except in area bounded by line from near Murupara, Hangaroa and upper reaches of Rangitaiki R., and in s. Manawatu, Wellington and s. Wairarapa. Also occur on many nearshore islands, including Three Kings Is, Hen and Chickens Grp, Little Barrier, Great Barrier, Mercury, Mayor and Kapiti Is (Oliver; NZ Atlas; NZCL; CSN). **SI** Mostly W of Southern Alps and other ranges in main divide. Widespread in Nelson and w. and n. Marlborough, W of line from e. Marlborough Sounds to upper reaches of Acheron and Awatere Rs, with a few scattered records E of Seaward Kaikoura Ra., from near Ward S to near mouth of Conway R. Widespread in w. and n. parts of Canterbury, S to c. 43°S, with scattered records farther S in area from near L. Coleridge, S to Springburn, E of Methven, and E to middle reaches of Ashley R. Rarely around Christchurch or elsewhere on Banks Pen.; absent from Canterbury Plains. In Otago, sparsely scattered from near Oamaru S to Milton, and in sw. Otago; more widespread in Southland. Widespread Stewart I. and associated islets, Fiordland and West Coast (Oliver; NZ Atlas; NZCL; CSN).

**Lord Howe I.** Endemic subspecies *albaria* now extinct. Last recorded in 1950s; said to have been heard in 1969, though these may have been introduced birds (Hindwood 1940; Disney & Smithers 1972; Hutton 1991; Garnett 1993; see below).

**Norfolk I.** Single female of endemic resident subspecies *undulata* survived till about 1996. After introduction of Boobooks from NZ (see below), hybrid population slowly increasing (Olsen 1996; P.D. Olsen).

**Chatham Is** Claim that subfossil remains found (Forbes 1893) considered doubtful (NZCL).

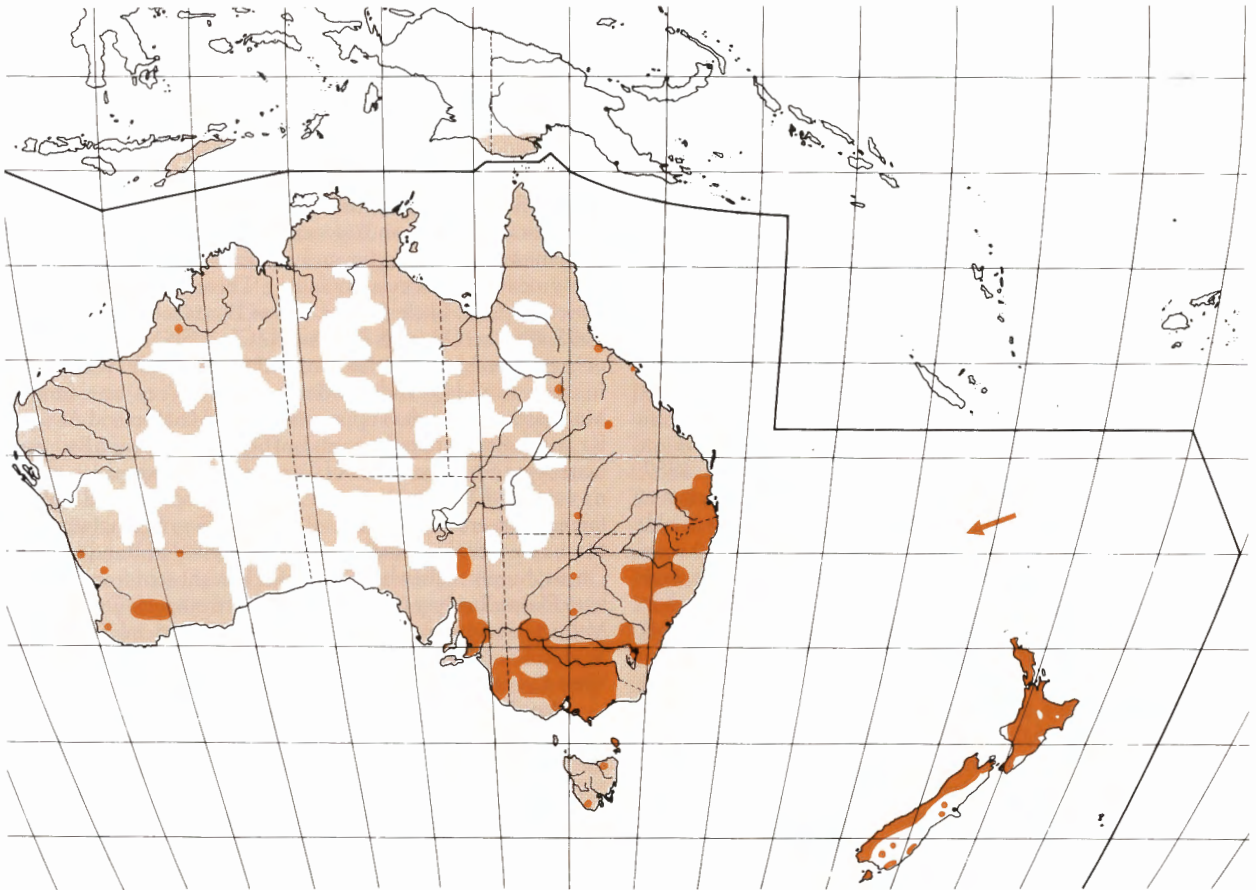
**Breeding** Probably throughout range in Aust. and NZ, though few records in n. or inland Aust. (Oliver; Aust. Atlas; NRS). Also Norfolk I. (Olsen 1996).

**Introductions** Two imported to NZ from Aust. by Otago Acclimatization Society and released at Waikouaiti in 1866; not recorded again (Thomson 1922; Long 1981). Several from NSW unsuccessfully introduced to Lord Howe I., 1922–30, to control rats (Hindwood 1940; McKean & Hindwood 1965; Long 1981). In Sept. 1987, two males imported from NZ to Norfolk I. to mate with lone bird of endemic subspecies, as a conservation measure to create and expand hybrid population (Olsen *et al.* 1989; Garnett 1993; Olsen 1996).

**Status** Extinct on Lord Howe I. (Hutton 1991; Garnett 1993). Endangered on Norfolk I. (Garnett 1993).

**Populations** Population in Tas., including islands in Bass Str., estimated at 42,500 pairs (Bell *et al.* 1996). On Norfolk I., single bird of endemic subspecies probably now gone (Olsen 1996); in late 1995, population was 13 birds, comprising single bird of Norfolk I. subspecies, single NZ bird, and 11 hybrids (Double & Olsen 1997). In Aust., recorded at densities of: 3 pairs in 26 ha, Currumbin, Qld (Fleay); 1 bird/8 ha, Inverell, NSW (Baldwin 1975);  $\geq 50$  pairs in 7360 ha, Jervis Bay, NSW (Debus 1997a); 1 pair/10 ha, Moruya, NSW (Marchant 1992);  $< 3$  territorial birds/100 ha, near Canberra (Olsen & Bartos 1997); 5 territories/km<sup>2</sup>, Boola Boola SF, Vic. (Loyn 1980). In NZ, estimated 30 pairs on Lady Alice I. (138 ha) (St Girons *et al.* 1986); estimated 40 pairs on Mokoia I. (135 ha) (Stephenson 1998); in Orongorongo Valley, two pairs in 16 ha of forest, plus





another nine birds heard calling along 4 km of adjoining road (Imboden 1975); four birds (apparently two pairs) in 100 ha of farmland in Nelson (O'Donnell 1980).

Most declines in populations caused by destruction of habitat, particularly loss of trees with hollows (see Habitat). Declines sometimes also ascribed to increased levels of competition or predation (see below), though no studies of these factors and real impact not known. In Aust., populations said to have declined in many areas, including Atherton Tableland (Bravery 1970), ne. Vic. (Traill *et al.* 1996), around Melbourne (S. Bamber), Tas. (N.J. Mooney), Murray-Mallee Region of SA (Boehm 1952) and in Wheatbelt of s. WA (Leake 1962; Masters & Milhinch 1974; Saunders & Ingram 1995). Populations in some parts of NZ, such as around Tauranga, Kawerau, L. Taupo, Masterton and Stewart I., also said to have declined (Stidolph 1977; Oliver; CSN), though numbers said to have increased on Hen I. and around Rotorua (Skegg 1964; CSN 6). In 19th century, probably occurred throughout Norfolk I. (Olsen *et al.* 1989; Olsen 1996), but after widespread clearance of forest said to have become confined to a few gullies surrounding Mt Pitt by 1907–8 (Bassett Hull 1909). Populations on Norfolk I. also substantially reduced by early scientific collecting: in 1912–13, one collector, licensed to take six specimens, took 30 from already depleted population; in 1926 seven more were taken on another expedition (Olsen *et al.* 1989; Olsen 1996). By 1960s, rarely recorded near Mt Pitt (Wakelin 1968). In 1978, total population estimated at three birds (Schodde *et al.* 1983); and by 1985, only one or two birds remained (Rooke 1986; P.D. Olsen). Current population, mostly hybrids, slowly increasing (Olsen 1996).

Declines in populations in various regions attributed, at least partly, to introduced species: in Tas., said to compete for nest-hollows with Laughing Kookaburras *Dacelo novaeguineae* and Common Starlings *Sturnus vulgaris* (Bell *et al.* 1996; Aust. Atlas); in NZ, said to compete for food with Little Owl (Moon 1967; Turbott 1979; Oliver; B.M. Stephenson) and for hollows with Common Brushtail Possums *Trichosurus vulpecula* (CSN); on Lord Howe I., said to compete with Masked Owls *Tyto novaehollandiae* for food and nest-sites, and eggs and young possibly eaten by rats (Hutton 1991; Garnett 1993); on Norfolk I., said to compete for nest-sites with Crimson Rosellas *Platycercus elegans*, Common Starlings and feral bees, as well as suffering predation by rats and cats (Garnett 1993; Olsen 1996; see also Olsen *et al.* 1989); in NZ, occasionally killed by cats (CSN 41; Oliver). Often struck by vehicles (e.g. Lindsay & Ordish 1964; Bravery 1970; Stokes 1982; Ashton 1985; Lepschi 1992; Bell *et al.* 1996; Hollands; CSN); of 50 museum specimens in Tas., 84% were killed on roads (Mooney & Hunt 1983); said that most road-kills occur in autumn (Templeton 1992). Sometimes collide with windows (Stokes 1982; Clark 1992; CSN 32); wire fences (Scarlett 1961; Lendon 1966; Baker-Gabb 1987); or overhead wires (Moncrieff 1929). Rarely, caught in rabbit-traps (Fletcher 1903). In general, rarely shot (Fletcher 1903; Wheeler 1966; Olsen 1996; North; ABBBS; S.J.S. Debus), though in NZ, shot by early settlers because Boobooks killed 'desirable' introduced species (Turbott 1979). Sometimes die after eating rats poisoned with rodenticide (Olsen 1996; QM); in NZ, three of 14 birds died of secondary poisoning after eating poisoned mice during eradication program (Stephenson 1998). Ingestion of DDT-based pesticides has caused thin-

ning of eggshells by up to 36%, though average thinning of 6% probably has no significant effect on overall populations (Olsen *et al.* 1993).

**MOVEMENTS** Based mainly on contribution by S.J.S. Debus. Not well known in Aust. or NZ. In Aust., considered resident in some areas (e.g. Garnett & Cox 1983; Durrant & MacRae 1994; Saunders & Ingram 1995), or present year-round in many areas (see below); partly migratory in S: some Tas. birds migrate to se. Aust. in winter (*contra* Green 1989); partial altitudinal movement out of highlands of SE in winter suspected; may comprise females and juveniles (Olsen & Trost 1998). In Pilbara Region, WA, considered both resident and winter visitor from S (Storr 16); may be resident and passage migrant round Perth (Storr 28). No evidence for claims in secondary sources that locally nomadic (e.g. Aust. RD; Schodde & Mason). Changes in reporting rates or detections at least sometimes result of changes in behaviour and conspicuousness (Debus 1997c; Vic. Atlas; see Voice). Single specimen from Kai Is similar to subspecies *ocellata* and may have been winter vagrant from Aust. (White & Bruce 1986).

**Aust.** Over most of mainland present all year: nw. Qld (Horton 1975); se. Qld (Passmore 1982); s. NSW (Smith 1984; Marchant 1992); sw. NSW (NSW Bird Reps); central (Roberts 1975) and s. Vic. (Batey 1907); se. highlands at 1500 m (Gall & Longmore 1978); se. (Storr 27) and sw. WA (Jenkins 1931). In e. NSW, seasonal detection indices highest in spring, lowest in winter (Debus 1997c). In s. coastal NSW, present winter to summer, with no seasonal difference in detectability (Kavanagh & Peake 1993a). At higher elevations in Vic., reporting rate lowest in winter; in lowlands, reporting rate uniform through year; overall, seasonal reporting indices lowest in winter, but not known if through movement or behavioural change (Vic. Atlas). Recorded coastal SA all months except Jan.–Mar. (Ashton 1985); not heard ne. coastal Qld, where breed, in summer (Longmore 1978). Southernmost populations partly migratory: some Tas. birds winter in Vic. and NSW (Mees 1964); claim that such migration said to have stopped in recent decades (Aust. RD; Schodde & Mason) incorrect, with recent sightings and specimens (e.g. Conole 1985; Vic. Bird Reps; R.M. O'Brien). Island-hop across Bass Str. (Aust. Atlas); specimens taken at sea in Bass Str. and off Gabo I., Vic. (Mees 1964). Some passage migration or winter residence of more s. populations also suspected in WA (Storr 9, 16, 21, 28, 35). Possibly also some altitudinal migration on se. mainland: in NSW and Vic., most often recorded autumn–winter in s. coastal urban areas (Hindwood & McGill 1958; McNamara 1974; Clancy 1977; Baker-Gabb 1984; Gould). However, at least some remain in snow-covered highlands over winter in se. Aust. at >1300 m (Schulz 1991); and some or most remain in Tas. in winter (Mees 1964).

In highlands of se. Aust., juveniles become independent late summer, when said that female leaves family group and possibly migrate (Olsen & Trost 1998). In Yarra Valley, Vic., juveniles disperse late summer–autumn (Pizzey 1958). Said that juveniles disperse locally (Aust. Atlas). Non-breeding males may occur in breeding territories, as satellites or floaters (Olsen & Trost 1998).

**NZ** Poorly known. Throughout range, generally present all year, but with regular autumn influxes to some coastal areas (Moncrieff 1929). On Mokoia I., in L. Rotorua, adults sedentary; juveniles disperse Mar.–May, usually moving to opposite side of island (Stephenson 1998). Some banded birds resident up to 5 years and high turnover of other birds (Imboden 1975).

**Banding** Of 518 banded in Aust., 1953–96, 59 recoveries (11.4%): 45 (76.3%) <10 km from banding site; 9 (15.3%), 10–49 km; 1 (1.7%), 50–99 km; 4 (6.8%) ≥100 km. Long-distance recoveries: Armidale, NSW, to Wentworth Falls, NSW (377 km, 198°, 6 months, Mar., 1+); Aitadale, near Perth, WA, to near Brunswick Junction, WA (137 km, 181°, 1 month, Aug., 1+); East Cannington, WA, to near Harvey, WA (111 km, 181°, 2 months, Sept.); Yanchep, WA, to Madora Bay, WA (105 km, 173°, 12 days, July, 2+, M). Longest lived 70 months (J. Olsen & S. Trost).

**FOOD** Carnivorous; taking invertebrates, amphibians, reptiles, but mostly small birds and mammals. **Behaviour** Nocturnal and crepuscular, but sometimes active before sunset on dull days and occasionally still actively forage at, or after, dawn (M'Lean 1911; Paton 1966; Glass 1975; Baker-Gabb 1984; North). Forage mainly in evening and before dawn and intermittently through night; often perch in middle hours of night, particularly on moonless nights (Fleay 1926; Stidolph 1931; Dove 1939; Olsen & Bartos 1997; Fleay; Schodde & Mason), when may be resting or searching for prey (Stephenson 1998). On dark nights in autumn–winter or in bad weather may return to, or remain in, roost for night, and may forage during day (McNabb 1982; Stephenson 1998; Fleay). When feeding young, forage till 01:00–02:00 or intermittently throughout night, but mainly in first hour after dark, though sometimes there are extended lulls after last light (Pizzey 1958; Beste 1970; Hollands); sometimes still forage at or after dawn (M'Lean 1911; Paton 1966; Glass 1975). In large pine plantation, one nesting bird seen possibly hunting during day in dark of plantation (Stead 1932). For details of departure from and return to roosts, see Social Organization: Roosting. Catch some birds at sunset as they go to roost (Wilkinson 1927; Davies 1980); take others from foliage roosts at night (Lane 1913; Sharland 1958; North). Foraging during day may be opportunistic or, sometimes, result of food shortages (Kilpatrick 1934; Lawrence 1959; McNabb 1982; Gould; Campbell; North; Fleay). In NZ, seen actively hunting during day, and one bird seen eating then caching fresh prey in mid-afternoon (Stephenson 1998). **FORAGING METHODS:** Mainly by perch-hunting; birds searching an area by sight or sound from elevated perch (M'Lean 1911; Mellor 1915; Baker-Gabb 1984; Debus 1997b; Olsen & Bartos 1997; Mathews); can spend long periods perched moving head rapidly, watching for movement or looking in direction of sounds (Stephenson 1998). At dusk, change perch every few minutes, flying 10–20 m between perches; later in night, perch for up to 30 min at a time, and fly farther, traversing territory (Imboden 1975; Olsen & Bartos 1997; Stephenson 1998). Catch insects attracted to lights (Dove 1939; Pizzey 1958; McCann 1959; Rose 1973; Boekel 1980; Frauca 1980; Hollands); catch mice flushed by agricultural activities (Wilkinson 1924); attack birds caught in mist-nets (Imboden 1975). Suggested that learn to activate movement-sensitive lights so as to attract prey (Debus 1991). Locate cicadas in foliage by their rustling sounds (Pizzey 1958), and may flutter into foliage to disturb cicadas (Stephenson 1998). **CAPTURE METHODS:** Seize prey by sallying: sally-strike individual prey in air; sally-strike by direct flying attack from foliage; or sally-pounce to catch prey on ground (Lane 1913; Oliver 1922; Fleay 1926; Stidolph 1931; Dove 1939; Roberts 1957; Pizzey 1958; McCann 1959; Beste 1970; Clancy 1977; Frauca 1980; Sibson 1989; Ralph 1994; Debus 1996, 1997c; Olsen & Bartos 1997; Hollands). When sallying for insects from perches, fly every few seconds over 1 min (Debus 1996), or once every 3 min over 15 min (Debus 1997b);

seen to catch flying insects up to 100 m away by this method (Stephenson 1998). Also flush-pursue insects by crash-landing in foliage, or by beating foliage with wings (Pizzey 1958; Ralph 1994; Debus 1996; Peter 1997; Stephenson 1998). Once seen catching House Sparrows *Passer domesticus* by thrusting itself into foliage (Sibson 1989). Sometimes flying insects caught with bill (Stephenson 1998). **KLEPTOPARASITISM:** Once attempted to snatch live Silvereye *Zosterops lateralis* from person's hand (Cunningham 1948); once seen chasing Tawny Frogmouth *Podargus strigoides*, which had large centipede in bill, from tree to tree (Maher 1988). **HANDLING OF PREY:** Prey seized in feet, then transferred to bill at perch or on ground; eaten at perch or sometimes on ground (Fleay 1926; Dove 1939; Moon 1967; Frauca 1980; Stephenson 1998a; Fleay; Schodde & Mason; Hollands; S.J.S. Debus). Eat invertebrates by lifting them in foot to bill (Stidolph 1931; Stead 1932; McCann 1959). Vertebrates killed by clutching them in feet and biting through neck at base of skull; crush skull and main bones with bill; swallow prey whole if small, pluck and dismember if large (Fleay 1926; Fleay). Claim that rats sometimes skinned from neck down by anchoring in feet or wedging in tree-crotch (Oliver; St Paul 1977) doubtful; usually just tear pieces from prey (Stephenson 1998). Small prey carried in bill, large prey carried in feet (Beste 1970; Hollands). Cache surplus prey or daytime captures outside nest (e.g. end of a broken branch 3–4 m above ground) or in crevices inside nest-hollow (Stead 1932; Stephenson 1998; Campbell; Fleay). **PELLETS:** Ejected at roost during day (Chandler 1944; Fleay), in afternoon (Cunningham 1948); sometimes at night (Olsen & Bartos 1997); in NZ, usually within 1 h of leaving roost in evening (Stephenson 1998).

**Adults Aust.** ON N. COAST OF NSW, WINTER (60 items from 17 pellets; Campbell & Rose 1996): **INSECTS:** Unident. 2% no.; Coleoptera: unident. beetles 7; Carabidae 23; Curculionidae 2; Elateridae 2; Scarabaeidae: *Heteronychus arator* 38; unident. scarab beetles 5; Orthoptera 18. **MAMMALS:** Marsupials: Dasyuridae: Brown Antechinus *Antechinus stuartii* 2; Eutherians: Muridae: Swamp Rat *Rattus lutreolus* 2.

IN E. NSW (20 stomachs, from 20 localities; Rose 1996, incorporating data of Rose 1973): **SPIDERS:** Araneae: 35% freq. **INSECTS:** Blattodea: cockroaches 20; Coleoptera: beetles 60; Curculionidae 5; Lepidoptera: moths 75; Mantidae: mantises 5; Orthoptera: crickets and grasshoppers 60; Phasmatodea: Phasmatidae: stick insects 15. **BIRDS:** Common Starling 5. **MAMMALS:** Muridae: House Mouse *Mus domesticus* 1.

Also in E. NSW (12 pellets collected from 10 localities; Rose 1996): **SPIDERS:** Araneae: 17% freq. **DIPLOPODS:** millipedes 8. **CRUSTACEANS:** Decapods: crabs 8. **INSECTS:** Blattodea: cockroaches 8; Coleoptera: beetles 92; Hemiptera: Cicadidae: cicadas 8; Formicidae: ants 8; Lepidoptera: moths 42; Orthoptera: grasshoppers and crickets 33; Phasmatodea: Phasmatidae: stick insects 8. **REPTILES:** Lizards: Scincidae and Agamidae 17. **BIRDS:** Common Myna *Acridotheres tristis* 8; small birds 42. **MAMMALS:** Marsupials: Dasyuridae and Petauridae 25; Eutherians: Chiroptera: Bats 25; Leporidae: European Rabbit *Oryctolagus cuniculus* juv. 8; Muridae: small rodents 58.

IN MURRAY R. VALLEY, N. VIC. (10 items in 10 pellets; Calaby 1951): **SPIDERS:** Araneae: 1 item. **CRUSTACEANS:** Parastacidae: *Cherax* 1. **INSECTS:** Coleoptera: Cerambycidae 1; Hydrophilidae: *Hydrophilus* 2; Scarabaeidae: *Trissodon*, *Anoplognathus* not quantified; Tenebrionidae 1; Dermoptera: Labiduridae: *Labidura truncata* 2. **BIRDS** 1. **MAMMALS:** Muridae: House Mouse 1.

AT WERRIBEE, VIC. (189 items in autumn, 154 in winter; from pellets; Baker-Gabb 1984, 1985a): **ARTHROPODS** (Araneae, Coleoptera, Dermoptera) 3% no. autumn, 1% biomass autumn;

41% no. winter, 1% biomass winter; Orthoptera 67, 22; 18, 5. **BIRDS:** Small passerines (one House Sparrow, one unident.) 1, 3; 1, 3. **MAMMALS:** Muridae: House Mouse 29, 74; 40, 82.

IN TAS. (484 items from 90 pellets and loose material; % freq. calculated for pellets only; % no. calculated as proportion of all items except insects, which were in large numbers and not counted, so that % no. is considerable overestimate; Green et al. 1986): **SPIDERS:** Araneae: Ctenizidae 61% freq., 75.0% no. **CRUSTACEANS:** Decapods: Grapsidae: 1, 0.5. **INSECTS:** Coleoptera 100, not quantified. **AMPHIBIANS:** Hylidae: *Litoria ewingi* 18, 12.0. **BIRDS:** Golden Whistler *Pachycephala pectoralis* –, 0.6; Striated Pardalote *Pardalotus striatus* –, 0.2; European Goldfinch *Carduelis carduelis* 7, 1.5; House Sparrow 1, 1.7; Common Starling 2, 1.7; unident. small bird 7, 0.5. **MAMMALS:** Eutherians: Bats: Vespertilionidae: *Vespardelus* –, 0.5; Leporidae: European Rabbit juv. –, 0.2; Muridae: House Mouse 8, 5.0.; rat *Rattus* –, 0.2. (Some species of beetles listed in Other records.)

**NZ** IN TARANAKI (160 items from 19 stomachs [7 males, 10 females, 2 unsexed] in non-breeding period; Clark 1992): **SPIDERS:** Araneae: unident. 2.5% no.; Phalangiidea 1. **INSECTS:** Blattodea: Blattidae 4; Coleoptera: ad. beetles 13.0; Scarabaeidae 1; Lepidoptera: ad. moths 58, larv. 2.5; Orthoptera: Stenopelmatidae 10.5; Tettigoniidae 2.5; Phasmatodea: Phasmatidae 1. **BIRDS:** Small passerine 1.5. **MAMMALS:** House Mice 2.5.

IN MASTERTON (413 items in pellets and fragments; Cunningham 1948): **SPIDERS:** Araneae: Unident. 4% no. **INSECTS:** Coleoptera: ad. beetles 5; Lepidoptera: ad. moths 84, larv. 0.5. **BIRDS:** House Sparrow 3; Grey Fantail *Rhipidura fuliginosa* 0.5; Song Thrush *Turdus philomelos* 0.5; Unident. 1.5. **MAMMALS:** Muridae: House Mouse 1.

NI (404 items in 25 stomachs; Lindsay & Ordish 1964): **SPIDERS:** Araneae 5.0% no. **INSECTS:** Blattodea: Blattidae: *Polyzosteria* 1.5; Coleoptera: unident. ads 3.2, larv. 13.5; Cerambycidae 2.7; Diptera: Tipulidae 0.5; Hemiptera: Cicadidae 2.0; Lepidoptera: ad. moth 31.5, larv. 12.0; Hymenoptera: Oxycaenus 7.3; Noctuidae: larv 1.0; Orthoptera: Stenopelmatidae: *Hemidenia* 6.3; *H. thoracica* 9.7; Tettigoniidae: *Caedicia simplex* 2.0; Phasmatodea 1.2. **BIRDS** 0.5. **MAMMALS:** Muridae: House Mouse 0.5.

**Other records—Aust.** **ANNELIDS:** Oligochaetes: Lumbricidae<sup>33</sup>. **SPIDERS:** Araneae<sup>19,24,33,44,50,52</sup>; Heteropodidae: *Isopoda*<sup>42</sup>; Lycosidae: *Lycosa*<sup>42</sup>; Sparassidae<sup>20</sup>. **CRUSTACEANS:** Decapods: land-crabs<sup>45</sup>. **SCORPIONIDS**<sup>33</sup>. **CHILOPODS:** Centipedes<sup>50</sup>. **INSECTS**<sup>2,15,25,33,45</sup>: Blattodea<sup>36,42</sup>: Blattidae<sup>19,50</sup>; Blaberidae: *Laxta*<sup>42</sup>; Coleoptera: beetles<sup>1,5,8,19,20,21,24,28,47,49</sup>; Cerambycidae<sup>24,50</sup>; Acrididae: *Acrida*<sup>42</sup>; *Phoracantha fallax*<sup>33</sup>; *P. recurva*<sup>13,47</sup>; *P. synonyma*<sup>33</sup>; *Uracanthus*<sup>42</sup>; Chrysomelidae: *Paropsis*<sup>33</sup>; Curculionidae<sup>33,42</sup>; Elateridae<sup>24</sup>; Geotrupidae: *Elephastomus proboscideus*<sup>33</sup>; Scarabaeidae<sup>50</sup>: *Anoplognathus*<sup>36,43,50</sup>; *A. viriditarsus*<sup>42</sup>; *Aphodius tasmaniae*<sup>33</sup>; *Heteronyx*<sup>33</sup>; *Isodon pecuarius*<sup>47</sup>; *Onthophagus pentacanthus*<sup>47</sup>; *Pharochilus potilus*<sup>33</sup>; Hemiptera: Cicadidae<sup>50</sup>; Lepidoptera: moths<sup>16,19,21,43,50,52</sup>; Cossidae<sup>50</sup>; Hymenoptera: *Abantiades hyalinatus*<sup>42</sup>; Noctuidae<sup>47</sup>: *Agrotis*<sup>13,50</sup>; *Agrotis infusa*<sup>13</sup>. Mantodea: Mantidae<sup>28,49,50</sup>; Odonata; Orthoptera: grasshoppers and locusts<sup>1,5,8,19,26,28,44,45,49,51</sup>; Acrididae<sup>42,50</sup>; Gryllacrididae<sup>36,50</sup>; Gryllidae<sup>50</sup>; *Teleogryllus commodus*<sup>42</sup>; Gryllotalpidae<sup>33,42</sup>; Tettigoniidae<sup>19,40,42,50</sup>; *Caedicia*<sup>42</sup>; Phasmatodea: Phasmatidae: *Didymuria violescens*<sup>42</sup>. **AMPHIBIANS:** Frogs<sup>11,48,50</sup>; Hylidae: *Litoria ewingi*<sup>33</sup>; Myobatrachidae: *Crinia signifera*<sup>33</sup>; *C. tasmaniensis*<sup>33</sup>. **REPTILES:** Lizards: Gekkonidae<sup>49</sup>. **BIRDS**<sup>23,33,45</sup>: Common Diving-Petrel *Pelecanoides urinatrix*<sup>41</sup>; Rock Dove *Columba livia*<sup>45</sup>; Australian Ringneck *Barnardius zonarius*<sup>10</sup>; Eastern Rosella *Platycercus eximius*<sup>27,35</sup>; unident. parrot<sup>9</sup>; Pilotbird *Pycnoptilus floccosus*<sup>46</sup>; thornbill *Acanthiza*<sup>42</sup>; Grey Fantail<sup>33</sup>; Rufous Whistler *Pachycephala rufiventris*<sup>30</sup>; Magpie-lark *Grallina cyanoleuca*<sup>3</sup>;



House Sparrow<sup>17,22,25,42,50</sup>; Silvereye<sup>12</sup>; Common Starling<sup>50</sup>; Common Myna<sup>18</sup>; Blackbird *Turdus merula*<sup>39</sup>; unident. passerines<sup>43</sup>; captive finches<sup>45</sup>. MAMMALS<sup>45</sup>: Marsupials: Acrobatidae: Feather-tail Glider *Acrobates pygmaeus*<sup>42</sup>; Burramyidae: Eastern Pygmy-possum *Cercartetus nanus*<sup>33</sup>; Dasyuridae: Brown Antechinus<sup>42</sup>; Common Dunnart *Sminthopsis murina*<sup>42</sup>; Peramelidae<sup>54</sup>; Petauridae: Sugar Glider *Petaurus breviceps*<sup>42</sup>; Pseudocheiridae: Common Ringtail Possum *Pseudocheirus peregrinus* juv.<sup>7,32,42</sup>; Eutherians: Bats: Vespertilionidae: Gould's Wattle Bat *Chalinolobus gouldii*<sup>42</sup>; Lesser Long-eared Bat *Nyctophilus geoffroyi*<sup>42</sup>; Leporidae: European Rabbit juv.<sup>53</sup>; Rodents: Muridae: unident. small rodents<sup>31,45</sup>; House Mouse<sup>6,15,21,23,26,34,36,45,47,49,50</sup>; Delicate Mouse *Pseudomys delicatulus*<sup>24</sup>; rat *Rattus* young<sup>4,5,23,48</sup>; Polynesian Rat (Kiore) *R. exulans*<sup>38</sup>; Bush Rat *R. fuscipes*<sup>42</sup>; Brown Rat *R. norvegicus*<sup>25</sup>; Black Rat *R. rattus*<sup>14,29,50,54</sup>; Long-haired Rat *R. villosissimus*<sup>37</sup>.

REFERENCES: <sup>1</sup>Mathews 1909; <sup>2</sup>Hill 1911; <sup>3</sup>Lane 1913; <sup>4</sup>Barnard 1914; <sup>5</sup>MacGillivray 1914; <sup>6</sup>Mellor 1915; <sup>7</sup>Rodda 1916; <sup>8</sup>White 1917; <sup>9</sup>Carter 1911, <sup>10</sup>1923; <sup>11</sup>Fleay 1926; <sup>12</sup>Kilpatrick 1934; <sup>13</sup>McKeown 1934; <sup>14</sup>Sutton 1937; <sup>15</sup>Sedgwick 1938; <sup>16</sup>Dove 1939; <sup>17</sup>Tarr 1950; <sup>18</sup>Lawrence 1959; <sup>19</sup>Green 1919, <sup>20</sup>1969; <sup>21</sup>Disney 1971; <sup>22</sup>Green & McGarvie 1971; <sup>23</sup>Vestjens 1973; <sup>24</sup>Frith & Hitchcock 1974; <sup>25</sup>McNamara 1974; <sup>26</sup>Rix 1976; <sup>27</sup>Davies 1980; <sup>28</sup>Frauca 1980; <sup>29</sup>Burbidge 1982; <sup>30</sup>Fitzgerald 1983; <sup>31</sup>Hughes & Hughes 1984; <sup>32</sup>Veerman 1985; <sup>33</sup>Green et al. 1986; <sup>34</sup>Braby 1987; <sup>35</sup>Lewis 1987; <sup>36</sup>O'Brien 1990; <sup>37</sup>Maher 1992; <sup>38</sup>Coate et al. 1994; <sup>39</sup>Harvey 1994; <sup>40</sup>Ralph 1994; <sup>41</sup>Bone 1995; <sup>42</sup>Rose 1996; <sup>43</sup>Olsen & Bartos 1997; <sup>44</sup>Gould; <sup>45</sup>North; <sup>46</sup>Campbell; <sup>47</sup>Lea & Gray; <sup>48</sup>Fleay; <sup>49</sup>Hall; <sup>50</sup>FAB; <sup>51</sup>Storr 9; <sup>52</sup>Hollands; <sup>53</sup>Tas. Bird Reps; <sup>54</sup>QM.

**Other records—NZ** ANNELIDS: Oligochaetes<sup>8</sup>. INSECTS<sup>2,7,8,9,10,12,13,16,21</sup>: Coleoptera: ad. beetles<sup>5,6,11,12</sup>; Cerambycidae: *Diotimana undulata*<sup>13,14</sup>; Scarabaeidae<sup>9</sup>; Huhu Beetle *Prionoplus reticularis*<sup>9</sup>; Tanguru Chafer *Stethaspis suturalis*<sup>2</sup>; Hemiptera: Cicadidae<sup>9,14</sup>; Lepidoptera: moth<sup>14,17</sup>; Orthoptera<sup>12</sup>; Gryllidae<sup>8</sup>; Stenopelmatidae<sup>11,14,18,20</sup>; *Hemideima thoracica*<sup>9</sup>; *Insulascirtus nythos*<sup>13</sup>. AMPHIBIANS: Frog<sup>19</sup>. REPTILES: Gekkonidae: *Hoplodactylus pacificus*<sup>15</sup>. BIRDS: White Tern *Gygis alba*<sup>13</sup>; Sacred Kingfisher *Todiramphus sanctus*<sup>15</sup>; Whitehead *Mohoua albicilla*<sup>15</sup>; Saddleback *Philesturnus carunculatus*<sup>15</sup>; Bellbird *Anthornis melanura*<sup>15</sup>; Stitchbird *Notiomystis cincta*<sup>14,15</sup>; Grey Fantail<sup>15</sup>; unident. thrush *Turdus*<sup>15</sup>; Common Blackbird<sup>14</sup>; Common Starling<sup>1,14,15</sup>; Silvereye<sup>1,11,15</sup>; Grey Warbler *Gerygone igata*<sup>14</sup>; captive Canaries *Serinus canaria*<sup>7</sup>; European Goldfinch<sup>16</sup>; House Sparrow<sup>1,4,11,16,22</sup>; unident. passerines<sup>8,9,12,18</sup>; eggs and nestlings<sup>1</sup>. MAMMALS: Muridae: House Mouse<sup>1,3,4,10</sup>; rat *Rattus*<sup>1,3,4,10</sup>; Polynesian Rat<sup>12</sup>.

REFERENCES: <sup>1</sup>M'Lean 1911; <sup>2</sup>Oliver 1922; Wilkinson <sup>3</sup>1924, <sup>4</sup>1927; <sup>5</sup>Moncrieff 1928; <sup>6</sup>Stidolph 1931; <sup>7</sup>Cunningham 1948; <sup>8</sup>Lindsay & Ordish 1964; <sup>9</sup>Imboden 1975; <sup>10</sup>St Paul 1977; <sup>11</sup>Moon 1979; <sup>12</sup>St Girons et al. 1986; <sup>13</sup>Olsen 1996; <sup>14</sup>Stephenson 1998; <sup>15</sup>Oliver; CSN <sup>16</sup>24, <sup>17</sup>27, <sup>18</sup>31, <sup>19</sup>32, <sup>20</sup>33, <sup>21</sup>38, <sup>22</sup>43.

**Young** Nestlings fed same range of prey as adults. For descriptions of feeding of nestlings and fledgelings, see Social Organization, and Breeding. Prey brought to nestlings or remains found inside nest-hole in Aust., NZ and Norfolk I. include: SPIDERS: Araneae<sup>19</sup>. CHILOPODS: Centipedes<sup>12,19</sup>. INSECTS<sup>8,6,7,9,10,16</sup>: Blattodea<sup>12</sup>; Blaberidae: *Panesthia cribata*<sup>15</sup>; Coleoptera<sup>6,7,12,19</sup>; Cerambycidae: *Diotimana undulata*<sup>15</sup>; Curculionidae: *Psepholax pascoei*<sup>15</sup>; Tenebrionidae: *Pimelops fischeri*<sup>15</sup>; Huhu Beetle *Prionoplus reticularis*<sup>10</sup>; Hemiptera: Cicadidae<sup>8,20</sup>; Lepidoptera: ad. moth<sup>6,7,12,15,19</sup>; Mantodea<sup>12</sup>;

Orthoptera: crickets and grasshoppers<sup>5,6,7,19</sup>; Stenopelmatidae<sup>6,7,10</sup>; crickets *Insulascirtus nythos*<sup>15</sup>; Tettigoniidae: unident.<sup>6,7</sup>; *Austrosalomona personafrons*<sup>15</sup>; Phasmatodea<sup>6,7</sup>. REPTILES: Lizards: Gekkonidae<sup>6,7</sup>; *Hoplodactylus*<sup>5,13</sup>; Pygopodidae<sup>12</sup>. BIRDS: Stubble Quail *Coturnix pectoralis*<sup>11</sup>; Common Diving-Petrels<sup>18</sup>; Little Shearwater *Puffinus assimilis*<sup>14,17</sup>; White-faced Storm-Petrels *Pelagodroma marina*<sup>18</sup>; White Tern nestling<sup>15</sup>; Australian Ringneck<sup>11</sup>; Australian Owllet-nightjar<sup>3,12</sup>; Scarlet Robin *Petroica multicolor*<sup>15</sup>; Richard's Pipit *Anthus novaeseelandiae*<sup>19</sup>; Saddleback<sup>17</sup>; Southern Whiteface *Aphelocphala leucopsis*<sup>3</sup>; Slender-billed White-eye *Zosterops tenuirostris*<sup>15</sup>; Silvereye<sup>6,7,10</sup>; European Goldfinch<sup>4,10</sup>; Chaffinch *Fringilla coelebs*<sup>10</sup>; Greenfinch *Carduelis chloris*<sup>8,22</sup>; House Sparrow<sup>4,10</sup>; Common Myna<sup>4</sup>; Common Starling nestlings<sup>22</sup>; unident. ad. birds<sup>4,8,19</sup> and nestlings<sup>6,7</sup>. MAMMALS: Marsupials: Dasyuridae: Fat-tailed Dunnart *Sminthopsis crassicaudata*<sup>3</sup>; Eutherians: Bats: Mystacinidae: Lesser Short-tailed Bat *Mystacina tuberculata*<sup>2</sup>; Muridae: House Mouse<sup>8,6,7,10,12,19,21</sup>; *Rattus*<sup>1,4,10</sup>; Polynesian Rat<sup>5,14,16</sup>. (REFERENCES: <sup>1</sup>Wilkinson 1927; <sup>2</sup>Stead 1932; <sup>3</sup>Elliott 1938; <sup>4</sup>Bryant 1941; <sup>5</sup>Chambers et al. 1955; <sup>6</sup>Moon 1957, <sup>7</sup>1967; <sup>8</sup>Pizzey 1958; <sup>9</sup>McCann 1959; <sup>10</sup>Hogg & Skegg 1961; <sup>11</sup>Mack 1965; <sup>12</sup>Beste 1970; <sup>13</sup>Ramsay & Watt 1971; <sup>14</sup>Anderson 1992; <sup>15</sup>Olsen 1996; <sup>16</sup>Olsen & Trost 1998; <sup>17</sup>Stephenson 1998; <sup>18</sup>Oliver; <sup>19</sup>Hollands; CSN <sup>20</sup>24, <sup>21</sup>27; <sup>22</sup>D. Mudge.)

**Intake** For details of contents of individual stomachs, see Rose (1973, 1996).

**SOCIAL ORGANIZATION** Prepared by S.J.S. Debus. Not well known. Account based on unpublished information from S.J.S. Debus and J. Olsen, and studies in ACT, which included colour-banding and radio-telemetry (Olsen & Bartos 1997; Olsen & Trost 1998), in Orongorongo Valley, NZ (Imboden 1975), and on Mokoia I., NI, NZ (Stephenson 1998); other observations at nests by Moon (1957, 1967), Pizzey (1958), Beste (1970) and Hollands; also studied in captivity (Fleay 1925, 1926; Olsen 1997; Fleay). Solitary or in pairs throughout year; often seen in family groups of pair with fledgelings or male with nearly independent juveniles in summer.

**Bonds** Apparently monogamous. On Norfolk I., bonds permanent (P.D. Olsen). In highlands of se. Aust. bonds possibly seasonal, with some females appearing to leave territories after breeding, possibly when young still dependent (Olsen & Trost 1998; Roe & Roe 1998); in NZ, females remain in territories after breeding (Stephenson 1998). In ACT, one male with same mate for 2 years then had new mate in third year; another male had same mate for 3 years then had new female in fourth year; one breeding male did not breed in first year of pairing with new mate (J. Olsen & S. Trost). In NZ, one resident bird had three successive partners over 5 years; another neighbouring bird, resident for 5 years, had one partner for 3 years (Imboden 1975); each of three pairs stayed together for 2 years, even though two of the pairs bred unsuccessfully; in another pair, female died, male paired again by late Sept. and pair seemed to be going to breed together (Stephenson 1998). On Mokoia I., NZ, first pair within 6 months of fledging, possibly as early as 4.5 months; one female had paired with male c. 1.5 km away, whose mate had died; pair seemed to attempt breeding as female disappeared for several months and then reappeared and roosted near her mate again; within 3.5 months of fledging, another female paired with male c. 1.5 km away from natal area, but uncertain if breeding attempted (Stephenson 1998). On Norfolk I., first breed at 3–4 years old (Olsen 1996). In captivity, first form pairs when 1 year old; first breed when 2 years old; pair-formation starts in late winter (Fleay 1926; Fleay). In wild, no evidence of co-operative breeding, but



satellite or itinerant adult males tolerated in territories during fledgeling phase, their role unknown (Olsen & Trost 1998). Suggestion of co-operative breeding (Strahan) based on captive observations only; helpers, which were extra adults of either sex, shared incubation or feeding of nestlings (Fleay 1926; van Aperen 1969; Olsen 1997; Fleay). One wild female seen trying to feed captive begging young (Fleay). **Parental care** Both sexes prepare nest (mostly by male) and defend nest; only female incubates and broods; male guards nest and provides most food for family for first few days after hatching; only female known to feed young nestlings, though males will enter hollows; both sexes feed older nestlings and young fledgelings, and defend young; only male feeds older juveniles (Fleay 1926; Moon 1957, 1967; Beste 1970; Olsen 1997; Olsen & Trost 1998; Stephenson 1998; Fleay; Hollands; NRS). When mate died, one female continued to feed and attend newly fledged young (NRS). In se. Aust., during fledgeling period, some females leave family group, or, if female stops defending or feeding young, family group may leave female (Olsen & Trost 1998); this not observed in NZ (Stephenson 1998). Juveniles beg from, and fed by, parents for 6–7 weeks after fledging in ACT (Olsen & Trost 1998; J. Olsen & S. Trost); 8 weeks in NZ (Stephenson 1998). May stay in natal territory for up to 2–3 months (Hollands); possibly up to 4 months, dispersing in late summer or early autumn (Pizzey 1958) or possibly in early winter (Olsen 1996); in NZ, two females dispersed within 3.5–6 months of fledging; another male occasionally roosted outside natal territory 2.5 months after fledging, and found dead in natal territory c. 7 months after fledging (Stephenson 1998).

**Breeding dispersion** Nest solitary. In Riverina, NSW, active nests of two neighbours, 1 km apart (Hollands); in ACT, <3 territorial birds/100 ha, with core area of territory of one pair 900 m from active nest of neighbour (Olsen & Bartos 1997), and three active nests 0.77, 1.05 and 0.77 km apart (J. Olsen & S. Trost); in NZ: on Mokoia I., seven pairs had nests within 200–300 m of another nest (Stephenson 1998); on one of Hen & Chickens Is, three nests in <0.8 ha (Stead 1932); for estimates of density, see Populations. **Territories, Home-range** Defend all-purpose and apparently permanent territories (Olsen & Trost 1998; Stephenson 1998). Seem to be territorial all year on Mokoia I., NZ, calling throughout year in same manner (Stephenson 1998); in Aust., not certain if territorial all year (S.J.S. Debus). May allow fledgelings of neighbours in territory (J. Olsen & S. Trost), in some cases possibly because they do not call and go unnoticed (B.M. Stephenson). In se. Aust., during breeding season, male ranges throughout territory, defending perimeter; during fledgeling period, adult female may leave family group, at first remaining in nest-area but then possibly leaving territory; meanwhile male and fledgelings gradually range farther from nest to boundaries of territory (Olsen & Trost 1998; J. Olsen & S. Trost); in NZ, where adult female does not leave territory, fledgelings often roost within 50–100 m of nest, often with both adults; after several months, young slowly disperse (Stephenson 1998). Boundaries of territories can alter between years (Olsen & Trost 1998; J. Olsen & S. Trost), but in NZ most seem to be quite rigid (Stephenson 1998). Migrating birds may defend winter feeding territories away from breeding territories. In highlands of se. Aust., in suburban bushland, territory of one breeding male estimated to be 100 ha (radio-telemetry); that of a colour-banded neighbouring breeding male, 50 ha (Olsen & Trost 1998; J. Olsen & S. Trost); in dry forest and woodland, home-range of paired, non-breeding male in summer, 37 ha, with most time spent in 8 ha (Olsen & Bartos 1997). In NZ forest in spring, home-ranges of two neighbouring

pairs over 6 weeks estimated as 5.3 ha and 3.5 ha, with ranges increasing at end of study; there was slight overlap at a concentrated source of food (Imboden 1975).

**Roosting** Roost during daylight; either sleep or remain immobile. Usually solitary (M'Lean 1911; Cunningham 1948; Imboden 1975), sometimes in pairs (M'Lean 1911; Barnard 1926; DeWarren 1928; Whittell 1933; Sedgwick 1947; Cunningham 1948; Warham 1957, 1960; Imboden 1975; Rix 1976; Green *et al.* 1986; Olsen & Bartos 1997; North; Hollands); in family groups in post-fledging phase (Frauca 1980; Smith 1995; Williams 1995; Olsen & Trost 1998; Roe & Roe 1998; Stephenson 1998; Fleay; Hollands); on Mokoia I., roost solitary during autumn and winter, after fledgelings have dispersed; at start of breeding in Sept.–Oct., pair often roost together or within several metres of each other (Stephenson 1998). Roost in dense foliage of trees or shrubs and often roost in tree-hollows; also roost in caves, animal burrows, rock crevices and the like; sometimes on ground in grass tussocks and in buildings (see Habitat). Roost-sites are within territory, and are often traditional. Bird or pair uses several roosts in rotation, using each for between several days to weeks (Imboden 1975; Olsen & Bartos 1997; Stephenson 1998; Schodde & Mason). Noted regularly roosting in same hollow for weeks (Hollands), but some foliage roosts used regularly, others not (Cunningham 1948; Disney 1971; Imboden 1975; Olsen & Bartos 1997; Olsen & Trost 1998; Stephenson 1998). While female incubates, male usually roosts near nest (Fletcher 1918; Elliott 1938; Hogg & Skegg 1961; Mack 1965; Stephenson 1998); though both adults sometimes flushed from hollow during daylight (NZ NRS). Female roosts in nest with nestlings (Bryant 1941; Pizzey 1958; Moon 1967; Beste 1970; Hollands; NRS); male usually roosts in nearby tree (Pizzey 1958; Hogg & Skegg 1961; Mack 1965; Moon 1967), though occasionally in nest with female and chicks (Marshall 1933; Braby 1987; Hollands); later in nestling stage, female roosts outside nest (Stead 1932; Stephenson 1998; J. Olsen & S. Trost). Fledgelings roost side by side in foliage or roost apart but in same tree (Williams 1995; Stephenson 1998; P.D. Olsen). In se. Aust., family groups use succession of roosts in territory, moving progressively farther from nest (Olsen & Trost 1998); in NZ, may roost as family group (NZ NRS); on Mokoia I., often roost in same area for c. 1 week after fledging; after young independent, roost in territory on their own (Stephenson 1998). Adults start calling at sunset or dusk; return to roost by daybreak (M'Lean 1911; Wilkinson 1927; Pizzey 1958; O'Donnell 1980; Hollands); on Mokoia I., return just after dawn (Stephenson 1998); sometimes active during day (see Feeding). In NZ, in spring, left roost 17:30–18:00 (later as day-length increased); if pair roosted together, they left together or within 30 s of each other; returned to roost at first light, 05:40–06:30 (earlier as day-length increased) (Imboden 1975); on Mokoia I., in Jan. and Feb., tend to leave just as light decreases in forest, from 1 h before to 8 min after sunset; if roosting together, members of pair usually leave 3–31 min apart; arrive at roost from 12 min before to 32 min after sunrise; if birds roost together, they usually arrive at different times (Stephenson 1998). In ACT, in summer, left roost 19:25–19:40, 10–25 min before fully dark; returned to roost 05:05–05:35, 30–90 min after first light and dawn chorus (see Olsen & Bartos 1997). Fledgelings start to call 20 min before leaving roost and leave 20 min before dark; may or may not be active before parents leave; fledgelings settle to roost (with calling), 30 min before first light. Fledgelings often quite active during day, sometimes calling, preening and moving around (Williams 1995; Stephenson 1998). Fledgelings

sometimes beg on and off all night (Williams 1995); though sometimes stop calling for periods of >1 h (Stephenson 1998). For details of nocturnal activity, see Food. On dark nights in autumn–winter or in bad weather may return to, or remain in, roost for night, and may forage during day (McNabb 1982; Stephenson 1998; Fleay).

**SOCIAL BEHAVIOUR** Account prepared by S.J.S. Debus. Not well known; based on unpublished information from S.J.S. Debus and J. Olsen, and studies at nests in wild (Moon 1957, 1967; Pizzey 1958; Beste 1970; Braby 1987; Olsen & Trost 1998; Hollands) and in captivity (Fleay 1925, 1926; Olsen 1997; Fleay). Inconspicuous by day and night, but calls familiar and heard often. Vociferous in breeding season, particularly before laying, when with nestlings, and after young fledge (S.J.S. Debus; J. Olsen & S. Trost). Bathe in shallow water, often before dawn, but incubating females will also bathe in evening (Fleay 1926; Fleay). Sunbathe on ground, lying prone with wings and tail spread (Fleay). **Aerial activity** Said to perform display and territorial flights, but no details other than said to be mainly by male (Strahan).

**Agonistic behaviour** **Territorial advertising, Threat Boobook Call** given as territorial call from high perches (Olsen & Trost 1998; Hollands). Call throughout year, with some seasonal variation in rate of calling (see Voice for details). Males may call on and off all night in period before laying (Fleay 1925); birds call often in Oct., when at least some pairs incubating (Elliott 1938); probable that female quiet during incubation, but males continue to call (S.J.S. Debus). Call persistently in reply to rivals, sometimes all night near sites of intrusions (Jackson 1986; S.J.S. Debus). Birds of established neighbouring territories counter-call at each other at mutual territorial boundary (Imboden 1975). Neighbouring territorial males counter-call, approach and challenge each other with vocal duels at mutual boundary (Olsen & Trost 1998). Por Calls by two or three rival birds at a site escalate to vocal duels, sometimes with one bird pursuing other till it leaves (M'Lean 1911; Olsen & Trost 1998). In response to chorus of Boobook Calls from captive birds, wild pair approached with Por Calls (Fleay 1926; Fleay). Similar response given to playback of calls, and Por Calls may escalate to Boobook replies (Debus 1996, 1997b), especially if tape played for too long, when both members of pair may come in and call (Stephenson 1998). In NZ, both members of a breeding pair called in response to tape-playback (Stephenson 1998). In more direct threats, bristle feathers of head, snap bill and glare at opponent (Fleay); fully expose pale supercilia by raising feathers (Olsen & Moon 1990); or approach rival with feathers raised and wings drooping and partly spread (Olsen 1989). At one nest with nestling, appeared that male defended boundaries of territory and female defended nest-site (J. Olsen & S. Trost). **Attack, Fight** At mutual boundary, if one male enters neighbour's territory, duel of Por Calls escalates to brief physical altercation with chattering calls before combatants break away. Boundary of territory may shift after duels (Olsen & Trost 1998). If chased, intruder may flee territory (M'Lean 1911). Attack other species during and outside breeding season: other owls, such as Sooty *Tyto tenebricosa* and Powerful *Ninox strenua* Owls (Hyem 1979; McNabb 1994, 1996; Debus 1997c), Tawny Frogmouths (Dove 1909; Lohse 1927), Australian Magpies *Gymnorhina tibicen*, crows *Corvus*, ringtail possums and people (North; Keartland 1912; Fleay 1926; Beste 1970; Olsen 1997; Olsen & Trost 1998; Fleay; Hollands). Attack by swooping or chasing, sometimes striking with talons or even grappling and fighting. Near nest with

chicks, once drove away Sulphur-crested Cockatoos *Cacatua galerita* at dusk (Braby 1987). A possum near nest was struck by Boobook with its talons (D. Mudge). **Alarm** When agitated or excited, snap bill loudly, especially when handled; may also give Squeak call (Stead 1932; Stephenson 1998; S.J.S. Debus). When intruder approaches, adults at daytime roosts in foliage sometimes avoid detection by adopting sleeked, upright cryptic posture (Stephenson 1998; North; Fleay); if pressed, or flushed from hollow, seek alternative shelter in foliage or another hollow (H.L. White 1922; Alexander 1923; Marshall 1933; S.J.S. Debus). During daylight, when in flight and when perched, may be mobbed by smaller species of birds (e.g. Fleay; Schodde & Mason; S.J.S. Debus; J. Olsen & S. Trost); often mobbed even when seemingly well camouflaged at foliage-roost (Stephenson 1998); if perched, Owl often watches through half-closed eyes, though eyes can appear to be fully closed; if bird stays still, smaller birds may leave (Stead 1932; Stephenson 1998); occasionally struck and may even be killed by larger species, e.g. Laughing Kookaburra (Stead 1932; Whiter 1989; Stephenson 1998); in NZ, a Tui *Prosthemadera novaeseelandiae* knocked an immature Boobook out of air to ground (Stephenson 1998).

**Sexual behaviour** Male gives vocal advertising displays in late winter and spring before laying, uttering Boobook Calls from vantage perches, mostly near nest-site; peak of calling said to be in first few hours of night (Fleay 1925, 1926; Singor 1996; Debus 1997c), though in NZ usually call all night, but call much in early morning (03:00) (Stephenson 1998). As well as advertising territory, giving Boobook Calls from vantage perches by individual territorial males before laying also has sexual function. Some records of males and females duetting are possibly misidentification of two territorial males duelling, and care should be taken by observers (Olsen & Trost 1998; J. Olsen & S. Trost). However, duetting occurs: captive pairs duet (P.D. Olsen); in wild, two birds, apparently male and female, both giving Boobook Call, were collected together from same tree (Whitlock 1923); in NZ, birds close together sometimes seem to duet rather than duel. **Courtship and pair-formation** Starts with male giving Boobook Calls. Before mating, female replies with Boobook Calls (Fleay 1926; Fleay). Lone unmated females also give Boobook Call, probably to attract male, e.g. sole female on Norfolk I. (Olsen 1989, 1996). Pair-formation proceeds with both sexes calling to each other with soft Por Calls, and long bouts of Boobook Calls by male. Male flies to perch beside female, and gives long bouts of Por Calls; female preens his head and gives low Trills; male then gives excited, vibrating Boobook Calls (Fleay 1925, 1926; Fleay). Male of one pair that was perched together gave long bout of Por Calls, while female droned (Dove 1922). During nest-selection, both sexes perch and give Por Calls at hollows in winter; one or both roost in hollow for weeks before laying, though pre-season roost not always chosen as nest (Hollands). At start of season, occupation of nest advertised, probably by male, with long bouts of Boobook Calls near nest and Por Calls from hollow (Singor 1996). One bird noted perching beside hollow, giving Por Call with wings spread, while other bird gave Por Calls from hollow (Olsen 1989). Female starts roosting in nest 2–3 days before laying (Olsen 1997; Fleay). **Greeting** When with nestlings: male starts giving Por Call from roost after dusk and female replies with same call from nest; male then flies to nest and female emerges and both perch together; they then forage separately (Pizzey 1958). **Courtship feeding** During courtship, male gives female small prey items, bill to bill, at a perch near nest (Debus 1996; NRS). When food transferred, female calls

with soft Bray, and male replies with soft guttural call; male calls female to transfer-perch, and both duet with respective calls and bill each other; female then takes food to nest (Beste 1970). During incubation, Braying by female suggestive of begging, and she may sometimes be fed by male; she continues to Bray early into nestling period (J. Olsen & S. Trost). When feeding nestlings, female takes some food from male to eat for herself and some to feed to nestlings (J. Olsen & S. Trost). **Copulation** Seen before laying. Once, at night, radio-tagged male and female in neighbouring trees called softly, moved toward each other and began duet of cooing and grunting Por Calls; then mounted with fluttering wings (Imboden 1975). Another time, at dusk, male was giving Boobook Call, then flew to perch beside female on branch near nest; occasional soft Boobook Calls heard, then male fluttered onto female's back; during copulation, Por Calls were heard (probably by male), and copulation finished with Squeal (probably by female); copulation lasted 19 s. Male left immediately, female stayed on perch (Debus 1996).

**Relations within family groups** Chicks beg continually with trilling Begging Call; parents feed chicks bill to bill (Pizzey 1958; Fleay; Hollands; NRS). Some brood-reduction: large chicks occasionally trample smallest, which may also starve (Bryant 1941). Nearly fledged young jostle for position at entrance to nest (Braby 1987; NRS). Fledged young continue to call for food and may follow parents (NRS; J. Olsen & S. Trost), though on Mokoia I., NZ, they do not follow parents over entire territory (Stephenson 1998). In one family, newly fledged young fed mostly by female, who tended to use Single Hoot more than male at this time; later, male took greater role in feeding, and he then tended to use Single Hoot more (J. Olsen & S. Trost). **Anti-predator responses of young** Chicks claw at older who handle them (Stead 1932; Stephenson 1998). Older nestlings snap bill loudly at intruders (Fleay 1926; Bryant 1941; Fleay); retreat inside hollow when diurnal raptors fly over at dusk (Hollands); give shrill whistle or scream when frightened or disturbed (Stead 1932; Stephenson 1998). Fledgelings explode from roost in different directions if threatened; retaliate with claws if caught (Frauca 1980). **Parental anti-predator responses** Incubating or brooding females flush if nest approached closely, snap bill at intruder (Bryant 1941; Moon 1967; Fleay); if nest regularly inspected by observer, after a while some females do not flush (Stephenson 1998; J. Olsen & S. Trost). If intruders near eggs, nestlings or fledgelings, adults may swoop, sometimes striking with talons or calling (Fleay 1926; McNabb 1996; Olsen 1997; Olsen & Trost 1998; Stephenson 1998; Fleay; Hollands; NRS). One female Brayed between attacks, which sometimes attracted male; when nestlings handled by observers, female sat in nearby tree and Brayed (Stephenson 1998; J. Olsen & S. Trost). Single Hoot by parent seems to act as warning signal to fledgeling (J. Olsen & S. Trost). May strike with feet at possums near nest (D. Mudge).

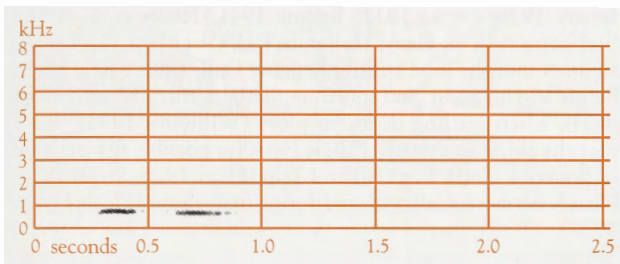
**VOICE** Account based on contribution by S.J.S. Debus. Reasonably well known, but no detailed studies. Boobook Call a familiar call of Aust. night. Probably has widest known range of calls of any Aust. *Ninox*; calls variously described as hoots, croaks, brays, yelps, growls, trills, screams, and squeals. Calls vary from low to loud, and from soft to strident; Boobook Call the most common (Hollands). Vociferous, and persistently noisy before laying. Soft calls occasionally heard in daytime (Hall 1902); Boobook Call heard from within roost-hollow during day when much bird noise outside (S.J.S. Debus); occasionally start to utter Boobook Call in late afternoon on

overcast days (M'Lean 1911), or from 15:00 on clear days before laying (Imboden 1975), and c. 17:00 during summer (Stephenson 1998), but often start calling at, or a little after, sunset (Wilkinson 1927). Call at all times of night, but particularly in first few hours after dusk and with minor peak again before dawn; call regardless of cloud cover or phase of moon, but rate of calling may be reduced in wind, rain or frost (M'Lean 1911; DeWarren 1928; Marshall 1935; O'Donnell 1980; Kavanagh & Peake 1993a; Debus 1996, 1998; Singor 1996). Once, drought-breaking rain seemed to stimulate calling (Storr 1954). More vocal on some nights than on others, for no apparent reason (M'Lean 1911; St Paul 1977; Stephenson 1998). Call throughout year (M'Lean 1911; O'Donnell 1980; Olsen 1989; Marchant 1992; Olsen 1997; Debus 1997c; Schodde & Mason; Hollands) but with variation in rate of calling: rate increases late winter or early spring (Legge 1908; Hall 1924; Fleay 1925, 1926; Whittell 1933; Marshall 1935; Heron 1970; Burbidge 1982, 1985; Sedgwick 1988; Templeton 1992; Fleay; Hollands; ACT Atlas; ACT Bird Reps); less vocal late summer to early winter (Dove 1939; Sedgwick 1956; Debus 1997c); most vocal at start of breeding season (Debus 1996, 1997, 1998; Singor 1996; Olsen 1997; Hollands), adults do not call much when with nestlings or fledgelings, other than soft calls near nest, unless provoked into duels of Boobook or Por Calls by intruding rivals (Beste 1970; Williams 1995; Debus 1997c; Start & Falconer 1997; Olsen & Trost 1998; Hollands); also said to be more vocal in summer than winter (Lord 1956; Debus 1997c); some calling in autumn and winter, or autumn peak (Dove 1909, 1939; Stidolph 1925; O'Donnell 1980; Debus 1997c; Gould; ACT Bird Reps), possibly in defence or advertisement of winter territories. At Mokoia I., NZ, call throughout year (Stephenson 1998). Boobook audible up to 1 km or more (Kavanagh & Peake 1993a; Hollands); over 500 m in suburban site (Singor 1996). Eight pairs said to be audible from one location (St Paul 1977). **SEXUAL DIFFERENCES:** Vocabulary of each sex similar. Boobook Call of male clearer, quicker, shorter and higher pitched than that of female, which is hoarser and more deliberate (Fleay 1926; Fleay). Boobook Call given mainly by males (Olsen & Trost 1998), though also by females in reply to male before laying (Fleay 1925, 1926; Fleay; Debus 1996), by both sexes when nest robbed by predator (Hollands), and by lone unmated females (Olsen 1989; Olsen & Trost 1998; Stephenson 1998). Bray used mainly by females, particularly as food-begging call to male during breeding cycle (Olsen & Trost 1998); Bray of male higher pitched and thinner than that of female (Beste 1970; Debus 1996). Yelp said to be used mainly by females (Fleay 1925; Olsen & Trost 1998), but on Mokoia I., NZ, males regularly utter Yelp, sometimes in flight (Stephenson 1998). **INDIVIDUAL DIFFERENCES:** Slight; probably aid recognition of mates, neighbours or intruders (Strahan; S.J.S. Debus). Boobook Call said to vary seasonally, more highly pitched in autumn, e.g. n. Vic. (Cheney 1915), but may reflect presence of Tas. migrants (see below). **REGIONAL VARIATION** reported, though further study required: Boobook Call of Tas. *leucopsis* and NZ *novaezeelandiae* more rapid, higher-pitched and bell-like than those of mainland Aust. (Campbell 1903; Olsen & Moon 1990); Boobook Call of birds in NZ Alps said to be higher pitched than those from elsewhere in NZ (Potts 1882); Boobook Call of single female from Norfolk I. distinctive, throaty and raspy in comparison with calls of NZ males (Olsen *et al.* 1989; Hicks *et al.* 1990); *lurida* of tropical ne. Qld said to have more guttural, croaky Boobook Call, which used less often than elsewhere in Aust. (Hollands). Calls typical for A'sian *Ninox*; fairly similar to Barking Owl (q.v.); also similar to extralimital



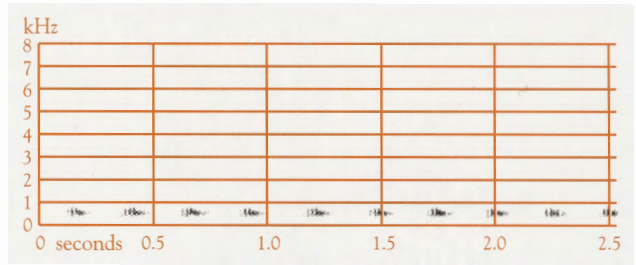
Papuan Boobook *N. theomacha* and Moluccan Hawk-Owl *N. squamipila*. NON-VOCAL SOUNDS: Adults and young snap bill loudly in defence and threat; chicks do so from 2 weeks old (Stead 1932; Bryant 1941; Williams 1963; Olsen 1997; Stephenson 1998; Fleay).

**Adult BOOBOOK CALL** (= Hoot of various authors): Clear characteristic two-note hooting *boo-book* (sonagram A), giving rise to variety of vernacular names: *ruru* of Maori, *koor-koor* or *buck-buck* of Aborigines, and *morepork*, *mopoke* and *boobook* (Buller; Gould; Fleay). Second note usually of same or lower pitch than first, but can be of higher pitch or accented or both; may be uttered at up to 40 calls/min, sometimes continuing for several hours, though with brief pauses (Buller 1888; Andersen 1926; Binns 1953; Storr 1954; Lindgren 1961; Singor 1996; Schodde & Mason; Hollands; R.H. Loyn). Given in bouts of 36–42 calls, with pause of 3–4 min or long bout of Por Calls between bouts (M'Lean 1911); bouts of 278–284 calls (Binns 1953; NSW Bird Reps). Once heard to give ten Boobook Calls in rapid succession, without pause (Stidolph 1925). Uttered through closed, or possibly slightly opened, bill, from perch,



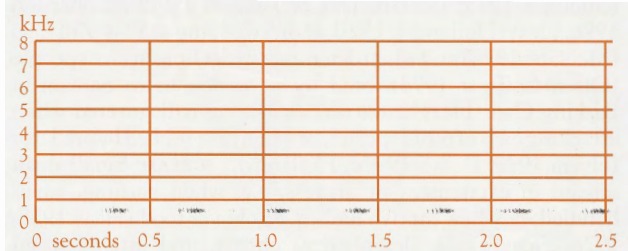
A F. van Gessel; Mt Field NP, Tas.; Dec. 1988; P40

throat pulsating with each note (Stephenson 1998; Schodde & Mason; S.J.S. Debus). Call has vibrato quality when heard close up (Hollands). A territorial and contact call, also probably used for individual identification (Olsen & Moon 1990; Hollands). Given by male in long bouts as advertisement and territorial defence, and probably to attract female; by female in response to Boobook Call of male (Fleay 1925, 1926; Debus 1996; Fleay; Hollands); by both in response to playback (Stephenson 1998); and by unmated females (Olsen 1989; Olsen & Trost 1998; Stephenson 1998). Also given by male as food call to female (Olsen & Trost 1998). Given excitedly in some circumstances, e.g. courtship (Fleay 1926; Debus 1996; Fleay). Harsher grating version of Boobook Call uttered when mobbing intruder near nest (Hollands). **SINGLE HOOT**: Monosyllabic hoot *book*, *book*, *book*... Given in alarm, defence of young, as warning to fledgeling, or in reply to Bray of mate; grating when in defence of nest (Olsen 1997; Hollands; J. Olsen & S. Trost). Seems to be uttered more often by females than males (J. Olsen & S. Trost). Series of deep guttural Single Hoots may be used as prelude to bout of Boobook Calls (Andersen 1926; Conole 1985). **POR CALL** (= Croak): Rapid continuous guttural croaking or grunting *por-por-por*... (part of sequence shown in sonagram B), repeated monotonously, sometimes with sudden changes in loudness; more deliberate in female. Uttered in long bouts in courtship and copulation, in greeting between mates, as prelude to series of Boobook Calls, and as response to Boobook Calls of rivals (Buller 1888; M'Lean 1911; Fleay 1925; Stidolph 1925; Pizzey 1958; Debus 1996, 1998; Stephenson 1998; Fleay; Schodde & Mason). Direct transition occurs, without interruption, from Por Call to Boobook Call and vice versa, Por Call becoming series of disyllabic guttural notes when changing to

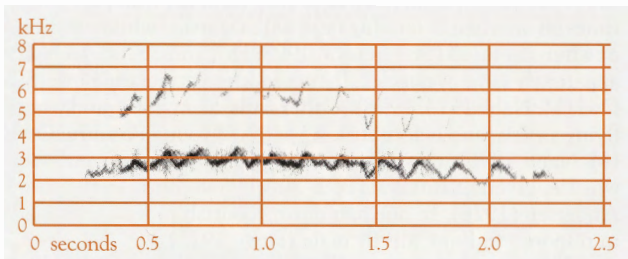


B E. McNabb; P81

Boobook Call (Singor 1996; Schodde & Mason; S.J.S. Debus). Often first call of evening, leading into bout of Boobook Calls (Conole 1985; Hollands; S.J.S. Debus). Used mainly in breeding season (Hollands), though also in response to intruding conspecifics at other times (McNabb 1982; Debus 1997c; J. Olsen & S. Trost). Once, 24 notes given in 8 s (Wigan *et al.* 1938). Bouts reported: 20–50 *por* notes; 4–9 min of Por Call; 450 *por* notes in 5 min, with another 5 min of Por Call after pause, reported (M'Lean 1911; Fleay 1925; Storr 1954; Lindgren 1961); bouts of 60 and 200–300 *por* notes reported during courtship (Dove 1922; Fleay 1926; Fleay). Uttered more often by male, and almost always by male arriving at nest for first visit of evening; also by female at or in nest while male preparing nest, before emergence from hollow at dusk while incubating or brooding, and in response to call of male at dusk, or arrival of male with food (Pizzey 1958; Olsen & Trost 1998; Fleay; Hollands). Also given in threat as low rapid staccato *bukbukbuk*... (Olsen *et al.* 1989; Olsen 1997). Sonagram C shows calls of one bird from sequence of counter-calling in which each bird made the *bukbukbuk*... call (Buckingham & Jackson 1990). **SQUEAL**: Rabbit-like wavering whistle (sonagram D); uttered after copulation (Debus 1996; J. Olsen & S. Trost). **BRAY**: Vibrating churring *cree*, *grreh* or *airck*, with an upward inflection, cooing or purring in quality when uttered softly through closed bill, strident when uttered loudly through open bill (Stidolph 1925; Andersen 1926; Stead 1932; Olsen *et al.* 1989; Fleay; Hollands; J. Olsen & S. Trost). Sonagram E shows one call of series where calls repeated about every 6 s. Call of female described as a trilling low-pitched rumble, probably a

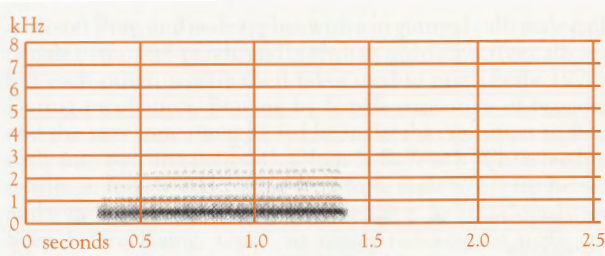


C F. van Gessel; Barrington Tops NP, NSW, Apr. 1989; P40

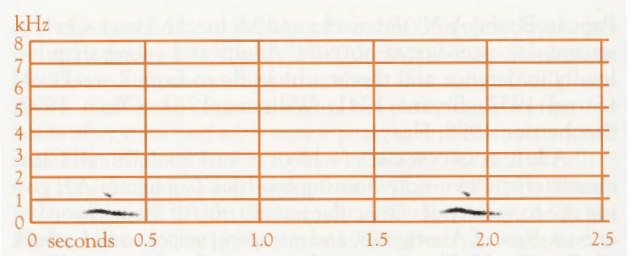


D W. Flentje; Newbridge, Vic., Aug. 1985; P40





E W. Flentje; Whipstick SF, Vic., Feb. 1987; P40



F W. Flentje; Killawarra SF, Vic., Jan. 1986; P40

continuation of Begging Call of chick (Fleay 1925, 1926; Olsen & Trost 1998; Fleay), while that of male a strident vibrating cry, louder and rising in pitch, higher and thinner than that of female (Debus 1996). To the contrary, Beste (1970) reports soft purring *arr-arr* from female, answered by much deeper *oohm-oohm* (and not Boobook) of male. Analogous to Bleat of Powerful Owl; mainly used near nest (Hollands), sometimes as contact call between mates (Williams 1963); heard mainly in breeding months, occasionally in autumn (O'Donnell 1980; Debus 1997c). Used by female as food-begging call to male during breeding cycle (Moon 1967; Beste 1970; Debus 1996; Olsen & Trost 1998); also used by male to attract attention of female in period before laying (Fleay), and as food call to female during breeding cycle (Moon 1967; Debus 1996). Soft version given by adults as food call when arriving with prey for nestlings (Hollands), though female may utter Bray when entering nest without food (Stephenson 1998). Thought to be used mainly by male, in courtship and nestling phases (Hollands), but after laying used mainly by female (Olsen & Trost 1998). Adult guarding nest gives same call at slightest move of observer in hide, becoming harsher and more grating if slightly alarmed (Hollands). **TRILL:** Female utters low rumbling trills during courtship by male (Fleay 1926; Fleay); also described as chirrups (Strahan). Variety of soft trills by female in nest with young (Hollands); breeding females occasionally give juvenile-like trills (Olsen 1997). Female coaxed fledgeling with trilling, mewling note (Moon 1967). **YELP:** Loud falsetto cat-like yelp *yow* (sonagram F), usually repeated, and uttered particularly during autumn or winter, and usually by females, though commonly by males on Mokoia I., NZ; uttered with open bill (Stidolph 1925; Buckingham & Jackson 1990; Stephenson 1998; Fleay; Hollands). Used when swooping at Powerful Owl (McNabb 1996) and when defending fledgelings against people (Olsen & Trost 1998). Said to be analogous to Scream of Barking Owl (Fleay). **GROWL:** A grating trill; uttered when attacking owls of other species, or when nest robbed by predator (Hyem 1979; Debus 1997c; Hollands). **SCREAM:** Small shrill scream in excitement or distress, e.g. when bathing, when handled, or when captive birds quarrel over food (Fleay 1925, 1926; Fleay). Also described as chitter, and uttered when fighting with rival conspecifics (Olsen & Trost 1998). **SQUEAK:** Short mewling squeak, likened to *poop* from toy trumpet; sometimes given when defending nest, when startled while roosting, or when captured (Stephenson 1998; Hollands; S.J.S. Debus); apparently same as quack call uttered when attacking Powerful Owl (McNabb 1994, 1996). **Other calls** *H, h, h, h* sound when flying swiftly, and before striking perched young Powerful Owl (McNabb 1996); this may be the *ffff-p-fff-p*, like an indrawn whistle, given at intervals of 2–30 s by two birds in flight, of Andersen (1926). In one pair during courtship, female droned in response to Por Calls by male (Dove 1922).

**Young** **BEGGING CALL:** A gentle high-pitched cricket-like trill, becoming more urgent and louder with length of absence

of adults, and reaching climax with return of a parent; given from day of hatching till voice deepens at c. 5 months old, when becomes much lower pitched trill, similar to Bray of adult (Fleay 1925, 1926; Bryant 1941; Paton 1966; Beste 1970; Williams 1995; Olsen 1997; Start & Falconer 1997; Debus 1997c; Olsen & Trost 1998; Fleay; Hollands). One-month-old chicks said to trill continuously at night (Fleay), but may stop calling for c. 1 h (Stephenson 1998). **ALARM:** When threatened, chicks hiss and click or snap bills (Stead 1932); or give shrill whistle or scream; and Squeal or Trill when handled (Fleay 1926; Stead 1932; Bryant 1941; Hicks *et al.* 1990; Stephenson 1998; Fleay; Hollands; P.D. Olsen). **JUVENILES:** In summer months loud trilling Begging Calls from young begin before leaving roost, and continue all night, till c. 30 min before dawn, when settling down to roost (Williams 1993). At 5 months old, start uttering Single Hoot (or possibly first syllable of Boobook Call), Por Call and Yelp (Fleay 1926; Stead 1932; Fleay). Boobook Call acquired during first winter (Fleay; Hyem 1979).

**BREEDING** Account prepared by S.J.S. Debus. Based mainly on long-term study in NZ (Stephenson 1998); unpublished observations by S.J.S. Debus, J. Olsen and S. Trost; studies of captive and wild pairs (Fleay 1925; Moon 1957, 1967; Gubb 1978; Olsen 1996, 1997; Olsen & Bartos 1997; Olsen & Trost 1998; Fleay; Hollands); observations at single nests (Elliott 1938; Bryant 1941; Pizzey 1958; Hogg & Skegg 1961; Beste 1970; Braby 1987); and analysis of clutch-sizes and laying dates by Olsen & Marples (1993). To July 1997, 40 records in NRS; some records from NZ NRS also analysed. Breed in simple pairs, solitarily. No evidence for co-operative breeding in wild (see Social Organization).

**Season Aust.** Strongly seasonal, with little variation across range. Most clutches Sept.–Nov., with maximum in Oct.; fewer July–Aug. and Dec.–Feb.; exceptional clutch Apr. (Olsen & Marples 1993). One supposed clutch from May, in NT (Le Souëf 1902; Frith & Davies 1961), re-identified as Barn Owl *Tyto alba* (White 1909). Eggs laid 2–3 days later for every degree of latitude southward, expressed by equation: Laying

#### Plate 39

Little Owl *Athene noctua* (page 812)  
1 Adult; 2 Juvenile; 3, 4 Adult

Southern Boobook *Ninox novaeseelandiae* (page 852)  
NOMINATE NOVAESEELANDIAE: 5, 6 Adult; 7 Juvenile  
SUBSPECIES BOOBOOK: 8, 9 Adult; 10 Juvenile; 11, 12 Adult  
SUBSPECIES LURIDA: 13, 14 Adult  
SUBSPECIES OCELLATA: 15 Adult  
SUBSPECIES LEUCOPSIS: 16 Adult  
SUBSPECIES UNDULATA: 17 Adult

date =  $239.2 + (1.3 \times \text{latitude})$  (Olsen & Marples 1993). QLD: Laying, Aug.–Oct.; fledging, Nov. (Frauca 1980; Roe & Roe 1998; Storr 19; NRS). In N, laying, Oct. (Lavery *et al.* 1968; Storr 19); nestlings, Nov. (Hollands); fledgelings, Nov. (Glass 1975); dependent juveniles, Dec. (Horton 1975). In S, eggs, Nov. (North); hatching, Oct.; fledging, Dec. (Elliott 1938); dependent juveniles, Jan.–Feb. (Lord 1956). NSW: Eggs, Sept.–Nov., but mainly Oct.; nestlings, Oct.–Dec., but mainly Nov.; fledgelings, Dec.–Feb. (NRS). In N, eggs, Oct.–Nov. (North). In S, nestlings, Nov.–Dec.; fledging, Dec. (Whiter 1991; Harvey 1994; Olsen & Bartos 1997; ACT Atlas). VIC.: Eggs, Oct.–Nov. (D'Ombrain 1905; Bryant 1941; NRS); hatching, Nov. (Fleay 1926; Bryant 1941; Fleay; Hollands); nestlings, Oct.–Dec. (ABBBS; NRS); fledgelings or dependent juveniles, Nov.–Feb. (Bryant 1941; Braby 1987; Fleay; Vic. Bird Reps); dependent juveniles, Jan.–Feb. (Rowley 1961; Vic. Bird Reps). TAS.: Laying, Nov. (Campbell); nestlings, Oct., Dec. (Fletcher 1933; North). SA: Eggs, Sept.–Dec. (Kingham & Fletcher 1927; NRS); laying, Oct.; hatching, Nov. (Mack 1965; Schulze 1966); nestlings, Nov.–Dec. (NRS); fledgelings, Nov.–Dec. (Paton 1966; Williams 1995; NRS). WA: Eggs, Sept.–Oct.; nestlings, Oct.–Dec. (NRS). In SW, eggs, Sept.–Nov. (Carnaby 1933; Ford 1968; Masters & Milhinch 1974; Storr 35). In central W, laying, July–Sept. (Storr 21); hatching, Sept. (Sedgwick 1949; Tarr 1949). In NW, eggs, Aug. (White 1909); laying Aug.–Sept. (Storr 16); nestlings, Aug. (Shilling 1948); young, Oct. (Hill 1911). NT: Laying, Sept., Jan. (Storr 7). NZ Laying, Oct.–Nov., with peak in Nov. (Stead 1932; Hogg & Skegg 1961; Moon 1967; Stephenson 1998; Oliver); eggs, Sept.–Feb.; nestlings, Nov.–Jan. (NZ NRS); fledgeling, Sept. represents exceptionally early clutch, with laying in mid-July, in mild winter (McCann 1959). Norfolk I. Laying, Sept.–Oct. (Olsen 1996); fledging, Dec. (P.D. Olsen).

**Site Aust.** In hollows of trees, typically eucalypts; tree living (Bryant 1941; Mack 1965; Braby 1987; Fleay; Hollands; NRS) or dead (Barrett 1916; Fleay 1925; Elliott 1938; Rhodes 1944; Pizzey 1958; Burbidge 1985; Campbell; North; Fleay; Hollands; NRS; J. Olsen & S. Trost). In vertical hollow, in spout, or hollow in limb (Fleay 1926; Kinghorn & Fletcher 1927; Fletcher 1933; Elliott 1938; Bryant 1941; Pizzey 1958; Beste 1970; Campbell; North; Mathews; Fleay; Hollands; NRS). Trees used include Manna Gum *Eucalyptus viminalis*, Messmate *E. obliqua*, Blue Mountains Ash *E. oreades*, Western Australian Flooded Gum *E. rudis*, *Angophora*, and large mallee (NRS); once each in hollow of Coast Banksia *Banksia integrifolia* (Cooper 1975) and rainforest tree (Hollands). Some hollows traditional, and re-used, particularly if breeding successful, in successive or subsequent years for up to 20 years or more (Pizzey 1958; Cooper 1975; Beruldsen 1980; Frauca 1980; Braby 1987; Stephenson 1998a; Campbell; Hollands; NRS); may use same tree but different hollow (NZ NRS). Usurp hollows of Galahs *Eolophus roseicapillus* containing eggs or chicks (Mack 1965; Schulze 1966; NRS). Use hollows that other hollow-nesting species have used in previous years (NRS). Sometimes nest near other nesting species (NRS): once in same hollow branch

as, and 1 m from, Laughing Kookaburras (D'Ombrain 1905); another nest 2 m from nest of Australian Kestrels *Falco cenchroides* (Baker-Gabb 1985b; Hollands). Exceptional sites: in old nests of corvids *Corvus* in eucalypts where hollows lacking (Sedgwick 1949; Tarr 1949; Campbell); caves or ledges of cliffs (Strahan). Now on Norfolk I. mainly use nest-boxes, though some use of natural tree-holes (Olsen 1996). NZ Usually in hollow of tree or, rarely, in centre of epiphyte (Stead 1932; Williams 1963; Oliver; NZ NRS); commonly in dense clump of *Astelia* in forks of trees (Stead 1932; Moon 1967); also in deep forks of trees (NZ NRS). Trees used include Kohekohe *Dysoxylum spectabile* (Wilkinson 1927), Mahoe *Meliclytus ramiflorus* (Stephenson 1998; NZ NRS; D. Mudge), beech *Nothofagus*, rata and pohutukawa *Metrosideros*, Matai *Prumnopitys taxifolia*, Macrocarpa *Cupressus macrocarpa* (Stead 1932; NZ NRS), Pukatea *Laurelia novaeseelandiae* (D. Mudge), and cabbage trees *Cordyline* (Stead 1932; Stephenson 1998; NZ NRS); in pines, such as *Pinus radiata*, on piles of needles in forks and where thick foliage overhead (M'Lean 1911); in hollows formed in broken-off trunks of tree-ferns and in fork of two tree-ferns (Stephenson 1998); once on top of old nest of House Sparrow (Stead 1932). Sometimes in burrows in river banks, in banks of earth adhering to roots of large trees or in caves (Stephenson 1998; Oliver; NZ NRS). On islands without mammalian predators, often nest on ground (Stead 1932; Chambers *et al.* 1955; Ramsay & Watt 1971; Anderson 1992; NZRD); on Mokoia I., several nests, well camouflaged, among fallen fronds of tree-ferns with various degrees of cover (Stephenson 1998); once on ground under huge rata (Stead 1932). Usurp nest-boxes from Common Starlings (Hogg & Skegg 1961), and nest in those provided for saddlebacks *Philesturnus* (Stephenson 1998). MEASUREMENTS: AUST.: Height of entrance (m): 7.2 (5.8; 3–30; 25) (NRS); 10.3 (7.5; 4–24; 13) (Ingle 1910; H.L. White 1922; Elliott 1938; Bryant 1941; Beste 1970; Braby 1987; Campbell; North; Hollands); 3–25 (Schodde & Mason). Height of nest-plant, 12.3 m (6.3; 8–30; 12) (NRS). Depth of nest-hollow: 30–120 cm (Marshall 1933; Elliott 1938; Beste 1970; NRS); 50–250 cm (Schodde & Mason; NRS). Diameter of hollow, 20–30 cm (Schodde & Mason; NRS). An old stick-nest 11 m above ground (Sedgwick 1949). NZ: Height of nest or entrance (m): 3.6 (2.7; 0.6–10; 22) (NZ NRS); 3.2 (2.1; 0.4–5.6; 8) (Stephenson 1998); 3.5 (2.6; 1.3–7.9; 5) but up to c. 12 m (D. Mudge); 1.5–6 (Wilkinson 1927; Stead 1932); sometimes on ground. Dimensions of entrance to hollow (cm): vary, e.g. 140 × 7.5–9; 87 × 2.5–16 (D. Mudge); 20 × 10 (Stephenson 1998); 90 × 30 (NZ NRS). Chamber or cavity in hollow 14 × 18 to 62 × 42 cm; depth, 10–150 cm from entrance; cavity on ground among fronds of tree-fern, 52 × 25; nest-cup in tree-fronds in fork of tree, c. 20 cm in diameter; chamber in bank of earth c. 15 × 20 × 15 cm down tunnel 45 cm long and c. 15 cm diameter (Stephenson 1998; D. Mudge).

**Nest, Materials** Eggs laid on wood-dust or decaying wood at bottom of hollow (Sandland & Orton 1922; Mathews 1930; Stead 1932; Elliott 1938; Campbell; Mathews; NRS); sometimes contains material from previous occupant, e.g. an old possum nest (Fleay 1926, Fleay). Said sometimes to line nest with leaves and twigs (Campbell; NRS) or dry grass (NRS), but in NZ nothing much added (Stead 1932; Stephenson 1998; NZ NRS) and nothing added on Norfolk I. (P.D. Olsen). In an old corvid nest, original lining still present and fresh green eucalypt leaves added at hatching stage (Sedgwick 1949; Tarr 1949). One in Mahoe tree had several entrances and was quite open (Stephenson 1998). Both sexes prepare hollow, though male does most; male flies in at dusk, giving Por Calls, shreds material

#### Plate 40

Sooty Owl *Tyto tenebricosa* (page 890)  
1 Adult male; 2, 3 Adult female

Lesser Sooty Owl *Tyto multipunctata* (page 902)  
4 Adult male; 5 Adult female; 6 Juvenile; 7, 8 Adult female

and scrapes depression; female attends, also giving Por Calls (Fleay 1925, 1926; Olsen 1997; Fleay).

**Eggs** Rounded oval; smooth, slightly lustrous, minutely pitted; white, though become stained in nest (North). **MEASUREMENTS:** AUST.: 41.6 (2.6; 37.8–46.3; 231) × 35.5 (2.1; 31.7–41.0) (Olsen & Marples 1993). NZ: 39.0 (1.5; 36.3–41.1; 9) × 32.9 (1.3; 31.2–35.2) (Stephenson 1998); 37.5 × 32.5, 38.5 × 34.5, 39 × 34 (Oliver); 38.3 × 33, 40 × 33.5 (Hogg & Skegg 1961); 33.9 × 37.5 (NZ NRS). **WEIGHT:** AUST.: Fresh weight (W), 27.1 (2.0; 22.4–30.0; 8); average weight loss during incubation, 12% (9–14; 8); daily weight-loss, estimated as 0.12W/30; numbers of days into incubation, estimated as W(X/daily weight-loss (X = weight of egg when removed)) (Olsen 1997). NZ: 24.1, 22.4, 21.0 (Stephenson 1998). **VOLUME:** AUST.: Estimated 26.7 cm<sup>3</sup> (41.0; 22.0–36.2; 231) (Olsen & Marples 1993).

**Clutch-size** One to five, normally two or three. **AUST.:** From museum data: 2.5 (1–4; 100); from graph, C/1 × 3, C/2 × 48, C/3 × 44, C/4 × 2 (Olsen & Marples 1993). Occasion-ally up to five (Hollands). From NRS, for acceptably complete clutches: C/2 × 5, C/3 × 5, C/4 × 2. **NORFOLK I.:** C/1 × 1, C/2 × 6, C/3 × 1 (Olsen 1996). NZ: Two, rarely three (Wilkinson 1927; Mathews 1930; Stead 1932; Hogg & Skegg 1961; Williams 1963; Moon 1967; Olsen & Moon 1990; Stephenson 1998; Oliver; NZ NRS) or one (Stephenson 1998).

**Laying** AUST.: Laying interval: 2 days, rarely 4 days between second and third eggs (Olsen 1997); rarely 6 days (Hobbs 1971); 1–2 days (Hollands); secondary sources give 1–3 days (Schodde & Mason) and 2–3 days (Aust. RD; Strahan). Claims of 1 day unlikely (S.J.S. Debus). NZ: Laying interval: 2 days (Williams 1963; Moon 1967), at least 2 days (NZ NRS); claim that interval 1 day (Hogg & Skegg 1961) unlikely. Single-brooded (Fleay); said, without evidence, to rear two broods in a season (Campbell). If eggs taken, lay replacement clutch in same or different nest (Sandland & Orton 1922; Campbell).

**Incubation** By female only. Leave nest at dusk for c. 0.5 h, sometimes to bathe (Fleay 1926; Olsen 1997; Fleay). In captivity, auxiliary female once relieved primary female, who was temporarily ill (Fleay); another time two females shared incubation (Olsen 1997). Begins with first (Williams 1963; Moon 1967; Schodde & Mason) or second egg (Olsen 1997), often leading to asynchronic hatching (Elliott 1938; Bryant 1941; Sedgwick 1949; Tarr 1949; Hogg & Skegg 1961; Williams 1963; Mack 1965; Moon 1967; Stephenson 1998) and fledging (Hobbs 1971; Braby 1987; Olsen 1997; NRS), though young often fledge close together (NZNRS). Clutches of two eggs synchronic in hatching and fledging, but in clutches of three, last chick hatches 1–4 days after second (Olsen 1997); in one brood there seemed to be a few days between fledging of eldest and that of younger two nestlings (NRS). Male feeds incubating female (Fleay 1926; Fleay). After hatching, eggshells probably eaten by female (Olsen 1997). **INCUBATION PERIOD:** For marked eggs, mean and mode, 30 days (29–31; 10) (Olsen 1997); for unmarked eggs, 30–31 days (Moon 1957, 1967; Gubb 1978); 30 days (Hogg & Skegg 1961); 33 days (Fleay); 31–32 days in captivity (Gubb 1978); also said to be at least 29 days (J. Olsen & S. Trost), 26–33 days and 34–36 days for *lurida* (Schodde & Mason) and 35 days (Hollands), though extremes of range seem unlikely.

**Young** Semi-altricial, nidicolous. Hatch in complete covering of sparse down, and blind (Fleay 1926; Stead 1932; Bryant 1941; Moon 1967; Olsen 1997; Fleay; see Plumages). In captivity, each egg hatched over 1–2 days (Gubb 1978). At 13 days, captive chick regurgitated first pellet (Gubb 1978). **Growth**

From Day 6, eyes start to open and are fully open at 15 days (Stead 1932; Moon 1967; Gubb 1978; Olsen 1997; Fleay). At 7–10 days, juvenile plumage starts to show (Stead 1932; Hogg & Skegg 1961) and thickly covers body at 2 weeks (Olsen 1997). At 8 days, pins on wings emerge and dorsal feathers start to burst. At 10 days, pins on tail visible (Olsen 1997). At 19 days, quills burst. At 24 days, spotting on wings visible. At 1 month, feathered on dorsal surface, with downy head and underparts. In Aust., fledge at 5–6 weeks; in NZ, at 38–40 days; fledge with short tail and downy head and underparts (Fleay 1925; Olsen 1997; Stephenson 1998). **WEIGHT:** At hatching, 20.0 (2.0; 19.0–20.8; 5); at fledging, 90% of adult weight; maximum weight, 270 for males, 320–350 for females. Wing fully grown at 70 days. Age of nestlings and new fledgelings in days (A) estimated by equation  $A = (WL - 0.99)/0.39$ . Tail fully grown by 65–70 days (Olsen 1997). For one chick: at c. 1 week, weight 82, length of wing 2.68 cm, culmen 1.06 cm, tarsus 3.18 cm; at c. 3 weeks: 209, 8.10, 1.20, 4.01; at c. 5 weeks, 296, 17.1, 1.34, 5.06 (J. Olsen & S. Trost). For further details see Bryant (1941), Gubb (1978) and Olsen (1997); for photographs see Fleay (1925, 1926) and Fleay. **Parental care, Role of sexes** Brooded by female only; continuously for first week; by day into third week (Fleay). Female roosts in nest with young till they fledge (Bryant 1941; Pizzey 1958; Moon 1967; Braby 1987), or roosts outside nest in second half of nestling period (Beste 1970; Stephenson 1998; Fleay; Hollands). Young fed piecemeal, bill to bill (Moon 1967); parent tears food for young till they fledge (Hollands), though older nestlings start tearing some food brought whole to nest (Stead 1932; Oliver). At 28 days in captivity, young used feet for holding food while tearing it with bills (Gubb 1978). Early in nestling period, male brings most food and female feeds young: male brings food to perch; female collects it from him and takes it to nest; sometimes food transferred in air, bill to bill, or male seems to deliver food to hollow (Moon 1967; Stephenson 1998; J. Olsen & S. Trost). When chicks >15 days old or from as early as second night, depending on feeding rate of male, female starts hunting. Both sexes feed chicks during second half of nestling period (Pizzey 1958; Moon 1967; Fleay; Hollands), though male sometimes still passes food to female to feed to nestlings (J. Olsen & S. Trost). Number of feeding visits to nest: every few minutes from dusk (Braby 1987); at one nest, 14 visits in 1 h after dusk, then three from last light to 02:00; at another, eight between 21:00 and 24:00 with four in first hour; at another, eight from 20:30 to 21:30, by both sexes, then 13 in 1.5 h from dusk on each of two nights, and 38 in 1 h from dusk for one night (Hollands); at another, 13 in 25 min; three in 2 min and sometimes at c. 2 min intervals (NRS); at another with nearly fledged young, in first hour after dark could be fed as often as every 1–2 min and up to three times in 1 min, male and female making similar number of visits (NRS); at another: on first night after hatching, male made five feeding visits in 4 h; on second night, male two and female made five in 2 h, of which four were in 4 min; on sixth night, female made eight visits in 2 h, with six in 10 min; at fledging, both sexes fed young every 4–5 min over 30 min (Moon 1967). Food may be kept in nest, on which young are fed from time to time; also food often stored nearby (Stead 1932). Young defecate and regurgitate pellets in nest; remains of food decay in nest, producing strong odour (Bryant 1941). **FLEDGING PERIOD:** 38–40 days (Stephenson 1998); 40+ days (Schulze 1966); 43 days (Fleay); 36 days (Hobbs 1971); c. 38 days (Olsen 1996); 6 weeks (Elliott 1938; Bryant 1941; Olsen & Trost 1998; J. Olsen & S. Trost); 5 weeks (Williams 1963; Moon 1967); one nearly 6 weeks old almost ready to fly (NRS).

In captivity, one brood of two fledged at 37 days; another of three, on successive days at 32–34 days (Olsen 1997); another made first attempts to fly on Day 30 and could fly competently by Day 42 (Gubb 1978). Second young fledged  $\leq 4$  days after first (Hobbs 1971b); third young fledged two nights after first (Braby 1987).

**Fledging to maturity** After fledging, chicks exercise, flap wings, bow and bob, and scramble up trunk or branches, but return to nest (Pizzey 1958; Moon 1967; Hollands; NRS); chicks may leave nest for several nights, but return during day (Stephenson 1998). At fledging, make short flights to nearby trees, and perch in or near hollow (Braby 1987; Schodde & Mason; Strahan). At one nest, elder fledgeling flew to perched female; then female enticed younger fledgeling out of nest by calling; family did not return to nest (Moon 1967). Often fly poorly at first (Moon 1967; Frauca 1980; Schodde & Mason). Sometimes roost in nest-hollow for first week, then roost outside with parents. Fledgelings given whole prey (Olsen & Trost 1998; Fleay). In one family, female fed newly fledged young more than male did, but after a while, male fed fledgeling more (J. Olsen & S. Trost). Said that at 8 weeks old, juveniles have reached adult size but head and underparts still downy; acquire adult-like brown plumage at c. 3 months, and resemble adults at 5 months (Fleay 1926; Fleay; Strahan); but also said to be smaller than adults at 10 weeks old (D.G. Hollands). Start catching own food 3 weeks after fledging, though still also fed by adults; leave nest-area by 4 weeks old (Braby 1987; NRS; NZ NRS); dependent for 6–7 weeks after fledging (Olsen & Trost 1998). Captive-bred young released by hacking independent and dispersed 11–12 weeks after fledging (Olsen 1997). Young may stay in natal territory for 2–3 months (Hollands); up to 4 months, till autumn (Strahan); or up to first winter (Olsen 1996).

**Success** In Aust., of 22 nests found with nestlings, average brood-size 2.8: B/1  $\times$  1 (from C/3), B/2  $\times$  7, B/3  $\times$  10, B/4  $\times$  4; in a few nests, later visits found one or two of nestlings had died or disappeared; of 17 families, average of 2.6 fledgelings or dependent young: seven had two young, seven had three and one had four (NRS; J. Olsen & S. Trost). In NZ, of 13 eggs in eight nests, seven hatched (some of those not hatched having been broken or deserted), and five fledged (Stephenson 1998); of six eggs in three nests, six hatched but at least four died at nestling stage (NZ NRS). On Norfolk I. (not representative): one pair, possibly with old female, fledged four young from 11 eggs over 5 years; younger pair fledged five young from five eggs in 2 years; causes of failure were breaking of eggs (reason not known), and appropriation of nest-box by feral bees (Olsen 1996). Some thinning of eggshells through ingestion of DDT-based pesticides shown, but probably has no significant effect on populations (Olsen *et al.* 1993). Eggs eaten by Common Brushtail Possums (P.D. Olsen). Nestlings taken by predators, which may occupy hollow afterwards (Hollands). Sometimes younger nestlings of brood become weak and die, one being partly eaten (Stead 1932; Stephenson 1998; NRS). In some areas, eggs and chicks possibly eaten by introduced rats and cats (Garnett 1993; Olsen 1996; NZ NRS). Dependent juveniles killed by vehicles (Williams 1995; NRS). Juveniles afflicted by eye ailments, including cataracts, resulting in progressive blindness (Stokes 1982; Wilson 1990). Juveniles also have high mortality during or after bushfires, e.g. 100+ beachcast after extensive fires in s. Vic. (Wegener 1984); are killed accidentally from entanglement in dodder *Cassytha* (Ashton 1996) and Buzzy *Acaena novaeseelandiae* (Mooney 1992); are taken by Brown Goshawks *Accipiter fasciatus*, Grey Goshawks *A. novaehollandiae*, and Masked Owls (Czechura *et al.* 1987; Olsen

*et al.* 1990; Mooney 1993), cats (QM), and, probably, by Powerful Owls (McNabb 1996) and Swamp Harriers *Circus approximans* (Stephenson 1998); occasionally killed by large mobbing birds (Whiter 1989). Endoparasites include tape-worms (Hill 1911; Cleland 1920); *Filaria* (Johnston 1912); and roundworms (White 1917; Hall; QM).

**PLUMAGES** Prepared by A.M. Dunn. Fledge in juvenile plumage. Begin partial post-juvenile (first pre-basic) moult to adult-like plumage at c. 3 months old. Then undergo a probably complete immature post-breeding (second pre-basic) moult to adult-like plumage, but not known when. Full adult plumage possibly not attained till third or fourth year (Schodde & Mason), and paler birds within a subspecies possibly younger birds. Thereafter complete post-breeding (pre-basic) moults each cycle produce successive adult plumages without change in appearance. Sexes similar or with only slight differences in plumage; some differences in size. Can breed in first year (see Social Organization). Seven subspecies recognized in HANZAB region (one extinct); both *novaeseelandiae* of NZ and *boobook* of se. mainland Aust. described below.

**Adult male** (Definitive basic). **NOMINATE NOVAE-SEELANDIAE:** HEAD AND NECK: Pale supercilium extends from lower forehead across top of upper mandible, above lores to above eye: mostly yellow-brown (c123C) but often with white visible along lower edge; feathers of supercilium, yellow-brown (c123C) with white bases and small dark-brown (21) tips; white bases usually visible across lower forehead. Rest of forehead, crown and nape, dark brown (21), often with small buff (c124) or yellow-brown (c123C) spots on edges of some scattered feathers of nape; amount of spotting varies individually, some having very little, others having much; in those with much spotting, spots can also occur on feathers of forehead and crown; amount of spotting possibly age-related. Hindneck and sides of neck, dark brown (21) with large buff (124) spots to edges of each feather. Feathers of lores, cheeks and ear-coverts around eye modified, with reduced barbules, and radiate out from eye; feathers near bill have elongated bristle-like spines and radiate over bill: ear-coverts, dark brown (21); cheeks, buff (c124) with black (89) spines; lores, white with black (89) spines. Chin, white to buff (c124), sometimes with dark-grey (c83) shaft-streaks. Throat and foreneck mostly buff (c124) to yellow-brown (123C) with broad dark-brown (21) shaft-streaks; and, in some, white edges to feathers. **UPPERPARTS:** Mantle and scapulars similar to hindneck, but spots on scapulars white and those on lower mantle very faint. Back, rump and uppertail-coverts, dark brown (21), usually with small faint off-white to buff (c124) spots, though some do not have spots on uppertail-coverts. **UNDERPARTS:** Breast, belly and flanks generally appear as mixture of dark-brown, white and yellow-brown streaks. Feathers of breast, belly and flanks, dark brown (21) with large pale spots on edges of feathers that vary individually from almost circular to very elongated, almost streaks; spots mostly white with yellow-brown (123C) or buff (124) suffusion at perimeter; spots tend to be larger on belly than on breast, so that belly appears paler. Vent, white, with yellow-brown (123C) suffusion and some dark-brown (21) mottling. Undertail-coverts, brown (c28) with two rows of large rounded white spots along margins; spots edged with yellow-brown (123C) suffusion. Feathers of thighs and tarsus, light brown (c39) with some dark-brown (21) mottling. Toes have very sparse covering of brown (28) bristle-like feathers. **TAIL:** All rectrices dark brown (121) with 6–7 faint brown (c28) bars that become lighter toward base of inner web of outer rectrices (2–3 bars at base of



t4–t6 usually white); bars c. 5 mm wide and spaced c. 10 mm apart. Underside slightly paler than upperside. **UPPERWING:** All secondary coverts, dark brown (21); some median and lesser coverts have small buff (c124) to off-white spots on outer webs; all greater coverts have white spot on outer web. Lesser and median primary coverts, buff (c124) with dark-brown (21) tips. Alula and greater primary coverts, dark brown (21). Remiges, dark brown (121) with faint brown (c28) barring; bars often do not reach edges of feathers and grade into white near bases of inner webs of feathers; p6–p9 have a row of white spots along outer edge. **UNDERWING:** Coverts, buff (c124) to yellow-brown (c123C) with dark-brown (21) mottling. Remiges as upperwing but slightly paler.

**SUBSPECIES BOOBOOK:** Generally much paler than nominate *novaeseelandiae*. **HEAD AND NECK:** Supercilium mostly white, though some feathers have black (89) shaft-streaks; sometimes feathers have yellow-brown (123C) tips and dark-brown (219) shaft-streak at tip. Upper forehead, crown, nape, hindneck and sides of neck, dark brown (219), with yellow-brown (123C) edges to most feathers of upper forehead and sides of neck and narrow line of feathers above supercilium to sides of neck; in some, feathers of crown, nape or hindneck have small paired off-white to cream (54) spots near edges. Structure of feathers of lores, cheeks and ear-coverts modified, as in *novaeseelandiae*: ear-coverts and some of cheek below eye, dark brown (c219); tone similar to or slightly darker than dark brown on feathers of forehead, crown and nape, but usually contrasts slightly with those areas because facial feathers lack pale edges. Lores and fore-cheeks, white with black (89) spines to feathers. Chin and throat, white with black (89) shafts to some feathers; patch of black bristle-like spines radiate over under-surface of lower mandible. Foreneck, yellow-brown (c123C) with thick dark-brown (219) shaft-streaks to feathers. **UPPERPARTS:** Mantle, scapulars, back, rump and uppertail-coverts, dark brown (c219) with small concealed paired off-white to buff (c124) spots to back, rump, uppertail-coverts and some feathers of mantle, and 1–2 concealed white bars or 1–2 rows of concealed large white spots to scapulars; in some, spots on mantle larger and visible, giving mottled or spotted appearance. **UNDERPARTS:** Feathers of breast, belly, flanks and undertail-coverts mostly brown (34) with large pair of white spots on edge of feathers and white convex bar above dark blue-grey (78) base; margin of white spots usually suffused yellow-brown (c123C); size of white spots and amount of yellow-brown suffusion varies individually. Vent, off-white with dark blue-grey (78) bases to feathers. Thighs and tarsus, feathered, buff (c124) with white bases to feathers. Toes covered with translucent bristle-like spines. Overall pattern of underparts varies greatly; most have predominantly streaked appearance to breast, with a more spotted appearance to belly, but in some, underparts appear mainly spotted. **TAIL:** Mostly dark brown (219) with faint light-brown (c223D) barring on inner web of each rectrix and light grey-brown (119C) fringe at tip; barring faintest on t1, boldest on t6. Underside slightly paler and greyer than upperside (colour matches do not alter). **UPPERWING:** All lesser and median coverts, dark brown (121) with partly concealed white spot on outer web of some larger lesser and all median coverts. Greater secondary coverts, dark brown (219) with white spotting or barring; innermost feathers have complete bars, which are reduced to row of spots on outer webs toward outerwing. Alula and greater primary coverts, dark brown (219), often with faint light-brown (c25) barring or partial barring. Primaries, dark brown (c219) with light-brown (c25) barring; bars (slightly darker than on secondaries), c. 8

mm wide and spaced 10–20 mm apart; on p5 or p6 to p10, outer edge of bars very pale near middle of feather, sometimes forming white spots on outer edge. Secondaries and tertiaries, dark brown (c219) with bars that grade from light brown (25) near outer edge of feathers to white near inner edge. **UNDERWING:** Lesser and median coverts vary individually, from buff (123D) to buff-brown (c39), and inner and median primary coverts have brown (28) to dark-brown (219) shaft-streaks. Greater coverts, dark brown (c121) with broad white barring. Primaries and secondaries, dark brown (c121) with broad white barring, which is faint on distal half of outer 5–6 primaries.

**Adult female** (Definitive basic). **NOMINATE NOVAESEELANDIAE:** As adult male. **SUBSPECIES BOOBOOK:** Very similar to adult male and most probably inseparable. However, based on examination of a large series of birds, females tend to have more spotting or streaking on crown, nape, hindneck and mantle; and underparts often appear more streaked than in adult male because spots at sides of feathers often more elongate.

**Downy young** **NOMINATE NOVAESEELANDIAE:** Hatch in slaty-grey down, which becomes white within 1 week of hatching (Oliver); hatch in sooty-grey down (P.D. Olsen). Also see Stead (1932) and Moon (1967). **SUBSPECIES BOOBOOK:** Sparsely covered in white down (Fleay 1926; Bryant 1941; Olsen 1997; Fleay).

**Juvenile** **NOMINATE NOVAESEELANDIAE:** No skins available; based on photos (Olsen & Moon 1990; Moon 1992; unpubl.: B. Chudleigh). Differences from adult. White downy projections, remnants of natal down, present on tips of all feathers when plumage first attained; these gradually lost with wear; retained longest on head (Oliver). **HEAD AND NECK:** Ground-colour of crown, nape, hindneck and sides of neck darker and greyer than in adult, dark brownish-grey (brownish 83). Feathers have fluffy down-like texture, except for feathers of ear-coverts, cheeks, lores and around eye, which are similar to those of adult. **UPPERPARTS:** Not seen; probably of similar tone to crown, nape and hindneck and with fluffy down-like texture. **UNDERPARTS:** All feathers have fluffy down-like texture. Mostly dark brownish-grey (brownish 83) mottled with white and light brown (c223D). **TAIL:** Similar to adult, but often have fault-bars. **UPPERWING:** Similar to adult. **UNDERWING:** No information.

**SUBSPECIES BOOBOOK:** Head, neck and upperparts much paler than adult and feathers of these tracts have fluffy down-like texture. Also much paler than juvenile of *novaeseelandiae*, which has mostly brown, rather than white, underparts. **HEAD AND NECK:** White areas of forehead and supercilium much broader than in adult, contrasting with dark feathers round eye; most of forehead, white, except for a few black (89) bristle-like shafts to feathers of lower forehead. Most feathers of crown, nape, hindneck and sides of neck, brown (28) with off-white or cream (c92) edges, but some feathers mostly off-white (ne) with narrow brown (c28) shaft-streaks and brown (28) tips; all have fluffy down-like texture. Foreneck slightly paler than in adult. Rest as adult. **UPPERPARTS:** Similar to adult but slightly paler, with larger white spots, and feathers have fluffy down-like texture. Spots on scapulars appear larger than on adult and are only partly concealed. **UNDERPARTS:** Breast, belly, flanks and undertail-coverts mostly white with narrow light-brown (c26) shaft-streaks and concealed grey (84) bases; shaft-streaks often narrowly edged yellow-brown (c123B). Vent and feathered tibia and tarsus, white. All feathers have fluffy down-like texture. **TAIL:** Similar to adult, but often have fault bars. **UPPERWING:** Similar to adult or with slightly bolder spotting to coverts. **UNDERWING:** Coverts much paler than adult: mostly off-white (ne); primary coverts, off-white with brown (28) to dark-brown (219) shaft-streaks. Rest as adult.

**First immature** (First basic). **NOMINATE NOVAESEELANDIAE**: Difficult to distinguish from adult, but at least some birds with much spotting on crown and nape probably first immatures. Retain juvenile remiges and rectrices, and presence of fault bars in rectrices may be used to distinguish from older birds. **SUBSPECIES BOOBOOK**: Forecrown heavily streaked, more so than adult male or female. Hindcrown and nape more heavily spotted and mottled off-white. Appear paler and more streaked on underparts because spots on feathers more elongate. Retain juvenile remiges and rectrices, and latter often show fault bars.

**Second and subsequent immatures** (Second and subsequent basic). Not known exactly when adult plumage attained. **NOMINATE NOVAESEELANDIAE**: Little known, but birds with much spotting on crown and nape probably younger birds. **SUBSPECIES BOOBOOK**: Similar to adult but with more spotting on crown, hindneck and mantle.

**BARE PARTS** Based on photos (Olsen & Moon 1990; Trounson & Trounson 1991; Moon 1992; Egerton 1993; Fleay; Aust. RD; NZRD; Hollands; Strahan; unpubl.: B. Chudleigh; B.M. Stephenson). **Adult NOVAESEELANDIAE**: Bill, light bluish-grey (bluish 85) with a dark-grey (c83) to black (89) cutting edge. Cere, light bluish-grey (bluish 85), pearl-grey (c81) or pale grey (c86). Iris, yellow (55) or orange-yellow (c18). Orbital ring, cream (c54) or grey (c84). Feet, buff-yellow (c53), orange-buff (118) or pale yellow (c157). Claws, black (89). **BOOBOOK**: Bill mostly black (89) with light blue-grey (c88) base to culmen ridge. Cere, light blue-grey (c88). Iris, straw-yellow (56), light greenish-grey (c44) or orange-buff (118). Orbital ring, dark grey (83). Feet, light grey (85) or pink-brown (c219D) in some; usually grey (P.D. Olsen). Claws, grey-black (82). **Downy young NOVAESEELANDIAE** (Based on photos of rather large individuals, probably 1–2 weeks before fledging): Bill and cere similar to adult or slightly paler. Iris, pale yellow (157) or bright yellow (P.D. Olsen). Feet, pale yellowish-grey (yellowish 86). **AUST. SUBSPECIES**: Very little information available and subspecies not identified in most material examined, but probably no differences between Aust. subspecies. Bill mostly pale grey (86) to light blue-grey (88) with dark-grey (83) tip. Cere, pale grey (86). Iris, powder-blue (Bryant 1941); changes to straw-yellow (56) before fledging. Orbital ring, brownish grey (80). No other information. **Juvenile NOVAESEELANDIAE**: Similar to adult, but younger birds can have paler, greyer feet, and slightly paler iris: yellow (c55) to pale yellow (c157). **BOOBOOK**: Bill, orbital ring and cere as adult. Iris, straw-yellow (c57). Feet, very pale pink (very pale 108D); also grey (P.D. Olsen).

**MOULTS** Based on examination of 74 adult skins of *novaeseelandiae* from NZ; 78 adult and three juvenile skins of *boobook* from Qld, NSW, Vic. and SA; 48 adult skins of *ocellata* from Qld, NT and WA; 19 skins of adult *lurida* from Qld; and 59 adult skins of *leucopsis* from Vic. and Tas. (AIM, AM, ANWC, HLW, MV, NMNZ, QM, QVM, SAM); and published information (Stephenson 1998). **Adult post-breeding** (Pre-basic). Complete; primaries outward, starting from p1. Those with active moult of primaries had between one and three growing primaries in each wing. **NOVAESEELANDIAE**: Only four of 74 skins examined had active moult of primaries: in Nov. (PMS=7, 18), Dec. (PMS 7), Feb. (PMS 23); suggests moult probably begins about Nov. and probably finished about Mar. The rest based on information from live birds on Mokoia I., NZ (Stephenson 1998). Moult occurred Dec.–Mar., after breeding, with most apparently in Jan.–Feb. Start of moult of individuals

coincided with end of unsuccessful breeding attempt or after young fledged. Began with body, which was usually nearly finished in birds with active moult of remiges and rectrices. All birds examined in Jan.–Feb. had active moult of primaries, with moult in each wing usually synchronous. No apparent pattern to replacement of secondaries. Replacement of rectrices either simultaneous, irregular or centripetal; most were without a tail at some stage in Jan. or Feb., and thus simultaneous moult of tail probably most common. Moult of tail occurred over similar period to moult of primaries. **BOOBOOK**: Probably begin late spring or early summer, but few examined actively moulting. Between Oct. and Apr., only six of 42 skins (14%) examined had active moult of primaries: Oct. (PMS=5), Jan. (PMS 8, 24), Feb. (PMS 24), Apr. (PMS 39, 39). Nine of 25 skins (36%) examined between Oct. and Apr. had active moult of body, which appeared to be heaviest in Feb. and Mar. None of 36 skins collected between May and Sept. were moulting primaries or body. No skins had active moult of tail. **OCCELLATA**: Timing probably similar to *boobook* or slightly earlier. Between Oct. and Mar., seven of 16 skins (44%) examined had active moult of primaries: Oct. (PMS=2), Nov. (PMS 4, 19), Jan. (PMS 37), Feb. (PMS 32, 34), Mar. (PMS 28). Five of 11 skins (45%) examined between Nov. and Feb. had active moult of body, which appeared to be heaviest in Jan. and early Feb. Skins collected in Oct. and Mar. (n=5) also showed no moult of body. Only one skin, from Jan., had active moult of tail, with heavy moult, t3–t6 all growing at once; t1 and t2 were old. None of 32 skins collected between Apr. and Sept. were moulting primaries, body or tail. **LURIDA**: Very little information. Of 19 skins collected from most months of year, only one in Feb. had active moult of primaries (PMS=15) and another in Feb. had slight moult of body. **LEUCOPSIS**: Little information; few skins showed active moult. Birds collected from most months of year, but only one in Mar. had active moult of primaries (PMS=35). Six of 19 (36%) had active moult of body between Feb. and May; moult heaviest in one from Apr. None recorded with active moult from other times of year. **Post-juvenile** (First pre-basic). Little information. Subspecies probably similar. Partial; involves most plumage, except remiges and rectrices. Lose downy appearance at c. 3 months old (Fleay). In Aust., said to be finished in autumn (Schodde & Mason). **First immature post-breeding** (Second pre-basic). No information. Probably complete.

**MEASUREMENTS** Nominate *novaeseelandiae*, NZ: (1) Adults, skins (AIM, CM, NMNZ). (2) Adults, skins (Mees 1964). (3–4) Age not specified, live (Stephenson 1998): (3) Mokoia I., NI; (4) West Coast.

	MALES	FEMALES	
WING	(1) 189.3 (4.04; 181–196; 27)	192.4 (4.30; 179–200; 45)	**
	(2) 193.4 (4.80; 186–203; 12)	192.4 (5.86; 183–202; 21)	ns
	(3) 192.7 (4.41; 183–200; 14)	198.7 (5.67; 191–206; 10)	**
	(4) 187.4 (5.32; 5)	193.9 (3.91; 16)	**
TAIL	(1) 115.7 (4.00; 108–123; 27)	119.7 (5.03; 109–133; 47)	**
	(3) 116.5 (5.63; 108.5–128.9; 13)	116.6 (7.17; 102.5–124.8; 10)	ns
	(4) 116.8 (2.48; 5)	118.4 (3.05; 16)	ns
	BILL C (1) 14.1 (0.47; 13.3–15.0; 25)	14.6 (0.63; 13.0–15.8; 43)	**
BILL S	(1) 21.7 (1.23; 19.0–23.9; 27)	22.3 (0.71; 20.4–23.6; 48)	**
	(3) 21.3 (0.76; 19.7–22.5; 14)	21.7 (0.86; 20.2–23.5; 10)	ns
	(4) 20.4 (0.65; 5)	21.5 (0.81; 16)	**
BILL W	(3) 8.8 (0.29; 8.30–9.40; 14)	9.5 (1.10; 8.45–11.90; 10)	ns
	(4) 8.5 (0.65; 5)	8.8 (0.32; 16)	ns
TARSUS	(1) 33.7 (1.29; 31.3–35.9; 23)	33.5 (1.08; 30.1–35.8; 43)	ns
	(3) 38.2 (0.80; 37.2–39.9; 14)	37.2 (1.25; 35.0–38.9; 10)	**
	(4) 37.2 (0.60; 5)	37.1 (0.95; 16)	ns

TOE C	(1)	28.6 (2.11; 26.1–30.8; 5)	28.7 (1.08; 26.7–31.7; 21)	ns
THL	(3)	49.2 (1.24; 47.0–51.5; 14)	49.4 (1.64; 47.2–52.5; 10)	ns
	(4)	45.8 (0.90; 5)	48.1 (2.53; 16)	*

(5) Orongorongo Valley, NZ, live (Robertson *et al.* 1983).

UNSEXED				
WING	(5)	187.3 (6.02; 174–198; 57)		
BILL	(5)	20.7 (1.29; 19–23; 45)		
TARSUS	(5)	33.8 (1.74; 30–40; 32)		
TOE	(5)	34.1 (2.58; 28–39; 45)		

Subspecies *boobook*: (6–8) Adults, skins (ANWC, HLW, MV, SAM): (6) SA and Vic.; (7) NSW and Qld; (8) Kangaroo I., SA. (9–11) Adults, skins (Mees 1964): (9) SA and Vic.; (10) NSW and Qld; (11) Kangaroo I., SA.

	MALES	FEMALES	
WING	(6) 237.5 (6.55; 226–251; 24)	242.2 (5.43; 231–250; 25)	**
	(7) 241.0 (5.00; 233–248; 9)	246.6 (2.99; 242–250; 7)	*
	(8) 225.8 (4.94; 217–234; 17)	233.9 (7.59; 222–251; 19)	**
	(9) 238.1 (5.20; 230–248; 23)	238.7 (6.03; 227–249; 26)	ns
	(10) 244.0 (4.90; 233–255; 31)	249.8 (7.65; 228–261; 26)	**
	(11) 215, 226	236, 245	
TAIL	(6) 134.0 (4.68; 125–142; 23)	137.5 (6.90; 124–153; 24)	*
	(7) 136.7 (6.38; 125–147; 9)	135.7 (2.98; 132–140; 7)	ns
	(8) 130.6 (6.23; 117–143; 17)	131.1 (5.88; 122–143; 19)	ns
BILL C	(6) 16.1 (0.90; 14.0–17.8; 23)	16.9 (0.78; 15.7–18.5; 21)	**
	(7) 16.9 (1.03; 15.7–18.7; 9)	17.6 (0.83; 16.4–18.7; 7)	ns
	(8) 15.9 (0.42; 14.9–16.7; 17)	16.9 (0.77; 15.6–18.7; 18)	**
BILL S	(6) 24.9 (1.08; 22.0–27.0; 23)	26.0 (1.11; 24.6–28.2; 25)	**
	(7) 26.0 (1.28; 24.6–27.9; 9)	26.1 (1.69; 23.5–28.5; 7)	ns
	(8) 24.7 (0.95; 22.1–25.8; 17)	25.9 (1.35; 23.6–28.5; 18)	*
TARSUS	(6) 41.9 (1.56; 39.4–45.8; 21)	43.2 (1.54; 40.5–46.2; 20)	*
	(7) 42.9 (2.07; 38.6–45.9; 9)	44.0 (2.79; 38.3–46.9; 7)	ns
	(8) 39.8 (2.41; 32.6–42.8; 16)	41.3 (1.52; 38.1–44.0; 18)	*
TOE	(6) 26.0 (1.31; 23.6–27.8; 21)	27.6 (1.15; 25.2–29.8; 14)	**
	(7) 27.1 (1.41; 25.4–29.0; 8)	26.9 (0.81; 26.0–27.7; 4)	ns
	(8) 26.3 (0.94; 25.2–28.1; 8)	27.1 (1.39; 25.6–29.7; 8)	ns
CLAW	(6) 14.5 (0.94; 12.8–16.0; 24)	15.0 (0.72; 13.2–16.3; 25)	ns
	(7) 15.3 (0.86; 13.7–16.2; 9)	16.0 (0.53; 15.3–16.6; 7)	ns
	(8) 14.7 (0.59; 13.9–15.8; 17)	14.9 (0.86; 13.0–16.5; 18)	ns

Subspecies *ocellata*: (12) N. Qld, NT and WA, adults, skins (AM, ANWC, HLW, MV). (13–18) Adults, skins (Mees 1964): (13) SW. WA, N to about North West C.; (14) NW. WA, S to about Fortescue R.; (15) NT, except Melville I. and Groote Eylandt; (16) Melville I., NT; (17) Groote Eylandt, NT; (18) W. and n. Qld.

	MALES	FEMALES	
WING	(12) 221.8 (7.95; 203–233; 21)	226.6 (7.39; 216–245; 26)	*
	(13) 226.2 (6.50; 215–234; 13)	232.5 (5.57; 226–246; 22)	**
	(14) 224.2 (8.57; 208–239; 13)	228.6 (7.25; 216–240; 12)	ns
	(15) 222.1 (8.72; 213–237; 8)	226.6 (5.39; 218–237; 11)	ns
	(16) 203, 211, 213	199, 210	
	(17) 204, 206	212, 218, 220	
	(18) 224.0 (5.52; 218–232; 5)	227.8 (5.85; 220–234; 6)	ns
TAIL	(12) 123.5 (6.87; 111–136; 21)	125.2 (6.61; 114–144; 25)	ns
BILL C	(12) 15.9 (0.75; 14.6–17.4; 22)	16.8 (0.68; 15.7–18.1; 25)	**
BILL S	(12) 25.2 (0.76; 24.2–26.7; 22)	26.1 (0.92; 23.6–27.2; 25)	**
TARSUS	(12) 40.6 (2.56; 33.0–46.5; 20)	40.8 (1.67; 38.5–44.7; 26)	ns
TOE	(12) 26.6 (1.25; 23.4–28.4; 18)	26.7 (1.16; 24.6–29.0; 24)	ns
CLAW	(12) 14.6 (0.85; 13.0–16.5; 21)	14.8 (0.83; 13.2–16.9; 26)	ns

Subspecies *lurida*: (19–20) NE. Qld rainforests from Cooktown in the N to Paluma in the S, adults, skins: (19) From

AM, ANWC, HLW, MV, QM; (20) From Mees (1964).

	MALES	FEMALES	
WING	(19) 213.9 (5.04; 206–220; 9)	217.6 (4.66; 210–225; 12)	ns
	(20) 215.8 (4.65; 210–220; 4)	214.6 (5.55; 207–221; 5)	ns
TAIL	(19) 118.8 (4.41; 111–125; 9)	118.7 (4.85; 108–128; 12)	ns
BILL C	(19) 16.1 (0.94; 14.2–17.6; 9)	16.9 (1.28; 13.6–18.1; 11)	ns
BILL S	(19) 25.8 (0.82; 24.4–26.9; 9)	26.1 (1.41; 23.0–28.5; 11)	ns
TARSUS	(19) 38.2 (1.13; 36.0–39.8; 9)	38.5 (1.17; 36.9–40.8; 12)	ns
TOE	(19) 26.3 (1.15; 24.6–28.0; 9)	26.1 (1.74; 22.9–27.6; 10)	ns
CLAW	(19) 13.9 (0.88; 12.2–14.7; 9)	14.0 (1.33; 10.1–15.3; 12)	ns

Subspecies *leucopsis*: (21–22) Tas. and s. Vic., adults, skins: (21) From AM, ANWC, HLW, MV, QVM, SAM; (22) From Mees (1964).

	MALES	FEMALES	
WING	(21) 206.1 (4.89; 198–218; 30)	210.6 (4.84; 196–220; 35)	**
	(22) 208.9 (7.58; 198–222; 10)	208.7 (5.99; 203–220; 6)	ns
TAIL	(21) 117.0 (4.21; 110–124; 30)	120.7 (5.12; 111–133; 35)	**
BILL C	(21) 15.2 (0.75; 13.8–17.1; 29)	15.8 (0.72; 13.9–17.5; 35)	**
BILL S	(21) 23.2 (0.87; 21.7–25.0; 30)	23.5 (0.83; 21.8–24.9; 35)	ns
TARSUS	(21) 36.8 (1.22; 33.6–38.8; 29)	37.2 (1.99; 31.5–44.5; 34)	ns
TOE	(21) 23.8 (0.95; 21.7–25.5; 25)	24.2 (1.06; 21.9–25.9; 20)	ns
CLAW	(21) 12.7 (0.61; 11.6–13.8; 30)	13.3 (0.83; 11.5–16.0; 34)	**

Subspecies *albaria*: Lord Howe I., adults, skins. Single female skin (AM) had Wing 221; Tail 137; Bill C 16.5; Bill S 25.8; Tarsus 37.4; Toe 27.8; Claw 14.9. Mees (1964) gave Wing of adult males as 213.0 (2.71; 209–215; 4); adult females 218, 220, 222.

(23) Adults, skins (AM, ANWC).

UNSEXED				
WING	(23)	217.2 (5.62; 210–223; 4)		
TAIL	(23)	131.7 (2.36; 130–135; 4)		
BILL C	(23)	16.8 (0.57; 16.1–17.4; 4)		
BILL S	(23)	25.7 (1.11; 24.1–26.5; 4)		
TARSUS	(23)	37.8, 37.8, 38.0		
TOE	(23)	27.0, 27.0, 27.7		
CLAW	(23)	15.4 (0.56; 14.8–15.9; 4)		

Subspecies *undulata*: (24–26) Norfolk I., adults, skins: (24) From AIM; (25) From Mees (1964). (26) From Olsen *et al.* (1989).

	MALES	FEMALES	
WING	(24) 200	196	
	(25) 199.1 (2.71; 196–205; 9)	203.1 (2.75; 199–208; 15)	**
	(26) 198.0 (4.1 (189–203; 11)	201.8 (3.8; 197–209; 17)	**
TAIL	(24) 117	121	
	(26) 125.1 (6.6; 124–132; 9)	129.9 (5.4; 115–137; 14)	*
BILL C	(24) 15.8	16.0	
	(26) 24.0 (0.9; 23–26; 11)	24.6 (1.1; 23.5–27; 17)	ns
BILL S	(24) 23.0	23.7	
TARSUS	(24) 32.9	32.0	

A live adult female captured on Norfolk I. in Oct. 1986: Wing 204, Tail 126, Bill 26 (Olsen *et al.* 1989). An unsexed adult skin (HLW): Wing 206; Tail 132; Bill C 16.3; Bill S 22.4; Tarsus 29.8; Toe 24.1; Claw 12.8.

**WEIGHTS** Adults, from museum labels (AIM, ANWC, MV, NMNZ, QVM, SAM) unless stated. (1–2) Nominat *novaeesealandiae*, NZ: (1) NZ; (2) Mokoia I., NI, age not specified, live (Stephenson 1998). (3–5) Subspecies *boobook*: (3)

Qld and NSW; (4) Vic. and SA; (5) Kangaroo I., SA. (6) Subspecies *ocellata*: NT and WA. (7) Subspecies *lurida*: ne. Qld rainforests from Cooktown in the N to Paluma in the S. (8) Subspecies *leucopsis*: Tas. and s. Vic. (9) Subspecies *undulata*: live female Oct. 1986 (Olsen *et al.* 1989).

	MALES	FEMALES	
NOVAE-SEELANDIAE	(1) 160.1 (20.97; 105–195; 15)	166.0 (32.97; 105–215; 25)	ns
BOOBOOK	(2) 176.7 (16.03; 155–211; 12)	192.1 (19.96; 171–237; 11)	*
	(3) 252.2 (41.80; 182–320; 20)	315.6 (34.89; 250–365; 16)	**
	(4) 254.1 (37.2; 176–310; 13)	289.5 (50.76; 195–370; 13)	*
	(5) 251.1 (29.22; 215–321; 14)	282.4 (42.43; 202–343; 14)	*
OCELLATA	(6) 216.1 (22.23; 172–245; 8)	233.6 (27.65; 194–285; 11)	ns
LURIDA	(7) 200, 220, 225	227.3 (26.07; 184–260; 7)	
LEUCOPSIS	(8) 189.8 (33.64; 118–250; 22)	214.3 (40.48; 125–275; 29)	*
UNDULATA	(9) –	213	

UNSEXED BIRDS: Nominat *novaeseelandiae*, Orongorongo Valley, NZ, live, 174.1 (14.32; 140–216; 60) (Robertson *et al.* 1983). Subspecies not specified, Aust., live, 264.0 (59.03; 120–395; 46) (ABBBS)

**STRUCTURE** Based on subspecies *boobook*. Wing rather broad, with rounded tip. Eleven primaries: p7 longest; p10 48–55 mm shorter, p9 15–21, p8 0–5, p6 2–9, p5 21–33, p4 43–57, p3 55–67, p2 62–75, p1 69–81; p11 minute. About 14 secondaries, including about four tertials; tips of longest tertials fall between p4 and p5 on folded wing. Tail short and square; 12 rectrices. Bill short and broad. Upper mandible broad and straight at base, but strongly downcurved toward tip, which is sharp and extends slightly beyond blunt tip of straight lower mandible. Cutting edges of upper and lower mandibles slightly downcurved. Cere slightly bulging, with large rounded nostrils in front edge. Tarsus long, rounded and fully feathered. Tibia fully feathered. Toes sparsely covered with hair-like feathers or bristles. Outer toe 73–84% of middle, inner 77–91%, hind 49–58%. Inner and middle claws longest, hindclaw smallest.

**GEOGRAPHICAL VARIATION** Extensive geographical variation, and taxonomic relationships remain unclear at present. Opinions divided as to both number of species and number of subspecies within complex. Peters recognized 14 subspecies, including nine from HANZAB region. Mees (1964) recognized 16 subspecies, with ten in HANZAB region. Schodde & Mason recognized only four subspecies in Aust., synonymizing three that were recognized by Mees (1964). They also classified NZ population as a different species that included Lord Howe and Norfolk Is populations. However, Schodde *et al.* (1983) classified Lord Howe I. and Norfolk I. populations as separate species. Schodde & Mason (1997) used same classification as Schodde & Mason, but also recognized subspecies *halmaturina* from Kangaroo I., SA. Christidis & Boles (1994) followed Aust. CL in recognizing only one species in Aust. and NZ. Christidis & Boles (1994) followed here for specific arrangement and Schodde & Mason followed for subspecific arrangement within Aust. resulting in recognition of seven subspecies within HANZAB region: nominat *novaeseelandiae* from NZ; *boobook* from e. and s. Aust.; *lurida* from ne. Qld; *ocellata* from n., w. and central Aust.; *leucopsis* from Tas.; *albaria* on Lord Howe I. but now extinct; and *undulata* from Norfolk I., whose population has been reduced to a single individual. Recent molecular studies show that *leucopsis* of Tas., *undulata* of Norfolk I. and nominat *novaeseelandiae* form a group separate from those of mainland Aust.; further, *undulata* more closely related to

*novaeseelandiae* than *leucopsis* (Norman *et al.* 1998). Seven extralimital subspecies distributed from Timor to s. New Guinea, occurring on many islands; includes recently described subspecies *rotiensis* from Roti I. (Johnstone & Darnell 1997).

Subspecies differ mainly in tone of brown coloration and amount of spotting or streaking in plumage. Variation in pattern of spotting and streaking of underparts can be characterized in three broad categories, and one or two of these categories usually present in each subspecies: (1) STREAKED, with predominantly streaked pattern; (2) SPOTTED, with predominantly spotted pattern; and (3) STREAKED-SPOTTED, in which breast predominantly streaked and belly predominantly spotted. There are also some size and structural differences between subspecies. Subspecies from HANZAB region described below.

**NOMINATE NOVAESEELANDIAE** of NZ (fully described above): Generally rather small and dark compared with most Aust. subspecies. Pattern of underparts mostly of streaked type. Structurally, it has more rounded wings and disproportionately longer tail than Aust. subspecies (Schodde & Mason). Peters recognized two subspecies within NZ. Oliver noted that birds in NI tend to be lighter than those on SI, but suggested that differences were not sufficient to recognize different subspecies within NZ. Furthermore, Mees (1964) could find no differences between NI and SI populations, and consequently only one subspecies from NZ recognized here. Smallest subspecies; both sexes significantly smaller than *boobook* in all measurements ( $P < 0.01$ ).

**SUBSPECIES BOOBOOK** (fully described above): Distributed e. and s. Aust. from base of C. York Pen. in N following e. coast and Great Divide to about Port Augusta in the SW; w. edge of distribution, where it abuts *ocellata*, not clear, but appears to extend to westernmost foothills of Great Divide. Also abuts range of *lurida* in ne. Qld. Largest subspecies. Pattern of underparts appears to be mostly of streaked-spotted type, but some are of spotted type. Good collections of this subspecies were readily available and thus most subspecies comparisons were made with reference to this subspecies. Some variation within *boobook* in both size and coloration. There is clinal decrease in size from N to S: comparing n. populations (NSW and Qld) with s. populations (Vic. and SA), there were significant differences for Wing ( $P < 0.05$ ), Bill C ( $P < 0.05$ ) and Claw ( $P < 0.01$ ) of females, and Bill S was significantly different ( $P < 0.05$ ) in males. Other measurements showed this same trend but were not significantly different.

Population on Kangaroo I. did not show consistent differences in plumage from adjacent populations in SA and Vic. (this study). Mees (1964) classified this population as subspecies *halmaturina* and said it differed from subspecies *boobook* in having rufous-cinnamon, rather than white, markings to underparts. Recently, Schodde & Mason (1997) also recognized this population as a subspecies. Some individuals on Kangaroo I. do show this trend, having very strong yellow-brown (c123C) suffusion through underparts, but most are inseparable on plumage from birds from adjacent populations in SA and Vic. However, population on Kangaroo I. was significantly smaller than adjacent populations in SA and Vic. in Wing (adult male and female,  $P < 0.01$ ), Tail (adult female,  $P < 0.01$ ), Bill S (adult female,  $P < 0.05$ ) and Tarsus (adult male,  $P < 0.05$ ). Taxonomic status of this population needs further review.

**SUBSPECIES LURIDA**: Small dark subspecies of rainforest in ne. Qld, from about Cooktown in N to Paluma in S. Differences from *boobook*. **HEAD AND NECK**: Usually darker, with no spotting on crown, nape or hindneck. Amount of white on forehead and



lores much reduced. Supercilium much thinner and much less obvious. Checks and ear-coverts same shade of brown as rest of head and neck. Chin, buff (c124). **UPPERPARTS:** Usually darker, with no spotting on mantle, back, rump or uppertail-coverts. Most scapulars have large concealed white spot on outer web. **UNDERPARTS:** Usually darker, and spotting usually smaller. Legs much darker, dark brown (c121A). Pattern of underparts appears to be mostly of spotted type. **TAIL:** Often appears to lack barring, though faint barring present near base of inner web of outer rectrices. **UPPERWING:** Much less spotting on coverts. **UNDERWING:** Coverts much darker, dark brown (c121A) with some buff (c124) mottling.

Bare parts also differ slightly from those of *boobook*. Description based on single photo (Hollands): iris slightly greyer than *boobook*, pale greyish-yellow (ne). Feet appear darker than *boobook*, pink-brown (c221C).

Adults of both sexes significantly smaller than *boobook* in Wing ( $P < 0.01$ ), Tail ( $P < 0.01$ ), Tarsus ( $P < 0.01$ ) and Claw (male  $P < 0.05$ , female  $P < 0.01$ ) and females had significantly smaller Toe ( $P < 0.05$ ) and weighed significantly less ( $P < 0.01$ ).

**SUBSPECIES OCELLATA:** Pale but varying subspecies, widely distributed in n., w. and central Aust., including C. York Pen. Abuts range of *boobook* in e. Aust. and range of *virida* near base of C. York Pen. Much variation. Birds in sw. WA formerly recognized as subspecies *rufigaster* (see Mees 1961, 1964; Aust. CL), but characters used to separate this subspecies appear to vary in a cline: lightest in Kimberley Div. and darkest in SW but dark individuals can also be found in coastal areas of NT. Darkness of plumage probably strongly related to habitat. Schodde & Mason suggest that birds darker in wetter coastal areas and lighter in drier inland areas. There is also clinal variation in size within this subspecies. Birds at more s. latitudes tended to be slightly larger than those farther N; a trend that is reverse of that in *boobook*. Following description encompasses most variation in plumage: **Adult male** Differences from *boobook*: **HEAD AND NECK:** Feathers of crown, nape, hindneck and mantle, dark brown (c121A) with light-brown (c223D) edges, giving streaked appearance. Face very pale; forehead and lores white with black (89) shafts to feathers. Ear-coverts and cheeks, dark brown (c223D). Line of feathers from above supercilium to sides of neck much paler than in *boobook*; cream (c92) with dark-brown (c223) shaft-streaks. **UPPERPARTS:** Vary individually but not to extent of underparts. Feathers of back, rump and uppertail-coverts, dark brown (c121A) to brown (c121C) with light-brown (c223D) bases. Scapulars, dark brown (c121A) to brown (c121C) with large, partly concealed white subterminal spots or bars; spots or bars much larger than in *boobook* and often visible as white streak down sides of upperparts when at rest. **UNDERPARTS:** Vary greatly between individuals but usually paler and appear more streaked than *boobook*. Pattern in underparts appears to be mostly of streaked type, but some are of streaked-spotted type. Breast, belly and flanks vary from light brown (c123A) with broad white edges to feathers, to dark brown (c121A) with buff (c123D) edges to feathers; feathers usually have black-brown (c119) shafts. Some birds from Kimberley Div. very pale and look mostly white on underparts. Legs, buff (c123D) to buff-brown (39). **TAIL:** Pattern similar to that of *boobook* but usually lighter brown, brown (c121C) to dark brown (121A). **UPPERWING:** Mostly similar in pattern to *boobook* but usually paler, brown (c121C) to dark brown (c121A); and white spots on coverts usually closer to edge of feather and therefore more visible. **UNDERWING:** Lesser and median coverts much paler than in *boobook*; vary from orange-buff (c118) to yellow-brown (123B) with little or

no brown streaking on primary coverts. **Adult female** Similar to adult male and most probably inseparable on plumage alone. However, in large series, tend to have slightly browner upperparts and darker, more streaked underparts. **Juvenile** Shows similar differences from adult as those seen in *boobook*. Generally much paler than adult with contrasting dark feathers round eye and fluffy down-like texture to most body plumage.

Bare parts differ slightly from *boobook* for both adult and juveniles. Description based on photos (Trounson & Trounson 1991; Strahan): **Adult** Bill, black (89) with light blue-grey (c88) or pale-grey (86) base. Cere, light blue-grey (c88). Iris, straw-yellow (56) or buff-yellow (c53). Orbital ring, grey-black (82). Feet, light grey (85). Claws, black (89). **Juvenile** Bill mostly black (89) with light blue-grey (c88) base to culmen ridge. Cere, light blue-grey (c88). Iris, dark brown (121). Orbital ring, black-brown (119). Feet, cream (c92). Claws, black (89).

Adults of both sexes significantly smaller than *boobook* in Wing ( $P < 0.01$ ), Tail ( $P < 0.01$ ), Tarsus (male  $P < 0.05$ , female  $P < 0.01$ ) and weight (male  $P < 0.05$ , female  $P < 0.01$ ); females also had significantly shorter Toe ( $P < 0.05$ ).

Population on Melville I. rather small and dark and was formerly recognized as a separate subspecies *melwillensis* (see Mees 1964; Aust. CL), but Schodde & Mason considered this population to represent an end point in trends of size and coloration. This population is at the n. end of a cline in size, and the darkness of plumage fits a trend toward darker plumage in more humid coastal areas. Adults from Groote Eylandt also rather small (see Measurements), but little other information available.

**SUBSPECIES LEUCOPSIS:** Small spotted subspecies. Occurs in Tas., and some birds migrate to Vic. in winter; one specimen collected from NSW. Shows much less variation than seen in *boobook*. Plumage differs from *boobook* in both adult and juvenile plumage. **Adult** Differences from *boobook*: **HEAD AND NECK, UPPERPARTS:** Often darker and slightly redder. Amount of spotting on crown, hindneck and mantle varies individually, but usually much more than on *boobook*, and spots usually much cleaner and whiter. **UNDERPARTS:** Very similar to *boobook*, but spots on feathers usually smaller and rounder giving more spotted appearance to underparts. Pattern of underparts appears to be mostly of spotted type, but some have streaked-spotted underparts. Tend to have less yellow-brown suffusion to underparts. Rest similar to *boobook*. **Juvenile** Tends to be much darker than juvenile of *boobook*. Underparts mostly off-white.

Bare parts differ slightly from *boobook*. Description based on photos (Green 1989; Strahan; N.J. Mooney): **Adult** Bill, black (89) with light blue-grey (c88) base. Cere, light blue-grey (c88). Iris brighter than *boobook* and more similar to *novaeeseelandiae*, orange-yellow (c18) or yellow (55). Orbital ring, grey-black (82). Feet, pinkish grey (ne). Claws, black (89). **Juvenile** Iris and bill similar to adult. Rest not observed.

Very small and smallest Aust. subspecies. Both sexes significantly smaller than *boobook* in all measurements ( $P < 0.01$ ). Significantly larger than *novaeeseelandiae* of NZ for adults of both sexes in Wing ( $P < 0.01$ ), Bill C ( $P < 0.01$ ), Bill S ( $P < 0.01$ ) and Tarsus ( $P < 0.01$ ) and weight ( $P < 0.01$ ).

**SUBSPECIES UNDULATA:** Small reddish-brown subspecies confined to Norfolk I. Similar to *boobook* in shade of plumage of head, neck and upperparts, but modified feathers around eye hardly contrast with rest of head and neck. Underparts marginally redder than *boobook* and spots on feathers of underparts much smaller. Pattern in underparts appears to be mostly of

spotted type. Upperwing similar to *boobook* but with finer barring and spotting.

Bare parts of adult differ slightly from *novaeseelandiae*. Description based on photos (Olsen 1989; Strahan). Bill, black (89) with pale-grey (c86) ridge to culmen. Cere, olive-grey (c43). Iris, cream (c92) or yellow (P.D. Olsen). Orbital ring, dark grey (c83) or black (89). Feet, orange-buff (118). Claws, light grey (85). Downy young have bright-yellow irides and feet (P.D. Olsen).

Sample sizes for measurements very small, but appear to indicate that this subspecies is larger than *novaeseelandiae* but smaller than smallest Aust. *leucopsis*.

**SUBSPECIES ALBARIA:** Pale subspecies, formerly on Lord Howe I. but now extinct. Similar to *undulata* but much paler. Pattern of head, neck and upperparts like *boobook* but marginally paler and feathers around eye hardly contrast with rest of head and neck. Underparts mostly light rufous-brown (c139) with small white spots to feathers. Pattern of underparts appears to be mostly of spotted type. Bare parts from museum labels (AM): Bill, dark slate; iris, golden yellow; feet, greenish yellow.

Sample sizes for measurements very small, but appear to indicate that this subspecies is intermediate in size between smallest and largest Aust. subspecies. It appears similar in size or slightly larger than *lurida*.

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**Sponsors: Mr NW Arnold, Mr R McC Simpson, Sir John Young**





Volume 4, Plate 39

Little Owl *Athene noctua* (page 812)  
 1 Adult; 2 Juvenile; 3, 4 Adult

Southern Boobook *Ninox novaeseelandiae* (page 852)  
 NOMINATE NOVAESEELANDIAE: 5, 6 Adult; 7 Juvenile  
 SUBSPECIES BOOBOOK: 8, 9 Adult; 10 Juvenile; 11, 12 Adult  
 SUBSPECIES LURIDA: 13, 14 Adult  
 SUBSPECIES OCELLATA: 15 Adult  
 SUBSPECIES LEUCOPSIS: 16 Adult  
 SUBSPECIES UNDULATA: 17 Adult