AUSTRALIAN BIRD WATCHER 1993, 15, 168-191

The Mainland Masked Owl *Tyto novaehollandiae*: a Review

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Summary

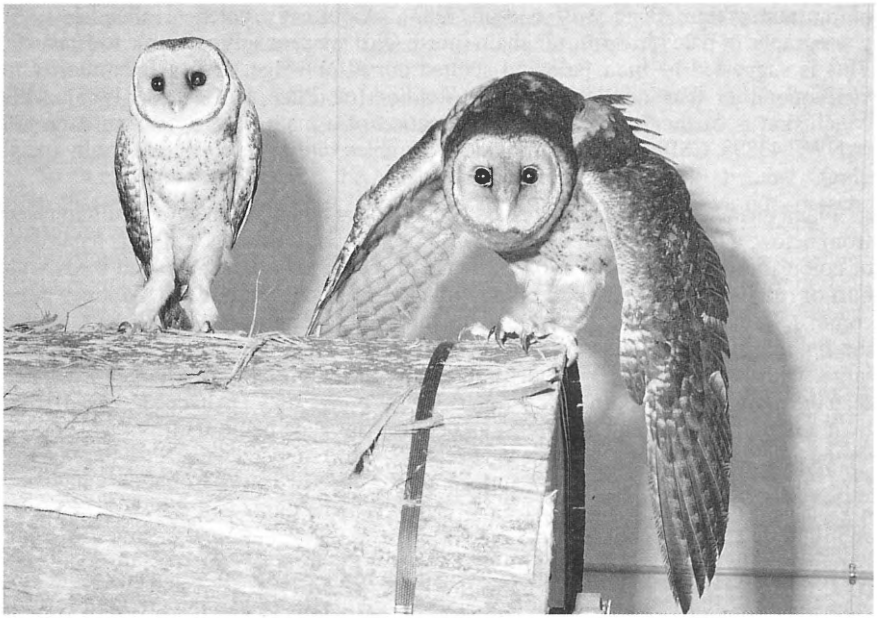
The literature concerning the mainland Masked Owl's morphology, behaviour, distribution, habitat, diet, hunting methods and breeding biology is reviewed and supplemented with field observations and museum data. The Masked Owl is considered an opportunistic generalist, widespread in coastal and subcoastal open forests and woodlands, and extending far inland in locally rich patches of habitat which provide tree hollows (e.g. riparian woodland) or other shelter (caves, gorges, rock overhangs) and adequate prey. Its inland occurrence is confirmed. Its varied diet includes birds and insects, but it prefers terrestrial mammals, detected by listening from low perches. Its biology and conservation status require investigation.

Introduction

The Masked Owl *Tyto novaehollandiae* is arguably the least-known owl species in mainland Australia, its races classified as potentially threatened and 'rare' or 'insufficiently known' by Garnett (1992a). Limited information on the southern mainland race *T.n. novaehollandiae* has been summarised by Schodde & Mason (1980), and supplemented by Roberts (1983), Conole (1986), Debus (1990), Kavanagh (1992), Davey (1993), Kavanagh & Peake (1993), Peake et al. (1993), Hyem (in Debus 1993) and Debus & Rose (in press). The other mainland race is *T.n. kimberli* of tropical northern Australia, with *T.n. troughtoni* of the Nullarbor Plain no longer recognised and the validity of *T.n. galei* of Cape York Peninsula recently reinstated (see Schodde & Mason 1980, Mason 1983). Insular races are *T.n. castanops* of Tasmania, *T.n. melvillensis* of Bathurst and Melville Islands and the recently described *T.n. calabyi* of southern New Guinea, with island forms in Wallacea regarded as separate species (Schodde & Mason 1980, Mason 1983). Of these, *castanops* is the best known and 'secure', with pest status on Lord Howe Island where it was introduced (Schodde & Mason 1980; Mooney 1992, 1993; Garnett 1992a).

Hollands (1991) has provided the most complete account of the breeding behaviour of the mainland Masked Owl. However, the distribution map of the owl's races in Schodde & Mason (1980), the plate in Mason (1983) and the discussion in Ford (1986) suggest that Hollands' data and photographs from Ingham (Qld) are referable to the northern race *T.n. kimberli*. If this is the case, and Hollands' data refer to *kimberli*, then there is no substantive published account of the nesting biology of nominate *novaehollandiae*. Therefore, *T.n. novaehollandiae* is one of the least-known owl taxa in mainland Australia. This is of concern because, unlike other poorly known owl taxa (e.g. northern Rufous Owl *Ninox rufa* races), it is restricted to the most severely disturbed parts of the continent.

Peake et al. (1993) and Debus & Rose (in press) discuss the occurrence and biology (including new diet data) of the owl in Victoria and New South Wales, partly in relation to forest management. The purpose of this review is to further examine the behaviour and biology of the Masked Owl, mainly in relation to research and environmental management. It is not a repeat of the work by Schodde & Mason (1980), but does critically re-examine and re-interpret some of their sources and conclusions in the light of more recent data. This literature review is supplemented with personal field observations (c. 40 nocturnal encounters in north-eastern New South Wales), museum data, and field notes from colleagues and other observers (Royal Australasian Ornithologists Union [RAOU], Atlas of Australian Birds unusual record forms



Captive Tasmanian Masked Owls, both dark morph: juvenile male (small bird), adult female (large bird, performing threat display). Note feathered legs.

Plate 24 Photo: N. Mooney

[hereinafter Atlas]; Bird Observers Club of Australia [BOCA], unusual sighting reports). I have concentrated mainly on *T.n. novaehollandiae*, because it occurs in the southern and eastern parts of Australia heavily populated by humans, and may be subject to pressures similar to those faced by the Sooty Owl *Tyto tenebricosa* and Powerful Owl *Ninox strenua* (see Garnett 1992a). Additionally, it faces continued clearance of dry forests and woodlands for agriculture. I also consider *T.n. kimberli* and *T.n. castanops* where aspects of their biology are relevant to the biology of *novaehollandiae*.

Field identification and plumage

On separating Masked Owls from other *Tyto* species, little further needs to be added to Schodde & Mason (1980), Debus (1990) and Hollands (1991) concerning perched birds, except to note that none of the paintings in recent, popular bird guides adequately represents the Masked Owl. Colour photographs convey a better impression of the bird, and those in Hollands (1991) are particularly recommended although they mainly show pale birds, apparently of the northern race. Colour photos are also provided in Schodde & Tidemann (1986) and Trounson & Trounson (1987). A dark southern mainland female is shown here, with two pairs of Tasmanian birds for comparison (Plates 24, 26, 27).

The similarity of *T.n. kimberli* to the Barn Owl *Tyto alba* has been acknowledged (Schodde & Mason 1980). *T.n. kimberli* of northern Australia is paler and slightly smaller than nominate *novaehollandiae*; nevertheless it is clearly in the Masked Owl size class and larger than Barn (measurements in Schodde & Mason 1980, Mason 1983). Northern Masked Owls are distinguished from Barn Owls by their strongly spotted and barred dorsal plumage, and relatively large feet and heavy legs (pers. obs.

of museum skins; Plate 2 of Mason 1983). As already noted, Hollands' (1991) photographs of pale birds from Ingham (north Qld) are probably referable to *kimberli*. This is suggested by their pale and spotted dorsal plumage, and their similarity to *kimberli* rather than nominate *novaehollandiae* (cf. Plate 2 of Mason 1983). This conclusion is further suggested by examination of a male specimen from Atherton (ANWC 43898, CSIRO, Canberra), which resembles *kimberli* specimens dorsally (pers. obs.).

Flight characteristics enable owls to be identified at night. When strongly illuminated from below, a flying Masked Owl always appears wholly pale underneath, regardless of colour morph (at least in my experience of moderately dark mainland birds with buff or rufous underparts). Darker individuals appear tan ventrally (N. Mooney pers. comm.). Its flight is strong, purposeful and direct on rhythmically beating wings, unlike the lighter and somewhat erratic flight of the Barn Owl. The Masked Owl appears large, with long wings and a short tail, giving the impression of a larger wingspan than the more compact Barn Owl. From below, a flying Sooty Owl appears grey (rather than white), often with a dark breast and contrasting pale belly; its flight is similarly strong and direct but it shows somewhat broader, more rounded wings than the Masked Owl. In flight the Powerful Owl appears very large, with long rounded wings and a long tail; its flight is strong and powerful. When illuminated (and dazzled?) by spotlight its flight can be slow and laboured (pers. obs.), but at other times its flight is remarkably quick and agile, with much use of the long tail for tight manoeuvring (C.J. Chafer pers. comm.). Separation of the Masked Owl from the Eastern Grass Owl *Tyto longimembris* is discussed by Hollands (1991).

Schodde & Mason (1980) stated that male Masked Owls are the paler and more sparingly marked in any mated pair, irrespective of colour morph. This is clearly not so in cases where dark-breasted (i.e. dark morph) males are paired with white-breasted (i.e. intermediate morph) females. Dark males occur in the same regions as intermediate females (e.g. northern New South Wales: pers. obs.), and the potential for such a combination exists; there are at least two records of pairs in eastern New South Wales where the male was darker than the female (dark males paired with intermediate females: Roberts 1983, R. Thomas et al./BOCA). This also applies in a minority of cases in Tasmania (about one in six pairs: N. Mooney pers. comm.).

Limited data from New South Wales support the suggestions of Schodde & Mason (1980) on the ratio of Masked Owl colour morphs in relation to climate and habitat structure. Virtually all of the few Masked Owl records from western New South Wales have been of pale-breasted birds, whereas dark and pale-breasted birds occur in the forests of the humid east coast (about 3 intermediate to 1 dark; a third of males dark and half of females dark: n = c. 60 records from Debus & Rose in press, Appendix 1; Debus pers. obs.; see also Peake et al. 1993 for data from Victoria).

Voice

Little needs to be added to Debus (1990) or to the excellent catalogue of Masked Owl calls in Hollands (1991), except to mention some calls used away from the nest. One is a very loud, abrupt, shrill scream, yelp or squeal (see Debus 1990, Debus & Rose in press), which may be the 'loud shout of "yow" ' described by Hollands; it seems to be used rarely, certainly much less frequently than the usual rich, deep rasping screech. Other calls are variants of the screeching and chattering calls, and are directed at territorial intruders (in my experience, intruding 'conspecifics' being simulated by playback of taped calls):

(a) a loud, deep, vibrating screech, uttered in a threatening manner from a nearby perch;

(b) a chattering call, also given from a perch, in response to each screech from the 'intruder' (further described in Debus & Rose in press). This can vary from a subdued rattle to a loud cackle.

Other (non-vocal) sounds include bill-snapping and tongue-clicking in interspecific threat (Fleay 1968, Schodde & Mason 1980, N. Mooney pers. comm.).

To an experienced observer, the Masked Owl's screech is readily distinguishable from that of the Barn Owl. The characteristically loud, rich and drawn-out screech, more powerful than the Barn Owl's falsetto, 'tinny' screech, is the main indication of the Masked Owl's presence in an area unless playback is used to elicit a response. Good examples of each are on the BOCA *Field Guide to Australian Bird Song* tape series, cassette no. 5 (first Masked Owl sequence and second Barn Owl sequence, respectively).

McAllan & Bruce (1989) suggested that there may be vocal differences between the races of Masked Owl (*novaehollandiae* versus Nullarbor Plain birds, which they regarded as racially distinct; and by implication the Tasmanian *castanops*, which they regarded as a separate species). The screeching calls of mainland and Tasmanian birds are virtually identical to the human ear, any slight difference probably being attributable to the greater body size (and hence vocal apparatus volume) of Tasmanian females, which can sound a little deeper and harsher than others (pers. obs.). To human ears, the courtship chattering and rattling calls of Tasmanian and southern mainland males are identical; mainland birds respond strongly to playback of the calls of Tasmanian birds and vice versa, and even to Barn Owl calls (pers. obs., N. Mooney pers. comm.). This suggests that the birds do not distinguish the calls of other Masked Owl races from those of their own race, and that there is no vocal isolating mechanism between these races. The Masked Owl's vocal response to 'conspecifics', and even other species, may be a simple reaction to potential competitors (see also 'Displays', p. 183).

Morphology

Schodde & Mason (1980), Mason (1983) and Mooney (1992, 1993) have discussed the Masked Owl's morphology and reversed sexual size dimorphism (female larger than male). An idea of the owl's size in south-eastern Australia is given by weights and measurements from specimens (New South Wales, Victoria and South Australia: museum data, Table 1). The data show that the Masked Owl is larger, heavier and more sexually size-dimorphic than the Barn Owl, and (especially in the case of females) has a much greater wingspan (Table 1). The data also show that the Masked Owl is larger and more size-dimorphic in south-western than south-eastern mainland Australia. From the formula quoted by Baker-Gabb (1984) and Mooney (1992, 1993) and the wing lengths in Table 1, south-eastern birds have a dimorphism index of 8.2 and south-western birds 10.7; for Tasmanian birds it is 12.8 (i.e. western birds are almost as size-dimorphic as Tasmanian birds, cf. Mooney 1992, 1993). This suggests that, as in Tasmania, south-western birds may be similarly subject to 'ecological release' from competitors, i.e. in the absence of other large forest owls, they have been able to expand their niche into the Powerful Owl/Sooty Owl class through an increase in female size.

Much has been made of the large size of the Tasmanian Masked Owl, but this may have been overstated in relation to southern mainland birds. From mean body weights in Table 1, and mean weights for Tasmanian males (525 g) and females (850 g) in Mooney (1992, 1993), south-eastern females are 77% and south-western females 87% of the mass of Tasmanian females; south-eastern males are 91% and south-western

Table 1

Weights and measurements of the Masked Owl from mainland south-eastern and south-western Australia (museum specimen data). Numbers in parentheses are means and sample sizes. Barn Owl shown for comparison (linear measurements from Schodde & Mason 1980; weights from Australian Museum).

Region and sex	*Weight (g)*	*Wing length (mm)*	*Wingspan (mm)*
Masked Owl			
South-east:			
Male	364-672 (478, 12)	300-315 (306, 8)	920-1080 (1016, 6)
Female	435-800 (652, 8)	319-348 (332, 12)	1004-1178 (1099, 12)
South-west:			
Male	480-530 (512, 3)	302-315 (309, 5)	
Female	548-900 (737, 4)	333-358 (344, 8)	
Barn Owl			
Male	190-415 (309, 17)	278	790-950
Female	178-470 (330, 29)	279	810-970

males 98% of the mass of Tasmanian males. The heaviest western females exceed the mean for Tasmanian females. This supports the existence of regional differences in degree of sexual size dimorphism, and illustrates that mainland females are nevertheless large members of the *Tyto* genus, exceeded only by female Sooty Owls (cf. Schodde & Mason 1980, Hollands 1991).

From the formula quoted by Cade (1982) and the weights and wing lengths in Table 1, the Masked Owl in mainland south-eastern Australia has a calculated wing-loading index of 0.38 and 0.44 g/sq. cm for male and female respectively. This is higher than the Barn Owl (0.30 and 0.31 g/sq. cm for male and female, from mean wing lengths and body weights in Table 1). These differences, and their consequences for flight performance (aerial buoyancy), are akin to those between the perch-hunting Brown Goshawk *Accipiter fasciatus* (0.33, 0.46 g/sq. cm) and the aerial Whistling Kite *Haliastur sphenurus* (0.33, 0.35 g/sq. cm; from measurements in Baker-Gabb 1984).

General habits and behaviour

Two aspects seem worthy of comment. One is the Masked Owl's 'tameness' or reluctance to flush in the presence of a human observer at night when the owl is perching, compared with the more wary, nervous Barn Owl (e.g. Debus 1990, Hollands 1991). For instance a Masked Owl which regularly used a roadside perch was difficult to flush, and flew only about 12-20 posts away before alighting again, whereas Barn Owls were wary and usually flew out of sight (D. Richards pers. comm.). Other observations (e.g. D'Ombrain 1905, Atlas and BOCA files) support the impression of a bird that allows a relatively close approach at night. This may be partly related to the energetics of flight (see 'Morphology', above): a high body weight and high wing-loading makes flight more demanding, therefore the Masked Owl spends less time flying than the Barn Owl. This has implications for hunting behaviour (perch hunting versus quartering flight: see p. 182). Size and inherent confidence or boldness may also play a part (e.g. Sooty and Powerful Owls are also more wary: pers. obs., R. Kavanagh pers. comm.). The Masked Owl's different 'demeanour' from that of the Barn Owl is reflected in two observers' comments: a perched Masked Owl seemed 'more defiant' (M. Schulz, field notes), and another 'appeared confident in its own

territory' (S.J.J.F. Davies/Atlas). Sharland (1981) noted that the Tasmanian race is not shy, and can be approached at dusk (though not always: N. Mooney pers. comm.). This difference may also be partly related to the ease of flight in open (Barn Owl) versus wooded or forested habitats (Masked Owl) at night, and the problem of avoiding obstacles in dim light (cf. Martin 1986). In general disposition, the Masked Owl resembles the Southern Boobook *Ninox novaeseelandiae* but is less active (N. Mooney pers. comm.).

The other aspect is the relative ease with which the Masked Owl may be trapped, and therefore its suitability as a subject for research involving live-trapping, banding and radio-tracking (e.g. to study home-range size and habitat use). Sooty and Powerful Owls are notoriously difficult to catch, and Masked Owls are also difficult to catch in forest by means of goshawk traps, pole traps and suspended mist-nets (Kavanagh 1992). Nevertheless, several observers have reported Masked Owls eating rabbits caught in gin-traps (e.g. D'Ombrain 1905, Hyem 1979), and there are many reports of the owls themselves being caught in gin-traps and other traps (e.g. Mees 1964). D'Ombrain (1905) deliberately caught a Masked Owl in a padded gin-trap baited with a dead rabbit, after the owl perched on a nearby fence-post and watched him set the trap. A Masked Owl was caught in a trap set for Bilbies *Macrotis lagotis* (Museum of Victoria: trap type not specified), and Barnard (1925) reported a Masked Owl caught in a trap (type not specified) on top of an aviary, where the owl was taking domestic birds. A male and female Masked Owl were caught accidentally in a rabbit trap on two consecutive nights (F. Henderson/Atlas). These reports came from Queensland, New South Wales and Western Australia, indicating that the habit is widespread on the mainland; Tasmanian birds behave similarly (e.g. Hill 1955, Fleay 1968, Sharland 1981). Padded leg-hold traps are sometimes used to live-trap large raptors unharmed for banding (e.g. Bloom 1987), but other traps such as the more usual types for capturing diurnal raptors may be more suitable and less risky for Masked Owls (e.g. flip-trap: Cam 1985; 'strine' goshawk trap: Baker-Gabb 1989; various types: Bloom 1987). It must be emphasised that although Masked Owls can be trapped in leg-hold traps, it does not mean that this is a suitable method. However, it does suggest that other, less dangerous, methods are worth trying. N. Mooney (pers. comm.) has trapped Tasmanian Masked Owls in Swedish goshawk traps, baited with laboratory rats or domestic doves, at least eight times, and also once on a bal-chatri and once on a noose carpet placed on a regular perch. Caution is also required with these 'entanglement' methods (see Bloom 1987).

Distribution

Schodde & Mason (1980) stated that the Masked Owl is restricted to the drainages of coastal rivers, with no confirmed records >300 km inland. They dismissed or ignored many inland records, and it is worth reconsidering these on a state-by-state basis. It is apparent that the Masked Owl occurs much farther inland than stated in recent bird books, and certainly in the Murray-Darling system which drains the inland side of the Dividing Range. Furthermore, if the Masked Owl was known to occur on the Nullarbor Plain, there seems no logical reason why it would not occur in similar country with caves or other shelter throughout inland Australia in localities where mammal prey is abundant. One might predict that it will be found in the MacDonnell Ranges and other ranges and 'breakaways' in Central and inland Western Australia, where water run-off creates locally favourable conditions for large river gums and mammalian prey; and particularly around high-nutrient sites such as chenopod shrubland near suitable daytime shelter.

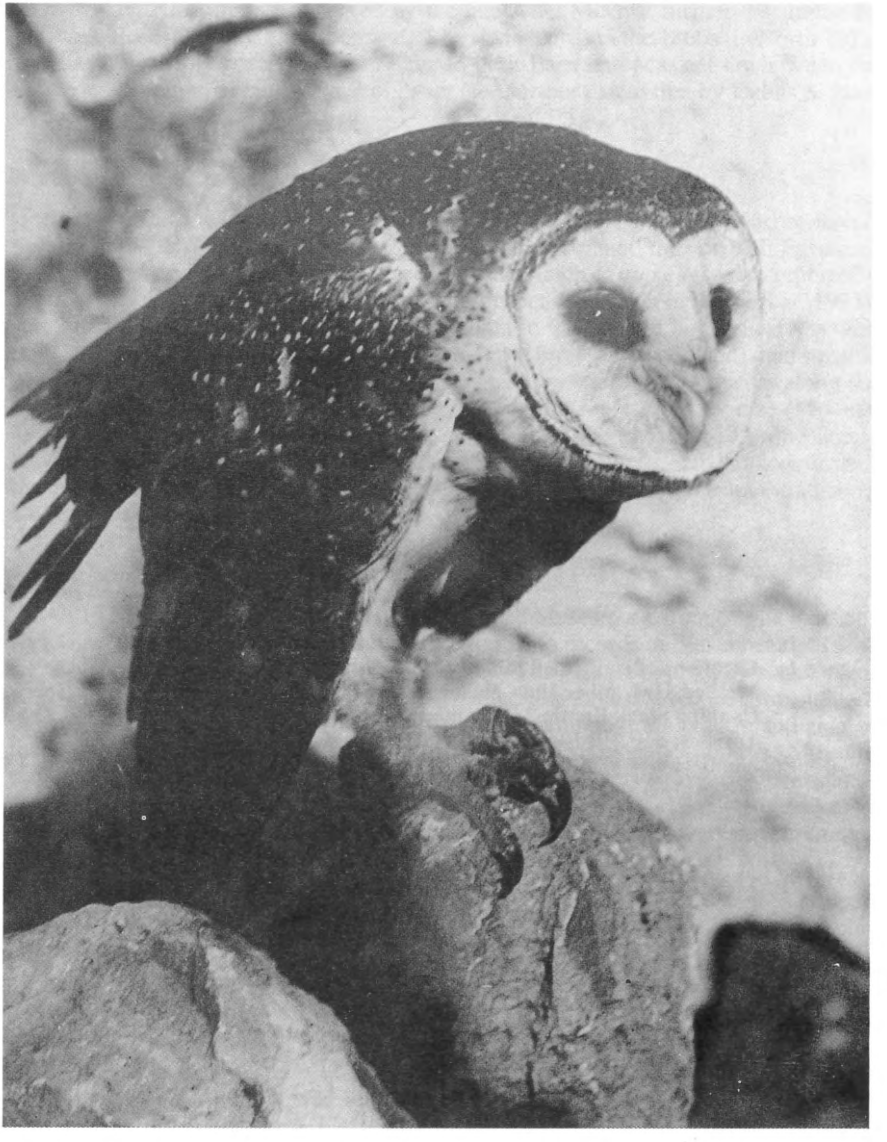
Western Australia

Schodde & Mason (1980) ignored Ford (1968), who provided evidence of the Masked Owl's occurrence in the inland, including a specimen from a gorge on the Canning Stock Route. They also considered the Nullarbor Plain owls a relict, isolated population, but Ford (1968) showed that it may be continuous with the south-western population. The suggestion that the Nullarbor population may be extinct has been perpetuated (McAllan & Bruce 1989), despite a sight record in 1980 (Blakers et al. 1984). This record was of a bird seen in daylight, at 30 m for 30 minutes, by S.J.J.F. Davies & P. de Rebeira: 8 June 1980 in the Loongana-Mundrabilla 1° block (30°S/127°E), which contains caves (description adequate; Atlas unusual record form sighted). Furthermore, another Atlas observer (A. Gillanders) reported a sighting for the Nullarbor: a *Tyto* owl much larger than a Barn Owl was standing at the edge of a roadside drain at 0345 h on 14 September 1981, at Cocklebiddy Roadhouse; it had feathered legs and 'dirty' cream-brown underparts (A. Gillanders in litt.; observer familiar with tropical Barn Owls in north Queensland). The sighting was discussed the following day with S.J.J.F. Davies and the then warden of Eyre Bird Observatory, who challenged the initial, tentative identification of 'Barn Owl'.

A further historical record of the Nullarbor Masked Owl is of interest (cf. Parker 1977): Plate 25 is a copy of a photograph apparently taken by K.A. Hindwood in the 1930s, of a Masked Owl in a cave on the Nullarbor. The owl is clearly a Masked Owl as shown by its dark, strongly spotted dorsum, feathered legs and large feet and claws. The following information relating to the photo was supplied by C.J. Chafer (in litt.). Notes on the reverse of the original print state 'Trans Australian Railway', and 'The Cave Owl of the Nullarbor Plain'. The print was with a collection of Hindwood's photographs, some showing Hindwood himself, found discarded at the Berry dump (N.S.W.). In keeping with the other material that was found, it appears that the prints had been sent to Aubrey Elliott, who corresponded and travelled with Hindwood before publication of a book (possibly A.H. Chisholm's *Bird Wonders of Australia*, in which some of the prints appear). The prints, including the Masked Owl, have suggestions for cropping and other notes concerning publication. Elliott (1935) studied Masked Owls, but his field notes indicate no personal experience of that species outside New South Wales. It seems that after Aubrey's death in 1943, his ornithological files were kept by his brother Arthur at Meroo (near Berry), and that another relative discarded the material after Arthur died *circa* 1988. In the Hindwood archives there is no material concerning the owl print, nor is the original glass plate in the Hindwood collection which is now lodged with the National Photographic Index of Australian Wildlife, Australian Museum (E.S. Hoskin in litt.). This case represents only the fifth confirmed record, and the only photographic record of a living bird, of the Masked Owl population formerly recognised as *T.n. troughtoni*.

South Australia

Parker (1977) by no means disposed of all inland records. He admitted specimen records from Tarcoola and (probably) Lake Torrens (i.e. north almost to 30°S), and listed a bird photographed north of Hawker. Smith (1977) reported probable Masked Owl pellets from caves in the northern Flinders Ranges, dating from about the time of European occupation. However, she later attributed these to the Barn Owl, without explanation (Smith & Medlin 1984). The size of the intact pellets (4 x 2.5 cm) could fit either Barn or Masked Owl (cf. Schodde & Mason 1980), but the presence of large prey (some not juveniles), including the Golden Bandicoot *Isoodon auratus*, Pig-footed Bandicoot *Chaeropus ecaudatus* and Bilby in the pellets (some fragmented), strongly



Historic photograph of Masked Owl in cave on Trans Continental Railway, Nullarbor Plain, apparently taken by K.A. Hindwood in the 1930s (see text).

Plate 25 Photo: courtesy Doug Rickers and Illawarra BOC

suggests Masked Owl. Finally, Francis (1992) reported a Masked Owl at the Coongie Lakes (verified by S.A. Parker from a photograph), and Hollands (1991) reported a Masked Owl feather found on the Birdsville Track (either north-eastern South Australia or south-western Queensland), i.e. the species probably occurs in the Channel Country, in large riverine eucalypts.

The unpublished diary notes of the late Len Harvey (oologist) mention a possible

Figure 1. Locations of confirmed inland records (specimen/detailed description) of the Masked Owl, other than Nullarbor Plain. 1 = Well 17, Killagurra Gorge, Canning Stock Route; 2 = Yandal Station, Wiluna; 3 = Tarcoola; 4 = Lake Torrens; 5 = Birdsville Track; 6 = Coongie Lakes; 7 = Fowlers Gap; 8 = Gunbar; 9 = Whitton; 10 = Nyngan; 11 = Narran Lake; 12 = Mitchell; 13 = Barkly Tableland; 14 =Avon Downs (sources: Ford 1968, Parker 1977, Hollands 1991, Francis 1992, Debus & Rose in press, this paper).

Masked Owl sighting in Gurney's Cave, Koonalda Station, on the South Australian section of the Nullarbor Plain (per Museum of Victoria). In September 1966 Harvey and another observer flushed a 'large white owl (Cave Owl)' in a huge sink-hole with caves, which ran deep to underground fresh water. Harvey was generally reliable on other records of Masked Owls and their eggs (see Peake et al. 1993). Nevertheless, this record must remain unconfirmed but does, in conjunction with the above Nullarbor records, suggest that the population is still extant and that further searches would be rewarded.

Western New South Wales

Parker (1977) was inclined to discount a specimen from Nyngan (Museum of Victoria, H.L. White collection no. 5314), on the grounds that it came from the Robert Grant collection and its label data were thus suspect. This may have led Schodde & Mason (1980) to ignore inland sight records reported in New South Wales Field Ornithologists Club annual bird reports 1970-79 (reviewed by Debus & Rose in press). However, in this case the specimen's registration details (per L. Smith) would seem specific enough: 'captured in trap set for Bilby on Graweed Station, near Nyngan (N.S.W.)' in 1890. The record is supported by a specimen from Whitton (Australian Museum O.17008) and by other inland sightings (including Nyngan), most notably of breeding at Deniliquin (Hobbs 1961), two birds at Jerilderie and a pair in a hollow

near Broken Hill (the last observed by the late A.R. McGill; further discussion by Debus & Rose in press). K.H. Bennett's Riverina records in the 1860s (in North 1911) were also probably correct, as he recorded both Barn and Masked Owls when the native small-mammal fauna was still intact (see further discussion by Debus & Rose in press).

North-western Victoria

The Masked Owl was listed for Mildura and Swan Hill, on the Murray River, by the late W.R. Wheeler (1967, 1979); he and his informant, the late N.J. Favaloro, were experienced ornithologists. A specimen and clutch of two eggs were reportedly taken at Lake Cardross near Mildura in 1937 (further discussion in Peake et al. 1993). The Murray Valley may provide suitable habitat in the form of large eucalypts with hollows (River Red Gum *Eucalyptus camaldulensis* forest and woodland), and suitable prey in the form of the exotic Brown Rat *Rattus norvegicus* which occurs along the Murray River (Strahan 1983) and is within the owl's preferred prey size (Mooney 1992, 1993). Rabbits are potential prey away from the most flood-prone areas. Nevertheless, Masked Owl records from north-western Victoria remain unconfirmed; the owl's potential presence requires investigation in view of records from the adjacent Riverina of New South Wales.

Queensland

All 14 Masked Owl specimens in the Queensland Museum are from coastal localities (per G.V. Czechura). However, one of the two inland records in Blakers et al. (1984) for the Maranoa River, Mitchell district (27 °S/147 °E) was supported by a specimen, which was photographed and measured (J. White/Atlas; unusual record form sighted; photos submitted to Atlas for verification). The Maranoa drains the inland side of the Divide. Furthermore, eggs and notes in the Len Harvey collection (per Museum of Victoria) provide a sighting and a breeding record for north-western Queensland. Harvey received a Masked Owl egg (no date) from the Barkly Tableland; all eggs labelled as Masked Owl in his collection are correctly identified on measurements (P. Peake pers. comm.). Harvey flushed a Masked Owl from a low hollow in the trunk of a Coolibah *Eucalyptus microtheca* on a tree-lined river on 'Avon Downs' (20 °02 'S, 137 °30 'E), on the Northern Territory border, in daylight in October 1967. It perched nearby and performed a threat display; Harvey noted that it was a 'northern phase' like the Barn Owl, but had noticeably big, feathered legs. Elsewhere in his notes, Harvey discussed the similarity of Barn Owls and northern Masked Owls, and noted the 'big, strong & thick legs' of the latter (see Peake et al. 1993 for further discussion of his credentials). The hollow contained a mass of native rat fur; Harvey heard the owls calling there at night with calls 'something like Barn Owl', and speculated that the hollow was ready for laying (not checked later).

Habitat

One aspect of the Masked Owl's habitat requirements seems worth elaborating on here: roosting habitat, and in particular the use of dense foliage and caves for roosting. Cases of foliage and cave roosting in New South Wales and Victoria are discussed elsewhere (Peake et al. 1993, Debus & Rose in press). Beardsell (in press) has also observed a Masked Owl pair roosting in a cave in the cliffs of a river gorge in Victoria. Cases of foliage roosting have been reported also in Queensland (Lord 1956, J. Squire/BOCA), South Australia (Parker 1977, Francis 1992), Western Australia (A. Milhinch/Atlas), and Tasmania (Skemp 1955) where the habit is common

(N. Mooney pers. comm.). Similarly, cave roosting has been reported also in Queensland (Lord 1956), coastal Western Australia (Douglas 1980) and Tasmania (Sharland 1958, 1981; Mooney 1992, 1993), which together with the other eastern records indicates that the habit is by no means restricted to the Nullarbor Plain. Although the Masked Owl prefers to roost and nest in tree hollows (Schodde & Mason 1980), it is apparent that in areas lacking hollows it is able to roost in caves and other secluded sites throughout its range. Perhaps where it lives in dense forest, it sometimes roosts 'outside' in thick foliage in gullies by choice, as does the Sooty Owl (Kavanagh 1992). Cave roosting is also by choice, as the site observed by Beardsell (in press) overlooked forest and woodland. Cave nesting has been claimed for Tasmania (Sharland 1981), but has not been confirmed and must therefore be rare (N. Mooney pers. comm.). Nevertheless, it has been suspected for southern Victoria (Beardsell in press) and seems likely in treeless areas; the Sooty Owl sometimes nests in caves in areas lacking suitable hollows (Hollands 1991). In Tasmania, in areas where nest trees are isolated, a common combination seems to be breeding in tree hollows and roosting in nearby caves/potholes (N. Mooney pers. comm.).

Previous analyses have concluded that the Masked Owl is most numerous in open forest and woodland, particularly in areas with a diversity of vegetation structural types and/or a mosaic of dense and sparse ground cover (see Peake et al. 1993, Debus & Rose in press). Additionally, the site of a resident pair in southern Victoria was regarded by Beardsell (in press) as optimal habitat: a mosaic of continuous and fragmented stands of forest and woodland adjacent to open country, with abundant prey, and bisected by a river gorge which provided a cave roost.

Hollands (1991) stated that 'recent observations suggest that [the Masked Owl] may colonise areas recently clear-felled of timber'. Also, that: it 'prefers to hunt in open country'; the view that 'it requires big forest... is only partly correct'; it 'needs to be close to open country'; and it 'often' nests in an isolated tree. These statements were based on Hollands' experience of a few pairs of the small tropical race nesting in remnant woodland patches among harvested canefields in north Queensland, in a year of exceptional rat numbers and at a time when the rats were made vulnerable. There were five owl pairs, of which only two bred, in a linear distance of 30 km, and the high breeding success in one year was followed by non-breeding by most pairs; in fact only one pair used an isolated tree. An alternative interpretation of that situation is possible. Namely, in a tropical environment with a fluctuating and sometimes high biomass and availability of ideally sized prey, a few owl pairs were living in the quite substantial woodland remnants (c. 100 ha) and breeding successfully in some years; their persistence is probably dependent on the future of the woodland even though they hunt in adjacent cleared areas.

Although it can use caves in treeless areas, in areas lacking caves the Masked Owl seems dependent on a tree stratum (e.g. Schodde & Mason 1980, Peake et al. 1993, Debus & Rose in press). The owl may be able to take advantage of a temporary flush of exposed and disoriented prey after timber- or cane-cutting operations by using disturbed areas for hunting, but proximity to standing forest or woodland for other purposes (roosting, breeding) would seem essential. Furthermore, it is clear that the Masked Owl does also live, hunt and breed in forest, kilometres from the nearest cleared country (see Peake et al. 1993, Debus & Rose in press for further discussion). In Tasmania the Masked Owl regularly nests in isolated or near-isolated trees (N. Mooney pers. comm.), but nevetheless its optimal habitat there is old-growth, dry eucalypt forest and tall woodland (Mooney 1992, 1993). In New South Wales there is anecdotal evidence of Masked Owls eventually deserting a traditional (forested)

territory after habitat disturbance and a decline in native mammal prey (Hyem in Debus 1993).

The foregoing relates to gross habitat disturbance, i.e. forest conversion, and the owl's response to partial clearing. It is recognised that this level of impact is not the same as forest disturbance, i.e. limited disturbance to, but retention of, existing wooded habitat. In terms of prey and nest-site availability, partial logging of forest may have a different impact from that of clearing. The impact of timber harvesting is discussed by Davey (1993), Kavanagh & Peake (1993) and Debus & Rose (in press), and will be examined in more detail elsewhere (Debus in prep., Kavanagh in prep.). The possible impact of fire is also discussed by Debus & Rose (in press). Additionally, Beardsell (in press) found that a pair of owls vacated a home range after it was burnt out by a bushfire.

Habitat use in forested areas of New South Wales and Victoria is discussed elsewhere (Peake et al. 1993, Debus & Rose in press). It is apparent that Masked Owls make use of the edge effect created by roads through forest in other areas as well, such as south-western Western Australia and Tasmania. Three of nine confirmed Atlas records for the south-western corner of Western Australia were road kills. Of 54 specimens from Tasmania, 44 (81%) were road kills (Mooney & Hunt 1983). These data suggest that throughout the more densely wooded parts of its range, the Masked Owl includes an ecotonal component in its habitat use. This can include forest/farmland or woodland/farmland interface, which suggests that the Masked Owl can tolerate some degree of habitat disturbance. The situation in south-eastern Australia may be somewhat different from that in the tropics (cf. Hollands 1991, discussed opposite), where ideally sized prey may be more abundant and where the owl can perhaps tolerate more disturbance than in the south.

Limited data suggest that there is some habitat partitioning between the sexes of Masked Owl, with females tending to hunt in more open areas than males (Hill 1955, Debus 1990). Of 23 sexed road-killed Masked Owls on the mainland, 11 were females and 12 were males, which suggests that both sexes hunt along roads. Where the habitat was given for road kills, four of the five birds found in open country were females and two of the four birds found in forest were males (museum and Atlas data). That is, one of three males was found in open country and two in forest, whereas four of six females were found in open country and two in forest. This very small sample suggests some partitioning of hunting habitat by the sexes, at least in areas where they have a choice (a mosaic of forested and cleared land along major roads in coastal eastern and southern Australia).

Diet

The mainland Masked Owl's diet has been summarised by Schodde & Mason (1980), with additional data in Hollands (1991), Kavanagh (1992), Peake et al. (1993) and Debus & Rose (in press). Beardsell (in press) found that its contemporary diet in southern Victoria, in dry forest and woodland adjoining open country, is mostly Rabbits *Oryctolagus cuniculus*, supplemented with rats *Rattus* spp. and occasional Common Ringtail Possums *Pseudocheirus peregrinus* and Sugar Gliders *Petaurus breviceps*. This is similar to the owl's contemporary diet in coastal New South Wales and in Tasmania (see Kavanagh 1992; Mooney 1992, 1993; Debus & Rose in press). It is also similar to the owl's prehistoric diet in southern Victoria (Peake et al. 1993), but with substitution of introduced mammals for similarly sized native terrestrial mammals (as in Tasmania: Mooney 1992, 1993).

Table 2

Prey species recorded for the mainland Masked Owl, in addition to those recorded for Queensland, New South Wales and Victoria (see also Hollands 1991, Kavanagh 1992, Peake et al. 1993, Debus & Rose in press). Mean or median adult prey weights from Long (1981), Strahan (1983), and Rowley (1990). Habits of mammals and roosting birds: T = terrestrial, A = arboreal. Sources: 1 = Douglas 1980; 2 = Le Souef (1921); 3 = Beardsell (in press); 4 = Hill (1911); 5 = Barnard (1914); 6 = Barnard (1925); 7 = Ford (1968); 8 = D. Shepherdson/Atlas. Le Souef's records were from the Nullarbor Plain.

Species	*Weight (g)*	*Habit*	*Source*
Small dasyurids	⟨100	T	1
Numbat *Myrmecobius fasciatus*	455	T	2
Marsupial Mole *Notoryctes typhlops*	55	T	2
Bandicoots	⟨500?	T	1
Common Ringtail Possum *Pseudocheirus peregrinus*	⟨500?[a]	A	3
Sugar Glider *Petaurus breviceps*	128	A	3,4[b]
Small marsupials	⟨500	T	2,4
Ghost Bat *Macroderma gigas*	150		1
Rat sp.	c. 100?	T	1,3,5
Rodents	⟨500	T	2
Rabbit *Oryctolagus cuniculus* (age?)[a]	?	T	2,3
Ring-necked Dove *Streptopelia decaocto*[c]	147	A	6
Galah *Cacatua roseicapilla*	328	A	7
Birds	?	?	2,4
Lizards			1
Insects			8

[a] probably juvenile
[b] identified as Barn Owl by Hill; referred to Masked Owl by Mees (1964)
[c] domestic bird removed from aviary

It seems worth listing other prey items recorded for mainland birds (Table 2), partly because some prey records for the Nullarbor population have received no mention in previous reviews. From the cave roost of a pair of Masked Owls on the Nullarbor, Le Souef (1921) found 'numerous' pellets of which 35% contained birds, 45% rodents, 10% small marsupials (including two Marsupial Moles *Notoryctes typhlops* and two Numbats *Myrmecobius fasciatus*), and 10% Rabbits. Masked Owl pellets from a cave in coastal Western Australia contained Ghost Bat *Macroderma gigas* and lizards as well as various mammals and birds (Douglas 1980). In addition, a Masked Owl was shot while attacking domestic chickens (per Australian National Wildlife Collection), and an escaped captive owl killed and ate a Spotted Turtle-Dove *Streptopelia chinensis* and a Tawny Frogmouth *Podargus strigoides* (D. O'Brien pers. comm.; not stated whether prey were captive or free). One owl was observed in a tree under an outdoor light, hawking insects attracted to the light (D. Shepherdson/Atlas).

The diet data suggest that the Masked Owl is opportunistic, and that although preferring small terrestrial mammals, it has as diverse a diet on the mainland as in Tasmania (cf. Mooney 1992, 1993). However, there are few quantitative data on its present-day diet on the mainland. Furthermore, its preferred prey size is 200-600 g, mean 327 g (Mooney 1992, 1993). Although Rabbit kittens ⟨600 g may be a valuable food supplement where alternative prey are available, in inland areas where small

native mammals are extinct and there are no exotic (or native) rats, Rabbit kittens may be an unreliable food source if they are not available continuously. They are also outside the preferred prey size of male Masked Owls, which do all the hunting in critical stages of the breeding cycle; this may limit the owl's inland breeding distribution (further discussion by Debus & Rose in press). Introduced House Mice *Mus musculus* may be too small to be an energetically worthwhile staple (Mooney 1992, 1993), and also an unstable and therefore unreliable food source. In inland southern Australia, these two exotics alone may be an insufficient prey base; the owl may require a diversity of small mammals (whether native or exotic) in the optimal prey size-range (further discussion in Peake et al. 1993, Debus & Rose in press). Although an inland Masked Owl was 'feeding on Galahs [*Cacatua roseicapilla*]' (Ford 1968), it is unlikely that birds provide a staple diet.

There are few data on daily food consumption of Masked Owls, despite the number of birds held in captivity. Schodde & Mason (1980) noted that captive birds could consume 18% of their body weight in a day, but at that intake would sometimes voluntarily fast for a day or two. Hollands (1971) noted that one owl twice ate a complete Rabbit (size not stated) at a sitting. A captive, injured female ate most of a small Rabbit and about 10 mice in a week (P. Peake pers. comm.). The daily fresh-weight food intake of four captive Masked Owls was 43-87 g or 6-12% of body weight (from Newgrain et al. 1993): 87 g or 8% for a 1142 g female; 73 g or 12% for a 624 g male; and 43 g (6%) and 50 g (8%) for unsexed birds of 664 g and 599 g respectively. The annual food demands of a Masked Owl family can be calculated as c. 140 kg or 430 average prey animals, assuming a 10% increment for active (wild) birds, 1.2 young per territory (from 'Breeding biology', p. 184) and mean prey size of 327 g. From this, and local diet data and prey densities, may be inferred the minimum home-range size required to support such a 'harvest' of prey at a given site.

Hunting behaviour

Schodde & Mason (1980) stated that 'most hunting is done on the wing and throughout the night... quartering...with slow flapping'. However, Hollands (1991) stated that the Masked Owl does more perching than the Barn Owl, with more still-hunting rather than quartering. One might predict as much from differences in the two species' wing-loading (see 'Morphology', p. 172). Schodde & Mason based their claim at least partly on D'Ombrain (1905) and Carter (1923). D'Ombrain's report (from the Messrs Dancocks) was almost certainly a misinterpretation of courtship behaviour (see p. 183), whereas Carter was probably observing misidentified Barn Owls which he only assumed to be Masked Owls ('large white owls' for which he gave no identification details; see also Mees 1964). For similar reasons, Schodde & Mason's claim of possible co-operative hunting by male and female, and mediated flushing (based on these same two sources), should be regarded as unproven and unlikely.

Of 21 nocturnal sightings of Masked Owls which could reasonably be assumed to be hunting (i.e. they were not engaged in courtship or nesting activity, or were not already holding prey), 18 (86%) were perched when first seen and three (14%) were flying when first seen (sources: D'Ombrain 1905, Conole 1986, Debus 1990, Atlas and BOCA files, C.J. Chafer, A. Gillanders, A.B. Rose pers. comm.). Of the flying birds, one may have been flushed by a vehicle and one had just departed (voluntarily) from its daytime roost and was apparently investigating human observers in its territory. The other appeared to be flying between hunting areas or perches,

i.e. it was flying directly, without intently quartering the ground (pers. obs.). P. Peake (pers. comm.) has also had an owl fly in to a perch to investigate while he was spotlighting on foot. In addition, D. Richards (pers. comm.) observed a bird regularly perching on the same roadside posts over four months, and when flushed it always flew a short distance to alight on another post. All 18 of the above birds were using low (<5 m) perches, mostly posts or logs c. 1 m high, or (in four cases) were standing on the ground. One bird on a fence-post allowed a cautious approach to c. 3 m, and took little notice of the observer, but instead peered intently at the paddock below its perch for 20 minutes (R. Shackleford/Atlas). Another was perching in a tree at dusk, peering about, and once flew c. 20 m to a neighbouring tree in a period of 30 minutes; it was 'not seen to strike', which implies that the observer thought it was hunting (S.J.J.F. Davies/Atlas). Of the Tasmanian race, Hill (1955) reported that a pair could generally be found on regular perches: the female on a conspicuous lower limb of a large eucalypt, the male on a more secluded branch in thick scrub. Of c. 50 nocturnal sightings of Tasmanian Masked Owls, 90% were of perched birds (N. Mooney pers. comm.). The number of road kills is consistent with the view that Masked Owls seem to like low perches near breaks in ground cover, which would optimise their chances of capturing terrestrial small mammals. This is also consistent with theories on the owl's habitat requirements (see Peake et al. 1993).

Baker-Gabb (1993) reported on the acute directional hearing of the Masked Owl, and concluded that, like the Barn Owl, it probably hunts at least partly by sound (as one may infer from the facial disc). Field observations support such a conclusion. One owl caught one of a group of Sugar Gliders that betrayed their presence by foraging noises (tearing of bark etc., Schulz 1987). Another was apparently attracted to the distress vocalisations of bats caught in a mist-net (Parkes et al. 1987, M. Schulz field notes): the owl approached to within 4 m, on a branch 3 m above ground, and slowly bobbed and craned its head while peering at the net. In late afternoon below a dense forest canopy, a Masked Owl perched 5 m away and 3 m above ground after a mechanical bird 'squeaker' was used to attract diurnal birds; the owl peered down with the upper part of its facial ruff in a 'frowning, beetling eyebrows expression' after discovery by the observer (J. Johnstone/Atlas). The fact that the Masked Owl is notorious for robbing rabbit traps suggests that it homes in on the distress cries of trapped rabbits, and also that it is quick to learn of a new food source. In Tasmania, N. Mooney (pers. comm.) has attracted Masked Owls on three occasions by using a fox whistle (i.e. simulation of rabbit squeals), on one occasion at sunset, when a Brown Falcon *Falco berigora* also approached.

Recent observations by Beardsell (in press) suggest some refinement of the foregoing conclusions. Beardsell observed that at dusk, Masked Owls hunted by 'quartering' [presumably slow, direct flight between perches] low over openings in lightly timbered country. Later in the evening they sat quietly on low vantages such as fence-posts, surveying for prey. This suggests that the owls adapt their foraging strategies to ambient light levels: partial dependence on visual cues, with some active flight, at relatively high light levels (dusk) and dependence on auditory cues, from stationary positions, at low light levels (remainder of the night). Beardsell also observed that Masked Owls foraged singly or as a pair, and that during 'quartering' flights they 'plucked' prey from the ground and took it to a tree. They also occasionally 'snatched' Ringtail Possums and Sugar Gliders from trees. This behaviour suggests that individuals of the larger species taken were all juveniles.

The above observations support the impression of a moderately large and heavy owl that is a somewhat reluctant flier, and which spends most of its foraging time

listening from low perches in bouts of 'long-stay' perch hunting, punctuated by occasional, short perch-to-perch flights. Vocalising while hunting, as claimed by D'Ombrain (1905), would negate the element of surprise and render pointless the special adaptations owls have for directional hearing and silent flight; this is a further reason for dismissing his informants' interpretation of the owl's behaviour. Similarly, the 'loud scream' supposedly uttered while hunting (Cayley 1965) must surely be associated with some other activity, probably territorial advertisement.

Differences in wing-loading suggest that male Masked Owls may fly more than females, but data on the relative use of aerial foraging are lacking. In my experience, male Masked Owls in sustained flight were engaging in courtship or territorial defence towards an 'intruder' (tape playback): flying in to investigate, landing and departing again, or sometimes chattering continuously and circling high over the treetops with slow, rhythmic beats, i.e. they were not hunting. Like many diurnal raptors, it seems that male Masked Owls reserve their best powers of flight for display rather than hunting.

Kavanagh (1992) noted that large forest owls, including the Masked Owl, are not impulsive attackers as are many diurnal raptors. Mooney (1992, 1993) noted that the Masked Owl is adapted for surprise attack not pursuit, that it is neither fast nor agile, and that it uses a slow, stealthy, silent attack. This is consistent with the sensory capacities of forest and woodland owls: they have unexceptional night vision but acute hearing, and depend on detailed knowledge of local topography for navigation (Martin 1986). From the foregoing, one may characterise the Masked Owl as a stationary hunter which uses a series of regular hunting perches in its territory (e.g. Richards cited opposite and by Debus & Rose in press), which locates its prey by sound, and which then assesses the situation and waits for an appropriate moment to take its prey completely unawares, without the need for pursuit. This would explain why Masked Owls are sometimes found dead under barbed-wire fences or powerlines (Debus & Rose in press): they probably strike unseen wires while flying between hunting perches, and it is highly unlikely that they pursue escaping prey under fences. This behaviour also suggests that if trapping of resident Masked Owls for banding or radio-tracking is to be successful, researchers should first determine the owls' regular hunting perches by nocturnal observation or deposits of excreta, and set traps near these perches. However, this may be difficult in forested environments. Some exposed roost sites on cliffs may be hunting perches (N. Mooney pers. comm.).

Displays

The Masked Owl's displays have been described elsewhere (Schodde & Mason 1980, Hollands 1991, Hyem in Debus 1993), and little need be added. As noted on p. 181, the behaviour reported by D'Ombrain (1905) was probably courtship (as conceded by Schodde & Mason 1980), and may indicate a pairing flight in this species as observed by Hollands (1991). A variant of display behaviour has been recorded: an owl was chattering while circling and gliding above the trees in its territory, then swooped down to a prominent perch; at intervals another bird screeched several hundred metres away, which caused the first bird to face that direction (I. Temby/Atlas). Similar behaviour has been observed in Tasmanian breeding birds (N. Mooney pers. comm.).

Schodde & Mason (1980) stated that the Masked Owl is not as strict or aggressive in territorial defence as the Sooty or Powerful Owls. However, in my experience and that of Hyem (in Debus 1993) the Masked Owl does sometimes respond strongly and aggressively to imitation or playback of its screeching territorial calls and chattering

courtship calls (see Debus & Rose in press for types of responses, and caution on the over-use of playback). Also, Masked Owls sometimes respond by screeching, with approaching/flying over, to imitation or playback of Sooty and Powerful Owl calls or to a rabbit whistle (pers. obs. and in prep., Hyem in Debus 1993, P. Peake pers. comm.), which suggests some interspecific territoriality. Nevertheless, there are many occasions when no response to playback is obtained, even in known territories, but this also applies to Powerful and Sooty Owls (pers. obs., R. Kavanagh pers. comm.).

One pair of Masked Owls responded strongly to two humans canoeing through a lakeside territory at night. The owls apparently perceived the craft and occupants as threatening: they followed or flew ahead and landed on perches, one holding its wings slightly out from its sides while craning its head from side to side and calling incesssantly with loud, piercing screeches; their calls eventually drove the observers from the area (A. Gillanders/Atlas). In Tasmania a female swooped low overhead, from behind, at a person jogging below the nest (N. Mooney pers. comm.); this display of threat suggests a propensity in some individuals to defend the nest against humans (see also Hollands 1991).

'Courtship' (supplementary) feeding of the female by the male in the pairing and pre-laying period has been recorded in some Australian owls (Powerful, Masked, Sooty, Lesser Sooty *Tyto multipunctata* and Barn Owls: Schodde & Mason 1980, Hollands 1991). McGowan (1903) reported that a wild Tasmanian Masked Owl regularly brought prey to three captive adults in the Launceston Zoo over the period September to April. It gave a chattering call near the cage, and left the hindquarters of young Rabbits, bandicoots and rats on the cage roof; on one morning there were five Rabbits and a bandicoot. This suggests that food provisioning is important for pairing and egg formation in the Masked Owl, as in other owls and in diurnal raptors (e.g. Newton 1979, Norberg 1987).

Breeding biology

The breeding behaviour of the Masked Owl has been described elsewhere (Schodde & Mason 1980, Hollands 1991), and meagre data on the breeding parameters of mainland birds are presented by Kavanagh (1992), Peake et al. (1993) and Debus & Rose (in press). Major gaps in knowledge concern breeding density and home-range size, quantification of breeding habitat and nest-site characteristics, accurate delimitation of breeding chronology (laying dates), fledging success, and post-fledging dependence period.

Very limited data suggest higher densities in forested parts of north-eastern New South Wales than in woodland remnants among canefields in north Queensland: about 1 km between two breeding pairs (N.S.W., de Warren 1928); c. 2-3 km between neighbouring pairs of conspecifics in all three forest owl species (N.S.W., Debus preliminary unpubl. data); five Masked Owl pairs over a linear distance of 30 km, or c. 7-8 km between pairs (Qld, Hollands 1991). The home range of one pair in north-eastern New South Wales was at least 1 km across in one direction (Debus 1990). In southern Victoria, the home range of one pair in optimal habitat with plentiful prey was 400-500 ha (Beardsell in press). These data for south-eastern mainland Australia are similar to a minimum inter-nest distance of 1.5 km, and inferred density and home-range size of c. 2 km^2 per pair, for Tasmanian Masked Owls (Mooney 1992, 1993). However, density may be higher in Tasmania, in the absence of competitors, than on the mainland (cf. Blakers et al. 1984).

Schodde & Mason (1980) stated that the Masked Owl breeds opportunistically at any time of the year, and is not restricted to well-defined seasons. However, recorded clutches in the south-eastern mainland suggest some seasonality, as predicted by Conole (1986): most clutches are started from early autumn to late winter, extending into early spring, with apparent avoidance of summer (see Kavanagh 1992, Peake et al. 1993, Olsen & Marples 1993, Debus & Rose in press). The owl's nesting chronology may tie in with peaks in abundance of the owl's most common mammal prey. Over the period when food demands are likely to be greatest (nestling to post-fledging periods, winter to summer), adult (mating) Brown and Dusky Antechinuses *Antechinus stuartii* and *A. swainsonii* are at their most vulnerable, and later (spring-summer) there are many young, inexperienced antechinuses, Common Ringtail Possums, Sugar Gliders and Bush Rats *Rattus fuscipes* abroad (from Strahan 1983; also Lazenby-Cohen & Cockburn 1993). However, empirical data are required on correlations between owl breeding chronology and success, and prey abundance.

In captivity the mainland Masked Owl is capable of breeding twice in a year on a plentiful food supply (Fleay 1981): a pair laid in late February, raised three young and laid again in July, raising two young. This suggests that in the wild, in years of abundant food, the Masked Owl may be able to breed more than once per year. The slight indication of a bimodality in laying peaks (autumn and spring: Hyem 1979, Olsen & Marples 1993) suggests that this may sometimes happen.

A captive Tasmanian Masked Owl pair recently eclipsed this with a remarkable performance (C. Spencer in prep., per N. Mooney), thus adding to previous data in Fleay (1968). The first clutch of three eggs was laid in mid September 1992, and three chicks hatched. When the brood was 64 days old and still housed with the adults, the second clutch of three eggs was laid in late December and a single chick hatched in late January 1993. When that juvenile was 93 days old and still housed with the adults, a third clutch of three eggs was laid in late April and three chicks hatched in late May. A fourth clutch of three eggs was laid in early September 1993. Eggs were laid at two-day intervals; incubation lasted 33 days, similar to Fleay's (1968) result of 35 days but shorter than the 42 days stated (though not measured) by Hollands (1991). Wild Tasmanian Masked Owls are spring breeders, raising one brood per year (Hollands 1991, N. Mooney pers. comm.), which suggests that food is limiting in other seasons at high latitudes.

In New South Wales, successful wild broods of one or two young fledge (Debus & Rose in press). In north Queensland, seven young were raised in six attempts for which the outcome was known (5 pairs; 1.2 young per attempt; mean successful brood size [B] 2.3; B/1 x 1, B/3 x 2: Hollands 1991). In the wild in Tasmania, breeding success from 13 attempts for which the outcome is known was 69% nest success (i.e. four failures); 1.2 young fledged per attempt; and mean brood size at fledging of 2.3 (B/1 x 3, B/2 x 5, B/3 x 1: N. Mooney unpubl. data).

One further observation adds a little to knowledge of the fledging stage: on 1 June 1981 in north Queensland a fledgling capable of some flight, but captured by hand, was found in daylight on the ground, amongst bushes under a tree. When placed on a branch it flew to another tree but was mobbed by Australian Magpies *Gymnorhina tibicen*, butcherbirds *Cracticus* sp. and a kookaburra *Dacelo* sp.; it then hid in bushes and stayed there all day until the adult owls found it that night (D. Regan/Atlas). In Tasmania, young may leave the nest hole while still downy; downy tips persist on the ventral feathers for several months (N. Mooney pers. comm.).

The late E.L. Hyem found that three different broods were dependent for one to

three months after fledging (Debus 1993). Hollands (1991) reported a post-fledging dependence period of 'several weeks'. In Tasmania, as judged by begging calls near the nest, the post-fledging period seems to last for about 4-6 weeks after young start flying properly; captive-raised young released by the hacking method may return to the hack site for longer than this (N. Mooney pers. comm.).

Masked Owls seem reasonably tolerant of study of their breeding biology, by close observation of the nest tree or occasional examination of nestlings, at least to the point of continuing to tend the nest in that season (Hill 1955, Hollands 1991, Hyem in Debus 1993). In this respect, the Masked Owl contrasts with the Powerful Owl which readily deserts an active nest (particularly eggs) after human intrusion (Hollands 1991). Nevertheless, in Tasmania a traditional Masked Owl nest was deserted for the ensuing eight years after ladders were installed to enable filming of the chicks (N. Mooney pers. comm.). Such an alteration to the site may have increased its accessibility to predators, at least in the owls' perception. This suggests the need for caution, and avoidance of activities that may lead to subsequent abandonment of the site. This consideration may be critical in areas where nest sites are scarce.

Niche partitioning

Morphological and limited ecological data on the Masked Owl suggest that it is adapted to more open habitats than the other large forest owls, particularly the Sooty Owl. Furthermore, distributional data show that the Masked Owl extends into sparsely wooded habitats of inland Australia, well beyond the range of the other large owls. In the forests of eastern Australia where they overlap, there is resource partitioning by this predatory guild in terms of predominant prey sizes and types, hunting habitats and foraging zones (e.g. Schodde & Mason 1980, Kavanagh 1992). The large Powerful Owl takes large arboreal marsupials from the canopy of open and tall open forest; the intermediate-sized Sooty Owl takes a wide range of arboreal and terrestrial, small and medium-sized mammals from a narrow habitat niche (rainforest, tall open forest); and the slightly smaller Masked Owl takes small and medium-sized terrestrial mammals from open forest and from openings or bare ground in tall open forest, as well as adjacent sparsely wooded habitats.

Schodde & Mason (1980) suggested that in Tasmania, in the absence of the other two species, the Masked Owl has expanded its niche into more open habitats. One would expect the opposite: that in the absence of its competitors, the Masked Owl would expand its niche into dense forest if an otherwise uncropped food resource were available. Furthermore, open habitats of the kind inhabited by Masked Owls in inland Australia do not exist in Tasmania. 'Ecological release' seems to have happened to some extent in Tasmania, where there are limited opportunities for it to move into the Powerful/Sooty Owl niche (few large arboreal marsupials, low mammal diversity and/or biomass in depauperate cool-temperate rainforest; e.g. Strahan 1983). There, the Masked Owl is larger and more size-dimorphic, lives in tall open forest (though not rainforest) and takes some large prey; nevertheless it remains typical of its species in its foraging ecology and preference for dry sclerophyll open forest and woodland (Mooney 1992, 1993). Comparative ecological data on the Masked Owl in the forests of south-western Australia would be valuable.

One might expect passive competition between Masked and Sooty Owls to be an important determinant of their respective niches. On the mainland, local overlap between them may be marginal; Masked may roost and breed in Sooty habitat, but there may be segregation of hunting habitat and foraging zone and hence of dietary

Rehabilitated female Masked Owl, dark morph, Nana Glen, N.S.W., October 1985.
Plate 26 Photo: S.G. Lane

Captive pair of Tasmanian Masked Owls: intermediate male, dark female.
Plate 27 Photo: D. Watts

resources. Where they overlap in forested habitats, Masked seems less numerous than Sooty (see Debus & Rose in press). This begs the question of the Masked Owl's optimal density and prime habitat in southern mainland Australia: presumably the drier open forests and woodlands of coastal and subcoastal regions. The Masked Owl therefore probably reaches (or reached, before widespread clearing) its highest densities in eucalypt forests and woodlands that are too dry and open for the Sooty Owl.

Conservation status

From the foregoing review, and related discussion (Peake et al. 1993, Debus & Rose in press), the Masked Owl's conservation status in cleared areas of southern Australia is of concern (also Garnett 1992a). If the Masked Owls studied by Hollands (1991) do belong to the northern race *kimberli*, then this necessitates a review of the state of knowledge and conservation status of Masked Owl races. If reclassification of the races according to IUCN criteria is warranted (cf. Garnett 1992a), then *kimberli* may be reasonably well known and 'secure' whereas nominate *novaehollandiae* may be 'insufficiently known'. The latter would be justified on the grounds of the poor knowledge of this race, and because in assigning priority for research 'insufficiently known' is rated after 'vulnerable' and ahead of 'rare' (Garnett 1992b). Taxonomic research in progress, on Masked Owl specimens from northern Queensland, should answer these questions (Schodde in prep.). Whatever the outcome, it is clear that more knowledge is needed on the distribution, status, biology and ecology of nominate *novaehollandiae*, particularly in non-coastal areas and/or non-forested/partly forested areas.

Discussion

This review suggests the need for some revision of the 'popular' perception of the Masked Owl as presented in recent books (e.g. Schodde & Mason 1980, Schodde & Tidemann 1986). From the foregoing review, one may infer that the Masked Owl is primarily a species of coastal and subcoastal open forests and woodlands and adjacent clearings, but extending far inland in riparian woodland with hollow trees, and perhaps also in gorges, 'breakaways' and caves where these provide alternative daytime shelter and nesting sites. The owl's inland occurrence may be related to mammal prey abundance, but it is able to feed on birds to some extent (e.g. Le Souef 1921, Ford 1968). In its hunting behaviour the Masked Owl appears to resemble other forest owls, which typically listen from low perches (see Martin 1986 and Norberg 1987 for further discussion).

This review, along with limited data on the other two species (Schodde & Mason 1980, Hollands 1991, Kavanagh 1992), suggests some tentative predictions on niche partitioning in Masked, Sooty and Powerful Owls. Local overlap between Masked and Sooty Owls may be marginal, with moderate prey partitioning by size/type and vertical foraging zone (ground versus trees) but strong segregation by foraging habitat. Geographical overlap with the Powerful Owl is complete, but there may be strong segregation on prey size and vertical foraging zone (arboreal versus terrestrial prey). The Masked Owl may be of marginal occurrence in the densest forests, but comparative data are lacking. Conversely, the Masked Owl's mainland distribution may overlap completely with that of the similarly sized Barking Owl *Ninox connivens*, and extend beyond into even more sparsely wooded habitats where there are caves. Comparative ecological studies of Masked and Barking Owls would be valuable; some dietary segregation may be expected (e.g. Masked may be more of a small-mammal specialist). However, there has been no detailed published study of the Barking Owl's ecology. These predictions require testing by further field investigation.

The Masked Owl seems to share some of the inherent *Tyto* breeding flexibility and high reproductive potential; it seems to have coped reasonably well with habitat fragmentation by using edges of forest clearings, and by switching to exotic prey species on the mainland (Debus 1990, Peake et al. 1993, Debus & Rose in press, Beardsell in press), as in Tasmania (Geering 1990; Mooney 1992, 1993). In coastal areas with high prey abundance and diversity, it uses a mosaic of wooded and open or cleared country (Peake et al. 1993, Debus & Rose in press, Beardsell in press). The creation of forestry roads may even have allowed it to penetrate denser, wetter forests than it might normally inhabit, as is the case with some other predatory birds (*Accipiter* species: Czechura 1985; Southern Boobook and Tawny Frogmouth in rainforest: pers. obs.; Wedge-tailed Eagle *Aquila audax* and Brown Falcon in Tasmania: N. Mooney pers. comm.). Nevertheless, open forest and woodland are probably the Masked Owl's prime habitat; confirmation is required by comparative surveys in forest versus woodland and partially cleared country.

Although the Masked Owl seems secure in coastal regions, the situation may be different in inland areas still subject to clearing and other habitat degradation. Native mammal species have been much more affected in drier habitats than in wetter forests, with mass extinctions in the arid and semi-arid zones (e.g. Strahan 1983). This raises the likelihood of the Masked Owl's disappearance from much of its former habitat in southern inland Australia (see also Debus & Rose in press).

One may argue that core habitats of the Powerful and Sooty Owls are in rugged and inaccessible country, much of it reserved, and at worst subject to logging operations in some areas. These owls are also subject to much research and some management, although the impact of forestry has not been resolved. This contrasts with the Masked Owl which is comparatively neglected, and may be subject to further habitat clearance for agriculture; I suggest that (*contra* Hollands 1991) further broadscale clearing would be detrimental to the species, particularly in non-coastal areas. The Masked Owl is also a much more suitable subject for study, being more easily trapped and less affected by nest disturbance than the others. Conservation of viable populations of the Masked Owl across its inland range may depend on adequate habitat reserves in the drier forests and woodlands. Because it is at the top of the food chain and requires a large home range, such action would cater for the many other woodland species that are also neglected, given the current focus on forests.

Acknowledgements

This paper has made use of unpublished notes of other observers, for which I am grateful. I thank the RAOU for access to Atlas unusual record forms, Peggy Mitchell for BOCA unusual sighting reports, and Lyle Smith for a catalogue of owl specimens in the Museum of Victoria. Atlas observers were: P. Congreve, S.J.J.F. Davies, D. Drakes, A. Gillanders, J. Hardy, F. Henderson, J. Johnstone, A. Milhinch, R. Moon, W. Okell, D. Regan, M. Shackleford, D. Shepherdson, P. Smith, I. Temby and J. White. BOCA observers were: M. Carter, J. Squire and R. Thomas. Chris Chafer, Alan Gillanders, Danny O'Brien, Del Richards and Tony Rose supplied information. Richard Loyn provided access to notes held at the Arthur Rylah Institute (Melbourne), and Martin Schulz kindly permitted his notes to be used. I thank the following for access to specimens and/or supplying data: Greg Czechura (Queensland Museum), Walter Boles (Australian Museum), John Wombey and Richard Schodde (Australian National Wildlife Collection, CSIRO, Canberra), Belinda Gillies and Rory O'Brien (Museum of Victoria), the late Shane Parker (South Australian Museum), and Ron Johnstone (Western Australian Museum). Doug Rickers and Brian Hales (President), both of the Illawarra Bird Observers Club, kindly provided a copy of the historic owl photograph and permission to repoduce it here; Ern Hoskin (Keith Hindwood Bird Recording Service) provided relevant comments. Field surveys of owls in northern New South Wales were supported by World Wide Fund for Nature Australia, and the Endangered Species Program of the (then) Australian National Parks & Wildlife Service. Library and museum research was supported by a Cayley Memorial Scholarship, administered by the Gould League of New South Wales. I thank Dr Hugh Ford, Chris Chafer, Rod Kavanagh, Nick Mooney and Paul Peake for comments, and Nick Mooney and Chris Spencer for unpublished data.

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Received 18 May 1992
Revised 5 September 1993

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