

## Mistletoe nesting in Australian birds: a review

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**Abstract.** Interactions between birds and mistletoes have been described in many regions worldwide, with most research focusing exclusively on the role of birds as seed and pollen vectors for these hemiparasitic plants. Mistletoe is also widely used by birds as a nesting site, with a recent family-level compilation identifying species in 43 families worldwide nesting in mistletoes. We reviewed breeding and nesting accounts of Australian birds to explore the extent of mistletoe nesting at the species level within an entire avifauna. In total, 217 species of Australian arboreal nesting bird from 29 families are here reported nesting in mistletoes, representing 66% of Australian species that nest in the foliage of trees. A further 28 species are also known to nest in mistletoes incidentally. This increases the total number of avian families known to exhibit this behaviour worldwide to 60, across 16 orders. Although no species can be considered an obligate mistletoe nester, several families regularly nest in mistletoes with >90% of Australian species known to have nested in mistletoes, including Pomatostomidae, Artamidae, Corvidae and Ptilonorhynchidae. Determining preference for mistletoe nesting is a priority for understanding this behaviour and we present guidelines for evaluating whether a particular species preferentially uses mistletoe as a nest-site. We postulate that the evergreen, dense habit of mistletoes provide a strong structural substrate on which to build a nest, offering a higher level of concealment and a more moderate nest microclimate than otherwise similar arboreal nest-sites. These features may also have a role in reducing nest predation and enhancing survivorship of nestlings. Future studies should focus on the mechanisms underlying this pattern using field experiments to evaluate the influence of mistletoe on nest microclimate, rates of predation and nest success.

### Introduction

Although mistletoes (abundance, species richness and biomass) form a minor component of most undisturbed habitats, they have a disproportionate impact on the vertebrate community (Watson 2001, 2002). Mistletoes provide food and shelter and also modify the structure of forests, increasing the forest's habitat value for many bird and mammal species (Bennetts *et al.* 1996; Watson 2001). Hence, mistletoes are considered to function as a keystone resource in many undisturbed habitats around the world (Watson 2001).

While the dispersal and pollination relationships between birds and mistletoes are well known (Calder 1983; Reid 1986; see also Watson 2001 and references therein), little attention has been given to the role of mistletoes as a nest-site. Watson (2001) first documented the popularity of mistletoes as a nest-site, identifying species from 43 avian families worldwide (and seven mammalian families) that nested or roosted in mistletoes.

In this contribution, we review the evidence for mistletoe nesting in all 454 species of land birds breeding in Australia (Ford 1989) to assess the occurrence and extent of mistletoe

nesting for an entire avifauna. Australia is the ideal region in which to conduct such a review since the avifauna is well known and nidification is described for most species (North 1901, 1906, 1912, 1913; Campbell 1974a, 1974b; Beruldsen 2004). Having documented the incidence of this behaviour, we review the evidence for preferential use of mistletoe. We then explore the potential underlying mechanisms, identifying structure, predator avoidance and microclimate as likely reasons for nesting in mistletoe. Finally, we identify gaps in our understanding of the role of mistletoe as a nest-site and present hypotheses to guide further work.

All accounts of the breeding biology of Australian birds published since 1900 in *Emu* and three monographs on the nests and eggs of Australian birds were searched for references to birds nesting in mistletoes (North 1901, 1906, 1912, 1913; Campbell 1974a, 1974b; Beruldsen 2004). The breeding sections of the *Handbook of Australian, New Zealand and Antarctic Birds (HANZAB)*, Volumes 1–7 (Marchant and Higgins 1990, 1993; Higgins and Davies 1996; Higgins 1999; Higgins *et al.* 2001, 2006; Higgins and Peter 2002) were also searched. For selected species the Birds Australia Nest Record Scheme (NRS) was searched.

In addition, unpublished records of birds nesting in mistletoe were solicited from ornithologists and bird-watchers throughout the country via a number of general requests and then via specific requests to selected ornithologists to ensure that we obtained national coverage. Finally, we extracted records from our own extensive field notes and unpublished observations. Many of these records were gathered over 20 years by John Young while working on film documentaries about birds in all parts of the country.

### Which birds will nest in mistletoe?

Two hundred and seventeen species of Australian arboreal nesting bird from 29 families have been recorded nesting in mistletoes (Table 1), comprising 47 species of non-passerines in eight families, and 170 species of passerines in 21 families. This represents 66% of the 330 Australian birds that nest above ground in the foliage of trees or shrubs (hereafter termed arboreal nesters, after Bennett and Owens 2002). Another 28 species, not normally arboreal nesters, or birds that do not build their own nests, have also been reported nesting in mistletoes (Table 2).

In 15 families, more than half the Australian species have been recorded nesting in mistletoes, including all Australian members of the Corvidae and Pomatostomidae and all but one of the Australian species in the Artamidae and Ptilonorhynchidae. The only species of Artamidae that has not been recorded nesting in mistletoes is the Black Currawong (*Strepera fuliginosa*), which is endemic to Tasmania, where mistletoes are absent (Barlow 1981).

Species that nest in mistletoes range from the 2.5 kg Australian White Ibis (*Threskiornis molucca*) that places its nest atop mistletoes (J. Young, personal observation) to the 9 g Mistletoebird (*Dicaeum hirundinaceum*) that builds its enclosed nest 'well hidden within the mistletoe clump' (NRS, record 564/57).

### Frequency of mistletoe nesting within Australian bird species

Could it be that nesting in mistletoes does not result from any specific decisions or site-selection criteria, but is merely accidental – that is, most arboreal nesters occasionally build a nest in mistletoe purely by chance? In all habitats in Australia, mistletoes represent a minor component, in terms of number of individual plants, species richness and overall biomass (Watson 2001). Therefore, although chance may explain the records for waterbirds and other species that nest in mistletoes infrequently, we suggest that chance alone is insufficient to explain the incidence of this behaviour recorded in other groups.

Where mistletoe nesting has been systematically quantified at the species level, it can occur frequently. For example, of 229 nests of Noisy Friarbirds (*Philemon corniculatus*) and 97 nests of Red Wattlebirds (*Anthochaera carunculata*) in northern New South Wales, 28 and 29%, respectively, were

in mistletoes (Ford 1999), whereas in the same forest 14% of Rufous Whistler (*Pachycephala rufiventris*) nests were in mistletoes ( $n = 264$ ; Bridges 1994). As the estimated abundance of mistletoes in this area is  $<0.1\%$  of the total canopy volume (H. A. Ford, personal communication), the selection of mistletoe as a nest-site at this study site seems to occur far more often than would occur by chance alone, even accounting for the site-fidelity demonstrated by some individual birds in Ford's (1998) study.

Another large honeyeater that frequently uses mistletoes as a nest-site is the Regent Honeyeater (*Xanthomyza phrygia*). Two studies of Regent Honeyeaters in northern and central New South Wales found that 17.6% ( $n = 51$ ; Oliver *et al.* 1998) and 5.6% ( $n = 144$ ; Geering and French 1998) of nesting attempts were in mistletoes. Like many species of *Accipiter* in North America, Brown Goshawks (*Accipiter fasciatus*) also regularly nest in mistletoes. Aumann (1989) found 14.6% of the nests of Brown Goshawks in Victoria were placed in mistletoes ( $n = 48$ ) and this is supported by the NRS that reports 15% of Goshawk nests in mistletoe. Further, the NRS has 9.9% ( $n = 92$ ) of Diamond Firetail (*Stagonopleura guttata*) nests in mistletoes. In contrast Noisy Miners (*Manorina melanocephala*; Whitmore 1984) and Black-eared Miners (*M. melanotis*; R. Clarke, personal communication) only nested in mistletoes on 3.7% ( $n = 54$ ) and 1.5% ( $n = 262$ ) of occasions, respectively, displaying a low rate of mistletoe nesting in these studies. However, in each of these last six examples there has been no quantification of the amount of mistletoe in the habitat, random nest placement cannot be ruled out and therefore the true significance of these frequencies is not clear.

### Other mistletoe–bird nesting interactions

In addition to the 217 species of arboreal nesting birds that nest in mistletoes, another 28 birds that do not usually nest in trees, or do not build their own nests, have been reported nesting in mistletoes (Table 2).

Six species of duck and one rail have been reported to opportunistically use partly submerged mistletoes in flooded creeks as platforms upon which to build their nests. Furthermore, many ground nesting species use fallen and dead mistletoe as a nesting substrate, such as the Rufous Scrub-bird (*Atrichornis rufescens*) and the Grey Grasswren (*Amytornis barbatus*), though in these two cases a more usual nesting substrate (*Lomandra* sp. and *Muehlenbeckia cunninghamii* respectively) had grown through the mistletoe and the nest was placed in this material. The record of a Laughing Kookaburra (*Dacelo novaeguineae*), usually a hollow nester, nesting in mistletoe (Smith 1992) was surprising, but may relate to the dense canopy provided by mistletoes.

The records of falcons nesting in mistletoes adds a further dimension; these birds not uncommonly co-opt a corvid or artamid nest. Similarly, all Australian species of the

**Table 1. Australian bird species recorded nesting arboreally in mistletoe**

Where no species of mistletoe is listed in the Notes column, the nest was located in an unknown mistletoe within the stated host plant, and where no notes occur only the occurrence of nesting in a mistletoe was recorded; letters or names in parentheses in Notes indicate the source where more than one source is cited. Abbreviations used in notes: *E.* denotes *Eucalyptus* species, *Am.* denotes *Amyema* species, *Ac.* denotes *Acacia* species; NRS denotes Birds Australia's Nest Record Scheme

Family and species	Common name	Notes	Citation <sup>A</sup>
Anhingidae			
<i>Anhinga melanogaster</i>	Darter		34
Phalacrocoracidae			
<i>Phalacrocorax sulcirostris</i>	Little Black Cormorant		34
Ardeidae			
<i>Egretta novaehollandiae</i>	White-faced Heron		31, 34, 41
<i>Egretta garzetta</i>	Little Egret		34
<i>Ardea pacifica</i>	White-necked Heron		34
<i>Ardea sumatrana</i>	Great-billed Heron	Above water in <i>Melaleuca leucadendron</i>	34
<i>Ardea picata</i>	Pied Heron	In <i>Lumnitzera</i> sp.	34
<i>Ardea intermedia</i>	Intermediate Egret		34
<i>Ardea ibis</i>	Cattle Egret		34
<i>Butorides striatus</i>	Striated Heron	<i>Am. mackayensis</i> in <i>Rhizophora stylosa</i> , Darwin, NT (RN); in <i>Avicennia marina</i> (JY)	34, 58
<i>Nycticorax caledonicus</i>	Nankeen Night Heron	Mostly in <i>Eucalyptus</i> spp.	34
<i>Ixobrychus flavicollis</i>	Black Bittern		34
Threskiornithidae			
<i>Threskiornis molucca</i>	Australian White Ibis		34, 41
<i>Threskiornis spinicollis</i>	Straw-necked Ibis		34
<i>Platalea flavipes</i>	Yellow-billed Spoonbill		34
Accipitridae			
<i>Aviceda subcristata</i>	Pacific Baza		3, 34, 42, 46
<i>Elanus axillaris</i>	Black-shouldered Kite		34
<i>Elanus scriptus</i>	Letter-winged Kite		34
<i>Lophoictinia isura</i>	Square-tailed Kite	In <i>Eucalyptus</i> spp.	34, 63
<i>Milvus migrans</i>	Black Kite		34
<i>Haliastur sphenurus</i>	Whistling Kite		34
<i>Haliastur indus</i>	Brahminy Kite		34
<i>Circus assimilis</i>	Spotted Harrier		3, 34, 42, 46
<i>Accipiter fasciatus</i>	Brown Goshawk	At Clunes, Vic. (JH); in dead mistletoe at Capertee Valley, NSW (VP)	1, 3, 28, 32, 34, 40, 42, 63, 68
<i>Accipiter novaehollandiae</i>	Grey Goshawk	In <i>E. grandis</i>	3, 28, 34
<i>Accipiter cirrhocephalus</i>	Collared Sparrowhawk	At Barrington, NSW (Hyem)	3, 29, 34, 59, 63
<i>Erythroriorchis radiatus</i>	Red Goshawk	<i>Am. pendula</i> in <i>E. intermedia</i> , Cape York Peninsula, Qld, and in <i>E. tetradonta</i>	34
<i>Hieraaetus morphnoides</i>	Little Eagle		34, 42, 63
Columbidae			
<i>Columba leucomela</i>	White-headed Pigeon	In <i>Acacia</i> spp. (Higgins and Davies); in rainforest plant (JY)	22, 34
<i>Streptopelia senegalensis</i>	Laughing Turtle-Dove		34
<i>Streptopelia chinensis</i>	Spotted Turtle-Dove		22
<i>Macropygia amboinensis</i>	Brown Cuckoo-Dove		34
<i>Chalcophaps indica</i>	Emerald Dove		34
<i>Phaps chalcoptera</i>	Common Bronzewing	At Casterton, Vic (RH).	20, 22, 34, 53
<i>Phaps elegans</i>	Brush Bronzewing		34
<i>Ocyphaps lophotes</i>	Crested Pigeon	<i>Am. miquelii</i> in <i>E. fasciculosa</i> Mt Lofty, SA (MW)	20, 22, 34, 39, 40
<i>Geopelia cuneata</i>	Diamond Dove	In <i>Ac. harpophylla</i> (Higgins and Davies)	22, 34
<i>Geopelia striata</i>	Peaceful Dove	<i>Loranthus</i> spp. in <i>E. fasciculosa</i> and <i>E. odorata</i> at Sandy Creek Conservation Park, SA (Rix); <i>Am. mackayensis</i> in <i>Rhizophora stylosa</i> (RN); East Kimberley (TS)	34, 58, 60, 67
<i>Geopelia humeralis</i>	Bar-shouldered Dove		34
<i>Leucosarcia melanoleuca</i>	Wonga Pigeon		22, 34, 47
<i>Ptilinopus superbus</i>	Superb Fruit-Dove		34

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Table 1. (continued)

Family and species	Common name	Notes	Citation <sup>A</sup>
<i>Ptilinopus regina</i>	Rose-crowned Fruit-Dove		22, 34
<i>Ducula bicolor</i>	Pied Imperial-Pigeon		22, 34
<i>Lopholaimus antarcticus</i>	Topknot Pigeon	In 'Forest Oak', on old Satin Bowerbird nest, Barrington, NSW (Hyem)	29, 34, 47
Cuculidae			
<i>Centropus phasianinus</i>	Pheasant Coucal	In <i>Grevillea</i> spp., Howard Springs, NT	73
Podargidae			
<i>Podargus strigoides</i>	Tawny Frogmouth	Mostly in <i>Eucalyptus</i> spp.	34
<i>Podargus ocellatus</i>	Marbled Frogmouth	In <i>Eucalyptus</i> spp.	34
Maluridae			
<i>Malurus coronatus</i>	Purple-crowned Fairy-wren	Dead mistletoe clump caught in <i>Pandanus</i> spp.	34
<i>Malurus cyaneus</i>	Superb Fairy-wren		34
<i>Malurus splendens</i>	Splendid Fairy-wren	In <i>Ac. aneura</i> near ground	34
<i>Malurus lamberti</i>	Variegated Fairy-wren		24, 40
<i>Malurus amabilis</i>	Lovely Fairy-wren	Dead mistletoe clump on ground among grass	34
Pardalotidae			
<i>Sericornis frontalis</i>	White-browed Scrubwren		34
<i>Sericornis magnirostris</i>	Large-billed Scrubwren	Dead mistletoe in <i>Allocasuarina torulosa</i> (Higgins and Peter)	23, 34
<i>Sericornis beccarii</i>	Tropical Scrubwren	Dead mistletoe hanging over a bank above water, Claudie River, Iron Range National Park, Qld	34
<i>Pyrrholaemus brunneus</i>	Redthroat	In dead mistletoe near ground, attached to <i>Ac. aneura</i> (Mulga), Flinders Ranges, SA	34
<i>Smicromnis brevirostris</i>	Weebill	Nest 1.3 m off ground in large clump of mistletoe in <i>Eucalyptus</i> spp., east of Hallett, SA	52
<i>Gerygone fusca</i>	Western Gerygone	<i>Loranthus</i> spp.	71
<i>Acanthiza katherina</i>	Mountain Thornbill	<i>Am. pendula</i> in <i>Syncarpia glomulifera</i>	34
<i>Acanthiza pusilla</i>	Brown Thornbill		34
<i>Acanthiza uropygialis</i>	Chestnut-rumped Thornbill	In <i>Ac. aneura</i>	34
<i>Acanthiza robustirostris</i>	Slaty-backed Thornbill		34
<i>Acanthiza inornata</i>	Western Thornbill		23
<i>Acanthiza reguloides</i>	Buff-rumped Thornbill		34
<i>Acanthiza iredalei</i>	Slender-billed Thornbill		34
<i>Acanthiza chrysorrhoa</i>	Yellow-rumped Thornbill	<i>Amyema</i> and <i>Muellerina</i> spp. (Higgins and Peter); <i>Am. miquelii</i> in SA (DH)	3, 12, 23, 27, 34
<i>Acanthiza lineata</i>	Striated Thornbill		23, 27, 34
<i>Aphelocephala leucopsis</i>	Southern Whiteface	<i>Lysiana exocarpi</i> in the Wimmera, Vic. (MM)	20, 23, 34, 38, 44
<i>Aphelocephala nigricincta</i>	Banded Whiteface	Two records in mistletoe in centre of <i>Ac. victoriae</i> at Valley Bore, NT (NRS records 469/5, 469/11)	34, 48
Meliphagidae			
<i>Anthochaera carunculata</i>	Red Wattlebird	In Sandy Creek Conservation Park, SA (Rix); in Eastwood State Forest, NSW (Ford); near Holbrook, NSW (Watson and Herring)	6, 18, 27, 34, 60, 70
<i>Anthochaera chrysoptera</i>	Little Wattlebird		24, 34
<i>Anthochaera lumulata</i>	Brush Wattlebird	In shrubs	24
<i>Acanthagenys rufogularis</i>	Spiny-cheeked Honeyeater	Mostly in <i>Ac. aneura</i> (JY); in Pilbara, WA (TS)	2, 6, 24, 34, 67
<i>Plectorhyncha lanceolata</i>	Striped Honeyeater	<i>Am. cambagei</i> on Gwydir River, Torryburn, NSW (DO)	14, 34
<i>Philemon buceroides</i>	Helmeted Friarbird	<i>Am. mackayensis</i> in <i>Rhizophora stylosa</i> , Darwin, NT (RN)	24, 58
<i>Philemon corniculatus</i>	Noisy Friarbird	Eastwood State Forest, NSW (Ford); near Holbrook, NSW (Watson and Herring)	17, 18, 24, 70
<i>Philemon citreogularis</i>	Little Friarbird		24
<i>Xanthomyza phrygia</i>	Regent Honeyeater		21, 24, 34, 50, 59
<i>Entomyzon cyanotis</i>	Blue-faced Honeyeater		34
<i>Manorina melanophrys</i>	Bell Miner		34
<i>Manorina melanocephala</i>	Noisy Miner	Two of 54 nests in mistletoe in <i>Ac. harpophylla</i> (Whitmore); <i>Am. miquelii</i> in SA (DH)	12, 20, 34, 72
<i>Manorina flavigula</i>	Yellow-throated Miner		24, 34

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Table 1. (continued)

Family and species	Common name	Notes	Citation <sup>A</sup>
<i>Manorina melanotis</i>	Black-eared Miner	Of 262 Black-eared Miner or hybrid Black-eared Miner and Yellow-throated Miner nests where tree species or position were recorded (or both), four were in mistletoe in eucalypts and one was in mistletoe in <i>Ac. colletoides</i> , in north-western Vic. (RC); <i>Am. miquelii</i> in <i>E. oleosa</i> , Gluepot Reserve, SA (DH)	12, 54
<i>Xanthotis macleayana</i>	Macleay's Honeyeater	In rainforest plant	34
<i>Xanthotis flaviventer</i>	Tawny-breasted Honeyeater		34
<i>Meliphaga lewinii</i>	Lewin's Honeyeater		34
<i>Meliphaga notata</i>	Yellow-spotted Honeyeater		34
<i>Meliphaga gracilis</i>	Graceful Honeyeater		34
<i>Lichenostomus hindwoodi</i>	Eungella Honeyeater	At Chelmans Road State Forest, north of Eungella, Qld	55
<i>Lichenostomus frenatus</i>	Bridled Honeyeater	In rainforest plant, Mt Spec, Qld	34
<i>Lichenostomus chrysops</i>	Yellow-faced Honeyeater		34
<i>Lichenostomus vireescens</i>	Singing Honeyeater	Nine records in NSW, NT, SA and WA in a range of host species (NRS records 608/55, 608/138, 608/157, 608/197, 608/213, 608/220, 608/222, 608/235, 608/245);	34, 45, 48
<i>Lichenostomus versicolor</i>	Varied Honeyeater		34
<i>Lichenostomus fasciogularis</i>	Mangrove Honeyeater		34
<i>Lichenostomus unicolor</i>	White-gaped Honeyeater		34
<i>Lichenostomus flavus</i>	Yellow Honeyeater		34
<i>Lichenostomus cratitius</i>	Purple-gaped Honeyeater	Dead mistletoe in <i>Ac. aneura</i> , Flinders Ranges, SA	34
<i>Lichenostomus keartlandi</i>	Grey-headed Honeyeater	In <i>Bauhinia</i> spp., Cloncurry, Qld (NRS record 621/12)	34, 48
<i>Lichenostomus ornatus</i>	Yellow-plumed Honeyeater	Dawson River, central Qld. (McGilp)	34, 43
<i>Lichenostomus plumulus</i>	Grey-fronted Honeyeater	Dead mistletoe in <i>Acacia</i> spp. at Argyle Diamond Mine, Kimberley Region, WA (FO'C)	15, 24, 34
<i>Lichenostomus fuscus</i>	Fuscous Honeyeater	<i>Am. miquelii</i> in <i>E. albens</i> in Capertee Valley, NSW (NRS record 613/65)	34, 48
<i>Lichenostomus flavescens</i>	Yellow-tinted Honeyeater		34
<i>Lichenostomus penicillatus</i>	White-plumed Honeyeater	Near Irwin River, WA (Serventy); <i>Loranthus</i> spp. at Penrith Public School, NSW (Hindwood)	26, 34, 65
<i>Melithreptus gularis</i>	Black-chinned Honeyeater	<i>Am. miquelii</i> on Gwydir River, Torryburn, NSW	14
<i>Melithreptus albogularis</i>	White-throated Honeyeater	In <i>Melaleuca</i> spp.	34
<i>Melithreptus lunatus</i>	White-naped Honeyeater	In <i>E. fasciculosa</i> at Sandy Creek Conservation Park, SA (Rix); in <i>E. viminalis</i> , Mt Crawford State Park, SA (NRS record 578/168); dying mistletoe in 'Stringybark', Swan Vale, NSW (NRS record 578/163); in <i>Eucalyptus</i> spp. (JY)	34, 48, 60
<i>Lichmera indistincta</i>	Brown Honeyeater		24, 34
<i>Grantiella picta</i>	Painted Honeyeater	Mostly <i>Am. pendula</i> in <i>Eucalyptus</i> spp.	3, 14, 24, 34
<i>Phylidonyris novaehollandiae</i>	New Holland Honeyeater		10
<i>Phylidonyris albifrons</i>	White-fronted Honeyeater	In <i>Ac. aneura</i>	24, 34
<i>Conopophila rufogularis</i>	Rufous-throated Honeyeater	In <i>Melaleuca</i> spp.	34
<i>Conopophila whitei</i>	Grey Honeyeater	In <i>Ac. aneura</i>	34
<i>Acanthorhynchus tenuirostris</i>	Eastern Spinebill		6, 24, 34
<i>Acanthorhynchus superciliosus</i>	Western Spinebill	In <i>Casuarina</i> spp. in Kings Park, WA (NRS record 592/2)	48
<i>Certhionyx pectoralis</i>	Banded Honeyeater		34
<i>Certhionyx niger</i>	Black Honeyeater	Mostly in dead trees	34
<i>Certhionyx variegatus</i>	Pied Honeyeater		24, 34
<i>Myzomela obscura</i>	Dusky Honeyeater		34
<i>Myzomela erythrocephala</i>	Red-headed Honeyeater	<i>Am. mackayensis</i> in <i>Rhizophora stylosa</i> , Darwin, NT (RN)	24, 34, 58
<i>Myzomela sanguinolenta</i>	Scarlet Honeyeater		34
<b>Petroicidae</b>			
<i>Microeca leucophaea</i>	Jacky Winter	Dead mistletoe in <i>E. tereticornis</i> , Mt Fox, Ingham, Qld	34
<i>Microeca flavigaster</i>	Lemon-bellied Flycatcher	In <i>Avicennia marina</i>	34
<i>Petroica multicolor</i>	Scarlet Robin		34, 63
<i>Petroica goodenovii</i>	Red-capped Robin		34
<i>Petroica phoenicea</i>	Flame Robin		34
<i>Petroica rosea</i>	Rose Robin	In rainforest plant	34

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Table 1. (continued)

Family and species	Common name	Notes	Citation <sup>A</sup>
<i>Melanodryas cucullata</i>	Hooded Robin	Canberra, ACT (NRS 385/128); in <i>E. blakelyii</i> , Mudgee, NSW (NRS record 385/25)	34, 48
<i>Tregellasia capito</i>	Pale-yellow Robin	In rainforest plant	34
<i>Tregellasia leucops</i>	White-faced Robin	In <i>Acacia</i> spp.	34
<i>Eopsaltria australis</i>	Eastern Yellow Robin		34, 63
<i>Eopsaltria pulverulenta</i>	Mangrove Robin	In <i>Lumnitzera</i> spp.	34
<i>Poecilodryas superciliosa</i>	White-browed Robin		34
Pomatostomidae			
<i>Pomatostomus temporalis</i>	Grey-crowned Babbler		34
<i>Pomatostomus superciliosus</i>	White-browed Babbler	<i>Am. miquelii</i> in SA (DH), near Holbrook, NSW (SJC)	12, 13, 23, 34, 64
<i>Pomatostomus halli</i>	Hall's Babbler		34
<i>Pomatostomus ruficeps</i>	Chestnut-crowned Babbler	<i>Am. miquelii</i> in SA (DH)	12, 34
Cinlosomatidae			
<i>Psophodes olivaceus</i>	Eastern Whipbird		34
<i>Psophodes cristatus</i>	Chirruping Wedgebill	In <i>Acacia</i> spp. (MacDonald)	3, 19, 34, 40
<i>Psophodes occidentalis</i>	Chiming Wedgebill	In <i>Acacia</i> spp. in WA (Robinson)	3, 19, 34, 40, 61
Pachycephalidae			
<i>Oreoica gutturalis</i>	Crested Bellbird	In <i>Ac. papyrocarpa</i> Naretha and Rawlina, WA; SA (NRS record 419/81, 80, 78); <i>Am. quandang</i> in <i>Ac. papyrocarpa</i> Uno Station, Gawler Ranges, SA (PL)	34, 48, 52
<i>Pachycephala olivacea</i>	Olive Whistler	In rainforest plant	34
<i>Pachycephala rufogularis</i>	Red-lored Whistler	<i>Am. pendula</i> in <i>Eucalyptus</i> spp.	23, 34
<i>Pachycephala inornata</i>	Gilbert's Whistler	In 'Sugarwood' near Vokes Hill, SA (Ford, p. 33); mistletoe in <i>Ac. colletoides</i> north-western Vic. (RC)	16, 54
<i>Pachycephala pectoralis</i>	Golden Whistler		34
<i>Pachycephala simplex</i>	Grey Whistler		34
<i>Pachycephala rufiventris</i>	Rufous Whistler	In <i>E. fasciculosa</i> at Sandy Creek Conservation Park, SA (Rix); Eastwood State Forest, NSW (Bridges)	4, 20, 34, 40, 60, 63
<i>Pachycephala lanioides</i>	White-breasted Whistler	In <i>Avicennia marina</i>	34
<i>Colluricincla megarhyncha</i>	Little Shrike-thrush		34
<i>Colluricincla boweri</i>	Bower's Shrike-thrush	In rainforest plant	34
<i>Colluricincla harmonica</i>	Grey Shrike-thrush	In <i>E. mannifera</i> (DC)	9, 23, 34
Dicuridae			
<i>Myiagra alecto</i>	Shining Flycatcher	In <i>Melaleuca</i> spp.	34
<i>Myiagra inquieta</i>	Restless Flycatcher	In <i>Eucalyptus</i> spp.	34
<i>Grallina cyanoleuca</i>	Magpie-lark	<i>Am. miquelli</i> in <i>E. albens</i> at Capertee Valley, NSW (RT)	34, 59
<i>Rhipidura rufifrons</i>	Rufous Fantail		34
<i>Rhipidura fuliginosa</i>	Grey Fantail		34
<i>Rhipidura phasiana</i>	Mangrove Grey Fantail	In <i>Avicennia marina</i>	34
<i>Rhipidura rufiventris</i>	Northern Fantail		34
<i>Rhipidura leucophrys</i>	Willie Wagtail	<i>Am. pendula</i> in <i>Eucalyptus</i> blakleyi at Bathurst, NSW (DMW)	13, 34, 63, 69
Campephagidae			
<i>Coracina papuensis</i>	White-bellied Cuckoo-shrike		34
<i>Coracina tenuirostris</i>	Cicadabird		34
<i>Lalage sueurii</i>	White-winged Triller	In <i>E. fasciculosa</i> at Sandy Creek Conservation Park, SA (Rix); <i>Am. miquelii</i> in <i>E. fasciculosa</i> at Mt Lofty, SA (MW)	3, 34, 39, 60
<i>Lalage leucomela</i>	Varied Triller	In <i>Acacia</i> spp.	34
Oriolidae			
<i>Oriolus sagittatus</i>	Olive-backed Oriole	Churchill National Park, Vic. (TB).	25, 34, 66
<i>Sphecothebes viridis</i>	Figbird	<i>Am. mackayensis</i> in <i>Rhizophora stylosa</i> , Darwin, NT (RN)	25, 34, 58
Artamidae			
<i>Artamus leucorhynchus</i>	White-breasted Woodswallow		25, 34
<i>Artamus personatus</i>	Masked Woodswallow		20, 25, 34
<i>Artamus superciliosus</i>	White-browed Woodswallow		11, 20, 34

Continued next page

Table 1. (continued)

Family and species	Common name	Notes	Citation <sup>A</sup>
<i>Artamus cinereus</i>	Black-faced Woodswallow	Murchison, WA (TS)	20, 25, 34, 67
<i>Artamus cyanopterus</i>	Dusky Woodswallow		34, 63
<i>Artamus minor</i>	Little Woodswallow		34
<i>Cracticus quoyi</i>	Black Butcherbird		34
<i>Cracticus torquatus</i>	Grey Butcherbird		6, 25, 34, 45
<i>Cracticus mentalis</i>	Black-backed Butcherbird	<i>Am. pendula</i> in <i>E. tetradonta</i>	34
<i>Cracticus nigrogularis</i>	Pied Butcherbird	<i>Amyema</i> spp. in <i>E. tetradonta</i> , Darwin, NT (RN); <i>Amyema</i> spp. in <i>E. miniata</i> in Litchfield National Park, NT (MW)	39, 34, 58
<i>Gymnorhina tibicen</i>	Australian Magpie	Victoria (KD).	25, 27, 34, 35, 69
<i>Strepera graculina</i>	Pied Currawong	Mt Airly in Capertee Valley, NSW (VP)	25, 34, 63, 68
<i>Strepera versicolor</i>	Grey Currawong	In <i>E. melliodora</i> 18 m tall, at Rockley Mt, NSW (SC)	62, 69
Paradisaeidae			
<i>Ptiloris paradiseus</i>	Paradise Riflebird	In rainforest plant	25, 34
<i>Ptiloris victoriae</i>	Victoria's Riflebird	In rainforest plant	34
<i>Ptiloris magnificus</i>	Magnificent Riflebird	In rainforest plant	34
Corvidae			
<i>Corvus coronoides</i>	Australian Raven	Dead mistletoe in <i>E. oreades</i> , NSW; in <i>Acacia</i> spp. SA; in <i>E. viminalis</i> , NSW (NRS records 930/54, 930/70, 930/363)	34, 48, 63
<i>Corvus tasmanicus</i>	Forest Raven		34, 63
<i>Corvus mellori</i>	Little Raven	In <i>E. fasciculosa</i> , SA; in <i>E. leucoxyton</i> , Vic. (NRS records 954/19, 954/76).	34, 48
<i>Corvus bennetti</i>	Little Crow	In dying <i>Flindersia maculosa</i> , NSW (NRS record 691/419)	34, 48
<i>Corvus orru</i>	Torresian Crow		34, 63
Corcoracidae			
<i>Struthidea cinerea</i>	Apostlebird	In <i>Ac. pendula</i> , NSW (NRS record 675/31)	34, 48
Ptilonorhynchidae			
<i>Ailuroedus melanotis</i>	Spotted Catbird		34
<i>Ailuroedus crassirostris</i>	Green Catbird		34
<i>Scenopoeetes dentirostris</i>	Tooth-billed Bowerbird		34
<i>Sericulus chrysocephalus</i>	Regent Bowerbird		34
<i>Ptilonorhynchus violaceus</i>	Satin Bowerbird	In <i>E. maculata</i> , NSW; in <i>E. haemastoma</i> , NSW (NRS records 679/30, 679/57, 679/86)	3, 5, 19, 33, 34, 40, 44, 48,
<i>Chlamydera maculata</i>	Spotted Bowerbird	<i>Am. lucasii</i> in <i>Flindersia maculosa</i> , NSW; <i>Ac. cambagei</i> , Qld (NRS records 680/1, 680/2, 680/4)	34, 44, 48
<i>Chlamydera guttata</i>	Western Bowerbird		34, 44
<i>Chlamydera nuchalis</i>	Great Bowerbird		34, 44
<i>Chlamydera cerviniventris</i>	Fawn-breasted Bowerbird	At Lockhart River, Cape York Peninsula, Qld (KU)	20, 34, 36
Passeridae			
<i>Passer domesticus</i>	House Sparrow	At Cairns Airport, Qld (KU)	25, 34, 36
<i>Taeniopygia guttata</i>	Zebra Finch	In <i>E. fasciculosa</i> at Sandy Creek Conservation Park, SA (Rix); in Riverina region of NSW (DB); the most common species nesting in mistletoes in the Pilbara, Tanami, Little and Great Sandy Deserts and southern Kimberley, WA (TS)	8, 34, 60, 67
<i>Taeniopygia bichenovii</i>	Double-barred Finch	<i>Am. thalassia</i> in <i>Avicennia marina</i> , Darwin, NT (RN); East Kimberley, WA (TS)	34, 58, 67
<i>Poephila acuticauda</i>	Long-tailed Finch	East Kimberley (TS)	30, 34, 67
<i>Poephila cincta</i>	Black-throated Finch		25, 34
<i>Poephila personata</i>	Masked Finch	East Kimberley (TS)	67
<i>Neochmia phaeton</i>	Crimson Finch		25, 34
<i>Neochmia ruficauda</i>	Star Finch		34
<i>Neochmia temporalis</i>	Red-browed Finch	<i>Amyema</i> spp., near Atherton, Qld (PD); <i>Am. miquelii</i> in <i>Ac. melanoxylon</i> , beside Yarra River, Heidelberg, Vic. (RL, SJNC)	20, 34, 51, 57, 64

Continued next page

Table 1. (continued)

Family and species	Common name	Notes	Citation <sup>A</sup>
<i>Stagonopleura guttata</i>	Diamond Firetail	Sandy Creek Conservation Park, SA (Rix); 11 of the 89 (12%) records in the NRS state that the Firetail nest was built in mistletoe; in pine trees at the Woodsreef Bird Route out of Barraba, NSW (RK)	3, 7, 25, 30, 34, 37, 45, 48, 49, 56, 59, 60, 63
<i>Stagonopleura bella</i>	Beautiful Firetail		34
<i>Stagonopleura oculata</i>	Red-eared Firetail		30
<i>Emblema picta</i>	Painted Finch	On ground in spinifex	34
<i>Erythrura trichroa</i>	Blue-faced Parrot-Finch	In rainforest plant	34
Fringillidae			
<i>Carduelis carduelis</i>	European Goldfinch		34
Dicaeidae			
<i>Dicaeum hirundinaceum</i>	Mistletoebird	In mistletoe clump, NSW (NRS record 564/59)	48
Pycnonotidae			
<i>Pycnonotus jocosus</i>	Red-whiskered Bulbul		34
Zosteropidae			
<i>Zosterops lutea</i>	Yellow White-eye	<i>Am. mackayensis</i> in <i>Rhizophora stylosa</i> , Darwin, NT (RN)	34, 58
<i>Zosterops lateralis</i>	Silvereye	Dead mistletoe, SA; in <i>E. fasciculosa</i> , SA; in <i>Santalum acuminatum</i> , SA (NRS records 574/76, 91, 109, 184, 189, 299)	34, 48
Muscicapidae			
<i>Zoothera lunulata</i>	Bassian Thrush	In rainforest plant	34
<i>Zoothera heinei</i>	Russet-tailed Thrush		34
<i>Turdus merula</i>	Common Blackbird		34

<sup>A</sup>List of sources; where only a name given it is a personal communication. (1) Aumann (1989); (2) Beruldsen (1980); (3) Beruldsen (2004); (4) Bridges (1994); (5) Campbell (1974a); (6) Campbell (1974b); (7) Cooney (2004); (8) D. Bourne; (9) D. Cook; (10) D. C. Paton; (11) D. Geering; (12) D. Holly; (13) D. M. Watson; (14) D. Oliver; (15) F. O'Conner; (16) Ford (1971); (17) Ford (1998); (18) Ford (1999); (19) Frith (1977); (20) G. Beruldsen; (21) Geering and French (1998); (22) Higgins and Davies (1996); (23) Higgins and Peter (2002); (24) Higgins *et al.* (2001); (25) Higgins *et al.* (2006); (26) Hindwood (1950); (27) H. Recher; (28) Hollands (1984); (29) Hyem (1936); (30) Immelmann (1965); (31) Ipsen (1940); (32) J. Harris; (33) J. Nicholls; (34) J. Young; (35) K. Durrant; (36) K. Uhlenhut; (37) Lord (1956); (38) M. Marone; (39) M. Ward; (40) MacDonald (1973); (41) Marchant and Higgins (1990); (42) Marchant and Higgins (1993); (43) McGilp (1945); (44) North (1901); (45) North (1906); (46) North (1912); (47) North (1913); (48) NRS; (49) O'Gorman (1981); (50) Oliver *et al.* (1998); (51) P. Downey; (52) P. Langdon; (53) R. Hill; (54) R. Clarke; (55) R. Farnes; (56) R. Kemp; (57) R. H. Loyn; (58) R. Noske; (59) R. Turner; (60) Rix (1976); (61) Robinson (1939); (62) S. Cox; (63) S. J. S. Debus; (64) S. J. N. Cooney; (65) Serventy (1929); (66) T. Bawden; (67) T. Start; (68) V. Powys; (69) Watson (2002); (70) D. Watson and M. Herring, unpublished data; (71) White (1921); (72) Whitmore (1984), (73) G. Maurer.

Cuculidae have been observed parasitising nests built in mistletoes. However, the selection of the nest substrate in all except one of these species is not attributable to that species (as they do not build the nest) and therefore will not be considered further.

### How significant is mistletoe to Australia's arboreal nesters?

More than half of Australia's arboreal nesting birds use mistletoes as a nest-site at least occasionally and, in each case where the extent of mistletoe use has been investigated, the study species has been shown to use it more frequently than would be expected from the abundance of mistletoes in its habitat. This raises some questions about the use of mistletoes as a nest-site:

- Do some species preferentially nest in mistletoes?
- What are the characteristics of, and relationships between, these species?
- Why might such a preference exist?

### Evaluating preference for mistletoe nesting

Determining that a particular species has a preference for the use of mistletoe as a nest-site should be a priority for future researchers wishing to understand this behaviour. This can be achieved by comparing the number of nests placed in mistletoes with the abundance of mistletoe in an area, as a proportion of the total number of potential nest-sites. Here we suggest a simple template for determining nest-site preference for a range of species whose nests can be identified.

To evaluate preference in Diamond Firetails we conducted a comprehensive search for Firetail nests in a defined study area (see Cooney and Watson 2005). When a nest was located we recorded the type of plant in which the nest was situated. To measure nest-site availability we assessed the relative amounts of each potential nesting substrate at randomly selected points within the study area. At each of these points the arboreal vegetation was recorded as mistletoe, *Eucalyptus* or other. We used a one-tailed Fisher's exact test



to compare the frequency of nests placed in mistletoe with the frequency of random points that coincided with mistletoe in the canopy.

While mistletoes conservatively accounted for ~2.3% of the canopy at our study site, 30% of the Firetail nests ( $n = 43$ ) were located in mistletoes – a highly significant result, consistent with a preference for nesting in mistletoe (Cooney and Watson 2005).

To understand the consequences of nesting in mistletoe, knowing which species do not exhibit this behaviour (or do so only occasionally) is also important. Are some nest-types more likely to be situated in mistletoe clumps – hanging cup nests typical of medium-size honeyeaters might be especially secure in mistletoe clumps, as opposed to shallow saucer nests or deep stick nests? In order to make these evaluations and draw inferences about preference or avoidance,

**Table 2. Other Australian bird species recorded nesting in mistletoe**

Birds recorded nesting in mistletoe that are not usually found nesting in the foliage of plants, that do not nest arboreally, or that do not build their own nests (falcons and cuckoos). Where no species of mistletoe is listed in the notes, the nest was located in an unknown mistletoe within the stated host-plant, and where no notes occur only the occurrence of nesting in a mistletoe was recorded; letters in parentheses attribute a record to an individual observer where more than one source is cited. Abbreviations used in notes: *E.* denotes *Eucalyptus* species; *Am.* denotes *Amyema* species; *Ac.* denotes *Acacia* species

Family and species	Common name	Notes	Citation <sup>A</sup>
<b>Anatidae</b>			
<i>Oxyura australis</i>	Blue-billed Duck	In an unknown plant growing in water	5
<i>Stictonetta naevosa</i>	Freckled Duck	In water on <i>Eucalyptus</i> sp.	5
<i>Anas rhynchotis</i>	Australasian Shoveler	In an unknown plant growing in water	5
<i>Anas gracilis</i>	Grey Teal	In an unknown plant growing in water	5
<i>Malacorhynchus membranaceus</i>	Pink-eared Duck	In an unknown plant growing in water	5
<i>Aythya australis</i>	Hardhead	In an unknown plant growing in water	5
<b>Falconidae</b>			
<i>Falco berigora</i>	Brown Falcon	16 m above ground in a <i>E. tricarpa</i> , Nagambie, Vic. (MR); on Australian Magpie's nest (JY)	5, 4, 3
<i>Falco longipennis</i>	Australian Hobby	On Collared Sparrowhawk nest	5
<i>Falco hypoleucos</i>	Grey Falcon	In <i>Acacia</i> spp.	5
<i>Falco peregrinus</i>	Peregrine Falcon	In raven's <i>Corvus</i> nest built in mistletoe, near Eildon, Vic.	2
<i>Falco cenchroides</i>	Nankeen Kestrel	In babbler's <i>Pomatostomus</i> nest	5
<b>Rallidae</b>			
<i>Gallinula tenebrosa</i>	Dusky Moorhen	In an unknown plant growing in water	5
<b>Cuculidae</b>			
<i>Cuculus pallidus</i>	Pallid Cuckoo	In nests of friarbirds <i>Philemon</i> and other honeyeaters, and orioles <i>Oriolus</i>	5
<i>Cacomantis variolosus</i>	Brush Cuckoo		5
<i>Cacomantis castaneiventris</i>	Chestnut-breasted Cuckoo	On ground	5
<i>Cacomantis flabelliformis</i>	Fan-tailed Cuckoo		5
<i>Chrysococcyx osculans</i>	Black-eared Cuckoo	In Yellow-rumped Thornbill nest in <i>Ac. aneura</i>	5
<i>Chrysococcyx basalus</i>	Horsfield's Bronze-Cuckoo		5
<i>Chrysococcyx lucidus</i>	Shining Bronze-Cuckoo		5
<i>Chrysococcyx minutillus</i>	Little Bronze-Cuckoo		5
<i>Chrysococcyx russatus</i>	Gould's Bronze-Cuckoo		5
<i>Eudynamys scolopacea</i>	Common Koel		5
<i>Scythrops novaehollandiae</i>	Channel-billed Cuckoo		5
<b>Halcyonidae</b>			
<i>Dacelo novaeguineae</i>	Laughing Kookaburra	In <i>E. leucoxydon</i> , Tarnagulla, Vic.	1
<b>Pittidae</b>			
<i>Pitta erythrogaster</i>	Red-bellied Pitta		5
<i>Pitta versicolor</i>	Noisy Pitta	In dead mistletoe lying on a dead stump	5
<b>Atrichornithidae</b>			
<i>Atrichornis rufescens</i>	Rufous Scrub-bird	In dead mistletoe on ground with <i>Lomandra</i> sp. growing through it	5
<b>Maluridae</b>			
<i>Amytornis barbatus</i>	Grey Grasswren	In dead mistletoe on ground with <i>Muehlenbeckia cunninghamii</i> growing through it	5

<sup>A</sup>List of sources; where only a name given it is a personal communication. (1) Smith (1992); (2) V. Hurley; (3) T. Hyde; (4) M. Ruff; (5) J. Young.

systematically collected data are required about the nidification of populations and species – data which currently are not available for most species. Even for those species that have been well studied, it is unclear how their findings should be interpreted. Before Watson (2001), the value of mistletoe as a nesting substrate had not been formally acknowledged, and thus mistletoe nesting may have been overlooked and mistletoe nests classified only as another foliage nest.

#### *What are the characteristics of mistletoe-nesting birds?*

The artamids, birds of paradise, corvids and bowerbirds all exhibit a high degree of mistletoe nesting at a familial level, with >90% of Australian species in each family having been recorded nesting in mistletoes. Of these families, three are considered sister taxa, whereas the fourth is closely allied (Christidis and Boles 1994).

At a specific level, the five malurid fairy-wrens that have been reported nesting in mistletoe form two closely related clades (Christidis and Schodde 1997). The blue *cyaneus* group (consisting of *Malurus cyaneus*, *M. splendens* and *M. coronatus*), as well as two of the four members of the chestnut-shouldered *lamberti* group (*M. lamberti* and *M. amabilis*), have been reported to nest in mistletoes.

This concentrated incidence of mistletoe nesting in some taxonomic groups suggests that there might be monophyletic groups of Australian birds that commonly nest in mistletoes. Perhaps this is an artefact of the type of nest built, rather than a phylogenetic trait. For example, nest architecture has previously been used to reconstruct avian relationships and to provide a test for the monophyly of taxa (Zyskowski and Prum 1999; Sheldon and Winkler 1999). Such an approach is a potentially rewarding new field of enquiry. However, we currently lack sufficient frequency data at the species level to support the investigation of phylogenetic relationships of mistletoe use, and therefore the significance of these apparent patterns remain to be tested.

#### *Why do birds nest in mistletoe?*

There are a number of possible benefits that may derive from nesting in mistletoes. The reasons for nesting in mistletoe may vary according to the different needs of the species exhibiting this behaviour. Nevertheless, at least three likely explanations warrant investigation:

- (1) the structural attributes of mistletoe;
- (2) different levels of predation between mistletoes and other arboreal nest-sites; and
- (3) differences between the microclimate of mistletoe nest-sites and other arboreal nest-sites.

##### *(1) Structural attributes of mistletoe*

It may be that the birds that nest in mistletoe are attracted only by the structure provided by mistletoes. In many woodland habitats, mistletoe plants are far denser than their eucalypt hosts, and potentially provide a superior nest-site than a

sparsely foliated eucalypt. In these incidences it is not the mistletoe itself that is attractive to the nesting bird, rather the habit of the plant possesses features that correspond to the type of nest-site attributes favoured by these birds.

Nest building is time-consuming and energetically expensive (Collias and Collias 1984; Mountjoy and Robertson 1988). By providing a dense clump of vegetation as a base for building, nests in mistletoes may require less time, effort and expertise to build a nest to completion. Furthermore, the rigid structural framework provided by a mistletoe clump and the secure nest-attachment provided by the haustorium can be a particularly strong and stable scaffold on which to build a stick nest (O’Gorman 1981; Oliver *et al.* 1998), reducing the risk of the nest collapsing or being blown from the tree in high winds. Many of the families that regularly nest in mistletoes employ a ‘fetch and drop’ method of construction, in which little attempt is made by the bird to interlock the nesting material, hence these nests require a stable base (e.g. Corvidae, Columbidae; Hansell 2000).

It is also noteworthy that the 32 Australian species that have been found nesting only in dead mistletoes are not deriving any concealment or chemical benefit from the foliage of the plant and are only exploiting the structural attributes of mistletoes. This supports the premise that the rigid branches of the mistletoe provide them with a suitable scaffold on which to build their nests.

##### *(2) Reducing the risk of predation*

Dense vegetation can impede the movement of mammalian predators through the canopy (Larivière and Messier 1998) and reduce the foraging efficiency of avian predators (Sugden and Beyersbergen 1986). Oliver *et al.* (1998) postulated that the dense habit of mistletoe nest-sites may afford greater protection from predation for Regent Honeyeaters than non-mistletoe sites. However, the dense foliage associated with mistletoe clumps also provides cover for ambush predators (Rose 1962; P. Vaughan, personal communication), potentially leading to elevated rates of predation in and around mistletoe clumps.

Despite this potential to reduce predation, all of the parasitic cuckoos (Cuculidae) in Australia have been recorded in nests placed in mistletoe, which suggests that against these species, concealment in mistletoes may not be an effective means of defence. Further, Ford (1999) found that nests of large honeyeaters in mistletoes were not subject to a reduced predation risk. However, the two species in Ford’s (1999) study actively defend nests (Higgins *et al.* 2001), a strategy that reduces the effectiveness of concealment as a predator deterrent (Weidinger 2002).

##### *(3) Nest microclimate*

Many bird species actively select nest-sites and engage in nesting behaviour that optimises the temperature and humidity within the nest (Calder 1973; Martin and Roper 1988;

Rahn and Paganelli 1990; With and Webb 1993; Hilton *et al.* 2004; but see Walsberg 1983). Mistletoes have the potential to ameliorate climatic extremes owing to their dense, evergreen habit and sturdy structure (Calder 1983). The semi-succulent nature of mistletoe leaves and their high water content relative to host leaves (Ehleringer and Marshall 1995) may have a profound effect on microclimate by moderating diel fluctuations in ambient temperature and relative humidity. This amelioration may be especially important for birds that nest in hot, arid regions (under which conditions nest-site selection becomes increasingly important; Ricklefs and Hainsworth 1969). Anecdotal evidence supports this argument. On a hot summer's day in a woodland in Canberra, Australia, the only place that birds could be found was in denser clumps of mistletoe, presumably because it had a cooler microclimate than the surrounding vegetation (A. Cockburn, personal communication). Furthermore, both Barking Owls (*Ninox connivens*; N. Schedvin, personal communication) and Koalas (*Phascolarctos cinereus*; S. Cox, personal communication) are known to shelter in mistletoe clumps on hot days.

### Future research

This review has shown that a large number of Australian bird species nest in mistletoes. Although this is not necessarily significant in itself, there is emerging evidence to suggest that mistletoes are used preferentially by at least some, and probably many, species (Cooney and Watson 2005; Ford 1999). This preference and the several possible reasons why mistletoe might be sought as a nest-site are potentially fertile areas for future research.

To guide further work and facilitate future investigations of this pattern, a series of explicit predictions can be formulated to understand the value of mistletoes as a nest-site. Relative to other arboreal nests, nests in mistletoes might be expected to:

- (1) require less time and effort to build;
- (2) provide a more stable structure and be less likely to be affected by windthrow;
- (3) experience reduced rates of predation; and
- (4) have a more moderate microclimate in terms of both relative humidity and temperature.

To test these hypotheses, more exploratory research is needed, both for individual bird species (especially those known to nest in mistletoes frequently) and for entire avian assemblages. Examining the distributions of mistletoe nesters in relation to mistletoe occurrence is also required to elucidate the relative importance of mistletoe for different species in different habitats and geographical regions. Furthermore, identifying how widespread this pattern is, why some groups (e.g. accipitrine hawks, bowerbirds, turacos, mousebirds) seem more disposed to this behaviour, and why some groups (bulbuls, sunbirds, tyrant-flycatchers, antbirds) rarely exhibit this behaviour are all open questions that must await further work.

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