

BREEDING BIOLOGY AND BEHAVIOUR OF THE SCARLET ROBIN *Petroica multicolor* AND EASTERN YELLOW ROBIN *Eopsaltria australis* IN REMNANT WOODLAND NEAR ARMIDALE, NEW SOUTH WALES

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Received: 13 January 2006

The breeding biology and behaviour of the Scarlet Robin *Petroica multicolor* and Eastern Yellow Robin *Eopsaltria australis* were studied at Imbota Nature Reserve, on the New England Tableland of New South Wales, in 2000–2002 by colour-banding and nest-monitoring. Yellow Robins nested low in sheltered positions, in plants with small stem diameters (mostly saplings, live trees and shrubs), whereas Scarlet Robins nested high in exposed positions, in plants with large stem diameters (mostly live trees, dead branches or dead trees). Yellow Robin clutch size was two or three eggs (mean 2.2; $n = 19$). Incubation and nestling periods were 15–17 days and 11–12 days respectively ($n = 6$) for the Yellow Robin, and 16–18 days ($n = 3$) and 16 days ($n = 1$) respectively for the Scarlet Robin. Both species were multi-brooded, although only Yellow Robins successfully raised a second brood. The post-fledging dependence period lasted eight weeks for Yellow Robins, and six weeks for Scarlet Robins. The two robins appear to differ in their susceptibility to nest predation, with corresponding differences in anti-predator strategies.

INTRODUCTION

The Scarlet Robin *Petroica multicolor* and Eastern Yellow Robin *Eopsaltria australis* (hereafter Yellow Robin) are small, socially monogamous passerines. The pair-breeding Scarlet Robin (approximately 13 g) inhabits open forest and woodland of eastern and south-western Australia, and the facultatively co-operatively breeding Yellow Robin (approximately 20 g) inhabits wet forest to semi-arid scrub in eastern Australia, with an equivalent allospecies (the Western Yellow Robin *E. griseogularis*) in south-western Australia. Only females build the nest, incubate and brood; both sexes feed nestlings and fledglings; and some Yellow Robin pairs have one or two auxiliaries (typically yearling sons) that help to feed the nesting female and young (Marchant 1985, 1987; Robinson 1990a; Higgins and Peter 2003).

Most aspects of the biology of these two robin species are well known (summarized by Higgins and Peter 2003). However, knowledge is deficient on the post-fledging period and transition to independence for these and most other Australian passerines (Russell 2000). Nestling growth-related morphology, fledgling growth and post-juvenile moult are little known for the robins considered here (Higgins and Peter 2003).

This paper describes the social organization, aspects of breeding, and juvenile morphology and maturation of the two robin species, as part of a study of their breeding and population parameters in the New England region of New South Wales (Debus 2006a). I studied the comparative ecology of the two robins in a woodland patch, while investigating possible causes of their decline in fragmented landscapes (Debus 2006b,c). Although some of this information on breeding biology and behaviour is not new, it supplements or confirms previous information, or

provides empirical data on aspects that may vary geographically with seasonal conditions, or with habitat or landscape context.

STUDY AREA AND METHODS

The study was conducted across three breeding seasons (egg-laying in August to January inclusive) from July 2000 to February 2003, a drought period (see Debus 2006a). The site was Imbota Nature Reserve (formerly Eastwood State Forest, approximately 270 ha), ten kilometres south-east of Armidale (30°30' S, 151°40' E) on the Northern Tablelands of New South Wales (1 000 m above sea level). The study area and methods are described elsewhere (Debus 2006a); Imbota NR consists of eucalypt grassy woodland with a patchy midstorey of shrubs and eucalypt saplings (for dominant trees and shrubs see Table 1).

Free-flying robins were captured by placing mist-nets in observed foraging areas, and around fledglings or nests with chicks (but not nests with eggs, to avoid desertion); call-playback with a mounted specimen was also used as a net lure (successfully for Scarlet Robins). New fledglings were caught by hand.

Robins of all ages, from nestlings to adults, were banded and individually colour-banded from July 2000 onwards (bands supplied by the Australian Bird and Bat Banding Scheme). Almost all the Yellow Robins in Imbota NR were banded; within each year, most of the adult male and about half the female Scarlet Robins were banded. Robin nests were monitored daily or almost so, and found mostly at the building stage by following nest-building females. For nests checked at intervals of greater than one day, the date of laying, hatching, fledging or failure was taken as the mid-point between penultimate and final checks. Fledgling Yellow Robins and Scarlet Robins, colour-banded as nestlings or new fledglings, were observed approximately weekly until independence (Yellow Robin: 18 broods; Scarlet Robin: four broods), to give a composite picture of growth, moult and maturation. Juveniles of each species (four Yellow, four Scarlet) were also retrapped in their natal territory one or more times between fledging and independence. For results on behaviour and vocalizations, terminology and interspecific comparisons follow data in Higgins and Peter (2003).

Nests heights were measured directly with a 2.4 metre pole graduated in centimetres or, for higher nests, estimated from a

TABLE 1

Nesting substrate types (*n*, %), nest height (m), and diameter at breast height (cm) of stem of nest plant (range, mean \pm SD) for Eastern Yellow Robins and Scarlet Robins at Imbota Nature Reserve, New South Wales.

Nest site	Yellow Robin	Scarlet Robin
<i>Eucalyptus caliginosa</i> :		
live tree	12 (21)	28 (52)
dead branch	1 (2)	7 (13)
dead tree	0	3 (6)
live sapling	24 (41)	5 (9)
dead sapling	0	1 (2)
<i>E. melliodora</i> :		
live sapling	4 (7)	0
<i>E. blakelyi</i> :		
dead branch	0	5 (9)
live mistletoe	0	1 (2)
live sapling	2 (3)	0
dead sapling	1 (2)	0
<i>E. viminalis</i> :		
live sapling	1 (2)	0
<i>E. bridgesiana</i> :		
live tree*	1 (2)	0
<i>Angophora floribunda</i> :		
live tree	1 (2)	0
Dead <i>Acacia</i> :		
<i>A. filicifolia</i>	1 (2)	1 (2)
<i>A. implexa</i>	1 (2)	3 (6)
Live <i>Cassinia</i> shrub:		
<i>C. quinquefaria</i>	7 (12)	0
<i>C. leptocephala</i>	1 (2)	0
Live <i>Olearia elliptica</i> shrub	1 (2)	0
Nest height (m)	0.6–11.0 (2.7 \pm 2.5)	1.8–14.0 (7.2 \pm 3.4)
Tree/shrub stem dbh (cm)	1.0–59.0 (9.9 \pm 11.9)	6.0–68.0 (28.5 \pm 16.8)
Total nests	58	54

*Dead-topped tree, nest in epicormic shoots on trunk.

two-metre person holding the base of the pole upright at arm's length below the nest. The circumference of nest-plant main stem or trunk was determined with a tape-measure and converted to diameter; for nests below breast height (e.g. in shrubs or saplings), the stem was measured just below the base of the nest. Two-sample *t*-tests were used to compare Yellow Robin and Scarlet Robin nest heights and nest-plant diameter at breast height (dbh).

RESULTS

Social organization

Over three years, a mean of 28 per cent of Yellow Robin pairs at Imbota NR had a helper or two at the nest (see Debus 2006a for further details). Six of 11 Yellow Robin helpers were known (from their later status as breeding birds), and the remainder were suspected from their behaviour (e.g. feeding the nesting female, or interactions with the primary male), to be male. In 2000 an unbanded female replaced an incubating female, building and laying within 14 days of the other's death. In 2002 four females changed mates or territories: two left their mates and replaced absent females in nearby territories, and two found vacancies in other territories after their original mates disappeared. Helper males occasionally visited other pairs several territories away from their natal site, but were repelled and returned to their own territories.

Scarlet Robins occurred as pairs or, in a few cases, territorial males that temporarily lacked a mate (one or two males in each year: see Debus 2006a for details). In spring

2001 unpaired, singing male Scarlet Robins, apparently in search of mates, moved up to 500 metres or one to two territories away from their own territory (where they had been banded as breeding males in 2000). Some males that lost their mate shifted their territory or occupied another vacant territory. One pair moved into the neighbouring area formerly occupied by a pair and unmated male after those birds disappeared. There were no known cases of adult females changing mates; known females that disappeared were not resighted elsewhere in Imbota NR. One female briefly visited another (non-neighbouring) territory one kilometre away after a breeding failure, but returned for another attempt with her mate.

Parental behaviour

For Yellow Robins and Scarlet Robins, only females gathered nesting material, built nests, and incubated and brooded. Both sexes fed nestlings and fledglings, often splitting broods of two (colour-banded) fledglings so that the male had charge of one juvenile and the female had charge of the other.

A helper male Yellow Robin (banded, later a breeding male) was once seen carrying nesting material, and a breeding male Yellow Robin (paired with a known female) appeared once to sit briefly on a nest with eggs or chicks. A male Scarlet Robin once covered a nest by crouching over it, though he did not sit, at the hatching stage.

In both robin species, males courtship-fed prelaying females, and called incubating females to receive food (Yellow Robin: soft 'chop-chop' call; Scarlet Robin: soft, brief version of the song). Males sometimes fed females on the nest, or passed food to chicks via the sitting female, although sitting females also left the nest to forage. Female Yellow Robins begged with calls similar to those of juveniles (soft, plaintive whistles), but female Scarlet Robins gave no audible begging calls. Parent robins with food called to fledglings in the same manner as males to females in the respective species.

The response to potential nest predators (humans) was similar for both robin species. Incubating females flushed if approached to within a variable distance of the nest (10–20 m for the wariest Yellow Robins, to less than 5 m for the more confiding individuals of both species). Brooding females performed an apparent injury-feigning distraction display on the ground if nestlings were approached to within 1–2 metres, and both sexes defended new fledglings by flying past the observer and scolding if the young were approached to within 1–2 metres.

Scarlet Robins were highly cryptic, sitting females being almost invisible. Nest-building females tended not to approach the nest while being watched, or flew erratically when carrying material. Incubating females 'froze' on the nest if a predator flew past overhead, and flushed suddenly in erratic flight, wing-bars and tail-edges flashing, if approached within about one metre by a Pied Currawong *Strepera graculina* or human. Adults with food for nestlings were cautious, going indirectly to the nest via several trees, and waiting several minutes before the final approach flight; they also crouched cautiously, in cryptic pose, on the approach perch or on the nest rim before feeding the young. By contrast, most Yellow Robins readily built or lined nests or fed nestlings, without such caution, if observed from a discreet distance (20 m).

Both robin species removed and carried away nestling faecal sacs almost until the fledging stage, but I did not observe whether sacs were dropped or swallowed. On the last day or two in the nest, the nestlings' droppings accumulated outside the nest or on the vegetation or ground below.

Two nest-building female Scarlet Robins once performed a descending 'butterfly flight' (Higgins and Peter 2003) as they left their nests, when clear of the tree. Brooding females also used butterfly flight as they dropped from the nest to perform a distraction display on the ground. In all cases the pale wing-bars flashed conspicuously.

Parent Yellow Robins performed enticement behaviour at the fledging stage, when predators or perceived predators (humans) were near the nestlings: for example, when a currawong was nearby, or the nestling(s) had just been banded. After the predator or human had retreated, the parent flew to inspect the nest and, instead of feeding the begging nestling(s), jumped about the nest in an agitated manner, giving a soft version of the 'chop-chop' call interspersed with single piping notes, then departed. The nestling(s) then jumped from the nest, fluttered to the ground and 'froze' in litter or sought cover. Adults similarly enticed new fledglings to follow them to other cover if an

observer handled them or approached their hiding-place closely. Some nestling Yellow Robins, within 1–2 days of fledging age, jumped out when replaced in the nest after banding. They either remained in the nest after being replaced again, and fledged naturally (one brood), or they stayed out of the nest and either reached independence or disappeared, presumed dead, within a few days of leaving the nest (two broods respectively).

After a newly fledged Scarlet Robin had been caught by hand and replaced on its log perch, the agitated female gave a series of 'chup' calls as she flew to nearby shrubs. The juvenile followed along the ground, climbed a shrub, and perched there for the next two days until it could fly well.

Vocalizations

Adult robins gave several previously undescribed calls. Yellow Robins engaged in social encounters with members of their group, involving mild chases, displacements or dominance, gave soft trills (apparently by the submissive bird) audible only at close range (less than 10 m). A contact call between mates, apparently when one was trying to locate the other, or when a food-bearing adult was trying to locate a hidden fledgling, was a single rising whistle.

The long, rattling pre-copulatory call of female Scarlet Robins (Higgins and Peter 2003) was a good indication that a nest, almost ready for laying, was nearby. Adult Scarlet Robins defending nests or fledglings gave harsh grating notes (two per second) similar in quality to the 'scolding' of Speckled Warblers *Chthonicola sagittata*, though more rhythmic. A male Scarlet Robin defending a newly started nest against a Pallid Cuckoo *Cuculus pallidus* gave a series of loud, shrill squeaks (two notes per second).

The begging call of fledgling Scarlet Robins was a single soft, high-pitched plaintive note, similar in quality to the contact call of the Chestnut-rumped Thornbill *Acanthiza uropygialis* and apparently similar to the thin piping whistle of fledgling Red-capped Robins *Petroica goodenovii*.

Nest sites and nest-building

Most Yellow Robin nests in Imbota NR ($n = 58$) were in rough-barked saplings (48%; stringybarks 41%), live stringybark trees (21%) or live non-*Acacia* shrubs (16%; *Cassinia* 14%), whereas most Scarlet Robin nests ($n = 54$) were in live stringybark trees (52%), dead branches in live trees (22%; stringybarks 13%, gums 9%) or in dead stringybarks or acacias (13%; 6% and 7% respectively) (Table 1). The two robin species also differed in mean nest height (Yellow 2.7 vs Scarlet 7.2 m; $t_9 = -7.91$, $P < 0.001$) and nest-plant stem diameter (Yellow 9.9 vs Scarlet 28.5 cm; $t_9 = -6.67$, $P < 0.001$) (Table 1).

Yellow Robins took a mean of seven days (6–16 days, $n = 4$ nests) from the start of nest-building to laying, with one other case of less than nine days. The longest time (16 days) was for a first nest of the season that had a latent period of five days from an apparently finished and lined nest to laying of eggs. Two other first nests of the season also had latent periods of six and 10 days from apparently finished and lined nest to laying.

Scarlet Robins took a mean of eight days (6–11 days, $n = 8$ nests) from start of nest-building to laying, with two

other cases of more than six days and three of more than five days. One female was observed building and lining over a period of seven days. Another had the outer nest cup half-built one day after starting, and apparently finished in two days, followed by a further nine days to laying.

There were two cases out of 66 initiated nests (3%) in which a female Yellow Robin built on an existing old nest. One female, after a successful brood in summer, built a new nest on the old nest in the following spring, again rearing a successful brood. The other was built by a new female on the remains of her predecessor's old nest; she was paired with a male that had fledged from the old nest a year earlier, but the second attempt failed. There were two other cases of new females building on the same fork as their predecessor, two years later, by which time there was no trace of the original nest; one of these attempts succeeded.

No Scarlet Robins were known to build on old nests or nest-sites.

Laying season

Yellow Robins laid eggs from mid-August to early January. Trapped females lacked brood-patches in late July, and had developing brood-patches in the first week of August ($n = 6$), in 2002. Adults were moulting, with no sign of re-nesting, from early January; one heavily moulting female had a regressing brood-patch in late January. In 2003, courtship feeding occurred on 20 July (pers. obs.), and a female was fed by the male as she attended a completed nest (apparently pre-laying) on 31 July (G. Lollback, pers. comm.). The latter observations suggest that laying may normally start in late July or early August and that early nests may have been missed, although search effort in July–August 2002 was intense and the exceptionally dry, cold winter may have delayed laying.

Scarlet Robins laid eggs from mid-August to early December. Adults were moulting heavily, with no sign of re-nesting, from mid-December (males) or mid-January (females); one female had a regressing, re-feathering brood-patch in late January, and another had no brood-patch in late February.

Clutch size and replacement

Nineteen completed clutches for Yellow Robins were $C/2 \times 15$, $C/3 \times 4$ (mean 2.2). The only completed clutches observed for Scarlet Robins were $C/2 \times 1$, $C/3 \times 2$.

Yellow Robins started a replacement clutch in a new nest 5–13 days (mean 9 days; $n = 12$) after failure at the egg or chick stage. Females were rebuilding three, four and seven days after failure. One female was rebuilding five days, and re-laid 11 days, after her newly fledged young died. Yellow Robins started a new clutch in a new nest 29 days, 34 days and about a month after fledging of successful nests, while the previous brood ($B/1 \times 1$, $B/2 \times 2$) was still dependent.

Scarlet Robins started a replacement clutch in a new nest 7–15 days (mean 10 days; $n = 15$) after failure at the egg or chick stage. Females were at various stages of rebuilding between one and 12 days after failure, in some

cases with new nests built in 6–9 days or half-built in four days. One female was building a new nest 15 days, and had started a new clutch 22 days, after her previous brood fledged and while the juvenile was still dependent.

For both species, successful pairs (that raised young to independence) attempted a subsequent clutch only if their initial fledglings were from their first clutch of the season. Pairs that fledged young in the later part of the season (from mid-November onwards), or lost late-season broods a few days after fledging (in mid-November or later), did not attempt a subsequent clutch. Two pairs of Yellow Robins started a new clutch after their mid-season broods died a few days after fledging (in October and early November), and one pair of Scarlet Robins started a new clutch after their mid-season brood died a few days after fledging (in October).

Robin pairs had up to six breeding attempts in a season, not counting nests that were abandoned before laying. In spring–summer 2002, for unsuccessful pairs whose attempts were all found, the figures were: Yellow Robin 3–5 nests per pair (mean 3.8, $n = 4$ pairs); Scarlet Robin 3–6 nests per pair (mean 4.3, $n = 6$ pairs). Initially or ultimately successful Yellow Robins had 2–6 attempts per pair (mean 3.8, $n = 6$ pairs), and Scarlet Robins 2–4 attempts per pair (mean 3.0, $n = 2$ pairs) in 2002.

Incubation and nestling periods

For the Yellow Robin, incubation periods were determined for four clutches as 15–17 days (mean and mode 16 days), with two other records of 17 ± 1 days and 16 ± 1 days. Nestling periods were determined for two broods as 11 days each, with other records of 11 ± 1 days ($n = 3$ broods), greater than nine days, and approximately 12 days. For another nest, total time from start of incubation to fledging was 28 days.

For the Scarlet Robin, incubation periods were greater than 15, greater than 16 and approximately 18 days for one clutch each. One nestling period was determined as 16 days. For another nest, total time from start of incubation to fledging was approximately 30 days.

Nestlings

Nestling Yellow Robins were naked and pink at hatching; naked until three days old (by which time the dorsal skin was dark grey); about half fledging size at five days; had dorsal pins at 4–5 days; pins burst at 6–7 days; were feathering at 7–8 days; and feathered at 8+ days ($n = 5$ broods).

Nestling Scarlet Robins had grey dorsal down from about day one, persisting as tufts on the head until fledging ($n = 6$ broods).

Fledglings

Fledgling Yellow Robins hid on the ground beneath shrubs, logs and coarse woody debris, where they were fed by the parents, and usually remained within the shrub layer until they were adult in proportion and could fly well at three weeks post-fledging. New fledglings, flushed from cover in their first week, fluttered up into the tree or shrub midstorey, but returned to ground cover in about 10–20

minutes. Even at four weeks post-fledging they spent much time in cover, but thereafter moved around more freely in trees or in the open, with their parents.

Fledgling Scarlet Robins perched cryptically in the tree or shrub midstorey, or in brush piles, shrubs or on branches of dead fallen trees in the lower storey. One flightless young that fledged prematurely, when its nest was raided by a predator, hid in a low shrub at ground level but did not survive more than a day. Most could fly well within a few days of fledging, moving around the tree canopy or midstorey in their first week and with their parents in the open at three to four weeks.

For Yellow Robins, the post-fledging dependence period lasted eight weeks. Juveniles made foraging movements at five weeks post-fledging, obtained some of their food by foraging at six weeks, but begged and were fed by their parents until eight weeks, when adult-like in appearance. By nine weeks they appeared independent of parental care, and from eight weeks made the adult 'piping' call. Juveniles either remained in or on the edge of their natal territory for three months or more and dispersed in autumn or winter, or remained as helpers in the following breeding season:

For Scarlet Robins, the post-fledging dependence period lasted six weeks. Juveniles started to forage at four weeks post-fledging, but begged and were fed by their parents until six weeks. They foraged independently and did not beg for food at seven weeks, when almost adult-like in appearance and still in their natal territory. At an undetermined time thereafter they dispersed, apparently in late summer or autumn.

Yellow Robins started post-juvenile moult at one week post-fledging, were adult-like in plumage (some 'scruffy') at eight weeks, and were fully coloured and adult-like at ten weeks (Table 2). At three months they were indistinguishable from adults in the field.

Scarlet Robins were in post-juvenile moult by four weeks post-fledging, and were mostly in adult-like plumage at

eight weeks. However, one male took longer to acquire adult plumage, having some red on the breast, but no other adult colouring, at 9–10 weeks (Table 2). One male was in full adult colours when retrapped in autumn at seven months, and two females were fully coloured breeding adults at one year old. All young birds were acquiring adult colours by their first autumn.

Parasitism and predation

A Scarlet Robin abandoned a newly started nest after a Pallid Cuckoo approached within 5–10 metres of the nest, and the male robin harassed the cuckoo while giving distress calls. Nest parasitism by cuckoos was not observed, but one female Yellow Robin adopted an already-fledged Pallid Cuckoo (apparently hatched by its attendant Fuscous Honeyeaters *Lichenostomus fuscus*) and left her own single fledgling in sole care of the male robin (which reared the young robin to independence).

Robin eggs (two Scarlet Robin clutches) and nestlings or new fledglings (one Yellow Robin brood) were taken by Pied Currawongs, and possibly by Grey Butcherbirds *Cracticus torquatus* (one Scarlet Robin brood) and Australian Magpies *Gymnorhina tibicen* (one Yellow Robin brood); observed predators of other passerine nests in Imbota NR (e.g. robin-like nests of *Myiagra* flycatchers in the tree canopy) included Black-faced Cuckoo-shrike *Coracina novaehollandiae*, Grey Shrike-thrush *Colluricincla harmonica*, butcherbird and currawong (further details in Debus 2006a).

DISCUSSION

Breeding biology and behaviour

Yellow Robins and Scarlet Robins appear to select different nesting sites at Imbota NR. Yellow Robins tend to nest in the middle and lower strata, in sheltered sites in saplings or shrubs, whereas Scarlet Robins tend to nest in the tree canopy or middle strata, in exposed sites. Exposure to the elements or extreme weather events had

TABLE 2

Stages of growth of fledgling Eastern Yellow Robins and Scarlet Robins, compiled from data on 18 and four broods respectively. Week = week post-fledging; Scarlet ♂♂1 and 2 were siblings; ♀♀ were siblings.

Week	Description
Yellow Robin:	
1	Yellow ventral feather(s) starting to emerge
2	Adult colours starting to appear through mottled juvenile plumage
3	Blotchy adult colours; grey dorsum but no yellow rump
4	Blotchy adult colours except head; rump dull
5–6	Blotchy, almost fully coloured; rump yellow; head scruffy
7	Adult-like, some slightly scruffy; eye-ring skin dull pink (not grey)
8	Adult-like
Scarlet Robin:	
2	Tail half-length
3	Mottled juvenile plumage; adult in proportion
4	♂ (#1): red and black feathers starting to appear; ♂ (#2): plain
5	♂ (#3), ♀♀: acquiring adult colours
6	♂ (#3): blotchy adult colours; ♀♀: adult colours, pale dorsal flecks
7	♀♀: scruffy adult-like plumage
8	♂ (#1): almost in adult colours; ♂ (#2): plain plumage
9, 10	♂ (#2): acquiring bright red (i.e. adult male) breast feathers; singing

little effect on nest success in either species, even assuming that nest failures of unknown cause were weather-related; most failures were caused by predation (Debus 2006a). Scarlet Robins were particularly susceptible to nest predation, and for Yellow Robins nest success, fledging rate and survival to independence were related to the complexity of the understorey and the density of shrubs and saplings (Debus 2006b,c). The conservation and management implications of these findings, for fragmented and degraded woodland remnants in agricultural land in New England, are discussed in detail elsewhere (Debus 2006b,c).

Yellow Robins and Scarlet Robins differ in some aspects of their breeding biology, perhaps because Scarlet Robins suffer heavier nest predation (Debus 2006a,b). Scarlet Robins have natal down, which might camouflage or protect them; they have a longer nestling period and fledge at a more advanced stage enabling them to move around the woodland canopy or midstorey. Yellow Robins fledge in a less developed state, scarcely able to fly, and hide for weeks in shrub cover. Adult Scarlet Robins are more cryptic and cautious when attending nests, apparently as part of a more developed anti-predator strategy that includes 'exploding' off the nest in the face of a predator, with white plumage highlights flickering, perhaps to startle or distract.

Nest-site characteristics of Yellow and Scarlet Robins at Imbota NR were within known parameters or otherwise similar to previous descriptions, for nesting sites, substrates and heights (cf. Marchant 1984, 1985; Robinson 1990b; Higgins and Peter 2003). Clutch size for Yellow Robins at Imbota NR was similar to that reported elsewhere (cf. Marchant 1984, 1985; Zanette *et al.* 2000; Higgins and Peter 2003). For Yellow Robins at Imbota NR, time to re-nesting after success (one month) was slightly longer than reported for western New England at lower elevation (median 21 days; Zanette 2000).

Aspects of the biology of the Yellow Robin and Scarlet Robin agree closely with previous information (reviewed by Higgins and Peter 2003), for instance: rare re-use of nests or nest-sites; time taken to build nests; incubation and nestling periods; parental behaviour; and sex roles. The slightly greater latent time from presumed nest-finishing to laying, in the present study, may have reflected ongoing but unobserved building or lining activity by female robins, or perhaps cool weather at the beginning of the season compared with other sites. Yellow Robins may have built on the previous year's, still-existing nests because those nests were previously successful or were in sheltered sites, or on the sites of their predecessor's old (non-existent) nests because the fork was structurally suitable (although suitable forks appeared not to be in short supply).

The post-fledging dependence period of robins (6–8 weeks) lasted much longer than the 22 days assumed by Zanette (2000), and is long for small passerines though apparently typical for Australian species (Russell 2000). The behaviour of fledgling Yellow Robins emphasizes their need for ground cover, as protection from predators, in their first month. The development of fledgling robins suggests that post-juvenile moult occurs in relation to

fledging date, rather than to calendar month (cf. Higgins and Peter 2003).

The 'butterfly flight' of Scarlet Robins (Higgins and Peter 2003) appears to be an attention-catching display, either to advertise an occupied nest-site to rival females or to draw the attention of a predator from the nest and to the distraction-displaying female. The 'cuckoo alert' call of Scarlet Robins is a distinctive vocalization that draws other small passerines (e.g. thornbills, honeyeaters) to join in mobbing or chasing the cuckoo (pers. obs.).

Intragenetic comparisons

Results for Yellow Robins at Imbota NR were similar to relevant results for the ecologically equivalent Western Yellow Robin, although the latter nests in forks of mature smooth-barked gums in habitat dominated by such species (cf. R. and M. Brown, unpublished data cited in Zanette 2000; Cousin 2003). Results for Yellow Robins at Imbota NR were also similar to relevant results for the White-breasted Robin *Eopsaltria georgiana* in south-western Australia, although for the latter there was a higher incidence of pairs with helpers (cf. Russell *et al.* 2004). These minor differences may relate to geographic location, habitat features, or possibly lower nest predation in the absence of Pied Currawongs in south-western Australia.

Results for Scarlet Robins at Imbota NR were similar to relevant results for the marginally sympatric Red-capped Robin *Petroica goodenovii* elsewhere in south-eastern Australia, allowing for differences in nest heights related to differences in habitat; the latter species has delayed acquisition of male plumage (cf. Dowling 2003; Powys 2004a,b). Immature male Scarlet Robins usually have adult-like post-juvenile plumage, though sometimes female-like, whereas immature male Red-capped Robins vary in the intensity of red in their female-like post-juvenile plumage (Higgins and Peter 2003). This interspecific difference in maturation may relate to the two species' food supply, and hence nutritional state: the Bassian Scarlet Robin in stable, productive temperate woodlands, versus the Eyrean Red-capped Robin in arid and semi-arid woodlands with less predictable rainfall (though the Red-capped Robin extends marginally into temperate woodlands too).

CONCLUSION

The Scarlet Robin's parental behaviour is evidently shaped by nest predation, although its vulnerable nest-sites may have evolved with a lower density of predators than currently exists in remnant woodland (cf. Ford 1999). Scarlet Robins at Imbota NR had much lower nest success than Yellow Robins did (Debus 2006a). Nesting on precarious dead branches may reduce predation by some mammals, as suggested for the Leaden Flycatcher *Myiagra rubecula* (Trémont and Ford 2000), but the Scarlet Robin's nests are defenceless against large birds such as currawongs. By contrast, aspects of Yellow Robin breeding are correlated with attributes of the woodland understorey (logs, coarse woody debris, shrubs and saplings: Debus 2006c). The conservation implications for these robins in fragments such as Imbota NR are that, for the Scarlet Robin, nest predation may depress recruitment below replacement

level and populations apparently depend on immigration, whereas for the Yellow Robin local recruitment is apparently adequate (or nearly so) where the ground and shrub layers are adequate. Hence, for the Scarlet Robin, management should target ecologically based control of currawongs, and for the Yellow Robin, management should target restoration of the ground and shrub layers (Debus 2006a,b,c).

ACKNOWLEDGMENTS

This study formed part of a PhD project, supported by an Australian Postgraduate Award (administered by UNE) and by the Division of Zoology, UNE. The following provided field assistance: Justin and Julianne Billing, Ben Boland, Will Buchanan, Lachlan Debus, Tshering Dorji, Sandy Hamdorf, Annette and Matt Harrison, Andrew Ley, Greg Lollback, Karyn Moore, David Page and the Northern NSW Bird Banders, Jim Palmer, Gabriela Shuster, Atsuko Takemoto, Bruce Taylor, Kihoko Tokue, Steve Trémont and the TAFE team, Annie vander Meulen, Paul Webber, and the Birds Australia Northern NSW Group. Neighbours of Imbota, the Burton and Moffitt families, permitted field-work on their land. The project was aided financially by the Stuart Leslie Bird Research Awards (Birds Australia), the NSW Field Ornithologists Club research grants, the Joyce W. Vickery Scientific Research Fund (Linnean Society of NSW) and the NSW National Parks and Wildlife Service (Western Directorate, Dubbo), and in kind (with gratis mist-nets and colour-bands) by the Australian Bird Study Association's Fund for Avian Research. The research was conducted under UNE Animal Ethics permits AEC 2000/0081, 01/042 and 02/074, with authorisation from NSW NPWS, State Forests of NSW, and the Australian Bird and Bat Banding Scheme. Hugh Ford supervised the project and critically reviewed drafts, Doug Armstrong commented helpfully on the relevant thesis chapter, and several referees (notably Eleanor Russell and Mark Antos) helpfully reviewed the manuscript.

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