Corella, 2004, 28(1): 4–10

BREEDING BIOLOGY OF THE RED-CAPPED ROBIN *Petroica goodenovii* IN CAPERTEE VALLEY, NEW SOUTH WALES

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Received: 26 June 2002

This paper describes the breeding biology for 12 nesting pairs of Red-capped Robins *Petroica goodenovii* that were studied in 12 hectares of dry woodland in Capertee Valley, New South Wales, from September 2000 to March 2001. Individuals were reliably identified by plumage, song and territory. Twenty-nine nesting attempts by 12 pairs produced 12 fledglings from seven nests (24% nest success rate). Territory size averaged 1.02 hectares, with nests 35–170 metres apart, mean height above ground 4.5 metres. Nests took 2–5 days to build. Incubation began 2–4 days after the nest was completed. The incubation period was approximately 13–14 days; young fledged 13–14 days after hatching and were independent 33–40 days after fledging (aged 6–8 weeks). Nestlings were fed on average 5.5 times per hour over 14 days (n = 24 hours).

INTRODUCTION

The endemic Red-capped Robin *Petroica goodenovii* occurs in all Australian states except Tasmania, favouring acacia scrub and native pine woodland, with breeding records south of 21°S (Blakers *et al.* 1984). The species is widespread and conspicuous but is under-represented in biological literature. Limited studies have been made on captive nesting birds (George 1950, 1951a, 1951b and Hutton 1991). Breeding biology for three pairs was studied by Coventry (1988). Major *et al.* (1999a,b) measured the population density of breeding male Red-capped Robins, and studied nest depredation using artificial nests and eggs. Limited information for the species occurs in field guides (Stewart 1976; Frith 1984; Simpson 1986; Boles 1988; Schodde and Tidemann 1988; Slater 1989; Pizzey 1997; Morcombe 2000). Breeding biology and behaviour of two closely related robin species has been detailed by Robinson (1990a,b) and some comparisons are made here.

This paper details the breeding biology of 12 pairs of Red-capped Robins in adjoining territories during the breeding season 2000–01 at Capertee Valley on the Central Tablelands of New South Wales, and expands on Coventry's (1988) data, adding new information for the species. In a concurrent paper I describe the breeding behaviour, vocalizations and plumage for the same 12 pairs of Red-capped Robins referred to in this present study (Powys 2004).

METHODS

Study site

Capertee Valley is located on the western slopes of the Great Dividing Range in New South Wales, but is within the Central Tablelands geographic division. Mean annual rainfall is 500 millimetres and summers are often hot and dry with low humidity. Temperatures for December to February in the study area averaged 32.6°C maximum and 16.6°C minimum. The 12 hectare study site (33°07'S, 150°08'E) is 15 kilometres east of Capertee township and 380 metres above sea level. Aspect is north-east with stony soils supporting dry woodland including Motherumbah *Acacia cheelii*, Black Cypress Pine *Callitris endlicheri*, Narrow-leaved Ironbark *Eucalyptus crebra*, Tumbledown Red-gum *E. dealbata*, with an understorey of native herbs and grasses. Motherumbah grows to 10 metres as a mulga-like tree and most of the 12 hectare study site comprised 15 year-old Motherumbah regrowth plus ironbark saplings, and scattered mature ironbarks with some grassy clearings. The study site is more widely surrounded by woodland and is not considered to be remnant habitat.

Materials and methods

Red-capped Robins were observed using Swarovski 8 × 20 close-focusing binoculars, and 25 robins were colour-sketched from field notes in November and December for ongoing reference. Individual birds were reliably identified by plumage irregularities which did not change from October to December, considered in combination with territory and mate. Adult-plumaged males were separated by noting variations in the width of the white wing-stripe, intensity of black and red plumage and the size of the red breast patch.

Females varied with the size and intensity of the rust-coloured cap, with the clarity of the wing-stripe and with overall tonality of plumage. One darker-plumaged female had a pink spot on the breast and a large rust-coloured cap. Paler, smaller females with faint or no rust-coloured cap and indistinct wing-stripes were judged to be younger; (George 1950 observed that captive females had not developed rust-coloured caps at two years of age).

All brown-plumaged males had rust-coloured caps confined to the forehead and initially were indistinguishable from rust-capped females. Breeding behaviour was the main clue to their gender; brown males sang and defended territories, and copulated with females. After confirming their gender from behavioural observations, there were sufficient plumage differences in brown pairs to monitor individuals. Brown males were judged to be less than two years of age (Boles 1988). Plumage of breeding brown males did not change from November until mid-to-late January. Moulting brown males were then re-sketched in January, February and March to monitor plumage changes (details in Powys 2004).

Pairs of Red-capped Robins were given a code name, with letters indicating the location and a numeral indicating successive nests for any one pair e.g. 'nest H6' refers to the sixth nest built by pair H.

From September 2000 to the end of March 2001, daily searches and observations were made at random hours, initially within 40 hectares of continuous habitat but later confined to 12 hectares, from which I collected more than 500 hours of data. Male Red-capped Robins called often prior to nesting and were located aurally.

Distances between 12 adjacent nests were paced, and a compass used to compile a field map. In mid-December when nest building peaked, 11 nest locations within 12 hectares were mapped (Fig. 1) and approximate territory size was calculated from the map using graph paper. Territorial boundaries were judged to be where disputes between neighbouring males occurred. Where territory boundaries were not

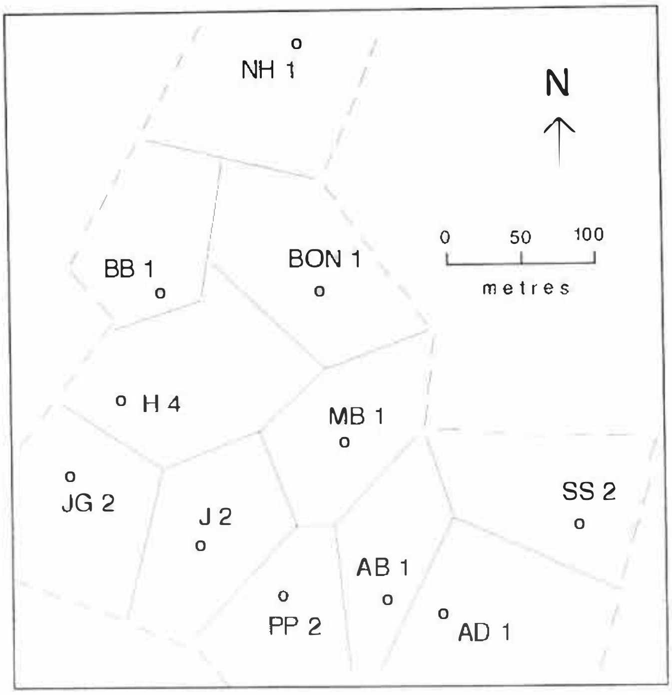

Figure 1. *Map showing the 12 hectare study site on 10 December 2000, with 11 occupied nests and approximate territory boundaries. Another occupied nest, CV, is top right, off map. Mean territory size for 11 territories was 1.02 hectares. Unbroken lines indicate boundaries shared by a rival pair, and dotted lines indicate the extent of foraging territory.*

shared with a rival pair, the extent of that territory was less clear, but a dotted line on the map (Fig. 1) indicates the extent of foraging. A 12th nest (off map) was positioned about 300 metres from the nearest neighbour's nest, but as no interaction between those neighbouring males was witnessed, this nest was excluded from mapping calculations. The mean distance between nests was calculated from 11 measurements, each representing the distance to the nearest active nest, for each territory in mid-December. Nests were constantly being relocated, so territory size and boundaries for each pair varied significantly from September to March.

Nest sites were checked daily and occupied nests were monitored for 10 minutes to 3 hour periods, with the observer usually seated about 20 metres from the base of the nest tree. No attempt was made to visually confirm the presence of eggs, with the exception of one nest (H6). For 28 out of a total of 29 nests, it was assumed that sitting females on high nests were incubating eggs. Date of laying was judged to be soon after completion of the nest when the female began sitting on the nest. Date of hatching was judged to be when the parents began to bring food to the nest. Older nestlings were visually monitored through binoculars. Estimated dates shown in brackets in Table 1 were calculated by adding or subtracting averaged known intervals, from the nearest known date.

Nest H6 was unusually low at 2 metres height, and its position also allowed the observer to monitor the nest from a partly concealed position 6.5 metres away. Nest contents were quickly checked at nest H6 using a small hand mirror. On one occasion this caused great distress to the female and jeopardized nest safety, but on six other occasions the disturbance was minimal. During the 14-day nestling period nest H6 was observed for a total of 24 hours, comprising 1–3 hour watches made daily in daylight hours between 0600–2100 hours Daylight Saving Time. Field notes tallied the timing and number of feeds and if brought by male or female parent; type and size of food; timing of removal of faecal sacs; general behaviour, and vocalizations.

Height of nests was measured to the nearest metre during March when nests were no longer occupied.

RESULTS

Habitat preference

Although I searched 40 hectares of dry woodland adjacent to the study site during October-November, Red-capped Robins bred only within 12 hectares where Motherumbah was the dominant species, combined with a north-east aspect. Where Motherumbah occurred with a west aspect, no robin nests were found. Favoured nest sites in the study area were at the edge of Motherumbah thickets rather than in the centre, and usually faced north-east, but not always. In spring, flowering Motherumbah supported small caterpillars that were used as food for nestlings, and its tangled, twiggy growth gave fledglings some protection from swooping birds-of-prey. The grassy understorey between Motherumbah clumps was extensively used for foraging by the robins, and acacias, ironbarks, red gums and larger rocks provided sallying perches close to the ground.

Territory establishment

From September to March eight red-plumaged males and four brown-plumaged males established territories, paired with females, advertised and defended their territories, as described in (Powys 2004).

Size of territory

In mid-December, the inter-nest distance from each of 11 active nests to the nearest neighbouring active nest ranged from 35 to 170 metres, mean 81 metres, (s.d. = 37.6 m) (Fig. 1). Territory size for 11 territories in mid-December averaged 1.02 hectares, (s.d. = 0.23 ha.). Territorial boundaries were adjusted when new nests were re-sited 10–30 metres from the previous nest, or when pairs abandoned their territory after nest failure. In February parents with fledglings expanded their territories to include the territory of unsuccessful pairs or previously unoccupied west-facing scrub.

Nest

NEST SITE AND MATERIAL

Nests of Red-capped Robins were built in three or four-way vertical or horizontal tree forks at heights of 2–7 metres, mean height 4.5 metres (s.d. = 1.5 m), (n = 29) (Table 1). Of 29 nests, 16 (55%) were built in Motherumbah acacia, 11 (38%) in Narrow-leaved Ironbark saplings, and two (7%) in Black Cypress Pine. Nests in Black Cypress Pine were built against the main trunk where a double branch occurred. All nests were open-cup, constructed of dry grass and cobweb and occasional shreds of bark. Nests in Motherumbah and Narrow-leaved Ironbark had very little lichen or moss on them (nor had the host tree), but nests in Black Cypress Pine were studded with lichen and moss, thus blending with the host tree. The nest lining (where seen) was of downy seeds from ground herbs, with a final sparse layer of feathers and fur. Nest fabric was stretchy and durable; one nest expanded to contain three active nestlings but eventually tore just before the young fledged. Of 29 nests, only one was re-used *in situ* when it was repaired after a storm. Eight nests (27%) were built of new material and 12 (41%) were built from recycled nests. For eight nests it was not known if they were new or recycled (Table 1).

TABLE 1

Table showing raw data for all nests studied August 2000 to March 2001. Of 29 nesting attempts, only seven nests produced fledglings. Estimated dates are in brackets. Code = the sequential nests for each pair, e.g. 'H6' = the 6th nest for pair H. Tree species: M = Motherumbah; NI = Narrow-leaved Ironbark; BCP = Black Cypress Pine. Brown-plumaged males were from pairs BB, NH, AB, and MB. 'R' = recycled; 'Rep' = repaired.

Code	Tree	Nest height (m)	New or recycled	Nest started	Nest complete	Incubation started	Young hatch	No. of young	Nest failed	Storm or predator	Nest stage	Young fledge	Young independent
H1	M	2	N	(23 Aug)	(28 Aug)	(1 Sept)	(15 Sept)	2	–	–	–	29 Sept	1 Nov
J1	M	5	N	(10 Sept)	(14 Sept)	(17 Sept)	(1 Oct)	1	–	–	–	14 Oct	21 Nov
H2	NI	5	R	10 Oct	(14 Oct)	17 Oct	–	–	21 Oct	p	egg	–	–
H3	M	2	R	24 Oct	(28 Oct)	1 Nov	–	–	3 Nov	p	egg	–	–
H4	M	4	R	5 Nov	(9 Nov)	12 Nov	25 Nov	1+	1 Dec	p	n'ling	–	–
CV1	BCP	7	?N	(10 Nov)	(14 Nov)	(17 Nov)	1 Dec	1	–	–	–	14 Dec	19 Jan
AD1	M	6	?N	(13 Nov)	(17 Nov)	(20 Nov)	4 Dec	2	9 Dec	p	n'ling	–	–
BON1	NI	5	?N	(20 Nov)	(24 Nov)	(27 Nov)	11 Dec	1	17 Dec	p	n'ling	–	–
BB1	M	6	N	19 Nov	24 Nov	28 Nov	11 Dec	1+	14 Dec	s	n'ling	–	–
JG1	M	4	?N	0 Nov	0 Nov	0 Nov	?	?	4 Dec	?	?	–	–
J2	NI	5	R	0 Nov	0 Nov	<2 Dec	–	–	4 Dec	p	egg	–	–
SS1	BCP	6	?N	0 Nov	0 Nov	0 Nov	?	?	<30 Nov	?	?	–	–
SS2	M	3	R	(26 Nov)	30 Nov	2 Dec	–	–	4 Dec	p	egg	–	–
PP1	NI	5	?N	0 Nov	0 Nov	0 Nov	?	?	28 Nov	?	?	–	–
NH1	NI	5	?N	26 Nov	30 Nov	4 Dec	–	–	11 Dec	p	egg	–	–
MB1	NI	4	N	28 Nov	1 Dec	5 Dec	–	–	9 Dec	p	egg	–	–
PP2	NI	4	R	28 Nov	1 Dec	4 Dec	–	–	6 Dec	s	egg	–	–
H5	M	5	N	2 Dec	6 Dec	8 Dec	–	–	10 Dec	p	egg	–	–
J3	NI	5	?N	3 Dec	7 Dec	11 Dec	–	–	14 Dec	s	egg	–	–
AB1	M	3	N	6 Dec	9 Dec	13 Dec	–	–	19 Dec	p	egg	–	–
JG2	M	7	R	6 Dec	10 Dec	(14 Dec)	–	–	15 Dec	p	egg	–	–
PP3	NI	4	Rep	8 Dec	11 Dec	14 Dec	–	–	16 Dec	p	egg	–	–
H6	NI	2	R	10 Dec	13 Dec	16 Dec	30 Dec–1 Jan	3	–	–	–	13–15 Jan	23 Feb
MB2	M	5	N	9 Dec	13 Dec	16 Dec	–	–	17 Dec	p	egg	–	–
AD2	M	6	R	10 Dec	12 Dec	16 Dec	–	–	20 Dec	p	egg	–	–
NH2	M	3	R	11 Dec	14 Dec	16 Dec	29 Dec	2	–	–	–	12 Jan	21Feb
J4	NI	5	R	16 Dec	21 Dec	24 Dec	7 Jan	1+	13 Jan	p	n'ling	–	–
AB2	M	4	R	20 Dec	23 Dec	25 Dec	8 Jan	1	–	–	–	21 Jan	27 Feb
AD3	M	5	N	21 Dec	24 Dec	27 Dec	10 Jan	2	–	–	–	22–23 Jan	1 Mar

NEST BUILDING CHRONOLOGY

Females alone built the nests which took 2–5 days to complete, averaging 3.5 days (n = 16). Time from nest completion to the start of incubation was 2–4 days, averaging 3.1 days (n = 16), (Table 1).

EGG LAYING

Twenty-five nests with sitting females were too high to visually confirm the presence of eggs. The contents of one nest, H6, were visually monitored with a hand mirror and three eggs were laid in that nest on consecutive days. Egg-shell colour was very pale green speckled with purple-brown to form a darker central band.

INCUBATION

Time from the start of incubation to hatching was approximately 13–14 days (n = 7 nests). At nest H6 (contents of which were visually monitored), three eggs hatched on consecutive days from 14 days after the first egg was laid. Female H incubated for short periods of time after the first egg was laid, and for longer periods of time after the second and third eggs were laid.

BROODING

At nest H6 from 0900–1200 hours the female brooded, preened and shaded her young for 24–42 (mean 33) minutes per hour (n = 6 hours) when nestlings were one to seven days old, and for an average of five minutes per hour (n = 5 hours) when nestlings were eight to 10 days old. The female no longer brooded or preened her young when they were 11–13 days old, but she shaded them from the hot sun for up to 38 minutes per hour (n = 3 hours) 1200–1500 hours during mid-January.

FEEDING CHRONOLOGY

Nest H6 was observed for a total of 24 hours during the 14-day nestling period, with 1–3 hour watches made daily in daylight hours from 0600–2100 hours Daylight Saving Time. The nest contained three nestlings. On average more feeds were brought to the nest 0600–1100 hours and 1500–2100 hours with less in the middle part of the day, for both male and female (Fig. 2). As a general observation, there was also less activity at other nests studied, during the middle part of the day. Feeding ceased temporarily if a predator ('hawk' or goanna) was near. Figure 3 shows a 0900–1100 hours feeding sample over 13 days (n = 11 hours), where the female brooded or shaded the nestlings for long periods in days 1–7 (n = 4 hours), and the male compensated by bringing many more feeds to the nest than the female. In days 8–13 (n = 7 hours) when the female was brooding much less, she brought more feeds to the nestlings on average than the male, 0900–1100 hours.

For nest H6, in days 1–6, feeds per nestling averaged 4.73 per hour (n = 5 hours), increasing in days 7–13 to

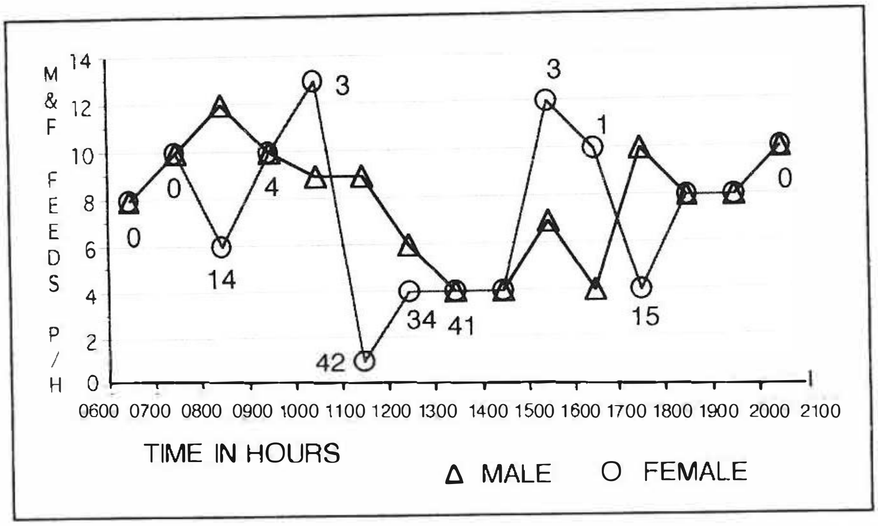

Figure 2. *Chart showing variation of feeding rates according to the time of day for three nestlings at nest H6: The hour-by-hour feeding pattern is shown as a composite "day" 0600–2100 hours Daylight Saving Time but was based on 18 hours observations over six days (days 7–13 in nest), with at least 1 hour observation for each daylight hour except for 1400–1500 hours and 1800–2000 hours where estimates are shown. In one 'day' the male brought 119 feeds, the female brought 112 feeds and also brooded for 2.6 hours. Minutes per hour for female brooding/shading are shown on chart, adjacent to female symbol. Chart shows a dip in the feeding rate in the middle part of the day for both male and female. Weather was fine with temperatures 16–31°C. Hours are rounded off to nearest hour.*

5.71 feeds per hour (n = 19 hours). The overall average number of feeds per nestling per hour for days 1–13 was 5.5 (n = 24 hours), and averaged 6.3 feeds per nestling per hour (n = 11 hours) in the 0900–1100 hours time slot (days 1–13). This was compared to nest NH2, where two nestlings averaged 5.0 feeds per hour each, 0900–1100 hours (n = 4 hours) (days 4–13). The highest number of feeds per hour brought to nest H6 was 31, which averaged 10.3 feeds per nestling per hour, on day 11, at 0700–0800 hours. In 13 days, for 15 hours a day, it is estimated (based on the known feeding rate) that nest H6 parents would have brought a total of 3 200 food items to the three nestlings.

Parents' foraging success rate for pouncing was one in six attempts for female H (n = 71 attempts); and one in eight attempts for male H (n = 31 attempts).

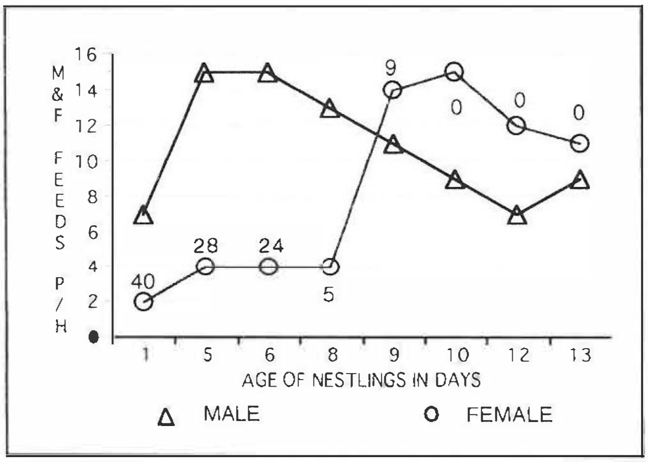

Figure 3. *Chart for Nest H6: 0900–1100 hours Daylight Saving Time data for three nestlings in 13-day nestling period, comparing male and female feeding ratio. Minutes per hour for female brooding/shading are shown on chart, adjacent to female symbol. In days 1–7 male parent compensated for low feeding rate of brooding female, but in days 8–13 when female was no longer brooding she brought more feeds to nestlings than the male. Data based on 11 hours observations, weather fine, hours rounded off to nearest hour.*

Food

At nest H6 recognizable food items included grasshoppers, katydids, small cicadas *Cicadetta labeculata* and *Pauropsalta encaustica*, spiders, bush cockroach, moths, butterflies, caterpillars, beetles, ants, dragonflies and mayflies. Large mud-wasps were numerous but were avoided as a food item. Tenderized caterpillars were fed to the nestlings for the first few days. After five days the nestlings were fed quite large items, whole. The largest item was a green grasshopper about five cm long, fed to a 13-day-old nestling. Generally the male brought the largest items to nest. Winged insects were always pushed head-first into the throat of the young.

Faecal sacs

At nest H6 faecal sacs were removed at a rate per nestling ranging from 0.3 per hour when 4–5 days old (n = 3 hours, 0900–1200 hours), gradually increasing to two per hour when 12–13 days old (n = 3 hours, 0900–1200 hours). The feeding parent would inspect the rear of the nestling after giving a food item, and if a faecal sac was produced, the parent would collect the sac in its beak and fly (sometimes with a fluttering flight) about 20–30 metres before dropping it.

Nestling chronology

The nestling period was 12–14 days (n = 4 nests) (Table 1). The number of nestlings per nest was between one and three, mean 1.6 (n = 12 nests). At nest H6, three young fledged over three days, from 14 days after the first egg had hatched; two young fledged within hours of one another, the third two days later. All three fledged between 1100–1300 hours.

Independence

The time from fledging to independence was 33–40 days, mean 37.4 days (n = 7 fledglings). Age at independence, post-hatching, was 47–53 days (6.7–7.5 weeks), mean 50.4 days (7.2 weeks) (n = 7 fledglings).

Nest success

During September–December, 29 nests were completed and of these 22 (76%) failed either at the egg or nestling stage (Table 1). Nests that succeeded in producing fledglings included five of 17 nests in Motherumbah, and one of two nests in Black Cypress Pine, but only one of ten nests in Narrow-leaved Ironbark. Horizontally and vertically forked sites fared equally, and nests between two and seven metres in height succeeded, so nest height and angle did not appear to be relevant to nest success. In September-October, two of three nests succeeded; in November all three nests failed; in December, 17 nests failed and one succeeded; in January, four out of five nests succeeded. Nests built either early or late in the breeding season were more successful than those built in November and December.

There were (mean) 2.4 nest attempts (range 1–6) per pair, for the 12 pairs of Red-capped Robins. Three of the four brown-plumaged males were apparently fertile after pairing with females and nesting. One brown pair fledged two young, another pair fledged one young; two nestlings of a third pair were lost during a squall. Eggs of the fourth brown pair were twice depredated and not proven fertile. The overall nest success rate (nests that produced fledglings per nest attempt) was 24 per cent, and was slightly higher in brown males (28%) than in coloured males (22%), but coloured males produced more fledglings per pair. Brown males produced a mean of 0.75 fledglings (range 0–2) per pair, coloured males produced a mean of 1.12 fledglings (range 0–5) per pair, compared with the overall mean of 1.0 fledglings (range 0–5) per pair. As a measure of multi-broodedness, only two of 12 pairs re-nested after a successful nest (Table 1); pair H fledged two young in late September, then after four unsuccessful attempts, fledged three more young from a sixth nest in mid-January. Pair J fledged one young mid-October, followed by three unsuccessful attempts.

Nest threats and predators

Of the 22 nests that failed, storm damage caused three failures but depredation was the probable cause of failure for 16 (55%) of the 29 nest attempts (Table 1). Nestlings less than one week old vanished from four nests. Assuming that sitting females on high nests were incubating eggs, 12 nests failed with eggs probably depredated. No depredation events were witnessed during the study period. A Black-faced Cuckoo-shrike *Coracina novaehollandiae* may have taken eggs from one nest (it was seen perched near the nest with something in its beak and the nest was rebuilt at a new site the following day). Collared Sparrowhawk *Accipiter cirrhocephalus* and nesting Brown Goshawk *Accipiter fasciatus* regularly patrolled the study area especially at dawn and dusk. Other possible avian predators seen in the study area (per Major *et al.* 1999a and pers. obs.) were Australian Hobby *Falco longipennis*, Brown Falcon *Falco berigora*, two nesting pairs of Pied Currawong *Strepera graculina*, Laughing Kookaburra *Dacelo novaeguineae*, Olive-backed Oriole *Oriolus sagittatus*, Grey Butcherbird *Cracticus torquatus*, Grey Shrike-thrush *Colluricincla harmonica*, Australian Raven *Corvus coronoides*, Australian Magpie *Gymnorhina tibicen*, and White-browed Babbler *Pomatostomus superciliosus*. In February 2000 a goanna *Varanus varius* took nestlings from a nest (pers. obs.) and during the study period several goannas were seen near nests.

Five species of cuckoo that are known to lay in Red-capped Robin nests were present in the study area. The robins always reacted aggressively towards cuckoos, but no cuckoo nestlings were seen in Red-capped Robin nests.

In late January 2001 temperatures reached 45°C during a week-long heatwave, but eight recently fledged young survived. Earlier in January three nestlings survived daytime temperatures that reached 44°C. A sitting female was injured during a squall and her nestlings lost (the female was seen the following day with feathers missing from the back of the neck). A newly-fledged bird was mislaid by its parents for a day following a squall but survived (parents and young became separated and loud cicada calls obscured contact calls).

DISCUSSION

Population density

Major *et al.* (1999b) measured population density for 196 male Red-capped Robins near Forbes in central New South Wales, and found more males per hectare (0.86) in large remnants than in small linear remnants (0.35), with population distribution in large woodland remnants being evenly spread despite a high degree of variation in habitat characteristics. The present study measured individual territory size rather than population density, and found that a breeding population of 12 pairs of Red-capped Robins was clustered in a specific habitat type within a much larger woodland area. For comparative purposes, there were 0.02 males per hectare based on the initial 40 hectare search, or 0.90 males per hectare based on the 12 hectare study site.

Coventry (1988) measured territory size for three adjacent territories of Red-capped Robins near Cooma in southern New South Wales; two were 0.5 hectares each, and a third was 0.25 hectares, which compares with a mean territory size of 1.02 hectares (n = 11) for this study. At Nimmitabel in the Southern Tablelands of New South Wales, Robinson (1990b) found a mean breeding season territory size of 3.2 hectares for Scarlet Robins *Petroica multicolor* and 1.7 hectares for Flame Robins *Petroica* *phoenicea*, where territories were defended interspecifically as well as intraspecifically.

Nests

Coventry (1988) measured average nest height for Red-capped Robins near Cooma at 3.6 metres (*n* = 11). This compares with an average nest height of 4.5 metres (*n* = 29) for the Red-capped Robins in this study. The northerly aspect noted by Coventry was also favoured by Red-capped Robins in this study.

Coventry (1988) found that three Red-capped Robin nests near Cooma averaged 8.0 days to complete, while Schodde and Tidemann (1988) reported 8–10 days, but Capertee Valley nests (*n* = 16) took only 2–5 days to complete, perhaps indicating more suitable weather conditions and nest material. Dry weather was advantageous to nest construction; in prolonged wet conditions when cobweb was scarce a female began a nest with no binding, and the nest material soon blew away. A drier climate and the extensive recycling of nest material with predominantly grass construction may have contributed to the shorter average building time of nests in this study. Nests for Flame and Scarlet Robins at Nimmitabel took 6–7 days to build (*n* = 14) (Robinson 1990a).

Incubation and nestling periods

Hutton (1991) observed an incubation period of 10–12 days for Red-capped Robins in captivity where the female began incubation the day after the first egg was laid. At nest H6 in this study (where nest contents were visually monitored) three eggs hatched on consecutive days 14–16 days after the first egg was laid. Coventry (1988) measured incubation periods for three clutches; each took 14 days to hatch. More data would be needed to explain why captive birds may have a shorter incubation period.

For captive birds Hutton (1991) noted that hatching to fledging took 14–15 days. Coventry (1988) observed five broods where the nestling period averaging 12.5 days (range 11–16 days). At nest H6, three young fledged 14–16 days after the first egg had hatched, and the nestling period averaged 12–14 days for four nests in this study.

Feeding of young

Coventry gave no feeding data for Red-capped Robin nestlings. In the present study, nest H6 averaged 16.5 feeds per hour brought to a nest with three nestlings during days 1–14 (*n* = 24 hours). As a general observation, more feeds per hour were brought to nests that contained two or three nestlings, than to nests that contained only one nestling. In a comparison of two nests 0900–1100 hours, more feeds were brought per hour to a nest that contained three nestlings (mean 18.9 feeds per hour, *n* = 11 hours), than to a nest that contained two nestlings (mean 10.0 feeds per hour, *n* = 4 hours). Robinson (1990a) tabled feeding rates for Scarlet and Flame Robins for days 1–18, which averaged 9.2 feeds per hour (*n* = 31) for Scarlet Robins, and 12.1 feeds per hour (*n* = 85) for Flame Robins, presumably per nest of 2–3 nestlings. In a study on Scarlet Robins at Cooma, Coventry (1989) found that (presumed 2–3) nestlings received 3.51 feeds per nest per hour (*n* = 8 hours). Further studies are needed to confirm that Red-capped Robins consistently bring more feeds to the nest, per nestling, than Scarlet and Flame Robins.

It was not clear why the nestling feeding pattern in this present study decreased in the middle part of the day (Fig. 2), but heat and overhead sun were probably the main contributing factors and the behaviour is probably typical for Australian passerines with open nests. Nest H6 was more exposed to mid-day sun than nest NH2, but the mid-day 'siesta' seemed to apply to both nests. The highly variable rate for the feeding of nestlings throughout the day indicates a potential difficulty in obtaining meaningful figures from small samples.

Independence

George (1950–1951) described Red-capped Robin young in captivity reaching independence two weeks after fledging (they ate mealworms from a tray); Hutton (1991) noted that young in captivity reached independence 3-4 weeks after fledging. Coventry (1988) observed Red-capped Robin parents tending their fledglings for at least two weeks, while Schodde and Tidemann (1988) reported three weeks. Red-capped Robin fledglings in Capertee Valley were fed by their parents for 5–6 weeks after fledging, while also self-foraging 1–2 weeks after fledging, suggesting a longer learning period and/or more difficult foraging conditions in non-captive birds. Flame Robin fledglings were fed for at least five weeks after leaving the nest (Robinson 1990b).

Nest success

Coventry (1988) found a nest success rate of 63 per cent (*n* = 8) for Red-capped Robins near Cooma. Robinson (1990a) at Nimmitabel found that only 25 per cent of Flame Robin clutches produced fledglings, and 10 per cent of Scarlet Robin clutches produced fledglings, (largely due to depredation of eggs and nestlings), compared to an average nest success rate for twelve Australian open-nesting passerine species of 30.6 per cent. This compares with a 24 per cent nest success rate for the Red-capped Robins in this study.

Robinson further found that fledglings per pair of Flame Robins per season was 1.20 (*n* = 36 pairs), and fledglings per pair of Scarlet Robins per season was 0.39 (*n* = 23 pairs), while Coventry (1988) found a rate of 1.2 fledglings per pair (*n* = 3) for Red-capped Robins near Cooma. This compares with 1.0 fledglings per pair per season for the 12 pairs of Red-capped Robins in this study. Hutton (1991) found a much higher fledgling success rate per season for Red-capped Robins in captivity; one pair produced seven fledglings from six nest attempts where five attempts were successful. The most successful pair in this present study (pair H) produced five fledglings from six nest attempts where only two attempts were successful.

Robinson (1990a) found that 32 Flame Robin pairs averaged 2.03 nest attempts per season, and 22 Scarlet Robin pairs averaged 2.64 nest attempts per season (both had a range of 1–5), which compares with 2.41 nest attempts per season (range 1–6) for the 12 pairs of Red-capped Robins in this study. Robinson also compared nesting success rates for three European flycatcher species with two Australian robin species, and found large differences. European flycatchers laid only one large clutch per season and suffered less nest depredation. Robinson found that Flame and Scarlet Robins, like other small insectivorous birds in Australia, laid many small clutches per season in a probable evolutionary adaptation to a high rate of nest depredation. In the present study, the high number of nesting attempts per pair of Red-capped Robins supports Robinson's findings.

Nest predators of Flame and Scarlet Robins identified by Robinson (1990a) were Grey Shrike-thrush, Pied Currawong, Eastern Brown Snake and Tiger Snake. Major *et al.* (1999a) used artificial nests and eggs in a study of nest depredation of Red-capped Robins near Forbes, and found a 34 per cent nest depredation rate, with predators being Grey Shrike-thrush, Grey Butcherbird, Australian Raven, Apostlebird *Struthidea cinerea*, Pied Butcherbird *Cracticus nigrogularis*, Australian Magpie, Pied Currawong, Grey-crowned Babbler *Pomatostomus temporalis*, and Rufous Whistler. There was a higher rate of nest depredation in this present study (55%) compared to Major's study, but no nest predators were positively identified.

A higher nest failure rate for Red-capped Robins in this study in December compared to January suggests December depredation by nesting birds-of-prey. Currawongs and larger birds-of-prey had finished nesting by January. Large cicadas were plentiful in late December and January and may have provided an alternative food source for predatory birds, and loud cicada calls in January may have camouflaged begging calls from the young. The more open and hawk-accessible canopy of Narrow-leaved Ironbarks may have been the reason for their higher nest failure rate, compared to the more enclosed canopy for Motherumbah nests.

Rowley and Russell (1991) and Rowley *et al.* (1991) showed that multi-broodedness in small passerine species was determined not by the overall number of nest attempts in any one season, but by whether or not pairs re-nested following a successful nest. The high number of nesting attempts for the 12 pairs of Red-capped Robins in this present study may have been largely a response to nest depredation, but two pairs (H and J) did re-nest after successfully fledging young. Hutton (1991) described five successful nest attempts in one season for a pair of captive Red-capped Robins protected from predators, clearly indicating the capacity for multi-broodedness for this species in the wild. Robinson (1990a) found that one-third of Flame Robin pairs laid second clutches in the same season if their first clutch was successful, but that none of the successful Scarlet Robin pairs did the same.

This paper covers only one breeding season but gives nesting biology data that could be compared with future studies on Red-capped Robins in other areas. Further studies on depredation and specific habitat requirements would also be useful.

ACKNOWLEDGMENTS

I wish to thank Syd Curtis for reading the first draft of this paper. The manuscript was improved by comments provided by Ian Rowley, Richard Noske, an anonymous referee and Don Franklin.

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