

Breeding of the Hooded Robin *Melanodryas cucullata* in native and exotic woodlands near Armidale, New South Wales

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The breeding behaviour and habitat of three groups of Hooded Robins *Melanodryas cucullata* were studied near Armidale, on the Northern Tablelands of New South Wales, from winter 2006 to winter 2007, by quantifying nest sites, colour-banding nestlings, and observing Robin families until beyond independence of the banded juveniles. Egg-laying commenced in September, and continued until December for the last of five consecutive unsuccessful clutches (all C/2). Two broods (each B/2) fledged, after an incubation to fledging period of 27 days, including a nestling period of more than 11 days. Breeding productivity was 1.3 fledglings/group and 0.57 fledglings/attempt (nest success and fledging success were both 29%; $n = 3$ pairs or groups, 7 nests). Fledglings were dependent on their parents for eight weeks, with post-juvenile moult starting at 6–8 weeks and completed by 6–7 months post-fledging (in autumn); one offspring acquired adult-like male plumage by this time. Breeding groups consisted of 2–5 adults, in home ranges of 30+ hectares; nest sites were in eucalypt saplings and in an exotic pine plantation. Nest-building, breeding behaviour, and food and foraging are described.

INTRODUCTION

The south-eastern subspecies of the Hooded Robin *Melanodryas cucullata cucullata* is considered nationally *near-threatened* (Garnett *et al.* 2011), and is listed as *vulnerable* in New South Wales (*Threatened Species Conservation Act 1995*). It is one of the typically open-nesting, ground-foraging, insectivorous woodland passerines that are declining in the sheep–wheat belt (Ford *et al.* 2001; Ford 2011; Watson 2011). This subspecies prefers large patches of woodland (>100 ha) that are well connected to other woodland, have moderate to high tree and shrub cover, and have logs, fallen branches and litter (Watson *et al.* 2001, 2002; Antos and Bennett 2006; Antos *et al.* 2008). It also prefers a ground cover of native, perennial tussock grasses on deep (i.e. productive) soils, on the edge of woodland remnants (Maron and Lill 2005; Friday 2010).

The biology of the Hooded Robin is now reasonably well known (Higgins and Peter 2002; Fitri and Ford 2003a,b), and it has been studied in the New England region of New South Wales (Courtney and Marchant 1971; Bell 1984; Fitri and Ford 1997, 2003a,b). However, there are few data on nestling growth, the post-fledging period, and acquisition of adult-like plumage (Higgins and Peter 2002; Fitri and Ford 2003b). This paper reports on these hitherto little-documented aspects. It also presents data on habitat use, including breeding in exotic pine forest, and reports on an attempted translocation and reintroduction. The Hooded Robin metapopulation around Armidale is highly dispersed and declining (Ford *et al.* 2009), hence the value of further data despite small sample sizes. Furthermore, there is a need for natural-history information to supplement science (Herman 2002).

STUDY AREA AND METHODS

The study area was within a 50-kilometre radius of Armidale (30°30'S, 151°40'E) on the Northern Tablelands of New South Wales (altitude 1000 m, annual rainfall 800 mm: see Fitri and Ford 2003a,b; Debus *et al.* 2004; Debus 2006a,b; Ford *et al.* 2009), and included some of the Hooded Robin sites described by Fitri and Ford (1997). One of those territories (in Yina Nature Reserve; see Debus 2006b and Debus and Ford 2012) was visited repeatedly throughout 2001–02 while a Hooded Robin group persisted there. In 2005 the one remaining Gara Travelling Stock Reserve (TSR) group (see Fitri and Ford 1997) was observed repeatedly, and in 2006–07 Yina and Gara were searched repeatedly, but no Hooded Robins were found breeding.

In 2006 three previously unknown pairs/groups were found around Armidale: two in or on the edge of Armidale State Forest (the Pine Forest, a Monterey Pine *Pinus radiata* plantation) where it adjoined eucalypt grassy woodland and grassland, and one in partly cleared eucalypt grassy woodland north of the University of New England campus (Kirby Road) (Fig. 1). The Pine Forest (~250 ha, in three discrete blocks of approximately equal area separated by clearings) is described elsewhere (Debus 1983; Debus *et al.* 2004). It consists mostly of mature pines with a sapling regrowth midstorey, and some blocks of advanced saplings planted in the preceding decade or so (in some cases with logging debris persisting from the previous cutting cycle). One corner remnant (~5 ha) consists of mature eucalypt grassy woodland. The surrounding land use is mostly livestock grazing, in grassy paddocks with remnant eucalypt woodland or scattered trees.

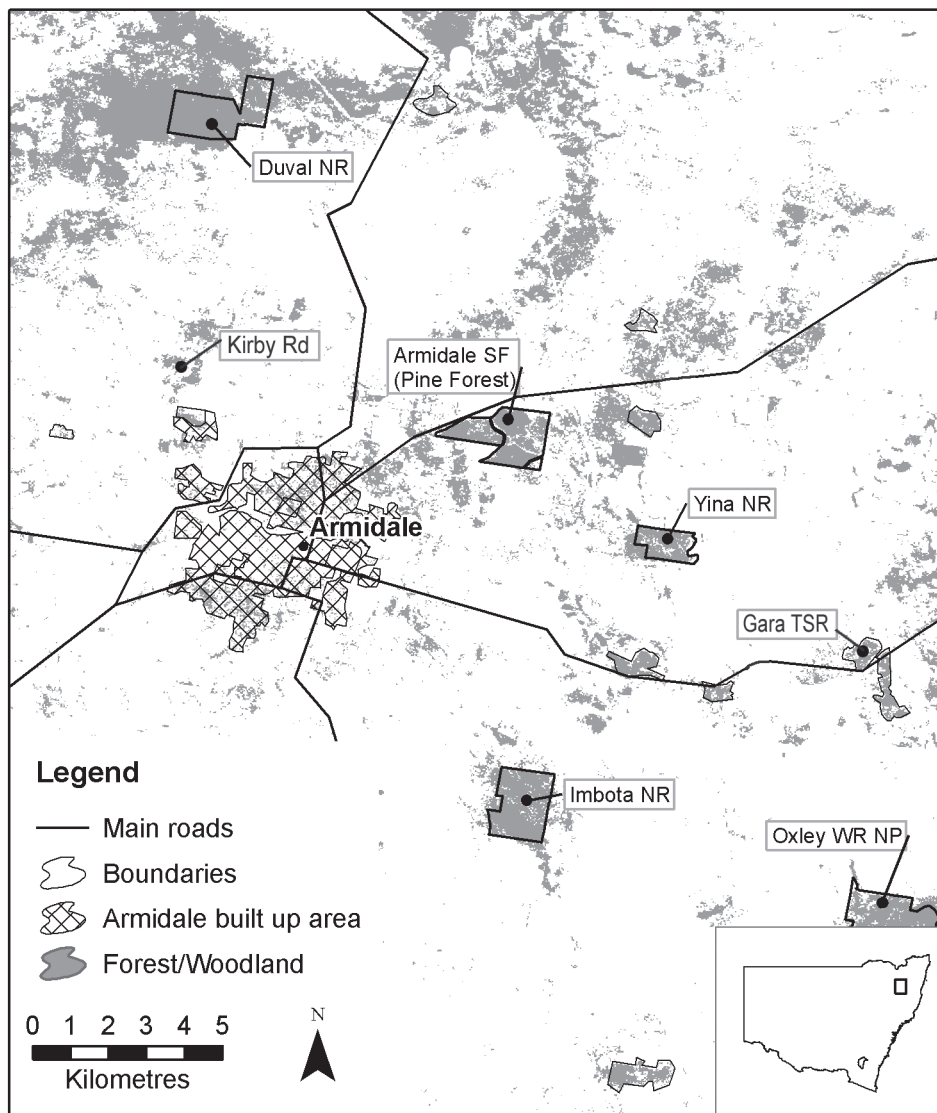


Figure 1. Map of main study area, showing locations mentioned in text. Outlying locations in Table 1 (Torryburn, Yarrawyck) are ~40 km west of Armidale.

The Kirby Road site was predominantly regrowth Yellow Box *Eucalyptus melliodora*–Blakely’s Red Gum *E. blakelyi* grassy woodland, with some Manna Gum *E. viminalis* (in gullies) and Rough-barked Apple *Angophora floribunda* peripherally, and some grassland; the native grass cover included Kangaroo Grass *Themeda australis* tussocks.

In spring–summer 2006 all nesting attempts of the Kirby Road pair and the two Pine Forest pairs (herein designated North and South) were monitored. Nest sites and aspects of nest microhabitat of the Kirby Road pair were measured (habitat complexity within 20 m of each nest, and density of trees, shrubs, dead trees/shrubs and logs in 1 ha enclosing the nest sites: see Debus 2006a,b). In spring–summer 2006–07 the two Pine Forest families with fledglings were followed until independence of their juveniles, after colour-banding their chicks in the nest a few days before nest-leaving age (metal bands supplied by the ABBBS). Care was taken not to flush incubating or brooding females off nests. Vacated nests and

their components were weighed on an electronic balance, and abandoned intact clutches (several days overdue to hatch) were examined for fertility. Terminology follows Higgins and Peter (2002) and Fitri and Ford (2003a,b), as applicable, and nest-site parameters (e.g. ‘tree’, ‘sapling’ and ‘shrub’ classes) were as defined elsewhere (Debus 2006b).

Resightings of colour-banded maturing juveniles, while still with their parents, were used to plot approximate home-range boundaries (on 1:25 000 topographic maps) where possible, although members of both groups sometimes could not be found, and the exact limits of their home ranges in some directions from the nest were undetermined. A basic polygon was drawn around all observations points, and areas and distances were estimated or measured from the maps. For the Pine Forest North group, the forest interior was frequently searched and netted for other robin species in 2006 (Debus and Ford 2012) without encountering Hooded Robins.

Table 1

Composition of Hooded Robin groups around Armidale. TSR = travelling stock reserve; NR = nature reserve; SF = state forest. N = north, S = south. M = male, F = female, imm. = immature.

Group	Site	Year	Comments
Gara	TSR; eucalypt grassy woodland	2005	Pair + imm. blotchy M (latter seen once on periphery of territory, in winter).
Yina	NR; eucalypt grassy woodland	2001	Pair + grey bird (sex?) in winter; pair + imm. blotchy M late next summer (+ fledgling)
Pine Forest N	SF; mature <i>Pinus</i> plantation	2006	Pair + two pied (adult-plumaged) M helpers and a grey helper (sex ?); after brood fledged, helpers dispersed, leaving pair + (by next autumn) first-year banded M offspring (acquiring pied plumage)
Pine Forest S	SF; young <i>Pinus</i> plantation	2006	Pair + one pied M helper; after brood fledged, one banded grey offspring (M? by size and behaviour) remained with adult trio through next winter.
Kirby Rd	Private land; eucalypt grassy woodland	2006	Adult pair only (raised no offspring during study)
Torryburn 1	Private land; eucalypt grassy woodland	2006	Adult pair only
Torryburn 2	Private land; eucalypt grassy woodland	2006	Four pied M, one imm. M (hooded, but dark grey-brown, not black); F not seen (could have been on nest, Aug.). Much chasing, but group seemed coherent.
Yarrowyck	Private land; eucalypt grassy woodland	2006	Pair + pied M

In spring 2006 an adult male and female of a trio (having a 'pied' male helper) were mist-netted approximately 10 kilometres north-west of Yarrowyck, west of Armidale (see Fitri and Ford 1997; Ford *et al.* 2009), fitted with radio transmitters (model BD-2, Holohil Systems Ltd), and translocated to Imbota Nature Reserve (see Debus 2006a,b), from which the species had disappeared by the 1980s. The transmitters weighed approximately one gram or five percent of the body weight of a Hooded Robin, attached as a backpack to a dissolving pelvic harness (Doerr and Doerr 2002). This procedure was part of an experiment investigating reintroduction, dispersal and use of corridors by Eastern Yellow Robins *Eopsaltria australis* (see Debus and Ford 2012). Over several days of trying to net adult Hooded Robins in two territories, observations were made on those and neighbouring pairs or groups of Hooded Robins: groups Torryburn 1 and 2, and Yarrowyck, in Table 1. The Yarrowyck territory was monitored occasionally for reoccupation, to assess the effect on the source population of the removal of a pair.

RESULTS

Social organisation

At the start of the breeding season, Hooded Robin groups ranged from simple pairs to up to three or possibly four helpers: commonly a trio of an adult pair plus an adult or maturing male, with most helpers being male (Table 1). In both Pine Forest groups, one fledgling (of two) disappeared around the time of independence. In both cases, the absent juvenile had moulted (from brown, streaked juvenile plumage) into a grey plumage, suggesting that both were females. The remaining (single) juveniles moulted into (a) pied plumage, i.e. male (Pine Forest North), and (b) grey plumage, but this bird was large and

dominant, and appeared to be male (Pine Forest South). The latter chased its grey sibling repeatedly, and the pied juvenile male also behaved aggressively towards its mother, in both cases around the time the respective sibling disappeared. The three helpers in the Pine Forest North group also disappeared, leaving only the pair and two juveniles, around the time the juvenile male started acquiring adult-like plumage.

Home ranges

The home range of the Pine Forest North group was at least 25 hectares, and 500 metres across in one direction, with nest-building forays of up to approximately 300 metres. This group mostly ranged out from the edge of the mature pines (where the nest was) into adjoining pasture with remnant eucalypts, and onto an old sportsfield surrounded by a low wooden fence and scattered eucalypts. The pines (and then only the grassy edge zone of the mature pines) appeared to form a small proportion of this group's home range, perhaps 15 percent, but these birds could not always be located and their habitat use at such times was unknown (other than being absent from the forest interior: see above).

The home range of the Pine Forest South group was at least 30 hectares, approximately 700 × 500 metres, and included young pines of various ages with open areas, standing dead or dead-topped young pines, pine logs, tracks and a wide powerline easement, and extended (in the non-breeding season) to the eucalypt woodland remnant and adjoining pasture with scattered eucalypts. The immature pines and open areas within appeared to form a large proportion (~70%) of this group's home range, particularly in the breeding season where they spent all their observed time.

Table 2

Hooded Robin breeding success, Armidale, spring 2006 (see Table 1).

Robin pair/group	Clutch	Brood	Outcome
Kirby Rd pair	C/2	–	Fail (predation)
	C/2	–	Fail (overdue, infertile; abandoned)
	C/2	–	Fail (destroyed; predation/storm?)
	C/2	–	Fail (overdue, infertile; abandoned)
	C/2	–	Fail (overdue, infertile; abandoned)
Pine Forest N group	C/2?	B/2	Both fledged, independent
Pine Forest S trio	C/2?	B/2	Both fledged, independent

The Kirby Road pair was seen, in the following winter, approximately 600 metres west of the nesting area, and in the 2009 season the pair had a nest also approximately 600 metres west-north-west of the 2006 nesting area.

Breeding season

At Armidale, one female Hooded Robin (Pine Forest North) had started nest-building by 1 September and laid around 10 September; two others (Pine Forest South, Kirby Road) were incubating first clutches by 6 and 21 September, respectively. One repeatedly unsuccessful female (Kirby Rd) laid her last clutch in the second week of December.

Nest-building

All seven nests examined were constructed of grasses and other fibres, bound with cobweb, and camouflaged externally with bark flakes (of native or exotic trees as available), much as described previously (see Higgins and Peter 2002; Fitri and Ford 2003b). Seven vacated nests weighed 7.6–14.2 grams (mean 10.0 g). Strands of nest fibre averaged 0.01 gram each, so there would have been approximately 1000 fibres and 10 or so bark flakes (~0.06 g per flake) per nest, representing approximately 100 collecting trips per nest if the female's beakful of material averaged 0.1 gram (10 fibres or two bark flakes). Females gathered beakfuls of multiple items, and flew sometimes more than 200 metres from source to nest. The male (of a simple pair) sometimes closely followed the female during the pre-laying phase and during her material-gathering forays, as if guarding. The Pine Forest North first (successful) nest was completed to the outer cup stage in three days from discovery of building behaviour, and took a further five days to egg-laying (i.e. >8 days from start to lay; lining, and latent time to laying, not recorded).

The Kirby Road pair started a second nest four days after the first was destroyed by an unknown predator (egg stage). On day 2 (after discovery) the base and sides were built; on day 3 the nest cup was formed and the inside walls lined; on day 4 the nest cup was complete (not fully lined?), no eggs; two days later (= day 6) the female laid the first of C/2. After that nest was abandoned (see Table 2), the female was suspected to be rebuilding four days later (= day 1); on day 3 she was building, and on day 7 she was already incubating the third clutch (i.e. laid the first of C/2 by day 6). After that nest was destroyed (egg stage), she was already rebuilding four days later and was incubating the fourth clutch another two days later (i.e. had laid the first of C/2 only five days after failure). When that nest in turn failed (egg

stage), the time to rebuild and lay was not recorded, but she was found already incubating a fifth (final) C/2 clutch within nine days (probably less) of failure. Thus, new nests were built and repeat clutches laid within 5–9 days of failure at the egg stage, with four replacement clutches in the season. Repeat nesting and laying occurred more rapidly than for the initial nesting.

Breeding biology

Five clutches (from one female) were all C/2, and two other females had a brood each of two chicks with no sign of unhatched eggs. Thus, seven clutches were probably all C/2. One female had five successive failed clutches within the 2006 season: two nests with eggs were destroyed (one by a predator, one possibly by a storm), and three clutches were abandoned a few days after hatching was due (all infertile or dead, with no developing embryo; Table 2). Two other females had one successful brood (B/2) each. Thus, nest success was 29 percent for nests with eggs, with four young from an assumed 14 eggs (= 29% fledging success); four young fledged from three groups (= 1.3 young/group) or from seven attempts (= 0.57 young/attempt) in 2006 (Table 2).

For one nest, incubation to fledging took 27 ± 1 days, and at another, the nestling period lasted at least 11 days. At one nest, the female was always brooding the chicks, when checked, until seven days before fledging, and brooded intermittently until five days before fledging. At both, the chicks were feathering at seven days before fledging (Table 3).

One adult female started a second nest 31 days after her young fledged, when the juveniles were still being fed. The nest was apparently completed in three days (no eggs yet), and was abandoned, apparently without laying, three days later. Another female was carrying nest material 59 days after her young fledged (5 days after independence), but the attempt did not proceed to laying. Thus, four repeat clutches were laid after successive failures, but no repeat clutches were found after a successful brood was raised.

Parental behaviour

Males courtship-fed females in the pre-laying phase. Incubating females were fed on the nest by the male, and gave food-begging calls, but also foraged for themselves. At one nest, a male attended (fed?) the chicks on day 6 of the nestling period, and at another, a grey helper fed advanced nestlings. Food-bearing adult males gave soft contact calls or a soft version of the song when approaching the nest.

Table 3

Growth stages of nestling Hooded Robins (two broods, each of two young), Armidale, spring 2006.
Day 1 = first day hatchlings seen (could have hatched on previous day).

Day	Description
1	Naked: dark skin, feather pins just emerging
2	As above
5	Covered in burst pin-feathers
6	Feathered; remiges ensheathed
7	Well feathered
8	Remiges ensheathed; no tail (visibly emerged by 7 d post-fledging; see Table 4)
11	Still in nest, fully feathered other than tail
12	Fledged (nest vacant, young invisible in cover)



Figure 2. Female Hooded Robin incubating, on nest, Gara TSR (native eucalypt woodland), spring 2011. A pair reappeared at Gara in 2011 (see text), but also had five successive unsuccessful nests that year.

Photo: Bob Shepherd

The adults of Pine Forest North defended the nest (the female also performed a distraction display, i.e. injury-feigning as described by Higgins and Peter 2002) when the near-fledged chicks were banded, but those of Pine Forest South did not. However, the adults of both groups (especially the male) defended the new fledglings hiding in low cover, and a male performed a distraction display. The North male vigorously defended the fledglings against two Grey Shrike-thrushes *Colluricincla harmonica* that were trying (unsuccessfully) to find them. Thus, there was some individual variation in the willingness of adult Hooded Robins to defend nestlings, but defence of fledglings was strong.

Post-fledging period

Fledglings at first hid in low cover of shrubs, logs or saplings, but within a week could fly well, within a month they were adult in proportion and starting to forage, within 6–8 weeks were in post-juvenile body moult (one male directly into adult-like body plumage), and were independent at 8 weeks (details in Table 4). One other dependent juvenile, at approximately six weeks post-fledging (begging, yellow gape) was also moulting directly into adult-like male (blotchy black) body plumage. Three others (apparently two females, one male from its size and dominant behaviour) moulted into grey

plumage (see Tables 1 and 4). Juvenile begging calls were similar to those of the Eastern Yellow Robin (see Higgins *et al.* 2002), though a little faster at times.

The pied immature male was still slightly scruffy and mottled in early February, four months after fledging, but was fully in adult-like male body plumage in mid May (7 months after fledging). The grey immature (male?) was losing its ventral mottling in late December, three months after fledging (compare week 8, Table 4), but was still slightly scruffy and mottled in early February (over 4 months after fledging), by which time its mother was moulting heavily; it was in full grey plumage in early April, six months after fledging. Both these immatures were still with their respective natal group when last checked in mid-July.

In the post-fledging period, both males and the female of the Pine Forest South trio fed the juveniles. In week 8, a male (parent?) and the female had charge of one juvenile each. Of the Pine Forest North group (three helpers), the adults and the grey helper fed the juveniles then, after the helpers had all dispersed by about week 7, both parents continued to feed the maturing juveniles.

Nests and breeding habitat

The first nest at Pine Forest North was 3.5 metres above ground in the horizontal subterminal fork of the lowest limb of a mature Monterey Pine (85 cm dbh), on the edge of the forest. The second was approximately 1.5 metres above ground in a fork against the trunk of a pine sapling, also near the edge of the forest. The nest at Pine Forest South (~1.3 km away) was 1.1 metres above ground in a fork against the trunk of a pine sapling (5 m tall, 13.5 cm dbh), amid extensive pine sapling regrowth, but near a linear clearing formed by a vehicle track and high-voltage powerline easement. The nest tree was next to two fallen dead mature pines and a thicket of Briar Rose *Rosa rubiginosa* and Blackberry *Rubus* sp. Bark used for external camouflage was from pines (the two sapling nests) or exotic deciduous trees in a nearby, otherwise cleared creekline.

The five nests in the Kirby Road territory were all low (<3 m) in native trees in a patch of eucalypt woodland (Table 5): three in the main forks of Rough-barked Apple *Angophora floribunda* saplings, one on the lateral branch fork of a small *Angophora* tree, and one in a fork against the trunk of a Yellow

Table 4

Behaviour and growth stages of fledgling Hooded Robins, compiled from two broods of two young. Week = week post-fledging; day 1 = fledging day.

Week	Day	Comments
1	1	Brood 1: hiding low (~1 m) in thicket, ~2 m from nest. Brood 2: hiding in cover (not visible, defended by adults).
	7	Brood 2: stubby tail, flew ~50 m across open ground
2	8	Brood 1: hiding in log pile >100 m from nest
	13	Brood 2: flew well, tail half-length
4	23	Brood 2: tail less than full (3/4?), not foraging
5	30	Brood 1: adult proportions, juvenile plumage; foraging, but dependent (begging, fed by adult)
	31	Brood 1: dependent (fed by adult)
	32	Brood 2: adult proportions; dependent (fed by adults)
6	39	Brood 1: streaky; adult-like proportions and agility, foraging; dependent (fed by adults). Brood 2: dependent (fed by adult).
	43	Brood 2: one sibling moulting into blotchy black hood, other moulting into grey; foraging, dependent (fed by adult)
7	46	Brood 1: dependent (fed by adult)
	50	Brood 1: fully mottled; foraging, dependent (fed by adult)
	55	Brood 1: moulting into grey ('female') plumage; dependent (fed by adult); one sibling chasing and displacing the other. Brood 2: blotchy adult-like colours (one male, one grey); dependent (begging).
9	60	Brood 1: only one sibling present hereafter; foraging, independent (not fed by adults over next month)
10	67	Brood 2: only one sibling present hereafter; blotchy adult-like male plumage
11	77	Brood 2: remaining sibling foraging, independent; blotchy black except wing coverts, scruffy mottled head; aggressive towards adult female

Table 5

Characteristics of five Hooded Robin nests in one territory at Kirby Road, Armidale (see text) in eucalypt woodland: range (mean) in 0.13-ha nest-centred plots. Habitat complexity = sum of above-ground contacts on a 2.4-m Levy pole at points 10 m and 20 m from the plot centre on four cardinal axes; cover = no. items in which a fledgling robin could shelter; distance = distance to nearest cover (see Debus 2006b).

Nest height (m)	Tree dbh (cm)	Complexity ^A score	Cover ^B (n items)	Distance (m)
1.1–2.5 (1.7)	6–17 ^C (11)	0–5 (2.8)	0–3 (1)	0.3–5 (1.8)

^AItems scored: logs, coarse woody debris, shrubs, saplings, branches

^BLive or dead shrubs, saplings, branches, brush-piles, stumps, logs, <3 m above ground

^CNest on side branch 7 cm in diameter.

Box sapling. External camouflage was of *Angophora* or Box bark flakes, according to nest-tree species. These nests were either on the edge of the woodland patch (two nests) or several metres into it (0–14 m, mean 5.8 m), and all fell within the one-hectare plot measured for breeding-habitat characteristics.

The five Kirby Road nests were all built in the one patch of young regrowth eucalypt woodland, dominated by rough-barked trees and saplings, with few shrubs, some standing dead trees and many logs (Appendix 1). Casual observations of groups west of Armidale (Yarrowyck and Torryburn, Table 1) revealed a high density of standing dead timber, amid grassland and open woodland, in occupied home ranges.

Food and feeding

Foraging Hooded Robins were observed opportunistically, ground-gleaning in the open, on bare ground, and perching on sticks in an open grassy paddock (winter); low ground-pouncing (spring); hawking, snatching and ground-pouncing (sometimes from high powerlines) for small aerial, foliage and ground insects around young pines and adjacent open ground (warm, humid

summer morning); ground-pouncing around a small clearing in eucalypt woodland (autumn); pouncing from low sites (e.g. fences) onto freshly slashed grassland (autumn, where they had been absent in summer when the grass was tall); and pouncing and gleaning on open ground (subsequent winter). In the post-fledging period (late spring), one family frequented young pines and adjacent open areas with logs and standing dead timber, where they mostly pounced to the ground for prey. These observations were casual (non-systematic); the Hooded Robin's local foraging behaviour has been quantified elsewhere (Fitri and Ford 2003a).

Food items observed included a froglet *Crinia* sp. (taken from a creek bank), a moth (Lepidoptera), a larva/pupa, a spider (Araneae), and a small green moth or leafhopper. Insects seen hawked and snatched by Hooded Robins in summer were abundant (swarming?), and surprisingly small (<4 mm) for the size of the birds taking them. One male Robin in eucalypt woodland took a large sawfly larva (Hymenoptera: Pergidae), and beat it on a branch to eject the gut (which contains the noxious 'spitfire' defensive fluid), before feeding it to his incubating mate.

Predator avoidance

In the pre-nesting period, one pair of Hooded Robins was courtship-chasing and ground-hopping (foraging) in the open. When a Peregrine Falcon *Falco peregrinus* flew over, the male 'froze' crouching on a dead treetop (his song-post, where his plumage blended with his perch in that posture), and the female fled rapidly approximately 50 metres low across the paddock to the centre of a dense small tree (exotic fruit tree), where she effectively hid although it was leafless (deciduous) at the time. These two responses illustrate both the Robin's cryptic plumage (even the male, among dead timber), and the importance of shelter from avian predators.

Reintroduction

Of the two Hooded Robins translocated to Imbota, the male was killed by a predator (only his transmitter found, with blood-stained feathers attached), and the female was also found dead, both on the day following their release. After the pair had been captured (in August), the remaining pied male of the trio was singing 12 days later, and had a new mate in the following May. Thus, the territory was still occupied after two adults were removed, and a dispersing female was available in that population for pairing with a lone male. The depletion of the adult population in that area was therefore only temporary.

DISCUSSION

This study adds several pieces of new information on Hooded Robins. Higgins and Peter (2002) did not mention exotic pine plantations as a habitat for this species, nor the use of exotic nest materials. The two Pine Forest pairs were successful and productive breeders, compared with Fitri and Ford's (2003b) data for eucalypt woodland. Although the sample size is small, some pine forests may be valuable sites for Hooded Robins where the diversity of habitat structure (age-classes, shelter) and feeding substrate (e.g. open areas, logs, dead timber) is high. Also, there were few avian nest predators in the plantation (e.g. the few Pied Currawongs *Strepera graculina* were only in the mature pines; butcherbirds *Cracticus* spp. and shrike-thrushes were uncommon, and mostly in the mature pines). Hooded Robins have disappeared from many sites around Armidale (Ford *et al.* 2009), giving this remnant population in pine forest importance locally. The Pine Forest also retains a significant Eastern Yellow Robin population (Debus *et al.* 2004).

This study confirmed that multi-helper groups may disperse after a successful breeding event (leaving the pair and new pied son as a trio through the winter). It also showed that new offspring may disperse in autumn, in at least one case apparently encouraged by aggression from a male sibling (which stayed on through winter). In each group, the dispersing brood-mate was apparently female. In multi-helper groups, grey helpers occurred in those groups that already had one or more pied helpers, and perhaps acquisition of pied plumage is delayed (inhibited) in first-year male helpers in such groups.

This study also identified the age at which post-juvenile moult started, and found that some juvenile males moulted directly and completely (body feathers only) into adult-like male plumage in their first autumn. The post-fledging period was twice as long as previously reported (8 vs 4 weeks; Fitri and Ford 2003b). However, the latter referred to when juveniles left the nest area, whereas in the present study juveniles continued

to be fed in the wider home range of 30+ hectares, for a total uninterrupted breeding cycle (nest-building to independence) of approximately 90 rather than approximately 70 days. Post-fledging dependence periods in Australian passerines are long (Russell 2000), and in this respect the Hooded Robin closely resembles the Eastern Yellow Robin (8 weeks: Debus 2006a). The Hooded Robin's juvenile begging (and some other) calls were similar to those of the Eastern Yellow Robin, which suggests that the Hooded Robin is more closely related to *Eospaltria* than to *Petroica*.

The findings of this study are consistent with, and supplement or confirm with further empirical data, those of prior compilations and studies (Bell 1984; Higgins and Peter 2002; Fitri and Ford 2003b) on most aspects of the Hooded Robin's biology, including: social organisation (group size and composition, roles of helpers); home-range size and dispersion of nests (within a season) in the breeding territory; nests (sites, materials) and nest-building; and breeding biology (e.g. season, clutch size, breeding behaviour, incubation and nestling periods, nest success). For instance, a combined incubation–nestling period of 27 days fits a mean of 15 and 12 days for each phase, respectively.

Hooded Robins around Armidale fed mostly by pouncing or gleaning on the ground, consistent with previous information (see Higgins and Peter 2002; Fitri and Ford 2003a). They also tended to forage higher in warm weather, as previously found. The froglet and sawfly larva ('spitfire') are novel prey items for the Hooded Robin, and the latter item illustrates an ability to deal with certain noxious prey, although other Australian robins variously take small skinks or potentially noxious insects (coccinellid beetles, pentatomid bugs), and beat large prey (Higgins and Peter 2002). Foraging substrates (e.g. logs, standing dead timber, open ground) and microhabitat components (e.g. woodland/grassland edges, saplings, native tussock grasses) are consistent with previous knowledge on the Hooded Robin's ecological requirements (e.g. Higgins and Peter 2002; Recher *et al.* 2002; Fitri and Ford 2003a,b; Maron and Lill 2005; Antos and Bennett 2006; Antos *et al.* 2008; Priday 2010).

This study provides further insights into the Hooded Robin's requirements, and suggests some possible management implications. Nest predation was apparently lower, and breeding productivity high, in exotic vegetation where avian nest predators were scarce and cover for nests and fledglings was plentiful. Exotic vegetation also provided nest materials. Therefore, care should be taken not to remove exotic vegetation without first checking for the presence of rare or locally declining species. This finding suggests that ecological control of avian nest predators in native woodland, by removal of the exotic, invasive berry-bearing plants that support currawong populations, may also lead to better breeding productivity of Hooded Robins. However, such removal should occur as a phased process where alternative native shrubs and habitat components are provided well before all exotic habitat is removed.

The failed translocation suggests that reintroductions of this species are not a useful management option, at least until aspects of habitat quality and nest predation are addressed in areas where Hooded Robins have disappeared (see also, e.g., Ford *et al.* 2009; Ford 2011; Debus and Ford 2012).

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Appendix 1

Habitat characteristics of 1-ha plot enclosing five successive Hooded Robin nesting attempts in one territory at Kirby Road, Armidale, spring 2006 (see text). 'Tree' and 'shrub' size classes as defined elsewhere (Debus 2006b).

Parameter		<i>n</i> items in nesting territory
Trees:	rough-barked	109
	gums	12
	total	121
Saplings:	rough-barked	338
	gums	29
	total	367
Shrubs ^A :		3
Standing dead ^B		31
Logs ^C		218

^AMore than 1 m high

^BTrees, saplings, shrubs

^CIncludes rotting coarse woody debris more than 10 cm thick × 50 cm long