Observations on nesting Grey Falcons, *Falco hypoleucos*

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Abstract

The breeding behaviour of a pair of Grey Falcons was documented for 20.8 h during incubation and for 274.7 h during the nestling stage. The birds' daily routine, their diet, interactions with other species and other breeding information were recorded. Only the female was observed incubating the eggs and brooding the young. The female did almost all of the provisioning of food to the nestlings although the male caught most of the food items, probably exclusively birds. Vocalisations used by the falcons and the circumstances of the calling were documented. Both adults interacted, at varying intensities, with other species near the nest tree, although their reactions were mostly undemonstrative. Two young fledged.

INTRODUCTION

The rare, endemic Grey Falcon, *Falco hypoleucos*, of the Australian arid zone qualifies for a national listing of Vulnerable (Garnett, Szabo and Dutson 2011), but has been little studied. Previous summaries of its biology (Cade 1982; Marchant and Higgins 1993) were based on anecdotal accounts of its breeding behaviour (Cupper and Cupper 1980, 1981; Hollands 1984). Subsequent accounts of its breeding behaviour were similarly anecdotal and based on single or a few nests (Falkenberg 2011; Sutton 2011), or were curtailed by nest failure during incubation (Watson 2011). Studies on its diet and vocalisations have been more detailed (Aumann 2001; Baylis, van Gessel and Debus 2015; Janse *et al*. 2015). The most detailed, continuing work on the species is that of Schoenjahn (2011a,b, 2012, 2013).

This study arose out of our ongoing investigations into the avifauna in Queensland's Channel Country, resulting in several papers including that of Ley, Tynan and Cameron (2011) which references much of our previously published work. Here we document observations on a single Grey Falcon nest for 295 h 28 min during the egg-laying, incubation and nestling stages. We present, for the first time on this species, quantified parental time-budgets (sex roles in chick care and feeding rates) for the entire nestling period and detailed descriptions of the falcons' calls and their contexts, as well as the largest quantified prey sample to date. The nest of this study was first sighted on 2 August 2014 beside a man-made earth tank in Bladensburg National Park, Queensland (park headquarters at 22°30'S, 143°02'E) during a Birds Queensland expedition to the national park.

METHODS

Observations were made from an open and exposed (to the sight of the birds) position about 120 m from the nest tree, which point was clearly outside the birds' alert distance as indicated by their lack of interest in us. The nest tree and the important perches regularly used by the birds were clearly visible using 10 × 42 binoculars and a 25 × spotting scope. Given that female Grey Falcons are larger than males (as in other members of the genus) and given the behavioural differences between the sexes that were immediately obvious, we were usually able to distinguish between them.

Before the nestling stage we recorded the birds' activities in diary form, covering 12 h 25 min of observation during the early incubation stage and 8 h 23 min during the middle incubation stage.

During the nestling stage we tried to cover the twelve hours of daylight evenly, mostly between 0600 and 1800, but with two hours of observation before 0600 and six hours after 1800. Observations during the nestling stage were made over 38 consecutive days in 48 sessions ranging from 70 min to 12 h 40 min, average 5 h 43 min, at an average of 7 h 14 min per day. Total observation time during the nestling stage was 274 h 40 min. On five days (Days 6, 13, 20, 27, 35) we observed the nest continuously from before dawn until after sunset. All observations were recorded in a field notebook, using Eastern Standard Time throughout. Discrete and usually brief events were generally not timed and are excluded from Tables 1 and 2, including prey deliveries and transfers, reactions to intruders, and the frequent short flights from and a quick return to a perch. Most periods of inactivity in Tables 1 and 2 were punctuated, sometimes frequently, by these activities.

We numbered each day of the nestling period, from the first day of our nestling period observations, 8 September (Day 1) up to the last day of our observations on 14 October (Day 38). As the young falcons hatched on or very close to 7 September, the Day number approximates the age of the nestlings in days.

We recorded the falcons' activities, including calls. We recorded prey deliveries to the nest tree and nest, which birds participated and how, and the fate of the prey item; we identified the prey item when possible. In a few cases a prey delivery was inferred from the behaviour of the falcons. Identification of prey was by observation only: we collected no pellets or remains from beneath the nest tree. We recorded each interaction between the falcons and other species and the nature of the encounter.

We compiled a daily list of all bird species observed in the immediate vicinity of the nest site during the nestling stage (Appendix 1).

The earth tank near the nest tree (henceforth 'the dam') was built for livestock, contained water, and was well used throughout the day by Cockatiel, *Nymphicus hollandicus,* Budgerigars, *Melopsittacus undulatus,* Zebra Finches, *Taeniopygia guttata,* and other species. It is built in a well-treed, generally north-south drainage line, with sparse tree cover to the west and bare gibber plain to the east.

RESULTS

The nest was about 2 m from the top of an emergent Coolibah, *Eucalyptus coolabah,* about 20 m tall and 30 m from the water of the dam (Figures 1, 2). As falcons do not build nests, it is likely that the nest was built by Australian Ravens, *Corvus coronoides,* the common corvid in Bladensburg National Park.

Except for one ambiguous prey transfer that may have occurred in an adjacent, lower tree, and for one probable aerial transfer, all manipulations of prey observed by us took place on perches in the nest tree and always on perches in the top one-third of the tree.

The falcons spent much time loafing on perches in the nest tree. The male roosted on a perch in the nest tree (while the female roosted on the nest). There was one exposed branch emergent at the top of the nest tree (Figure 1) about 2 m above the nest, this perch being much used by both birds for perching and prey transfers, and many defensive attacks or other flights were launched from it. The male commonly moved here first thing in the morning to loaf and preen in the sun for up to two hours while the female continued to brood on the nest.

Once during the nestling period the male left the nest tree and landed on the stony ground 100 m or so to the east where he spent several minutes

Figure 1. The nest tree from across the dam. The nest is about 2 m below and to the right of the bird perched on the exposed branch at the top of the tree. Image Shane Hume

Figure 2. The nest tree (centre of photo) from the east Image Shane Hume

and pecked at the ground, possibly collecting 'rangle' (small stones to aid digestion).

During the nestling period the weather hardly varied from clear, sunny days with warm–hot temperatures. The long-term average maximum temperature at nearby Winton is 31°C for September and 35°C for October.

Incubation

2 August. At 0815 the pair perched together on an exposed branch of the nest tree. The male took off, flew a circuit of the tree, landed on the female and copulated, quickly and without ceremony. The male left and at the dam caught a Budgerigar which he gave to the female, which plucked and ate the prey then moved onto the nest. At 1710, with the female on the nest, the male brought in an unidentified prey item which he plucked and ate. At 1735 a Black Falcon, *Falco subniger,* flew past the nest tree below the level of the nest but was ignored by the perched male, except that he reversed direction on the perch to watch the intruder depart; a Brown Goshawk, *Accipiter fasciatus,* perched quietly in a leafy tree beside the dam was ignored.

3 August. At 0850 the male arrived at the nest tree carrying a Budgerigar which he plucked and ate. Both falcons flew out to harass a passing Whistling Kite, *Haliastur sphenurus,* before returning and perching together. At 0905 copulation occurred then the male departed. At 0910, at the dam, the male caught a Budgerigar which he plucked and partly ate in the nest tree before giving the remains to the female. A Black Kite, *Milvus migrans,* passing the nest tree at about nest height was ignored. At 1545 the female was sitting tightly on the nest and the male was absent.

4 August. The female sat tight on the nest for 1 h 30 min from 0740 as the male was flying about the dam and stooping, apparently without making a capture. At 1530 the female was sitting tightly on the nest.

5 August. At 0755, at the dam, the male caught a Budgerigar and ate it in the nest tree. The male ignored an Australian Hobby, *Falco longipennis*, passing 50 m from the nest tree. At 0840, at the dam, the male caught another Budgerigar which he partly plucked before giving it to the female at the nest; she ate it at a nearby perch. At 0905 a Wedge-tailed Eagle, *Aquila audax*, flying high over the nest tree was watched by the falcons but not approached but later, at 0948, a passing eagle was twice stooped at by the high-soaring male falcon. At 1000 the female was tightly on the nest. From 1655 to 1735 the female remained tightly on the nest.

6 August. From 0700 to 0800 the male perched at the top of the nest tree while the female remained tightly on the nest.

18 August. The female remained on the nest. The male loafed at the top of the nest tree for >1.5 h from before 0730, preening, before departing. At 1613 the male arrived at the nest tree grasping a Budgerigar which he plucked and ate. At 1658 the male arrived with another Budgerigar which he began to pluck, but paused for 41 min (perhaps because the observer was too close to the nest) before eating the prey.

19 August. The female spent most of the time on the nest. Again the male loafed in the sun, preening until 0900, before departing. At 1038 the female left the nest and the pair spent several minutes perched close together at the top of the nest tree before she returned to the nest.

If the eggs were laid over the two days on which we observed copulation, 2 and 3 August, and if they hatched on or very close to 7 September, then the duration of incubation was, or was close to, 34–35 days. Only the female was observed incubating.

The observations for 18–19 August were made by C. Martinez (pers. comm.).

Nestling stage

Activity budgets of adults

The female closely attended the nest, but her nest attendance decreased after Week 2, with a corresponding increase in maternal perching and absence (Table 1). From Day 1 to Day 17 the young were brooded closely by the female for most of the day. On Day 17 she left the nest unattended several times for up to 30 min, and on Day 18 she was off the nest for 7 h except when feeding the young; on this day she spent most of the time perched in the nest tree. On Day 20 she was not brooding at 0555, although she was perched on the nest, suggesting that she may not have brooded throughout the night. We never recorded the male brooding.

Exemplifying the close attendance at the nest by the female in the early nestling period, on Days 6 and 13 she spent almost the whole time at or settled on the nest (Table 2). Later in the period she spent much time perching away from the nest, including extended periods away from the nest tree. The male by contrast spent most of his time perching in the nest tree, mostly at the start of each day, or, especially, away from the tree (Tables 1 and 2). We have no information on what the falcons did or where they were during these sometimes extended absences.

The male was sometimes a very slow starter to the day. On Day 5 he first appeared at 0615. He spent most of the next 115 min preening and apparently relaxing on various perches in the nest tree, but he also made several short flights out from the nest tree and returned. Several times he briefly and half-heartedly harassed intruders. He three times feinted at Budgerigars at the dam, without urgency nor apparently real hunting intent. At 0810 he left and flew purposefully away; at 0834 he was making what appeared to be serious stoops at the Budgerigars at the dam.

On Day 10 his first movement away from the nest tree was at 0801. On Day 13 he did not leave his roost perch until 0633, 17 min after dawn, and

Table 1. Activity budgets (in minutes) of adult Grey Falcons over five weeks during the nestling period. Percentages are rounded.

	Activity	Week 1	Week 2	Week 3	Week 4	Week 5	Total
Day numbers		1-7	8-14	15-21	22-28	29-35	1-35
Observation time (min)		3715	3720	2960	3305	2310	16010
Male	Perching (1)	1130	722	375	520	725	3472
		30.4%	19.4%	12.7%	15.7%	31.4%	21.7%
	At nest (2)	61	45	56	20	194	376
		1.6%	1.2%	1.9%	0.6%	8.4%	2.3%
	Away from nest tree (3)	2355	2563	2284	2660	1343	11205
		63.4%	68.9%	77.2%	80.5%	58.1%	70.0%
	Unclear (4)	169	390	245	105	48	957
		4.5%	10.5%	8.3%	3.2%	2.1%	6.0%
Female	Perching (1)	19	15	1318	557	656	2565
		0.5%	0.4%	44.5%	16.9%	28.4%	16.0%
	At nest (2)	3648	3536	1359	1426	822	10791
		98.2%	95.1%	45.9%	43.1%	35.6%	67.4%
	Away from nest tree (3)	22	108	129	1322	698	2279
		0.6%	2.9%	4.4%	40.0%	30.2%	14.2%
	Unclear (4)	26	61	154	0	134	375
		0.6%	1.6%	5.2%	0%	5.8%	2.3%

Table 2. Activity budgets (in minutes) of adult Grey Falcons on five full days of observation during the nestling period.

	Activity	Day 6	Day 13	Day 20	Day 27	Day 35
Total observation time (minutes)		735	745	750	760	755
Male	Perching (1)	163	147	168	94	195
	At nest (2)	0	6	0	0	43
	Away from nest tree (3)	572	592	442	644	577
	Unclear (4)	0	0	140	22	0
Female	Perching (1)	7	10	495	87	240
	At nest (2)	728	713	123	178	245
	Away from nest tree (3)	0	12	132	495	191
	Unclear (4)	0	10	0	0	79

Notes: (1) Perching in the nest tree but away from the nest; see text for further discussion. For the male this was mostly at the beginning of the day.
(2) Includes brooding young and perching on the nest.
(3) Bird out of sight of the observer and activities not described.
(4) Whereabouts of bird unclear, active participants ambiguous, etc.

did not leave the nest tree until 0801, returning with the first prey item of the day at 0900. On Day 20 he remained at his roost until 0644, 36 min after dawn, and did not become active until 0740 after perching and dozing for a further 56 min. In an unusual variation, on Day 12 he was active from 0630 and brought in the first prey item of the day at 0658.

Roosting

Early in the nestling stage the female certainly spent the night at the nest, either tightly brooding the young or perched on the rim of the nest. The male roosted on a branch of the nest tree, but more within a leafy part of the tree than were most of his daytime perches. He may have spent one night on the exposed high perch at the top of the nest tree.

Diet and feeding

Prey capture

Most prey items were captured away from the nest tree and out of our sight. In a few cases the capture was at the dam. Sometimes the male simply emerged from the vicinity of the dam carrying prey, or the capture followed a fast stoop, which happened so quickly it was often unclear whether he had made a capture until he rose from the dam with prey. Sometimes he made a fast turn at the bottom of the stoop, to return to take a victim apparently unsettled by the stoop.

Once, both falcons together chased an unidentified bird east of the nest tree, but if this was a hunting manoeuvre it was unsuccessful.

Prey species

We observed 158 prey items brought to the nest tree during the nestling period (Table 3). Most were identifiable as birds, of which by far the commonest was Budgerigar, probably around 50% of all prey captures. After about Day 21 it became difficult to identify prey items because the male largely stopped transferring prey on exposed perches, and prey was mostly taken straight to the nest.

Parental feeding behaviour

In the first three days of the nestling period all observed prey deliveries by the male were taken straight to the female on the nest. This pattern became less frequent through the nestling period,

Table 3. Identity of prey items delivered to the nest tree over 38 days of observation during the nestling period.

	Days 1-20		Days 21-38	Whole period (Days 1-38)	
Species	Count	%	Count	Count	%
Budgerigar	43	40	5	48	30
Unidentified	41	38	38	79	50
Unidentified, not Budgerigar	20	19	5	25	16
Woodswallow sp.	2	2	1	3	2
Rainbow Bee-eater	1	1	0	1	<1
Willy Wagtail	1	1	0	1	<1
Fairy Martin			1	1	<1
Total prey items	108		50	158	
Total hours of observation	169		106	275	
Hours of observation per prey item	1.6		2.1	1.7	

Table 4. Gender roles in processing prey items brought to the nest tree.

Brought in by	Days 1-3	Days 4-20	Days 21-38	Total	
Male, given to female	0	57	9	66	42%
Male, straight to nest	11	20	12	43	27%
Female, straight to nest	0	9	23	32	20%
Male, eaten by him	1	2	2	5	3%
Circumstances unclear	0	0	0	12	8%
Total prey deliveries				158	

as the female took an increased role away from the nest and nest tree (Table 4).

Prey items brought to the nest tree by the male and transferred to the female occurred in 66 or 42% of 158 prey deliveries. This pattern was common in the middle part of the nestling period, but declined as the female roamed more widely later in the period (Table 4). The transfer took place on a perch in the nest tree when the female snatched the prey from the male's foot with her beak, then took the prey (in her foot) to the nest where she fed the young. Frequently, she circuited the nest tree once or twice, carrying the prey item, before going to the nest, perhaps as a territorial advertising display. Once, the transfer probably took place while the birds were in flight and once probably in a tree adjacent to the nest tree. Especially early in the nestling period, when she was tightly tied to the vicinity of the nest, the female saw the male approaching, or otherwise anticipated his arrival, and flew to meet him as he arrived in the nest tree. The gender roles were clear and the female was obviously dominant: he was almost always unresisting as she took the prey. Prey items brought to the nest tree by the female and carried straight to the nest became increasingly common as the nestling period progressed and the female roamed further afield (Table 4).

A few prey items were wholly eaten by the male, which seemed particularly to relish the guts of Budgerigars, which were often eaten first. Once, on Day 26, he refused to give the prey item to the female as she approached him; he changed perches by a metre or two several times to evade her lunges at the prey. She gave up and perched nearby watching as he ate the entire prey item.

Frequently, the prey item brought to the nest tree was partly or fully plucked and often partly eaten. Often the male ate part of the item after he arrived at the nest tree, before the item was taken by the female for the nestlings or carried to the nest by the male. Once, the male partly plucked a prey item in flight.

We could not unequivocally attribute any prey-capture to the female. In each of the 23 times when the female brought prey to the nest, the prey could have been captured by the male and then transferred to the female while they were out of our sight. In the second half of the nestling period, both commonly arrived at the nest tree, the female carrying a prey item and the male apparently guarding her return after a transfer.

The nestlings were fed exclusively by the female, except once on each of Days 12, 14 and 15 when they were fed by the male. On Day 12 the male began to feed the nestlings until the food item was taken by the female which continued feeding the young; on Day 14 the male took a prey item to the nest and fed most of it to the young, watched for part of the time by the female perched on the nest rim. On Day 15 the female was at the nest while the male fed the young until the prey item was consumed. Late in the nestling stage, on Day 36, the male delivered a prey item straight to the nest and dropped it there for the young while he perched on the nest and the female perched nearby.

Table 5. Provision of prey items to the nest tree, by hour of day

Hour	0500-0559	0600-0659	0700-0759	0800-0859	0900-0959	1000-1059	1100-1159	1200-1259	1300-1359	1400-1459	1500-1559	1600-1659	1700-1759	1800-1859
Hours of observation (to nearest hour)	2	16	19	23	26	26	20	18	24	28	27	22	21	6
Delivery of prey items to the nest tree by hour of day														
Number of prey items		1	5	17	20	22	18	15	8	16	15	12	7	2
Hours of observation per prey item		16	3.8	1.4	1.3	1.2	1.1	1.2	3.0	1.8	1.8	1.8	3.0	3.0
Prey items per hour of observation		<0.1	0.3	0.7	0.8	0.8	0.9	0.8	0.3	0.6	0.8	0.5	0.3	0.3
Timing of deliveries of prey items to the nest tree during five full days of observation														
Day 6				• •	•		•	•	•			•	•	
Day 13				•		•		•		•	•	•	•	
Day 20				•	•			•		•	•	•		
Day 27			•		•		• •	•						
Day 35				•	•		•		•			•		

Prey delivery rate

The 158 prey items delivered to the nest tree in 274.7 h of observation were at an average rate of one item per 104 min (0.58 item/h). The rate was slightly slower later in the nestling period: 102 items delivered in 155.7 h on Days 1 to 19 was at an average rate of one item per 92 min (0.66 item/h); 56 items delivered in 119 h on Days 20–38 was at an average rate of one item every 128 min (0.47 item/h). Prey delivery throughout the day was erratic: sometimes the young were fed at short intervals such as at 1416, 1444 and 1506 on Day 5, at 0810 and 0815 on Day 6, at 1143 and 1149 on Day 7, at 0837 and 0845 on Day 16, and at 1150, 1200 and 1221 on Day 23; conversely, the young often went unfed for three or four hours at a time, but longer periods without were rare.

On Day 21 the nestlings were not fed from 1335 when observation started until the birds went to roost, then the first feed the next morning, Day 22, was not until 0935. The first feed of the day was sometimes very early, at 0658 on Day 12 and at 0710 on Day 17, but was sometimes several hours after dawn, for example at 1031 on Day 5 and at 0953 on Day 8. The last feed of the day was sometimes early in the afternoon, for example at 1420 on Day 8 and at 1207 on Day 27, but was sometimes late in the day such as at 1807 on Day 9 and after sunset at 1827 on Day 19.

During the five days of unbroken watch of the nest, Days 6, 13, 20, 27 and 35, the young were supplied with eight, seven, six, five and five prey items respectively (some of which were full carcases and some of which were a partly eaten carcase): a total of 31 items in 60 hours of daylight, an average rate of one item per 116 min (0.52 item/h). Overall, prey was delivered throughout the day, particularly mid-morning to midday and in mid-afternoon, but seldom before 0700 (Table 5).

Vocalisations

We distinguished three categories of calls given by the falcons in the nestling period. Names of calls follow Marchant and Higgins (1993), and sonograms of the first two types are provided by Baylis, van Gessel and Debus (2015).

1. *Cackle*. A multi-syllable, measured call of varying length and urgency: *kek-kek-kek-…* given by both sexes in several different circumstances (Table 6). The male frequently, but not always, cackled as he approached and arrived at the nest tree with a prey item. We recorded this 15 times. The male often gave this call when he first left his roosting perch and moved to his more exposed 'morning perch' and he sometimes also did so as he moved to roost at the end of the day. The cackle was given by one or both falcons when an intruder came near the nest tree: sometimes the call was the only response, whereas at other times the falcon(s) called and flew to challenge the intruder. On one occasion an approach by us

Table 6. Fifty-one instances of the use of the cackle call by nesting Grey Falcons

Circumstance	Caller		
	Male	Female	Uncertain
Male arrives at nest tree with prey	15		1
Male arrives at nest without prey	2		
Male moves from roosting perch first thing in the morning	7		
Male goes to roosting perch last thing at night	2		
Female approaches male to receive a prey item		2	
Acknowledging a passing intruder with or without flying to intercept	4	6	8
Departing from nest tree		3	
Unspecified from nest tree			1

(thinking both adults were elsewhere) elicited this call from within the nest tree.

2. *Begging Whine*. A single plaintive syllable but sometimes oft-repeated call; hoarse and varying in intensity and pitch, at times grading into an excited high-pitched whistle and sometimes persistent. We did not record the male using this call, but noted 47 occasions when the female whined when receiving or anticipating a prey item from the male as he arrived at the nest tree or nest. She also used the whine seemingly to encourage the male to provide food and from about Day 20 she whined intermittently but persistently for up to two hours at the start of the day, sometimes while the male was still perching and preening and clearly not yet ready to hunt. Sometimes she approached the perched male and whined directly into his face. She also sometimes whined in the same way towards the end of the day. During these extended bouts early or late in the day the calling rose in intensity in response to movement by the male. What sounded to us like the same call was given by the nestlings, first heard faintly on Day 21 and consistently from then on as the call gained in strength and loudness, although it never reached the loudness of the female's version.

3. *Cluck*. A single syllable given intermittently by the female as she fed the young at the nest, and possibly also, rarely, by the male. We recorded the cluck at least 21 times as the female fed the young and once as she moved to take a prey item from the male. Once it was probable that the male used the cluck during one of the few times he fed the young, and once he may have used it as he arrived near the nest with prey, but use of this call by the male remains to be confirmed. We noted the cluck from Day 2, but its use declined and it was uncommon by Day 15 and not heard at all after Day 17.

Development of nestlings

Up to Day 5 the young were obviously very small, but on that day the top of a nestling's head was visible above the rim of the nest from our vantage point; by Day 12 the whole heads of two nestlings were visible.

On Day 13 we first observed a nestling exercising its wings and by Day 18 both were vigorously scrambling about the nest and pecking at prey items. On Day 22 they were sitting up grabbing at food and perching high on the rim of the nest; they were also gulping larger pieces of food. By Day 26 they were perching tall on the rim of the nest, stretching and vigorously flapping their noticeably long wings. On Day 33 there was more vigorous wing flapping although they were down in the nest on this hot day. At about Day 21, at first faintly they were using the begging whine; from then on they called frequently.

There was little or no conflict between the young for food, and each appeared to receive a share at feeding times. On Day 36 we recorded for the first time the nestlings feeding themselves when the male brought a prey item and simply dropped it onto the nest; he remained on the nest rim while the young tore at the food. The female made no attempt to involve herself and did not leave her high perch.

On Day 30 the nestlings had short feathered tails, and by about Day 32 they looked close to adult sized and had changed from downy white nestlings to predominantly grey-plumaged, although with recognisable juvenile streaking on the breast. The two differed noticeably in size.

On Day 24, the hottest day they had experienced so far, and on Day 25, the young pushed head first under the breast of the female perched on the nest rim as if seeking shelter from the hot sun.

Both nestlings fledged, and were seen in the vicinity of the nest tree in the company of the adults for several weeks thereafter (S. and S. Cupitt and A. Hartley pers. comm.). The time to fledging somewhat exceeded our observation period of 38 days.

Relations with other species

We observed 58 incidents during the nestling period when the falcons reacted (35 times), or appeared not to react (23 times), to the presence of intruders in or near the nest tree (Table 7). When the birds reacted, the action varied from a cackle call only (which appeared to be directed at, or in response to, the intruder) to watching the intruder by turning the head, to direct harassment such as flying to intercept the intruder or, rarely, strong stoops at the intruder. Most actions were rated by us as mild and on only five occasions was there anything approaching a vigorous reaction.

Galahs, *Eolophus roseicapillus,* Little Corellas, *Cacatua sanguinea,* and Apostlebirds, *Struthidea cinerea,* were often present in and about the nest tree and have not been classified as 'intruders' here. Their presence was usually tolerated, but 23 times they were harassed by the falcons although none of the 'attacks' was anything more than mild in intensity. A group of Apostlebirds passing through the nest tree sometimes appeared to react to the female falcon on the nest. On Day 8 they gathered close to the nest, actively bouncing about and calling, and one flew close to the brooding bird and may even have struck her, but apart from twisting her head to keep an eye on the interlopers she remained impassive on the nest.

Table 7. Responses of Grey Falcons to intruders in and near the nest tree

Intruder species	Number of interactions	No reaction
Australian Pelican	1	
White-necked Heron	4	
Whistling Kite	4	5
Black Kite	15	7
Brown Goshawk	2	1
Collared Sparrowhawk	1	2
Wedge-tailed Eagle	4	1
Nankeen Kestrel		3
Brown Falcon		2
Black Falcon	2	1
Peregrine Falcon	1	
Pied Butcherbird		1
Australian Raven	1	

Some species were routinely ignored, including Zebra Finches nesting in the base of the falcons' nest, and White-plumed Honeyeaters, *Lichenostomus penicillatus,* active in the foliage near the nest. While on his exposed perch at the top of the nest tree the male falcon was sometimes dive-bombed by White-breasted Woodswallows, *Artamus leucorhynchus,* causing him to flinch.

On Day 17, a passing Peregrine Falcon, *Falco peregrinus,* swooped towards the male Grey Falcon perched at the top of the nest tree, and although they interacted briefly the Grey Falcon did not leave his perch and the Peregrine moved on. On Day 6 the male falcon interacted with a Collared Sparrowhawk, *Accipiter cirrocephalus,* at the dam and, in the ensuing mêlée, the falcon appeared to end up being chased by the sparrowhawk.

DISCUSSION

Breeding biology and behaviour

The nest location was typical for Grey Falcons, near water or a dry watercourse and near the top of the tallest tree in the area (Marchant and Higgins 1993; Falkenberg 2011; Sutton 2011; Watson 2011; Janse *et al.* 2015). More recently, microwave repeater towers have become a favoured location (Schoenjahn 2013).

Information on the pre-laying period (nest selection, courtship/mating) is limited (see Watson 2011), although White and Warrener (2016) confirmed courtship feeding associated with copulation by Grey Falcons. We were not present in the pre-laying phase, but the male supplied food to the female during the laying phase while copulation was still occurring.

Both adult falcons apparently always roosted in the nest tree during the nestling period, our observations suggesting that the male always returned for the night. However, Schoenjahn (2011b) observed that both parents were probably away from one nest and indeed from the tower on which the nest was located for the entire night when the nestlings were about 10 days old.

Adult behaviour (e.g. gender roles, prey deliveries) in the incubation period was similar to that in previous accounts, although other pairs have perch trees (e.g. dead trees if available) near the nest tree, and some males share incubation (cf. Cupper and Cupper 1980, 1981; Hollands 1984; Falkenberg 2011; Watson 2011). Our quantified account of parental time budgets and behaviour in the nestling period confirms and substantially enlarges on previous anecdotal accounts, although some males share brooding of chicks and some females hunt prey for the growing nestlings (cf. Cupper and Cupper 1980, 1981; Hollands 1984; Falkenberg 2011). Thus, with these few minor individual differences, our behavioural observations seem typical for the Grey Falcon, so far as can be ascertained.

An incubation period of 34–35 days confirms the estimate of about 35 days of Marchant and Higgins (1993) and Sutton (2011), and is consistent with 33 days for the Peregrine Falcon and 34 days for the Black Falcon (Marchant and Higgins 1993). Our nestling period of more than 38 days is consistent with a previous estimate of 41 days or greater for the Grey Falcon, and similar to that of the Peregrine Falcon of 39 days or more and the Black Falcon of 38–40 days (Marchant and Higgins 1993) or 42–43 days (Charley, Lutter and Debus 2014).

Diet and feeding

Our finding of 30%, and perhaps up to 50%, Budgerigar in the falcons' breeding diet agrees with prior studies that found a moderate to high frequency of Budgerigar (Aumann 2001; Falkenberg 2011; Sutton 2011; Watson 2011; Schoenjahn 2013; Janse *et al.* 2015). Those studies were mostly based on analysis of pellets, so have a higher prey identification rate (albeit with smaller sample sizes). Budgerigars were among several potential prey species (e.g. pigeons, doves, other parrots, finches) seen daily or almost so around the falcons' nest site (Appendix 1), but we have no data on their relative abundance. The prey data suggest that the falcons preferentially took Budgerigars. Furthermore, Budgerigar abundance may have been low at the time, given the drought conditions in the area.

The Grey Falcon is almost exclusively a bird eater, and among the extensive list of prey species are larger species than we observed, such as Crested Pigeons, *Ocyphaps lophotes,* Galahs, medium-sized parrots (Blue Bonnets, *Northiella haematogaster*, Australian Ringnecks, *Barnardius zonarius,* Red-winged Parrots, *Aprosmictus erythropterus*) and Cockatiel (Marchant and Higgins 1993; Falkenberg 2011; Sutton 2011; Schoenjahn 2013; Janse *et al.* 2015). We did not confirm prey larger than about woodswallow size, nor any Cockatiel. We should have recognised Cockatiel prey by their long wing and tail feathers, but many incomplete items (plucked and partly eaten elsewhere) brought to the nest tree could have included some of these larger species.

In our study the male Grey Falcon provided the food and the female fed the nestlings and herself, with few exceptions. In Black Falcons (Charley, Lutter and Debus 2014) and Peregrine Falcons (Turner, Lawrence and Czechura 1993) the roles were more equal and the males took a greater part in feeding the young, although Turner, Lawrence and Czechura (1993) noted a difference in the contribution by the male at the same nest in different years. In the genus *Falco* generally, the male's role in directly feeding the young may vary from nest to nest (Cade 1982).

Hollands (1984) noted that the male of one pair seemed to handle food provision with ease and

noted, like us, the male's relaxed start to the day and the extended periods when he was absent. It seemed to us that the male could leave and catch a prey item almost at will. There are no data with which to compare parental feeding rates in the Grey Falcon, other than the anecdotal report of Hollands (1984) that a male brought two items per day during incubation and six per day to chicks. The feeding rate in our pair was within the range recorded for the Black Falcon (0.3–0.7 item/h to nestlings: Charley, Lutter and Debus. 2014).

We saw no indication that the falcons were caching food, a practice which may be universal in the genus *Falco* (Cade 1984) and has been documented in Australia at least for the Black Falcon (Charley, Lutter and Debus 2014) and the Peregrine Falcon (Turner, Lawrence and Czechura 1993).

Vocalisations

We never heard the male falcon scream as he approached the nest, nor gurgling cries from the female as she flew to meet him, nor screaming by both as they interacted near the nest, as described by Hollands (1984). We did not hear a 'whinnying' type of call ('distress chitter') as described by Watson (2011) when a Grey Falcon was harassed in flight by an Australian Hobby. A 'guttural double cluck' described as a 'harsh, scolding, coughing noise' is also unfamiliar to us but may be associated with the incubation stage, which is when Watson (2011) heard it; Falkenberg (2011) also noted a double cluck given by nesting Grey Falcons.

The cackle is equivalent to the Peregrine's chatter described by Marchant and Higgins (1993), and designated the greeting call by Baylis, van Gessel and Debus (2015). There are many descriptions of this call and its variants; for example, Charley, Lutter and Debus (2014) referring to the calls of the Black Falcon, and the Grey Falcon's 'hoarse chatter' described by Cupper and Cupper (1980).

The whine is overwhelming a call of the female Grey Falcon. The widely-used designation of wail for this call seems inapt, given that it lacks mournfulness but rather is demanding, peevish and complaining. Cade (1982) referred to the whine as a 'food-begging wail' that resembles the begging of a juvenile and stimulates the male to hunt and return with prey. The nestlings may use this call as early as 7–10 days old (Cade 1982) when it would have been too faint for us to hear from our observation point.

The cluck is appropriately referred to as 'maternal' by Falkenberg (2011) (although his word is 'chup') as it was mostly used by the female and associated with feeding the young when they were small. Cade (1982) described this as a food presentation call which stimulates the young to gape, consistent with its cessation by the time the young were approaching three weeks old and needing little prompting to accept food. We did not hear the 'double cluck' referred to by Cupper and Cupper (1980) and others as used by Grey Falcons, and by Debus and Tsang (2011) and Charley, Lutter and Debus (2014) for the Black Falcon, that being the 'creaking call' or 'ee-chip' of Cade (1982) typical of the nest-selection and pre-laying phase and some aggressive contexts, and used by both sexes.

Relations with other species

Although Grey Falcons can be 'very aggressive' towards other raptors, especially near the nest (Marchant and Higgins 1993; Falkenberg 2011), we saw scant evidence of this and our birds were mostly little excited by intruders, including other raptors. Vigorous responses were uncommon and not obviously related to the distance from the nest tree of an intruder. Schoenjahn (2013) observed many instances where other raptors were tolerated near Grey Falcons' nests, including extended bouts of perching by other species near the nests; in one case a pair of Nankeen Kestrels, *Falco cenchroides*, nested on the same repeater tower as an active Grey Falcons' nest. Black Falcons had a similar

range of reactions to other species near their nests and appeared to ignore at least some intruders (Charley, Lutter and Debus 2014).

Related *Falco* species

In its breeding behaviour the Grey Falcon resembles other large falcons in Australia such as, at least during the nestling period, the Black Falcon (Charley, Lutter and Debus 2014) and the Peregrine Falcon (Turner, Lawrence and Czechura 1993), including: food provision largely by the male; the dedicated nest attendance by the female, especially in the early nestling phase; and the rather mild interactions and treatment of intruders near the nest. All three species are predominantly bird eaters, a practice which is most highly developed in the Grey and Peregrine Falcons. Within the limits imposed by terminology, the calls are alike and those of the Grey Falcon are sometimes described as being similar to those of the Peregrine.

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REFERENCES

Aumann, T. 2001. An intraspecific and interspecific comparison of raptor diets in the south-west of the Northern Territory, Australia. *Wildlife Research* 28: 379–393.

Baylis, T., van Gessel, F.W. and Debus, S.J.S. 2015. Some vocalisations of the Grey Falcon *Falco hypoleucos*. *Corella* 39: 73–76.

Cade, T.J. 1982. *The Falcons of the World.* Collins, London.

Charley, D., Lutter, H. and Debus, S.J.S. 2014. Breeding behaviour and prey of Black Falcons, *Falco subniger,* including food-caching. *South Australian Ornithologist* 40: 11-30.

Cupper, J. and Cupper, L. 1980. Nesting of the Grey Falcon *Falco hypoleucos*. *Australian Bird Watcher* 8, 212–219.

Cupper, J. and Cupper, L. 1981. *Hawks in Focus: A Study of Australia's Birds of Prey*. Jaclin, Mildura.

Debus, S.J.S. and Tsang, L.R. 2014. Notes on Black Falcons *Falco subniger* breeding near Tamworth, New South Wales. *Australian Field Ornithology* 28: 13–26.

Falkenberg, I.D. 2011. Aspects of the ecology of the Grey Falcon *Falco hypoleucos* in the South Australian arid zone. *Corella* 35: 23–28.

Garnett, S., Szabo, J. and Dutson, G. 2011. *The Action Plan for Australian Birds 2010*. CSIRO Publishing, Melbourne.

Hollands, D. 1984. *Eagles, Hawks and Falcons of Australia.* Nelson, Melbourne.

Janse, I., Kloecker, U., Roshier. D. & Witte, I. 2015. Breeding diet and behaviour of a pair of Grey Falcons *Falco hypoleucos* and their offspring in north-western New South Wales. *Corella* 39: 46–51.

Ley, A.J., Tynan, B. and Cameron, M. 2011. Birds in Diamantina National Park, Queensland. *Australian Field Ornithology* 28, supplement.

Marchant, S. and Higgins P.J. 1993. *Handbook of Australian, New Zealand and Antarctic Birds. Volume 2, Raptors to Lapwings*. Oxford University Press, Melbourne.

Schoenjahn, J. 2011a. Morphometric data from recent specimens and live individuals of the Grey Falcon *Falco hypoleucos*. *Corella* 35: 16–22.

Schoenjahn, J. 2011b. Grey Falcon 10-day-old young left alone for the night. *Boobook* 29: 15.

Schoenjahn, J. 2012. Nesting near Grey Falcons: mutually beneficial? *Boobook* 30: 14–15.

Schoenjahn, J. 2013. A hot environment and one type of prey: investigating why the Grey Falcon (*Falco hypoleucos*) is Australia's rarest falcon. *Emu* 113: 19–25.

Sutton, A.J.G. 2011. Aspects of the biology of the Grey Falcon *Falco hypoleucos* in the Pilbara region of Western Australia. *Corella* 35: 11–15.

Turner, L., Lawrence, P. and Czechura, G. 1993. Contributions to the natural history of Australian Peregrine Falcons *Falco peregrinus macropus*: behaviour at two Victorian nests. *Australian Bird Watcher* 15: 3–12.

Watson, C. 2011. A failed breeding attempt by the Grey Falcon *Falco hypoleucos* near Alice Springs, Northern Territory. *Australian Field Ornithology* 28, 167-179.

White, L. and Warrener, T. 2016. Courtship feeding and mating in the Grey Falcon, *Falco hypoleucos. South Australian Ornithologist* 41: 71-72.

Appendix 1

The bird community at the dam near the nest tree: species recorded during the Grey Falcon nestling stage, with the number of days on which the species was recorded of a possible 38 (i.e. frequency of observation); b = breeding.

Days	Species
22	Emu, *Dromaius novaehollandiae*
37	Crested Pigeon, *Ocyphaps lophotes*
27	Spinifex Pigeon, *Geophaps plumifera*
22	Peaceful Dove, *Geopelia striata*
1	Australasian Darter, *Anhinga novaehollandiae*
2	Australian Pelican, *Pelecanus conspicillatus*
21	White-necked Heron, *Ardea pacifica*
1	Eastern Great Egret, *Ardea modesta*
16	Whistling Kite, *Haliastur sphenurus*
17	Black Kite, *Milvus migrans*
3	Brown Goshawk, *Accipiter fasciatus*
3	Collared Sparrowhawk, *Accipiter cirrocephalus*
12	Wedge-tailed Eagle, *Aquila audax*
3	Nankeen Kestrel, *Falco cenchroides*
2	Brown Falcon, *Falco berigora*
38b	Grey Falcon, *Falco hypoleucos*
2	Black Falcon, *Falco subniger*
1	Peregrine Falcon, *Falco peregrinus*
3	Brolga, *Grus rubicunda*
4	Australian Bustard, *Ardeotis australis*
21b	Black-fronted Dotterel, *Elseyornis melanops*
38	Galah, *Eolophus roseicapillus*
37	Little Corella, *Cacatua sanguinea*
38	Cockatiel, *Nymphicus hollandicus*
1	Australian Ringneck, *Barnardius zonarius*
38	Budgerigar, *Melopsittacus undulatus*
13	Horsfield's Bronze-Cuckoo, *Chalcites basalis*
34	Rainbow Bee-eater, *Merops ornatus*
11	Spotted Bowerbird, *Ptilonorhynchus maculatus*
1	Variegated Fairy-wren, *Malurus lamberti*
1	Red-browed Pardalote, *Pardalotus rubricatus*
2	Singing Honeyeater, *Lichenostomus virescens*
37	White-plumed Honeyeater, *Lichenostomus penicillatus*
5	Yellow-throated Miner, *Manorina flavigula*

Appendix 1 continued

Days	Species
2	Spiny-cheeked Honeyeater, *Acanthagenys rufogularis*
17	Rufous-throated Honeyeater, *Conopophila rufogularis*
1	Crimson Chat, *Epthianura tricolor*
9	Brown Honeyeater, *Lichmera indistincta*
29	Little Friarbird, *Philemon citreogularis*
2	Varied Sittella, *Daphoenositta chrysoptera*
32	Black-faced Cuckoo-shrike, *Coracina novaehollandiae*
9	White-winged Triller, *Lalage sueurii*
23	Grey Shrike-thrush, *Colluricincla harmonica*
36	White-breasted Woodswallow, *Artamus leucorhynchus*
25	Masked Woodswallow, *Artamus personatus*
1	White-browed Woodswallow, *Artamus superciliosus*
5	Black-faced Woodswallow, *Artamus cinereus*
16	Pied Butcherbird, *Cracticus nigrogularis*
20	Australian Magpie, *Cracticus tibicen*
30	Willie Wagtail, *Rhipidura leucophrys*
26	Australian Raven, *Corvus coronoides*
2	Restless Flycatcher, *Myiagra inquieta*
37	Magpie-lark, *Grallina cyanoleuca*
32	Apostlebird, *Struthidea cinerea*
27	Jacky Winter, *Microeca fascinans*
6	Fairy Martin, *Petrochelidon ariel*
36	Mistletoebird, *Dicaeum hirundinaceum*
38b	Zebra Finch, *Taeniopygia guttata*
11	Australasian Pipit, *Anthus novaeseelandiae*

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Note on Grey Falcon research

A rumour has been circulated alleging research-related injury to a Grey Falcon in relation to Jonny Schoenjahn's conservation biology project on the species (www.jonnybird-australia.com/greyfalcon.htm) referred to in the Ley and Tynan paper published here. However, no falcons have been injured by Schoenjahn's project. There was a female falcon that had a slightly drooping wing, on Cotswold Station near Winton (Qld), before she was captured. Examination revealed that the wing was fine, and the falcon was released (banded and unharmed) without a satellite tag, according to Schoenjahn's policy of only tagging birds that are 100% fit. **Stephen Debus**