

Notes on Black Falcons *Falco subniger* Breeding near Tamworth, New South Wales

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Summary

Nest-site selection, diet, prelaying and foraging behaviour of a pair of Black Falcons *Falco subniger* were studied near Tamworth, on the North-west Slopes of New South Wales, during 81 hours' observation in the prelaying period (late June–early September 2010), until the breeding attempt was abandoned (apparently owing mainly to prolonged bad weather, and possibly predation of eggs by corvids). The Falcons' nest-sites, nest-based behaviours (copulation, nest-preparation, defence), vocalisations, and interactions with competing and harassing birds are described. Their vocalisations were most like those of other 'great' or 'desert' falcons (subgenus *Hierofalco*). Prey remains (n = 3) and pellets (n = 18 + fragments) consisted entirely of the remains of common farmland birds. Foraging methods included fast contour hunting over woodland treetops, sometimes in pairs, apparently with sharing of resulting kills. The findings reinforce the importance of riparian and other remnant woodland, with emergent trees, for the Falcon's nest-sites and foraging strategies in farmland.

Introduction

The complete breeding cycle of the Black Falcon *Falco subniger*, from nest-site selection to independence of juveniles, has never been documented. In one previous attempt, the nestlings were already half-grown when found (Debus *et al.* 2005). A further attempt was made in 2010, by locating a pair with an occupied nest during the prelaying phase, and using previous studies on Australian falcons as models for the kinds of detail sought (Nankeen Kestrel *F. cenchroides*: Bollen 1991; Paull 1991; Brown Falcon *F. berigora*: Bollen 1993; McDonald 2004; Australian Hobby *F. longipennis*: Metcalf 1989; Debus *et al.* 1991; Peregrine Falcon *F. peregrinus*: Turner *et al.* 1993; Olsen & Stevenson 1996). Meanwhile, concern has been expressed regarding the Black Falcon's conservation status in the Murray–Darling Basin and eastern sheep–wheat belt (Debus 2009a,b). In the absence of comprehensive research to date in the Falcon's heartland (e.g. South Australia), Debus & Olsen (2011) compiled available unpublished data and reviewed recent anecdotal information. Several anecdotal reports have also appeared recently (Harrison 2010; Courtney 2011).

This paper describes: (i) aspects of the Black Falcon's nest-site selection and prelaying behaviour, hunting behaviour and diet at one nest near Tamworth, New South Wales, until the breeding attempt was abandoned, and (ii) the harassment behaviour of other birds that may have contributed to that outcome. We also present data, obtained from informants retrospectively, on the Falcon population in the area around the time of the earlier study in 2004. The prelaying behaviour and vocalisations of the Falcon have been minimally described, and its mating behaviour is hitherto undescribed.

Field research on the Black Falcon may clarify a taxonomic issue. *Contra* Olsen *et al.* (1989), Marchant & Higgins (1993) and Debus (1998), the Black Falcon is a 'great' or 'desert' falcon (subgenus *Hierofalco*), most closely related to the Laggard Falcon *Falco jugger* of India (Wink *et al.* 2004), and not part of a group of 'Australasian hobbies'. It is thus the Australian equivalent of the Lanner *F. biarmicus*, Saker *F. cherrug* and Laggard Falcons, the last relationship first proposed by J. Olsen (1974, and in Czechura & Debus 1985), although Cade (1982) also recognised the possibility. The Black Falcon's breeding behaviour and vocalisations may throw light on its relationship to the 'great falcons' and closely related Peregrine Falcon (subgenus *Rhynchodon*), versus the hobbies (subgenus *Hyptriorchis*).

Study area and methods

The study area was as described previously (Debus *et al.* 2005; location map in Debus 2008), i.e. agricultural land with remnant woodland in that part of the central Peel Valley and its minor tributaries off the western end of the Tamworth airport, ~10 km west of Tamworth city, with dense quail populations (Brown *Coturnix ypsilophora* and Stubble *C. pectoralis*) and abundant parrots and cockatoos (Psittaciformes). Rabbits *Oryctolagus cuniculus* were scarce, although there was a small population in the grassy road verges ~0.5 km from the subject Falcons' nest.

In 2010, Black Falcons were initially found by observing the nest-site previously studied by Debus *et al.* (2005) (hereafter Nest A), and searching the area by slow driving and on foot within a radius of ~10 km north-west to south-east of Nest A, in May–June. W.S. Clark (pers. comm.) found a different active nest (hereafter Nest B), ~10 km west of the 2004 Nest A, in September 2006, and relayed his own and the landholder's information about it.

Observational methods on the pre-breeding Black Falcons, at their nest-site in 2010 (Nest C), were as previously described for other raptor studies in this series (e.g. Debus *et al.* 2005; Debus 2008), i.e. focal-animal sampling during timed observation periods, by observing the nest with binoculars and telescope from an unconcealed position outside the birds' alert distance (280 m from the nest-site). Observations were conducted for a total of 81 h over 29 days (0.5–11 h per day) during 30 June–2 September while the Falcons were occupying the nest area, spread through all 2-hour blocks of daylight (Table 1), and including overnight on site on five occasions to record dusk and dawn behaviour. Observations, coupled with searching in the wider study area as described above, continued for a further 30 h over 11 days to late October in order to locate the Falcons and a possible alternative nest, with occasional checks thereafter to early December. The Falcons were sexed, when together, by the female's larger size and longer tail, versus the male's more compact shape with wing-tips nearer his tail-tip at rest. They were similar in plumage, including barred crissum, although the female had a buff forehead, and the male appeared to have a darker forehead and less 'scaly' upperparts.

The weather was exceptionally wet, and cold for spring, throughout the entire search and nest-watch period, starting with intermittent rain that sometimes interfered with searches in May and culminating in floods in late July and August, before easing off to less rainy weather in September–October. However, searches and watches were conducted only in dry weather, and aborted when it rained. It also appeared that, after storms in 2005–2009, few Australian Raven *Corvus coronoides* nests in the study area had survived from one year to the next, and those that did in 2009–10 were mostly either reoccupied by breeding Ravens in 2010, or dilapidated. Thus, there may have been a local shortage of potential nest-sites for the Falcons.

Old or weathered pellets ($n = 18$ plus fragments of a further ~5; pellet mass 29 g) and prey remains ($n = 3$ ort samples + feathers) were collected from under the nest-tree, in the Falcons' absence, on three occasions in July and once in early August, representing a May (or earlier) to July dietary accumulation. The area under the nest-tree was also searched in September–October, after the Falcons had ceased attending the nest or roosting in the tree, but no further items could be found. Prey items were identified by comparison with a previous sample (Debus *et al.* 2005) and with material in the Zoology Museum, University of New England.

Table 1

Observation schedule (hours of observation) at Black Falcon Nest C (see text), in prelaying phase, Tamworth (NSW), during each 2-hour interval of daylight. Upper row: while nest(s) being attended (30 June–2 September 2010); lower row: after Falcons no longer attending nest (3 September–24 October 2010).

<0800	0801–1000	1001–1200	1201–1400	1401–1600	>1600
8.5	13.5	11	14.5	17.5	16
7.5	6	6	3.5	3	4

Results and discussion

Falcon population

Active Black Falcon Nest B, with a nestling close to fledging in late September 2006 (W.S. Clark pers. comm.), was 10.5 km west of the 2004 Nest A studied by Debus *et al.* (2005). As the landholder informed Clark that the nest had been used by the Falcons for the previous 6 years, the two nests were thus simultaneously active, giving an inter-nest distance of 10.5 km (the intervening area had been thoroughly searched in 2004). In 2007, Nest B was occupied by breeding Australian Hobbies, and in 2010 it had been rebuilt and was occupied by breeding Australian Ravens; the Falcons could not be found.

In May 2010, a pair of Black Falcons was active (foraging) in the Nest A area; a male was seen hunting in August, but a nest was not found in June–July. Focal Nest C, found in 2010 and apparently of a different pair, was 6.5 km south-south-west of Nest A, and 9.5 km south-east of Nest B (the intervening area had been searched in 2004 and 2010). The Falcons at Nest C in 2010 were thought by the landholder, a bird ‘atlasser’, to have been in the area for some years (G. Blaxland pers. comm.).

The existence of these other nests requires a revision of the distances at which the Nest A male was thought to have been seen from his nest (cf. Debus *et al.* 2005). The sighting at 6 km from Nest A, given the Falcon’s flight-path, may have been the Nest C male 5 km from his 2010 nest area, and the sighting at 12 km from Nest A was probably the Nest B male only 2.5 km from that subsequently found nest.

Nest A fell down in late 2004; was rebuilt and used by Australian Ravens in 2005 (and possibly subsequent years); and was vacant early in the 2010 season, when the Ravens built and used a new nest in a nearby tree. Nest A was occupied by an Australian Hobby in late September 2010.

In May 2009 a pair of Black Falcons soared over woodland tree-clearing operations 4.5 km east of Nest A, from a point at least 4 km north-west of Nest A; they retreated in the direction opposite to Nest A. They thus may have represented a further (fourth?) pair in the central Peel Valley. During the tree-felling, birds (including nocturnal, day-roosting Southern Boobook *Ninox novaeseelandiae* and Tawny Frogmouth *Podargus strigoides*) were repeatedly flushed and forced to alternative shelter, but the Falcons did not attempt any strikes, even on the disoriented night-birds.

In 2010 there was one Brown Falcon pair in the same area as Black Falcon Nest C, at least two other pairs between Nests A and C, at least two pairs between Nest C and a point halfway to Nest B, and at least one pair between Nest A and halfway to Nest B. That is, there were at least six Brown Falcon pairs in about half the area enclosing the three Black Falcon nests, suggesting that the density of Brown Falcons is much greater than that of the Black Falcon in the Peel Valley. There were also four known Australian Hobby pairs (three with confirmed nests) in that same area.

Among other potential competitors for nest-sites, the Wedge-tailed Eagle *Aquila audax* territory around Black Falcon Nest A (Debus *et al.* 2005) appeared to be vacant in 2010, and another Eagle pair was seen once ~1 km from Nest C, in June, but there were no known active Eagle nests near any of the Black Falcon nests. Similarly, although one or two Little Eagles *Hieraetus morphnoides* were occasionally seen near Black Falcon Nests A and C, there was only one known active nest (midway between Nests A and B) in 2010.

Nest-sites

Black Falcon Nest C in 2010 was (in June) the unoccupied 2009 nest of a pair of Australian Ravens, 25 m above ground in the upper canopy of an emergent Yellow Box *Eucalyptus melliodora* (30 m tall, 137 cm diameter at breast height) in a patch of remnant woodland (~4 ha) amid sheep paddocks and crop fields (oats and wheat). The nest-tree was 600 m across paddocks from a eucalypt-lined watercourse. There was an older, deteriorating Raven nest lower in the same tree, on the opposite side, but the Falcons showed no interest in this.

Nest B was also an old Raven nest, in the top of an emergent eucalypt in a woodland patch amid grazing paddocks. All three nest-trees (A–C) had horizontal or near-horizontal bare or dead branches near the nest, often used by the adults as perches, and all three had dead tree(s) nearby, also used by the adults. These three nests had easy (open) access on at least one side, so the adult Falcons could fly directly to the nest-rim.

Nest-selection and prelaying behaviour

Black Falcons investigated potential nests in May. Once, in the late afternoon, the pair at Nest A perched in a mature White Box *E. albens* containing an old Australian Magpie *Cracticus tibicen* nest, under mobbing by Pied Butcherbirds *C. nigrogularis*. The Falcons were not seen to return to this nest subsequently. Also in late afternoon, the Falcons were once observed perching in a mature live Yellow Box (~20 m tall, ~300 m from Nest A, in the same woodland patch) that had a vacant Wedge-tailed Eagle nest about halfway (i.e. ~10 m) up it; they were not seen near it again.

Nest C was found after the female soared up from the nest woodland on 28 May at ~1300 h, circling over the nest patch, and was joined in the air by the approaching male; both then left together on a long glide out of sight.

On 25 June, in the afternoon, the pair perched on a nest-side branch and copulated (Table 2). Before and after copulation, one Falcon uttered several guttural double clucks (hereafter ‘clucking’: the *ee-chip* call of Cade 1982 and Ferguson-Lees & Christie 2001, sounding more like *kuk-chip* and aptly rendered for the Peregrine Falcon as *krk-chuk...krk-chuk* by Jenkins 2009). During copulation,

Table 2

Sequence of events in episodic prelaying phase(s) of a pair of Black Falcons, Tamworth, NSW, June–August 2010 (see text). M = male, F = female.

<i>Date</i>	<i>Time (h)</i>	<i>Behaviour</i>
25/06	1515–1615	Pair perched on branch beside nest. F made brief sortie to take small ground prey and returned to swallow it on nest-branch, M followed in air as if guarding her. From perch, M circled round and landed on F's back as she crouched; copulated for ~5 sec., M flew and circled back to branch. Double clucks (see text) before and after copulation, wail during.
30/06	1600–1700	Last hour to dusk; nest unattended.
01/07	0630	Sunrise; rapid series of double clucks (see text), run together as continuous syllables, from pair's roost-tree in nest patch.
	0845–0925	F flew (from roost), clucking, to nest, via circuit of nest-tree. F sat on nest, turning and scratching with feet as if shaping it, then bill-digging, shuffling, sitting in incubation posture, pulling at sticks. F moved to branch; crouched, clucking, as M landed on her back; copulation for ~5 sec. with wailing calls. Both flew, then with repeated double clucks returned to perches in nest-tree (F beside nest).
	0926–1150	Both absent (F perched in nest woodland?).
	1152–1154	Both returned: F standing on nest, giving double clucks; M on nest-branch.
	1155	Both left on hunting flight for ~1.5 h (see text).
	1323–1330	Returned, with full crops: F stood on nest, M perched in nest-tree.
04/07	~1330	Pair soared together over nest area.
08/07	1655–1750	In half-hour to sunset: F attended nest, foraged briefly (see text), apparently roosted in nest woodland; M perched in nest-tree, moved to branch beside nest.
11/07	1030–1130	M perched conspicuously beside nest, then performed display flight, soaring around nest-tree in continuous figure-8 pattern for ~3 min.
	1140–1200	Conflict with Ravens over nest (see text and Table 3).
	1605–1700	M on nest-branch, F in nest area. [Lapse in nest-watches followed: see text.]
04/08	1655–1755	Last hour to dusk: F perched beside nest, flew quick circuit to nest and settled on it, clucking. M arrived on nest-branch, amid clucking (by F?), while she settled and turned in nest. F moved to branch, clucking and wailing, and bowing before brief, abortive mounting by M. F clucked and wailed while they perched side by side, then crouched (hunched, with feathers fluffed) as if soliciting. M looked uneasy, sidled away. At dusk M left for roost in woodland, F moved to roost-perch next to nest.
05/08	0630–0936	From sunrise: no action until 0931 h, when F approached from across paddocks (i.e. had left nest-side roost unseen, before sunrise) and went to nest, shuffling within. M soared up from night-roost; F moved to branch, then both left for ~1.5 h on hunting flight (see text).

Table 2 continued

<i>Date</i>	<i>Time (h)</i>	<i>Behaviour</i>
05/08	1102–1357	Both returned, having fed (full crops): M to nest-branch, F to nest where she clucked and turned. After perching for 20 min., F left and soared high over nest area until lost to view; M also left and soared after perching for ~3 h.
	1538–1725	Returned after ~2 h: both to nest-branch, M moved to nest-rim as F alighted beside him; M landed on F's back, copulation with wails. M then F left, separately (F on hunting flight: see text), and in hour to sunset did not return.
18/08	1730	Just after sunset, pair landed beside nest, on separate branches. M had full crop; F's crop not obvious, wailing as if begging or soliciting copulation; both left (separately) to roost elsewhere in nest patch. Last sighting at nest.

one (apparently the female) uttered a wailing call (the whine of Marchant & Higgins 1993 and Debus *et al.* 2005). Subsequent observations of copulation and other nest-based activity showed that the female gave most, if not all, of the clucking and wailing calls (Table 2).

The male's display flight at the nest on 11 July (Table 2) may have been elicited by the approach of the resident pair of Ravens, with which conflict ensued over the nest (see p. 20 and Table 3). The Falcons appeared to prevail, and were both in the nest area that afternoon (one perched beside the nest). They were again present nearby in the woodland patch on 14 July, but they were not seen in the nest area over the ensuing fortnight to 31 July, during watches or checks of 0.25–1.5 h on 6 days (variously between midday and sunset). However, any morning nest-based activity during that time would have been missed.

On 4–5 August the Falcons showed further interest in the nest (Table 2), but subsequently may have lost a (second?) clutch to Ravens (Table 3). Thereafter, to 18 August, the Falcons were seen intermittently in the nest area, soaring, hunting together or being harassed by other birds when the Falcons approached the nest (see p. 20), though not attending the nest. Late on 18 August both Falcons briefly attended the nest together (Table 2), the last occasion on which they were seen to do so, and thereafter they seemed to lose interest in it.

On 2 September, around midday, the male soared up from the nest woodland and left. The female then soared up from the nest patch, and made a long slanting glide to land on an old Raven's nest (neighbouring pair to Nest C) in a mature White Box, almost in a homestead backyard (~150 m from the farmhouse) and 800 m from Nest C. After clucking, shuffling, turning and shaping it, she stood on it for ~15 minutes then left. She was never seen back on or near this nest, and over that afternoon and next morning the Ravens (from their 2010 nest) occasionally went to the old nest and called from it, as if asserting ownership. This nest appeared small, i.e. it had probably deteriorated over the past year(s), and the female Falcon appeared not to fit in it well.

From 3 September to 24 October the Falcons were seen only intermittently in the general nest area: twice soaring together, distantly (~1 km away) in late September, then twice the male only (gliding high over to a destination >2 km away, and flying past, distantly, on a low hunting flight 0.5–1 km away), in mid-late October. It could not be determined whether the pair had found and occupied an

Table 3

Conflict between Black Falcons and harassing/interfering birds (Australian Raven, Sulphur-crested Cockatoo *Cacatua galerita*) during the Falcons' prelaying phase, Tamworth, NSW, July–August 2010. M = male, F = female Falcon.

<i>Date</i>	<i>Time (h)</i>	<i>Behaviour</i>
1/07	0715–0825	Between Black Falcon's dawn calls from night-roost in nest patch and F's arrival at nest at nearly 0900 h, one of local pair of Ravens used nest-branch as a calling post then briefly inspected nest, before both Ravens arrived at nest and one spent 1 min. moving around on and in it before they left. 0.5 h later, Falcons arrived and spent some of morning occupying nest or branch, and mating (Table 2), without further visits by Ravens.
11/07	1140–1200	Immediately after M's display flight about nest (Table 2), he started swooping nest as Raven pair approached. M retired to nearby dead tree; F appeared to flush from nest as Ravens perched beside it. F went to nearby tree, M resumed swooping and gliding around nest in figure-8 pattern for 5–6 min. before retiring to a tree. F then swooped nest in similar fashion as Ravens shuffled about on nest, inspecting it. When F retired to nearby dead tree, M resumed attacks for 5–10 sec., but Ravens refused to be dislodged and Falcons retired to distant perches (M ~500 m away, F ~1 km away).
05/08	0750	Almost 2 h before F visited nest, Cockatoo pecked and raked its bill in nest-cup (flushed by observer).
10/08	0725	Cockatoo at nest (flushed by observer).
12/08	1340–1500	Lambing time: in Falcons' absence, group of 8–10 intruding Ravens often occupied Nest-tree C and sometimes perched on and around Falcons' nest and other, older Raven nest in that tree, with up to three Ravens inspecting and pecking vigorously ('stabbing') in Falcons' nest. When one Falcon approached nest, it was chased off by Magpie, and when both did they were mobbed into retreat by group of highly defensive Noisy Miners <i>Manorina melanocephala</i> that had active nests. One Raven (of the breeding pair?) also chased Falcon away from nest patch.
13/08	0700–1100	Lambing time: both Falcons perched on limb under thick canopy of foliage of paddock tree 230 m from nest, apparently sheltering from mobbing Ravens and Magpies. The Falcons, initially unseen, inadvertently flushed when approached by observer. M flew off surrounded by Ravens; F flushed short distance, pursued by Magpie (see text), and returned to perch low in dead tree for >0.5 h before circling nest area and departing. When M departed low through nest area he was also chased by Magpie, but evaded and outflew it, without calling.
14/08	0700–1000	Intermittently: Cockatoo landed beside nest; Cockatoo landed on nest-branch, displaced by Raven (which left); four Cockatoos landed around nest, one approached and pulled at stick in base as if to demolish nest; then more Cockatoos landed in tree (flushed by observer).
22/08	0830–1030	One Cockatoo landed at nest twice, inspecting it for several seconds (flushed by observer).

alternative nest remote from Nest C; the female's behaviour suggested that, at least in early September, she was still looking for such. There was no sign of fledglings within a ~3-km radius of Nest C in late November and early December. The male, alone, soared up from a perch in the Nest C woodland in early December, but the female was not sighted after late September.

The Black Falcons' double cluck was very like that of the Peregrine Falcon, though more guttural and subdued, and the wailing call was virtually identical to that of the Peregrine Falcon (as also is that of another 'great' falcon, the Gyrfalcon *Falco rusticolus*: J. Olsen pers. comm.). Only the wail has so far been described for the little-studied Laggar Falcon (cf. Ferguson-Lees & Christie 2001). The cluck may be the call described by Baker-Gabb (1989), for prelaying Black Falcons at the nest, as the female's *kik-kik* and both sexes' *kit-kit-keek*, the latter possibly the female's deeper, guttural cluck followed by the male's higher *eeik* (*ee-chip* variant?) call (cf. Morcombe 2000). The discussion by Ferguson-Lees & Christie (2001) of the Peregrine Falcon's *ee-chip* call and variants could well apply to the Black Falcon.

The Black Falcon's nest-selection behaviour was similar to that of the stick-nesting Grey Falcon *F. hypoleucos*, in which only the female (*contra* Marchant & Higgins 1993) turned and clucked in two vacant nests (cf. Jackson 1919). The 'hitched-wing' precopulatory display posture (Cade 1982) was not observed, possibly because there was no room (e.g. as on a cliff-ledge) for the male Black Falcon to run around beside the female on the mating substrate, which was a branch; he alighted directly on her back from flight. The Falcons copulated about once per hour of nest-attendance time, during the periods when they were apparently preparing to lay (25 June–11 July and 4–5 August); four observed matings occurred in mid morning (once) and late afternoon (three times), with none seen during midday watches (Table 2).

Copulation and other prelaying behaviour extended over 2 months, as described for large falcons by Cade (1982). During this time, when actively interested in the nest (dates in Table 2), overall the Falcons attended the nest or nest-branch for 26% of observation time ($n = 23.5$ h), at various times of day (Table 2), usually together (male for 22%, female for 19%). In late June–early July, one or both attended for 30% of observation time (male 18%, female 22%; $n = 10.5$ h), and in early August they attended for 26% (male 22%, female 19%; $n = 13$ h).

Harassment and disturbance

Early on 1 July, in the Falcons' absence, the local pair of Australian Ravens visited Nest C (Table 3). Later that morning, the Falcons occupied the nest, in the Ravens' absence (Tables 2, 3). At this stage, the Falcons' and Ravens' visits to the nest did not coincide.

After a lapse in sustained observations, on 11 July immediately after the male Falcon's display flight about the nest (Table 2), conflict with the Ravens over the nest occurred (Table 3). The Falcons were not heard to call during their attacks on the Ravens at the nest (LRT), although another observer thought he heard a 'shrill call' (G. Mitchell pers. comm.). The Ravens were not repelled during these attacks, but the Falcons subsequently reoccupied the nest, including late that afternoon, and mated beside it in August (Table 2). On 27 July, the Ravens were building a new nest, which subsequently fledged young, 200 m away in the same woodland patch, thus avoiding further direct conflict with the Falcons over

a nest-site. (Soon after the young Ravens fledged, a pair of Hobbies successfully fought the adult Ravens for the new nest and occupied it.)

It was not clear whether the Ravens had destroyed a first clutch of the Black Falcons: behavioural clues were inconclusive. There may not have been sufficient time for laying between 4 July (when the Falcons were seen soaring together) and 11 July, given that prelaying lethargy was not observed, the likely 2-day laying interval (cf. Marchant & Higgins 1993 for the Peregrine Falcon), and the fact that the female roosted away from the nest on 8 July (Table 2). One observer thought that the Ravens did not appear to be eating eggs or to have yolk on their bills (G. Mitchell pers. comm.). Conversely, the subsequent apparent lapse in nest attendance of nearly a month is consistent with a 'recovery' period of 3–4 weeks, for Peregrine Falcons, before laying a replacement clutch in the same nest (Marchant & Higgins 1993). However, it was not possible to confirm a first clutch in July, observations between 4 and 31 July were sparse, and no clutch was confirmed in August–September.

Conflict with Ravens continued when the Falcons occupied the nest in August (Table 3). Lambing in the adjacent paddock attracted groups of scavenging Ravens (including to the farmer's lamb carcass dump ~100 m from Nest C), and led to consequent territorial defence against them by the resident Ravens. The latter resumed using Nest-tree C as an occasional calling post, as well as defending their own active nest if the Falcons approached the nest patch. The flock of Ravens may have destroyed a mid-August (second?) clutch of the Falcons (cf. Table 3).

In mid August, in their nest area, both Falcons were also attacked by other birds (Noisy Miner and Australian Magpie: Table 3). While under Magpie attack in flight, seemingly not unduly distressed, the female Falcon uttered a quiet, guttural, grating ('ratchety') cackle *chuck-chuck-chuck...*, ~2 notes/second, in quality similar to that of a Brown Falcon (SD pers. obs.).

Through August, Sulphur-crested Cockatoos interfered with the Falcons' nest, in the Falcons' absence, on four of five observation mornings until the Falcons were no longer visiting the nest, after which the Cockatoos were not seen to show any further interest in it (Table 3). On each occasion the Cockatoos were immediately flushed by the observer, but returned persistently. Their visits amounted to six in 20.5 hours, or once every 3 h on average, in the mornings. They approached the nest cautiously, walking slowly and warily along the branch while watching for the Falcons. One pair of Cockatoos had a nest-hollow lower in the tree.

The Falcons' nest survived intact until the end of observations in late October and subsequent brief checks to early December. The Cockatoos (and Little Corellas *Cacatua sanguinea*) also harassed the Hobbies that had started to use the Ravens' new nest near Nest C in mid October (see above), but the agile male Hobby was able to fend them off in aerial skirmishes. By mid November, the dependent juvenile Ravens and their parents gathered around Nest C, unchallenged by the Falcons.

A pair of Brown Falcons occupied the paddocks surrounding Nest C, but only one interaction between the Black Falcons and another raptor was observed. In late September, after the Black Falcons had lost interest in Nest C, while the pair circled high ~1 km away, one of them was swooped by a male Brown Goshawk *Accipiter fasciatus* after the latter had performed an undulating display in the same airspace. A Goshawk also appeared more frequently in or over the Falcons' nest patch after the Falcons had abandoned the nest. However, the Black Falcons were not seen to behave aggressively towards other raptors.

In early August, firewood gatherers were cutting fallen trees with chainsaws ~100 m from the Falcons' nest, in the Falcons' absence, over at least 0.5 h in the late afternoon. In late August, after lambing, the farmer set fire to the lamb carcass dump also ~100 m from the nest. Neither of these activities seemed likely to have disturbed the Falcons, as (i) they were obviously habituated to routine agricultural activity on the property; (ii) in early July the female arrived at Nest C, seemingly unconcerned, while the observer was still retreating ~150 m away from the tree; and (iii) in early September she landed on the alternative nest near the farmer's backyard (see p. 18), and proceeded to 'test' it, while the observer was still retreating ~50 m from the tree.

Prey and hunting behaviour

Prey remains consisted of one Rock Dove *Columba livia*, one Noisy Miner, and one raven *Corvus* sp. (Little Ravens *C. mellori* in autumn, as well as Australian Ravens, were observed in the area); the last (partial skull + severed maxilla) had the mandibles characteristically bitten off. Pellets (18 and fragments thereof) consisted entirely of feathers with some enclosed bone fragments, including quail *Coturnix* sp. (one pellet), Galah *Eolophus roseicapillus* (two pellets), Eastern Rosella *Platycercus eximius* (two pellets), Red-rumped Parrot *Psephotus haematonotus* (one pellet), parrot sp. (Rosella or Red-rumped Parrot: one pellet), Common Starling *Sturnus vulgaris* (four pellets), and unidentified birds (six pellets and fragments thereof). Pre-breeding dietary composition in this small sample was thus a subset of that previously recorded for the nestling period in the Tamworth area (cf. Debus *et al.* 2005), except for the raven which is a new dietary record for the species (cf. Marchant & Higgins 1993). All of the identified species are common farmland birds.

Black Falcons were observed hunting or departing on hunting flights on 10 occasions:

1. On a warm day in late May (around midday) the pair at Nest A foraged aerially for large locusts by hawking low over tall grassland. The Falcons repeatedly made long, shallow stoops, from soaring flight, to take locusts as they flushed from the grass, and ate them on the wing. The prey appeared to be abundant Spur-throated Locusts *Austacris guttulosa*, rather than Yellow-winged Locusts *Gastrimargus musicus*, both species of which were previously recorded as prey at this site (Debus *et al.* 2005).
2. In late June (late afternoon) the female at Nest C made a long (~100 m), shallow glide attack, from her perch beside the nest, to take small prey on the ground in the paddock, return to her perch and swallow it in one or two bites.
3. In early July (midday) the pair at Nest C left together in fast direct flight low over riparian trees, following the creekline out of sight; they returned together nearly 1.5 h later with full crops, apparently having shared a substantial kill.
4. In early July (late afternoon) the female at Nest C left her perch, made a fast glide over the treetops then darted towards the ground near the base of some trees (outcome unseen).
5. In early August (mid morning) the pair at Nest C left together and returned nearly 1.5 h later with full crops, apparently having shared a kill (Galah, by the pink feather stuck to the male's gape).
6. On the same day as above (late afternoon), despite having fed earlier, the female left the nest, flying fast in hunting mode low over the treetops along the paddock side of the road verge (outcome unseen; she did not return to the nest area in the ensuing hour to sunset and start of rain).

7. In early August (early morning) the Falcons at Nest C flew directly at treetop height, female just behind the male, along the paddock side of roadside trees; the male made a brief, unsuccessful grab at one of the numerous Musk Lorikeets *Glossopsitta concinna* foraging in the tree-canopy (flowering Yellow Box) and they continued on, up the narrow (single-lane) roadway between the verge trees on either side.
8. In mid August (early morning) the male at Nest C landed on a fencepost in a paddock, and after 2 minutes of scanning he made a short glide attack to the ground (outcome, and his departure, unseen); his position on the post was then taken by a Brown Falcon.
9. In mid August (late morning) the male at Nest A was soaring, and made a long, slanting glide to a position lower (twice treetop height) over a timbered creekline; seconds later he reappeared in low, dashing flight just over the treetops along the creekline for at least several hundred metres, apparently using momentum of a stoop to treetops to gain speed.
10. In late October (early morning) the male at Nest C was in low, direct (Hobby-like) flight at treetop height across paddocks, apparently in hunting mode.

These observations suggest that, in an agricultural and woodland mosaic, a substantial proportion of foraging consists of fast contour hunting at treetop height, sometimes in pairs, to take avian prey by surprise, and that in such a strategy woodland patches and strips (e.g. road verges, creeklines) are important. These observations also suggest that, although large insects may be taken in the warmer post-breeding and pre-breeding months, vertebrate prey is important in the prelaying phase, probably for egg formation in the female, as well as in the nestling phase (cf. Debus *et al.* 2005). Events (e.g. see Table 2) suggested that, although the Falcons shared kills, the female sometimes foraged for herself during the prelaying phase, even after both Falcons returned to the nest area together with full crops. That is, she was sometimes still hungry after sharing the male's kill.

Conclusions

Data from the Peel Valley (Debus *et al.* 2005; this study) suggest that the Black Falcon is much less numerous than the Brown Falcon locally, in the 'cereal steppe' landscape. The same applies in New South Wales generally, and Australia-wide, not only with respect to the Brown Falcon but also to the bird-eating Hobby and Peregrine Falcon (cf. Barrett *et al.* 2003). For instance, the Black Falcon's atlas reporting rate per grid was, on average, similar to that of the Peregrine Falcon, but it occupies only about half the area (i.e. 52% of the number of mainland grid squares occupied by the Peregrine Falcon: Barrett *et al.* 2003).

Black Falcon nest-sites in the Peel Valley had several characteristics in common, notably: they were old Raven nests in the tops of emergent, live woodland eucalypts; in patches of several hectares, but next to open fields; often riparian or near-riparian (lower parts of the landscape, where the favoured large Yellow Box trees occur); and they had easy access to the nest, bare branches near the nest for perching, and dead tree(s) nearby, also for perching. At least some of these features also apply elsewhere in the sheep-wheat belt (e.g. Marchant & Higgins 1993; Debus & Olsen 2011).

The two previous Black Falcon breeding events in the Peel Valley (Nests A and B) indicated a laying 'window' of early to mid July. The initiation of prelaying activity in 2010 also fitted this pattern, although the female continued nest-hunting until at least early September. To early December there was no indication of fledgling(s) from a subsequent clutch elsewhere in that territory, by which time the female appeared to be absent, although the male was still present (cf. also Debus *et al.* 2005: possible female post-breeding dispersal, while the male remained in the territory?).

The Black Falcon's most commonly heard calls were the double cluck (*ee-chip*), wail and guttural cackle, and its precopulatory behaviour included clucking calls and bowing, with wailing during copulation: all features of large falcons (Cade 1982). Its nest-site selection and nest-preparation behaviour was also like that of other large falcons (cf. Cade 1982; Marchant & Higgins 1993). The prelaying behaviour and vocalisations of the Black Falcon are most similar to those of other 'great' falcons and the closely related Peregrine Falcon (cf. Cade 1982; Ferguson-Lees & Christie 2001), and add weight to the genetic evidence of a relationship to these groups rather than to the hobbies (cf. Debus *et al.* 1991).

Some previous literature and database claims about the Black Falcon may be referable to misidentified dark-morph Brown Falcons (e.g. Czechura & Debus 1985; Debus & Olsen 2011). The findings of this study suggest that, for example, some of the behaviour and vocalisations attributed to the Black Falcon by Bedgood (1979) may be referable to the Brown Falcon instead.

The prolonged cold and wet winter–spring may have been the main factor in the Black Falcons' failure to breed in Nest C in 2010. Inclement weather has such an effect on the similarly stick-nesting Brown Falcon (McDonald *et al.* 2004). Brown Falcons and Nankeen Kestrels were also late in nesting, if they bred at all, in the Peel Valley in spring 2010; Hobbies were similarly late occupying nests and initiating breeding, which then failed or was abandoned (SD pers. obs.). We speculate that the weather may have depressed the male Black Falcon's ability to feed the female enough to bring her into laying condition while their seasonal 'window' of fertility lasted, and that perhaps vigorous defence of the nest against the Raven pair also tipped the female's energy balance at a critical time. However, it is also possible that Ravens destroyed one or two clutches of eggs; we could not determine whether the female left eggs unguarded while hunting for herself. Mobbing may have had little effect on the Black Falcons' breeding attempt, as the local Brown Falcons and Kestrels (i.e. less robust species) seemed to cope with mobbing Noisy Miners and Magpies by evading them and seeking shelter.

Interference from large, aggressive, overabundant 'increaser' species (Ravens, Sulphur-crested Cockatoos), in a landscape with declining trees and intense competition for nest-sites, may have been a negative factor for the Black Falcons, and the flock of scavenging Ravens on and around the nest may have been a strong deterrent. The sheer pressure from other birds was unexpected, as was the Cockatoos' damaging of the Falcons' nest, perhaps to deter their breeding (but see Olsen & Trost 2009). This scenario, of competition for nests and interference at Black Falcon nests, may be repeated throughout the sheep–wheat belt, at least near lambing paddocks and crop fields, and is perhaps a factor in the Black Falcon's apparent decline in that region (cf. Debus 2009a,b). The impression of competition for limited nest-sites was reinforced by the fact that Ravens rebuilt and reoccupied their old nests, in scarce emergent trees, even after falcon species had used them (sometimes for several years) in the interim. Other cases are known of Hobbies prevailing over Australian Ravens (Marchant & Higgins 1993; J. Olsen pers. comm.); it seems paradoxical that Ravens can disrupt breeding of the larger Black Falcon.

The Black Falcon's diet and foraging behaviour as reported in this study are consistent with previous information, and support the view that the Falcon is primarily a bird-hunter (Olsen 1974; Debus *et al.* 2005; Debus & Olsen 2011). This study also adds further examples of the Falcon's foraging technique of fast contour hunting, sometimes in pairs, to take birds by surprise.

Although the Falcons' breeding attempt was unsuccessful, the information gained on the prelaying phase may assist the interpretation of behaviour observed in other pairs. This attempted life-history study, although abortive, is a further step towards that required for conservation and management purposes, and perhaps suggests some limiting factors for the Falcon. With hindsight, the Falcons may have benefitted by experimentally (i) removing the resident Ravens (an unprotected species) and their replacements during June–August; (ii) supplement-feeding the female Falcon (e.g. with fresh, lead-free rabbit or hare carcasses) in June/July; and (iii) discouraging Raven flocks by placing lamb carcass dumps farther from the Falcons' nest, and disposing of carcasses more frequently.

It remains to document the Black Falcon's breeding cycle more completely, with quantitative data on the incubation, nestling and post-fledging periods, and better quantification of the prelaying phase of a successful nesting. Nevertheless, this study suggests that the Falcon would benefit from reducing (through farm-management and ecological means) the abundance of Sulphur-crested Cockatoos and Australian Ravens, perhaps via their food supply (e.g. grain storage and transport, livestock carrion), and redressing the loss of eucalypts from the agricultural landscape (e.g. on creeklines, road verges and paddock or property boundaries).

Acknowledgements

We thank Bill Clark (Raptours, USA) for his information on Nest B; Geoff Mitchell, Joan Dunn and Eric Fair (Tamworth Birdwatchers) for supplementary observations at Nest C; Murray Eden for sharing some observations and searches for the Falcons with LRT; Sofia Debus for sharing some observations with SD; Steve Trémont for loan of equipment; and Greg & Madeleine Blaxland and Mark & Bettina Blaxland and family for their interest, sighting information, permission to watch the Falcons on their land, and for their exceptional hospitality to SD. Thanks also to David Spong (neighbouring landholder) for his interest and information. SD's research travel costs were generously defrayed by the Fund for Avian Research (Australian Bird Study Association); SD also gratefully acknowledges the facilities of the University of New England. We thank Paul McDonald, Jerry Olsen and Tom Aumann for helpful comments on a draft.

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