Australian Field Ornithology 2019, **36**, 121–123
http://dx.doi.org/10.20938/afo36121123

Breeding behaviour and diet of the Brown Falcon *Falco berigora* near Goulburn, New South Wales, in 2018

C.J. Bollen

125 Hume Street, Goulburn NSW 2580, Australia
Email: wjbollen@bigpond.com

Abstract. The breeding behaviour and diet of a pair of Brown Falcons *Falco berigora* in the Southern Tablelands of New South Wales in 2018 were studied by *c.*54 hours of observation over 38 days from incubation to post-fledging, and by analysis of pellets and orts. Both the male and the female, primarily the female, incubated but only the female brooded and fed the chicks, and the male provided food at 0.2 item/h during incubation and 0.3 item/h during the nestling period. Observed prey brought to the nest area was, by number, 31% mammal, 31% bird, 23% reptile and 15% unidentified (apparently vertebrate), although some pellets included insects. The two juvenile Falcons appeared to be dependent for at least 3 weeks after fledging. These findings supplement those for a previous study in the general area almost three decades earlier, and for other recent studies in the nearby study region and elsewhere.

Introduction

Knowledge of the breeding biology, behaviour, vocalisations and diet of the Brown Falcon *Falco berigora* was summarised by Marchant & Higgins (1993), to which Bollen (1993) had contributed a preliminary study of breeding behaviour and diet at one nest over two breeding seasons (1990 and 1991) near Goulburn, on the Southern Tablelands of New South Wales. Since then, major studies of the ecology of this species have been conducted in central Australia (including diet: Aumann 2001) and in southern Victoria (including diet and breeding behaviour: McDonald 2003a, 2004; McDonald *et al.* 2003, 2004; McDonald & Baker-Gabb 2006). A comprehensive study of the Falcon's diet has also been conducted around Canberra (Australian Capital Territory), near Goulburn, in 2002–2009 (McDonald *et al.* 2012; Olsen 2014). The present study at Goulburn supplements the earlier one by Bollen (1993) with double the number of observation hours and pellets sampled, after an interval of almost 30 years.

Study area and methods

The study area at Goulburn (34°45'S, 149°40'E) was described by Bollen (1993). The present study site, in the general area of the earlier nest ~2 km away, is in a pastoral landscape of open rolling hills with patches of Candlebark *Eucalyptus rubida*, Inland Scribbly Gum *E. rossii* and Yellow Box *E. melliodora* woodland just west of Goulburn and bordering the Wollondilly River.

Observations of usually *c.* 0.5–2 h per day, with all time periods recorded, were made over 38 days between 12 September and 23 December 2018. These sessions were distributed through the breeding cycle as follows: incubation period, 21.3 h over 15 days (12 September–9 October); nestling period, 25.6 h over 18 days (18 October–20 November); and fledgling period, 6.7 h over 5 days (26 November–11 December). A further 3.8 h over 3 days (19–24 December) were spent watching the nest, but the adult and fledgling Brown Falcons were not detected from the observation point. Observations were made from a hide at ground level ~70 m from the nest-tree, using a telescope (20 × 50) and binoculars (8 × 30). Observations were strongly biased towards the middle of the day, especially during the nestling and fledgling periods (1000–1400 h Eastern Standard Time: Table 1).

About 25 regurgitated pellets and fragments, and two orts (prey remains), were collected during the incubation and nestling periods from beneath the Falcon pair's food-transfer perch near the nest. These were analysed by Dr S. Debus (Zoology, University of New England) macroscopically, with items therein visually identified to the lowest taxonomic level possible.

The adults were separated on plumage and size: the male had a cream chest with a few streaks and blotches, whereas the female's chest was heavily streaked with brown blotches that obscured the background colour, and when together the male appeared slightly smaller than the female.

Table 1. Observation schedule (hours of observation) at a Brown Falcon nest, Goulburn, New South Wales, during each time interval of nest-watching in 2018 (Eastern Standard Time): incubation period (12 September—9 October), nestling period (18 October–20 November) and fledgling period when the Falcons were still visible/audible from the observation hide (26 November—11 December).

Stage	*0900–1000*	*1001–1200*	*1201–1400*	*1401–1500*
Incubation	0.8	6.0	12.1	2.4
Nestling	4.0	17.8	3.8	0
Fledgling	0	4.8	1.9	0

Results

Nest-site

The Brown Falcons' nest, a bulky, untidy stick structure apparently the vacant nest of Little Ravens *Corvus mellori*, was situated ~12 m above the ground in a living Candlebark in a small patch of remnant woodland, on a hillside ~100 m from the Wollondilly River. The pair of Falcons used a dead tree 80 m from the nest (and 10 m from the observation hide) to transfer prey.

Incubation

The pair of Brown Falcons had been observed copulating in late August 2018, and incubation appeared to commence in early September. On 10 September, when the nest-site was first visited, the female sat tight and did not flush from the nest when the observer was underneath it, indicating that she probably had a clutch of eggs. The female performed most of the incubation (94% of 21.3 h), with the nest unattended for 3% of observation time (in absences of 3–18 minutes) when the female either collected and consumed food from the male or (once) flew around calling, to the transfer tree and back, when an intruding pale-breasted Brown Falcon landed with the male on the transfer tree. (The intruder was most likely a male, from M^{c}Donald 2003a.) The male incubated in one observed bout of 26+ minutes (2% of observation time). At the changeover, the male flew in calling and the female left for the dead tree, whereupon the male flew to the nest and settled. The female sometimes incubated in long bouts exceeding the duration of nest-watches (i.e. for >90–115 minutes), but occasionally stood and preened before resettling.

The male brought prey to the incubating female four times in *c.* 21 h (= 0.2 delivery per h) and either flew directly to the nest or to the transfer tree. He appeared to cache one item on the ground 100 m from the nest.

Nestling period

The first time that the chicks were observed being fed by the female was on 18 October (after a lapse in observations since 9 October). From an incubation period of 5 weeks (M^{c}Donald 2004) and incubation at Goulburn probably having started in the first week of September, the chicks probably hatched around 15 October. After the chicks were *c.* 3–4 days old, the female's attendance at the nest decreased. Overall, on the days on which she was observed brooding (inferred to be the second half of Week 1 to early in Week 2 of the nestling period), the female brooded for 40% of observation time (6.7 h): 67% in Week 1 (in bouts of 2–56 minutes, mostly 13–48 minutes; *n* = 3.9 h) and 10% in Week 2 (in bouts of 6 and 10 minutes; *n* = 2.8 h). At that stage she was absent from the nest, though usually in the dead tree, for 57% of 6.7 h, in bouts of 6–26 minutes late in Week 1 and 33–>84 minutes early in Week 2. She was not observed day-brooding after 23 October (*c.* Day 9 or 10), and thereafter spent the remainder of observation time perched on trees near the nest, typically a favourite perch in a tree ~100 m from the nest or flying around the nest-tree. She fed the chicks bill to bill in bouts of 4–19 minutes (mean 10.9 minutes) until the start of Week 4, but was not observed to do so thereafter, suggesting that prey was then dropped into the nest for the chicks. On 28 October, the chicks appeared to be *c.* 2 weeks old, being covered in cream down consistent with growth stages shown by M^{c}Donald (2003b).

The male appeared to do most of the hunting, delivering six prey items in 25.6 h (= 0.2 delivery per h) at the transfer tree, to the female which then fed the chicks. A further two prey items were cached (on the ground, by the female) rather than brought to the nest (= total 0.3 item brought to the nest area per h), and the male brought another item to the transfer tree but departed with the item. The female sometimes gave food-begging whines when meeting the male on the transfer tree.

Fledging and post-fledging

The two young Brown Falcons appeared to leave the nest sometime between 20 November (on which date they were still in the nest) and 26 November when they were newly fledged (mid-point: 23 November ± 3 days), consistent with a known fledging age of 6 weeks (M^{c}Donald 2004). For *c.* 3 weeks after they had left the nest, until 11 December (middle of Week 3 post-fledging), the young were still being fed by the adults, and at that stage did not appear to have acquired hunting skills. Thereafter, adults and young appeared to vacate the nest-tree, as they were not detected in the nest area during 19–24 December (late in Week 4 to early in Week 5). At that stage, they were not audible or visible from the observation point 70 m from the nest, and therefore probably not within ~500 m of the nest.

An adult delivered two prey items to the fledglings in 6.7 h in their second to third week out of the nest (= 0.3 item/h). In their first few days (*c.* Day 3 or 4), the fledglings were giving begging calls from the transfer tree where the adult female was perched and the male arrived. In Week 2, the young flew out to meet the food-bearing male on the transfer tree, then, as he departed, they landed on the ground and walked about. In Week 3, the young were still giving begging calls and flew to join the female on the ground. When the male delivered prey to one fledgling, it took the prey to a fence-post. From the end of Week 4 through Week 5, the Falcons appeared to have left the immediate area.

Diet

The Brown Falcons preyed on a variety of mammals, birds, reptiles and insects. The adults were observed bringing in pieces of European Rabbit *Oryctolagus cuniculus*, rodent(s) (rat and/or mouse), birds (Common Starling *Sturnus vulgaris*, Australasian Pipit *Anthus novaseelandiae*, possible quail Phasianidae and unidentified), a dragon lizard (Agamidae), small snakes (Elapidae?, one ~30 cm long) and two unidentified items (apparently vertebrate, one small). From observations of prey items (*n* = 13) brought to the nest area, the breeding diet was, by number, 31% mammal, 31% bird, 23% reptile and 15% unidentified. Items cached were a piece of Rabbit by the male (in the incubation period) and a piece of Rabbit and a Starling by the female (in the nestling period, Week 3).

Sixteen intact pellets measured 25.3–42 × 16.2–25.8 mm (mean 34.0 × 20.8 mm); 13 of those weighed 1.1–2.7 g (mean 2.0 g dry weight). A further 17 g of pellet fragments represented about nine whole pellets. Seventeen of 22 pellets (77%) contained mammal fur (mostly Rabbit), 12 (55%) contained bird remains (mostly feathers; identified species were Eastern Rosella *Platycercus eximius*, several Common Starlings and a possible Stubble Quail *Coturnix pectoralis*), 11 (50%) contained reptile scales (including small skink [Scincida] and larger scales, from snake or bluetongue lizard *Tiliqua* sp.), and 15 (68%) contained insect(s) (including beetles [Coleoptera] and a probable grasshopper [Orthoptera]). Only two pellets consisted of bird remains only; the others contained a combination of bird and/or mammal and reptile and/or insect, and five contained the remains of all four prey classes. The pellet fragments contained the same mix of prey types. Apart from Starling feet in two pellets, other remains included the foot of a small Rabbit kitten and the hindleg of a larger Rabbit.

Discussion

Sharing of incubation duties by both the male and the female, with the female taking the larger share, was consistent with previous findings, as was parental behaviour through the nestling period (cf. Bollen 1993; Marchant & Higgins 1993; M^{c}Donald 2004). However, observed activity patterns and feeding rates were strongly skewed towards the middle of the day and might have differed early in the morning or late in the afternoon. The post-fledging dependence period was apparently similar to the average duration recorded elsewhere (4 weeks: M^{c}Donald 2004), and to one anecdotal record of a banded fledgling on the New South Wales Northern Tablelands (*c.* 2 months: Debus 2019a). The prey delivery rate to the female Brown Falcon was higher in the incubation period in 2018 than in 1991 (0.2 vs 0.1 item/h), but the delivery rate to nestlings was the same in both years, for the same number of nestlings (0.3 item/h) (cf. Bollen 1993).

Pellet dimensions and mass were similar to a small sample from elsewhere (Corbett *et al.* 2014). The Falcons' dietary profile, in terms of prey classes and proportions, was broadly similar to that in other recent studies elsewhere (Aumann 2001; M^{c}Donald *et al.* 2003; M^{c}Donald & Baker-Gabb 2006; Corbett *et al.* 2014). It was similar to that at Goulburn in 1990–1991 (Bollen 1993) and was essentially a subset of that near Canberra in 2002–2009 (cf. M^{c}Donald *et al.* 2012; Olsen 2014).

The breeding biology, and especially the diet, of the Brown Falcon have now been described comprehensively. Previous studies on aspects of breeding behaviour have not described parental time-budgets in terms of the percentage of observation time that the male and female spend on various nest-based activities through the stages of the breeding cycle. Future observational study of the Brown Falcon might usefully describe parental time-budgets in greater detail, across all daylight 2-hour blocks of the day and weeks of the pre-laying, incubation, nestling and post-fledging periods, as has been done for some other Australian falcons and other raptors (for case studies see references listed by Debus 2019b).

Acknowledgements

I thank Dr S. Debus for literature, analysing and detailing the pellets and their contents, editing my notes and draft into a paper, and for his encouragement and support throughout the project. Thanks go also to Jerry Olsen, Sue Trost and Paul M^{c}Donald for reviewing a draft.

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.

Bollen, C. (1993). Breeding behaviour and diet of the Brown Falcon *Falco berigora* on the Southern Tablelands of New South Wales. *Australian Bird Watcher* **15**, 19–23.

Corbett, L., Hertog, T. & Estbergs, J. (2014). Diet of 25 sympatric raptors at Kapalga, Northern Territory, Australia 1979–89, with data on prey availability. *Corella* **38**, 81–94.

Debus, S. (2019a). Brown Falcon fledgling reunited with parents. *Boobook* **37**, 12.

Debus, S. (2019b). *Birds of Prey of Australia: A Field Guide*. 3rd edn. CSIRO Publishing, Melbourne.

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

M^{c}Donald, P.G. (2003a). Variable plumage and bare part colouration in the Brown Falcon, *Falco berigora*: The influence of age and sex. *Emu* **103**, 21–28.

M^{c}Donald, P.G. (2003b). Nestling growth and development in the Brown Falcon, *Falco berigora*: An improved ageing formula and field-based method of sex determination. *Wildlife Research* **30**, 411–418.

M^{c}Donald, P. G. (2004). The breeding ecology and behaviour of a colour-marked population of Brown Falcons (*Falco berigora*). *Emu* **104**, 1–6.

M^{c}Donald, P.G. & Baker-Gabb, D.J. (2006). The breeding diet of different Brown Falcon (*Falco berigora*) pairs occupying the same territory over twenty years apart. *Journal of Raptor Research* **40**, 228–231.

M^{c}Donald, P.G., Olsen, J. & Rose, A.B. (2012). The diet of breeding Brown Falcons (*Falco berigora*) in the Canberra region, Australia, with comparisons to other regions. *Journal of Raptor Research* **46**, 394–400.

M^{c}Donald, P.G., Olsen, P.D. & Baker-Gabb, D.J. (2003). Territory fidelity, reproductive success and prey choice in the Brown Falcon, *Falco berigora*: A flexible bet-hedger? *Australian Journal of Zoology* **51**, 399–414.

M^{c}Donald, P.G., Olsen, P.D. & Cockburn, A. (2004). Weather dictates reproductive success and survival in the Australian Brown Falcon *Falco berigora*. *Journal of Animal Ecology* **73**, 683–692.

Olsen, J. (2014). *Australian High Country Raptors*. CSIRO Publishing, Melbourne.

Received 2 May 2019, accepted 22 June 2019, published online 22 August 2019