

# The post-drought breeding behaviour and diet of a pair of Brown Falcons *Falco berigora* near Goulburn, New South Wales

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**Abstract.** The breeding behaviour and diet of a pair of Brown Falcons *Falco berigora* on the Southern Tablelands of New South Wales in the post-drought year of 2021 were studied by ~48 hours of observation over 28 days from incubation to fledging, and by analysis of pellets. Both the male and the female, primarily the female, incubated but only the female brooded and fed the three chicks, and the male provided food at 0.1 item/h during incubation and 0.3 item/h during the nestling period, boosted to a combined rate of 0.5 item/h by the female later in the nestling period. Observed prey brought to the nest area ( $n = 14$ ) was, by number, 79% mammal, 7% bird and 14% unidentified (apparently vertebrate), although some pellets included reptile scales and traces of insect. These findings supplement and compare with those for a previous study at the site in a dry year (2018); the diet was much more dominated by mice in 2021 during a plague of House Mice *Mus musculus* in the NSW grain belt.

## Introduction

The breeding behaviour and diet of a pair of Brown Falcons *Falco berigora* were studied near Goulburn, on the Southern Tablelands of New South Wales (NSW), in the dry year of 2018 by Bollen (2019), who reviewed the state of knowledge of the Brown Falcon at that time, including earlier dietary studies (e.g. McDonald *et al.* 2012). After the severe drought year of low rainfall in 2019 in the region (Rae *et al.* 2020), the breeding cycle of a pair of Brown Falcons in the same area was studied in 2021, after the drought had broken and there was a plague of House Mice *Mus musculus* in the NSW Sheep–Wheat belt to the west of Goulburn (Norgrady 2021). Meanwhile, Hollands (2021) presented some recent observations of Brown Falcon foraging behaviour, mostly in south-eastern Australia, that post-date his earlier work cited by Marchant & Higgins (1993). The present study at Goulburn supplements the earlier one by Bollen (2019), by presenting additional behavioural information and comparing the diet under contrasting climatic regimes.

## Study area and methods

The study area and habitat at Goulburn (34°45'S, 149°40'E) were as previously detailed (Bollen 2019). The 2021 nest was ~1 km south of the 2018 nest and 500 m from the Wollondilly River. On plumage, the female appeared to be the same individual, but the male was a 'new' bird with darker plumage (dark-brown upperparts and mottled brown breast), whereas the plumage should lighten with age (McDonald 2003). Given the distance between the nests and available information on the spacing of Brown Falcon nests (Marchant & Higgins 1993), it is likely that the 2021 nest was in the same Falcon territory as that in 2018.

Observations of usually 1–2 hours per day (occasionally up to almost 3 h) were made over 28 days between 7 September and 9 November 2021. These sessions were distributed through the breeding cycle as follows: incubation period 24.7 hours over 13 days (7–28 September); nestling

period 23 hours over 15 days (2 October–9 November). As precise laying and hatching dates were not determined, the days assigned to each phase around hatching time were inferred from the fledging date (9 November). Given an average of 6 weeks for the nestling period (McDonald 2004), the hatching date was therefore assumed to be c. 29 September (between the observation days of 28 September and 2 October). Observations were made from an unconcealed position on the ground ~100 m from the nest tree, using a telescope (20 × 50) and binoculars (8 × 40), as the Falcons appeared to behave normally in the observer's presence. Observations were strongly biased towards the middle of the day (1000–1400 h Eastern Standard Time: Table 1). Observations lapsed for periods of 6–8 days during nestling Weeks 2–3, 3–4 and in Week 6, and from late in Week 4 observation sessions were mostly of 1 hour.

Eight regurgitated pellets and 5 g of fragmented pellet material were collected from beneath the nest during the Falcons' breeding cycle. These were analysed by Dr S. Debus (Zoology, University of New England) macroscopically, with items therein visually identified to the lowest taxonomic level possible.

## Results

### *Nest site*

The Falcons' nest was situated ~12 m above ground in a living eucalypt on the edge of a patch of remnant woodland on a hillside. The pair used two dead trees 50 m from the nest (north and south—mostly the one to the north) to transfer prey.

### *Incubation*

The pair had been observed copulating on 6 September and about a week before, and on the basis of the approximate hatching date (29 September) and 5 weeks for incubation

**Table 1.** Observation schedule (hours of observation) at a Brown Falcon nest, Goulburn, New South Wales, during each time interval of nest-watching in 2021: incubation period (7–28 September) and nestling period (2 October–9 November).

Stage	0900–1000	1001–1200	1201–1400	1401–1600	>1600	Total
Incubation		9.25	14.0	1.4		24.65
Nestling	1.0	11.6	8.6	1.6	0.33	23.13

(McDonald 2004), laying probably occurred in the last week of August. On 7 September, when the nest site was first found and visited, the incubating female sat tight and did not flush from the nest when the observer was underneath.

The female performed most of the incubating (96% of 24.7 h), with the nest unattended for 3% of observation time (in absences of 1–14+ min., mostly 1–5 min.) when the female either collected and consumed food from the male, chased and once grappled with an intruding pale-breasted Brown Falcon, or perched on a dead tree or flew around, sometimes with the male or while calling (e.g. food-begging whine). The male incubated in two observed bouts of >1 and >14 minutes (1% of observation time). At changeovers, the male either flew to the nest and the female left, or he brought food that the female collected and consumed at the transfer tree, while he flew to the nest. There were also occasions when the male did not relieve the female while she fed on his prey. The female incubated in seven timed stints of 5–67 minutes (mean 24 min.), her shorter stints typically interrupted by the male arriving with or without food, or by an intruding Brown Falcon. She sometimes incubated in long bouts of >40 to >80 minutes, or even exceeding the duration of nest-watches (i.e. for >120 min.). Expulsion of an intruding Brown Falcon was observed three times throughout the incubation period.

The male brought food to the incubating female three times in c. 24.7 hours (= 0.1 delivery per hour), to the transfer tree or another tree nearby.

### Nestling period

The first time that the chicks were observed being fed by the female was on 9 October (after a lapse in observations since 6 October). The male took food to the nest on 6 October, suggesting that chicks were present on that date. From the considerations noted above (see Methods), the chicks probably hatched between 28 September and 2 October, during a lapse in observations. On 2–4 October (Week 1, inferred Days 4–6), the female brooded constantly through the middle of the day to mid afternoon, in stints that exceeded watch times (>1.7–2.6 h). On Day 6, when the male landed above the nest then flew to the transfer tree, the female rose and flew out then returned to the nest, whereupon the male departed, presumably to forage.

In Week 2, the female brooded for 96% of observation time (4.75 h), in stints of >165 minutes (Day 8), and >69 and >41 minutes (Day 11), with one absence from the nest of c.1 minute while she collected prey from the male. In Week 3, she brooded for 33% of observation time (3 h), in stints of >40 and >11 minutes (Day 19) and >7 minutes (once, Day 20 in mid morning). Her absences ranged from

c.1 minute to collect the male's prey to 26–37 minutes when she foraged and brought back prey. After a lapse in observations since Day 11, she was first seen to bring prey to the nest, possibly from a cache (see description below), on Day 19 and was first seen to forage, capture prey and take it to the nest on Day 20. Maternal feeding of the chicks, bill to bill, lasted 9 minutes (Week 2, Day 11), 4–7 minutes (Week 3, Days 19 and 20), and >1 to 10 minutes (Week 4, Days 26 and 27). The female was last seen to feed the chicks bill to bill on Day 27 (>1 min.), and from Day 27 food was dropped on the nest by either adult which then departed. From that stage onwards, the nest was otherwise unattended during 1-hour watches in the middle of the day, although to at least Day 33 either adult sometimes perched on a dead tree in the nest area.

The three chicks were downy on inferred Day 19, on Day 27 they appeared about half-grown and covered in thick woolly down, and on Day 28 one flapped its wings. On Day 26, one of the adults chased and grappled talons with an Australian Hobby *Falco longipennis*, apparently in nest or territory defence: the only such example observed of an interaction with any other raptor during the nestling period.

The male delivered seven prey items in 23 hours (= 0.3 delivery/h), mostly to the female which then fed the chicks, and later directly to the nest (Days 28 and 33). The female brought five items but consumed one herself (= 0.2/h to the chicks), for a combined parental feeding rate of 0.5 item/h to the nest. As late as Days 28 and 36, the female gave food-begging whines near the nest.

### Fledging

Two young Brown Falcons had left the nest on 9 November, with the third young fully feathered and still in the nest on that date. Observations then ceased, partly because of decreasing accessibility of the site as high rainfall encouraged vigorous grass growth.

### Diet and foraging

The female Brown Falcon was seen foraging twice. On Day 20 of the nestling period, she hovered, dived and then brought a mouse (probably a House Mouse) to the transfer tree, where she fed briefly then brought the prey to the nest. Later that day, from the transfer tree, she flew to the ground, jumped about then brought a mouse back to the tree, where she consumed it entirely before departing. On Day 19, from the transfer tree, she had flown off then quickly returned to the tree with part of a Rabbit *Oryctolagus cuniculus*, on which she fed briefly (~2 min.)

before feeding the chicks. The timing and prey condition suggested that she collected it either from the male or a cache. The male was seen hovering once.

Prey items seen brought to the female or nest area ( $n = 14$ ) included 10 mice (presumed House Mice in that environment), one Rabbit (as above), one adult Common Starling *Sturnus vulgaris* (by the male), and two unidentified items (apparently vertebrates): 79% mammal, 7% bird, and 14% unidentified.

Six intact pellets measured 24–38.5 × 16.7–24.3 mm (mean 30.2 × 19.4 mm); eight pellets weighed 0.8–2.3 g (mean 1.5 g). Seven of the eight pellets (88%) contained mammal fur (mostly mouse, some Rabbit in two), two (25%) contained grey-brown feathers of unidentified small birds, one (13%) contained reptile scales (from a snake or bluetongue lizard *Tiliqua* sp.), and two (25%) contained traces of insect (a very minor component). Only one pellet consisted of feathers only; the others contained mostly fur, and only one contained the remains of all four prey classes. The pellet fragments collectively contained the same mix of prey types (mostly feathers, with some mouse fur, reptile scales and a trace of insect).

## Discussion

Parental behaviour in 2021 was similar to that in the previous studies at the same location (Bollen 1993, 2019), with the latest study filling some of the gaps in the earlier ones at the site, and was again consistent with previous knowledge (cf. Marchant & Higgins 1993; M<sup>c</sup>Donald 2004). The inferred laying date was about a week earlier than in 2018 (late August vs early September), possibly related to food abundance (the mouse plague in 2021). The female brooded for a greater proportion of time in Weeks 2–3 of the nestling period in 2021, and for longer into the nestling period, than in the earlier studies at Goulburn, perhaps partly related to the wet spring of 2021 and the higher male food-delivery rate to the chicks. However, observed activity patterns and feeding rates were again strongly skewed towards the middle of the day, and might have differed early in the morning or late in the afternoon.

The prey delivery rate was lower in the incubation period in 2021 than in 2018 (0.1 vs 0.2 item/h), but the delivery rate to nestlings was higher in 2021 and boosted further by the female's contribution, for a larger number of nestlings (0.5 vs 0.3 item/h, three instead of two chicks; cf. Bollen 2019).

Pellet dimensions and mass were similar to the 2018 sample (Bollen 2019), though from a smaller sample size. The Falcons' breeding diet near Goulburn was substantially different in 2021 from that in 2018, and also from that in 1990–1991: a far greater proportion of mice in 2021, compared with a greater proportion of birds in 1990–1991 and a greater proportion of birds and reptiles in 2018; mammalian prey in the earlier years was also mostly Rabbit (cf. Bollen 1993, 2019). These differences, and

parental feeding rates, may partly reflect the abundance of mice in 2021. Some changes in dietary composition in the same Falcon territories, between decades, have been found elsewhere in a more stable and productive environment than Goulburn, although overall there was substantial dietary consistency over time within those territories (M<sup>c</sup>Donald & Baker-Gabb 2006).

The present study was again a snapshot across the middle of the day, when the Falcons' activity levels might be lowest. Future observational study of the Falcon might usefully cover all 2-hour blocks of the day across all weeks of the pre-laying, incubation, nestling and post-fledging periods.

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