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Breeding diet and behaviour of a pair of Grey Falcons *Falco hypoleucos* and their offspring in north-western New South Wales

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The diet of a pair of Grey Falcons *Falco hypoleucos* was investigated in Sturt National Park, arid north-western New South Wales, by analysis of pellets and orts collected during October–December 2003 beneath a nest in a riparian Coolibah *Eucalyptus coolabah* beside a gibber plain. The falcons fledged a brood of four young in a year of above-average rainfall in the first half (and average rainfall overall), from an estimated egg-laying date of early August. The falcons' breeding diet (n = 62 prey items from 58 dietary samples) consisted, by number, mainly of birds (99%, 63% being parrots) and one mammal; parrots formed most of the biomass (90%) of identified avian prey. Geometric Mean Prey Weight was 29.6 grams, and dietary diversity (Shannon Index) was 1.98. Small–medium (<100 g) granivorous birds were selected as prey (P <0.01). The juvenile offspring accompanied their hunting parents, associating with them for at least five months post-fledging.

INTRODUCTION

The endemic Grey Falcon *Falco hypoleucos*, of the Australian arid and semi-arid zones, was recently reassessed as meeting IUCN criteria for nationally vulnerable, with a global population estimated as possibly fewer than 1000 individuals (Garnett *et al.* 2011). It was also recently upgraded to endangered in New South Wales, under the NSW *Threatened Species Conservation Act 1995* (NSW Scientific Committee 2009, 2010). Previous unquantified prey lists, and recent quantified dietary studies, have characterised this falcon's diet as mainly birds (mostly granivorous pigeons and parrots), with secondary prey of small mammals and reptiles (see Czechura and Debus 1985; Olsen and Olsen 1986; Marchant and Higgins 1993; Harrison 2000; Aumann 2001; Falkenberg 2011; Sutton 2011; Watson 2011; Schoenjahn 2013a). However, no published studies exist on this species in New South Wales, where ecological information is required for its conservation and management.

The Grey Falcon's breeding and hunting behaviour is little described, other than anecdotally (see Watson 2011 for a review), although it has been suggested that the post-fledging dependence period may last almost until the next breeding season (e.g. Marchant and Higgins 1993; Schoenjahn 2011, 2013b). Baylis and van Gessel (2011) briefly described the behaviour of two Grey Falcon pairs and offspring early in the post-fledging period.

The present study sought to determine the breeding diet of a Grey Falcon pair and offspring in arid north-western NSW in 2003, in relation to potentially available prey species, and whether the falcons selected avian prey according to characteristics of prey species such as diet, social structure or habitat. Our study represents the largest quantified sample of Grey Falcon prey identified to species level reported to date. Some behavioural observations of the falcon pair and offspring associating during the post-fledging period, with juveniles accompanying the hunting adults, are also presented.

STUDY AREA AND METHODS

The study area was in Sturt National Park (NP; 325 329 ha) near Tibooburra (29°42 S, 142°03 E) in the extreme north-west corner of New South Wales (exact locality of the falcons' nest site withheld). The landscape within the study area consists of undulating gibber plains interspersed with mesas ('jump-ups'), vegetated with saltbush *Atriplex* spp., other chenopods and grasses (Mitchell grasses *Astrebla* spp. and others), and traversed by ephemeral creeks lined with River Red Gum *Eucalyptus camaldulensis*, Coolibah *E. coolabah* and Gidgee *Acacia cambagei*. The climate is arid, with a mean annual rainfall of 223 mm and mean annual temperature of 27.4°C (maxima up to 49°C) at the time of the study (Denny 1975; NPWS 1996; Montague-Drake and Croft 2004). Overall, Tibooburra received average rainfall in 2003, though above average in the first half of the year, with strong peaks in February and April and lesser peaks in June, August and November, before a decline to generally drier conditions in 2004 (other than a small peak in May 2004) (Australian Bureau of Meteorology data; Table 1).

The falcons' active nest in 2003 was a corvid's stick nest high in the crown of a living Coolibah approximately 15 metres tall, beside a well-wooded intermittently flowing creek adjoining an open gibber plain (Figure1). The nest site was within approximately 10 kilometres of each of three permanent water sources frequented regularly by many avian species. The nearest of these was an open earth tank preferred by flocks of small parrot species.

Table 1

Monthly rainfall (mm) for the study area in 2003 and 2004 against the long-term average 1886–2013 (Tibooburra weather station, Bureau of Meteorology data).

Year	J	F	M	A	M	J	J	A	S	O	N	D	Total
2003	2.2	44.6	0	58.6	12.8	23.8	2.8	33	0	8.2	20.2	16.6	222.8
2004	1.8	13	3.4	4.8	37.6	16	9.4	20.8	17.6	4	27	0	155.4
All (av.)	28	29.8	24.8	14.4	18	16.6	16.4	11.5	12.3	18.2	18	22.1	227.2

Figure 1. *Nest site of Grey Falcons, in crown of Coolibah* Eucalyptus coolabah *~15 m tall, Sturt National Park, 28 July 2003.*
Photo: David Roshier.

The nest was located within the Channel Country Bioregion (see Thackway and Creswell 1995; NPWS 2003), which is characterised by an extensive stream system with wide floodplains and large waterholes. Vegetation in this area consists of riparian eucalypts (River Red Gum, Coolibah and Black Box *Eucalyptus largiflorens*), with tall shrubs (Gidgee and River Cooba *Acacia stenophylla*) and lower shrubs (e.g. Prickly Wattle *A. victoriae*, Thorny Saltbush *Rhagodia spinescens*), amid gibber plains vegetated with grasses and low shrubs.

On 28 July 2003, DR and IW found the nest when one of a pair of Grey Falcons present flushed from the tree. In late August/early September, IW and UK confirmed a Grey Falcon incubating on the nest, and on 13 October observed four Grey Falcon chicks therein (in both cases observed distantly by telephoto lens). All four chicks had fledged by the time of the next visit by DR and IW on 29 October. The falcon pair and four fledglings were in flight nearby and, as activity around the nest tree presented no risk to the juveniles, the major dietary sampling was then conducted. By the next visit on 26 December, the falcons had vacated the nest area, although the group of six (assumed to be the same birds, given the rarity of the species) was still present in the wider area.

Pellets and other dietary remains were collected from the ground directly beneath the vacated nest on 29 October (55 pellets) by DR and IW, with a further three pellets collected on 26 December. The pellets were all of similar size, confidently ascribed to the Grey Falcon pair on the basis of their freshness when collected late in the breeding cycle, and because Grey Falcons had been observed in and around the tree over the past three months and no old pellets were found. To avoid disturbance, minimise visits to the site and maximise valuable data, the ground was not cleared or plastic sheeting/shadecloth emplaced before further collections. Although the lack of such collection practice may introduce dietary biases related to prior occupants of the nest (see Discussion), there was no reason to suspect that the pellets belonged to any other raptor species or previous breeding activity. Furthermore, the nest tree was in a creekline that floods, and the ground beneath the nest would be cleared of any pellets after significant rain, thus preventing long-term accumulations. On each site visit, the nest tree and contiguous creekline trees for two kilometres either side of the nest were searched (negatively) for other raptors and nests.

Each dietary sample (pellet or ort), stored at Sturt NP for later analysis by IJ, was individually bagged and labelled, soaked in 70 percent ethanol for 24 hours, washed with water on a mesh cloth, and dried for 48 hours. Prey items were identified using a local reference collection (bird specimens or feathers held at Sturt NP) and a bird identification key constructed from 94 avian species of body size less than 34 centimetres in total length (bill tip to tail tip, i.e. the maximum prey size recorded for Grey Falcons) known to inhabit the area, and using prey species listed in the literature (cited above) as a guide. Mammal hair was identified microscopically (400× magnification) using the software program 'Hair ID' (Ecobyte Pty Ltd; www.ecobyte.com.au). The minimum number of prey individuals of each species in the total sample was calculated from body parts and main feathers (remiges or rectrices); this method accounts for individual items appearing in more than one pellet, by not assuming that one pellet necessarily equals one prey item (e.g. Olsen *et al.* 2006).

The avian assemblage of Sturt NP was determined from the Park's extensive species lists (Sturt NP fauna database, per Park staff, researchers and visiting ornithologists: NPWS 1996; I. Witte). To investigate prey selection, avian prey-species variables (for species <34 cm in length) were categorised by diet (granivorous/frugivorous, omnivorous or insectivorous); preferred terrestrial habitats among those available in Sturt NP (open/saltbush, open/lightly timbered, lightly timbered, woodland, or all habitat types); and social structure (solitary/pairs, pairs/small groups, flocks, or all three). Information on these aspects of the ecology of prey and their mean body weights were obtained from the literature (Higgins 1999; Higgins *et al.* 2001; Higgins *et al.* 2006). Avian species found in pellets were categorised as 'small' (<20 g), 'medium' (20–100 g) and 'large' (>100 g). Adjusted prey biomasses, to account for wastage factors of different-sized prey, follow the formula of Baker-Gabb (1984) for avian and mammalian prey. Geometric Mean Prey Weight (GMPW) and dietary diversity (species richness and evenness: Shannon Index) were calculated following Aumann (2001) and Olsen *et al.* (2006) as applicable.

Data were analysed using PASW 17.0 (SPSS 2009). Statistical analysis was by Pearson chi-squared tests (Hannagan1997) in cross-tabulations for a normal distribution (expected versus observed) of recorded prey species against diet category, social structure and habitat for those species.

Opportunistic observations on the Grey Falcon pair and offspring in Sturt NP were made by IW around her residence for about five months post-fledging, over the period October 2003–February 2004 when the group of six falcons was seen regularly. During this time the juveniles were readily distinguishable by their dull bare-part colours, compared with the adults' bright yellow eye-rings (among *Falco*, a difference especially strong in Grey Falcons, e.g. Schoenjahn 2010). The juveniles were not marked, nor the nest tree climbed, to avoid disturbance to a rare and threatened species. As it is highly unlikely that there would be more than one group of six Grey Falcons in the area, it was assumed that the frequent sightings in October–February all referred to the pair and offspring from the sampled nest.

RESULTS

Breeding chronology

From comparison with photographs of known-age Peregrine Falcon *Falco peregrinus* chicks (in Olsen 1995, p. 157), i.e. the relative emergence of plumage versus down at weekly or fortnightly intervals, the Grey Falcon chicks were estimated to be about half-grown on 13 October (i.e. ~3 weeks old, from a known nestling period of six weeks for both falcon species), and had fledged by 29 October. Hatching would have been in mid-September and, allowing five weeks for incubation (Marchant and Higgins 1993), egg-laying would have occurred in early August.

The falcons did not use the nest in the following drier year (2004), when it was instead occupied by a breeding pair of Nankeen Kestrels *Falco cenchroides*.

Grey Falcons in Sturt NP

A pair of Grey Falcons had been present in the area of the subject nest at least since IW arrived in the Park in 2001, though rarely seen with offspring (other than in 2003), and in September 2012 a pair had two young in that area (IW pers. obs.). Based on our observations, and on reliable reports from other observers since 2001, there appeared to be three breeding pairs of Grey Falcons in the Park: one pair at a lake in the west and one pair around permanent ground tanks/dams in the north, as well as the subject pair in the east (respectively ~20 km apart).

Diet

The breeding-diet sample consisted, by number, of 99 percent birds, of which the most frequent were Budgerigar *Melopsittacus undulatus* (31%), Blue Bonnet *Northiella haematogaster* (19%) and Zebra Finch *Taenopygia guttata* (19%), and one percent small mammals (a single House Mouse *Mus musculus*; $n \geq 62$ prey items from 58 pellets). Cockatiels *Nymphicus hollandicus* contributed a further eight percent and parrots collectively 63 percent by number (Table 2). The unidentified small brown birds (8%) were presumably passerines, here assumed to be similar in size to the passerine species or genera listed in Table 2. The 11 identified bird species formed 12 percent of the potential avian prey species (i.e. ≤33 cm in length) recorded for Sturt NP. The House Mouse is a widespread introduced species, abundant in Sturt NP and partly diurnal (pers. obs.), whereas the local native rodents and dasyurid marsupials are predominantly nocturnal (Van Dyck and Strahan 2008).

Budgerigar was represented in almost half of the pellets (n = 23, 40%, representing 19+ individuals), with Blue Bonnet and Zebra Finch well represented (each in 15 pellets, 26%, 12+ individuals each), and Cockatiel in seven pellets (12%, 5+ individuals). The other three parrot species in Table 2 appeared in one pellet each (collectively, 5% of pellets). Five identified avian prey species (46%) were small, four (36%) were medium and two (18%) were large. Forty individual bird items (66%) were small, 19 (31%) medium and two (3%) large, indicating a strong bias for small–medium birds (<100 g) (χ^2 = 35.698, d.f. = 2, P = 0.0005; i.e. selection for small birds, avoidance of large birds).

By biomass, Blue Bonnets contributed 37 percent, Budgerigars 23 percent and Cockatiels 17 percent, and parrots collectively 90 percent to the dietary sample (Table 2). The medium-weight species in the prey profile, i.e. the mid-sized parrots listed in Table 2 (Blue Bonnet and Cockatiel), contributed nearly two-thirds (60%) of dietary biomass. GMPW and dietary diversity (Shannon Index) were 29.6 grams and 1.98, respectively.

More granivorous/frugivorous species were found in the dietary sample than expected from the local avian assemblage of appropriate body size, and fewer insectivorous species (46% vs 18%, with 36% omnivorous; χ^2 = 9.786, d.f. = 2, P = 0.007). By contrast, the avian assemblage (species <34 cm) of the land habitats of Sturt NP was dominated by insectivorous species (58%, with 30% omnivores and only 12% granivores/frugivores). There were no significant deviations from the expected occurrence of prey species in the dietary samples, with respect to social structure (χ^2 = 5.395, d.f. = 3, P = 0.145) or the prey species' preferred local habitats (χ^2 = 5.523, d.f. = 4, P = 0.238). However, 82 percent of prey individuals were from species that commonly flock. The falcons' prey profile in Sturt NP can thus be characterised as predominantly flocking, ground-feeding granivores.

Table 2

Breeding diet of a pair of Grey Falcons and their nestlings in Sturt National Park, from pellets and orts (n = 58 samples) collected in October–December 2003. Unidentified birds are assigned a mean weight for the identified passerines. Adjusted biomasses (to nearest gram), allowing for wastage, follow Baker-Gabb (1984).

Species	Wt (g)	*n*	% *n*	Adj. biomass (g)	% biomass
Cockatiel *Nymphicus hollandicus*	88	5	8.1	385	17
Red-winged Parrot *Aprosmictus erythropterus*	150	1	1.6	132	6
Australian Ringneck *Barnardius zonarius*	127	1	1.6	112	5
Blue Bonnet *Northiella haematogaster*	82	12	19.4	864	37
Mulga Parrot *Psephotus varius*	60	1	1.6	57	2
Budgerigar *Melopsittacus undulatus*	29	19	30.6	532	23
Splendid Fairy-wren *Malurus splendens*	9	1	1.6	9	<1
Variegated Fairy-wren *Malurus lamberti*	8	2	3.3	15	<1
Crimson Chat *Epthianura tricolor*	10	1	1.6	10	<1
Horsfield's Bushlark *Mirafra javanica*	23	1	1.6	22	1
Zebra Finch *Taeniopygia guttata*	12	12	19.4	132	6
Unidentified small brown bird	12	5	8.1	55	2
House Mouse *Mus musculus*	17	1	1.6	15	<1
Total		62	100.1	2325	100

Behaviour

The four offspring were still together with the parents five months post-fledging. One sighting was of the juveniles accompanying the hunting adults over a homestead garden and around nearby earth tanks, the falcons repeatedly swooping as a group above the house and garden. The garden was densely planted with native vegetation and regularly watered, creating a moist refuge in the predominantly arid landscape. It thus harboured a high density of small birds. The effect of the falcons swooping was possibly to flush the small birds that had taken cover in this refuge. Otherwise, the group of six falcons was often seen flying or perching around the homestead dam in the early or late afternoons, throughout the observation period (October–February).

DISCUSSION

Nest site and breeding

The nest site, breeding habitat and estimated laying date are consistent with published information on this species (e.g. Marchant and Higgins 1993; Falkenberg 2011; Sutton 2011). Similarly, the successful brood of four is consistent with prior inferences about the relationship between effective rainfall in the pre-breeding months and the Grey Falcon's breeding productivity (Falkenberg 2011; Sutton 2011). Elsewhere in the arid zone, avian species richness and the presence of nomadic bird species (i.e. Grey Falcon prey) are positively related to rainfall, notably in some cases with that falling in the first half of the year (Paltridge and Southgate 2001; Burbidge and Fuller 2007; Bell *et al.* 2013).

The adoption of the nest by Nankeen Kestrels in 2004 provides another example of Grey Falcons not reusing a nest in subsequent year(s) (e.g. Falkenberg 2011; Schoenjahn 2013a). The possible reasons deserve investigation, but may relate to non-breeding by Grey Falcons in poor seasons.

Diet

The dietary sample from the Grey Falcon nest in Sturt NP consisted almost entirely of birds, especially ground-feeding granivores that were abundant in the open/semi-open landscape during the breeding event, with selection for small–medium birds and particularly parrots of 30–90 grams. Pigeons or doves, as found in other studies (e.g. Schoenjahn 2013a), were not recorded as prey in Sturt NP, even though they were present. The falcons did not otherwise select prey species on the basis of habitat or social structure, although prey individuals were predominantly from flocking species.

Given that most pellets (95%) dated from the nestling period and potentially earlier, it is possible that much of the prey was caught by the male while the larger female was incubating or brooding. In Grey Falcons, and raptors generally, males provide most of the food to the incubating/brooding female until the chicks can thermoregulate and thus free the female to hunt (e.g. Marchant and Higgins 1993; Olsen 1995; Falkenberg 2011).

Potential biases in this study include the likely male-biased prey provision in the October sample, and possible scavenging (by foxes) or weathering (by rain) of post-October pellets, as only three pellets were found in late December. The adult female may have contributed more (and larger) prey in November–December than was represented by those few pellets. On the other hand, incidental literature records of prey as large as the Crested Pigeon *Ocyphaps lophotes* and Galah *Eolophus roseicapillus* may reflect biased observations (e.g. sightings at waterholes, feeding on large prey on the ground in the open (Olsen and Olsen 1986), and hence ease of seeing and identifying large prey).

The Grey Falcon's prey profile in north-western NSW, including its GMPW and specialisation on a narrow range of avian prey, was similar to that of comparable samples from elsewhere in the arid zone (Aumann 2001; Sutton 2011;

Schoenjahn 2013a). It also confirms or amplifies smaller samples or anecdotal (unquantified) prey lists from the arid zone (Olsen and Olsen 1986; Marchant and Higgins 1993; Harrison 2000; Falkenberg 2011; Watson 2011), including an apparent preference for Blue Bonnets and Red-rumped Parrots *Psephotus haematonotus* in south-western New South Wales (Schrader in Czechura and Debus 1985). Being granivores, the falcon's prey species would need to drink daily, or almost so, thus providing a focus for predation at water sources. Such water sources, even in national parks, now of necessity include retained artificial stock-watering points, following the past degradation and loss of natural sources (e.g. 'native wells') by stock, feral animals and changed human land use (see Croft *et al.* 2007).

It is recognised that dietary analyses based on orts and pellets from beneath active nests may be subject to biases, including those resulting from multiple raptor species sequentially using the same nests or perches and depositing pellets or orts thereunder (e.g. Schoenjahn 2013a). However, this bias is unlikely in our study (e.g. the Brown Falcon *Falco berigora* and Peregrine Falcon were not recorded in the area during the study; the nest was in a live tree, in a solitary rather than semi-colonial raptor situation, and not on a popular perch such as a telecommunications tower). As most prior Australian raptor dietary studies based on pellets or orts are potentially affected by this bias, albeit minimally, inter- and intraspecific comparisons of dietary parameters would still be valid. Furthermore, the Grey Falcon's prey profile in this study is very similar to that based on direct observation of prey by Schoenjahn (2013a): he recorded 99 birds and two mammals captured, all 23 identified birds being ground-feeding granivores in the same size range as found in the Sturt NP sample.

Behaviour

The long period of juvenile association with parents is consistent with previous observations that the Grey Falcon's post-fledging dependence period may last many months, and perhaps up to a year (Marchant and Higgins 1993; Schoenjahn 2011, 2013b). That juveniles accompany hunting adults for five months or longer suggests they practise the difficult and complex task of catching birds in flight by observing and perhaps imitating the adults, although hunting behaviour is at least partly innate and refined by experience (e.g. Olsen 1995). The many anecdotal reports of parent-offspring groups of Grey Falcons being maintained for long periods post-fledging, and the lack of credible reports of Grey Falcons eating insects or carrion (e.g. Marchant and Higgins 1993), suggest that juveniles have a long 'apprenticeship' on mostly avian prey. This aspect contrasts with some other bird-eating falcons in which juveniles initially take 'easy' prey such as insects and/or some carrion (e.g. Australian Hobby *Falco longipennis*, Black Falcon *F. subniger*: Marchant and Higgins 1993; S. Debus pers. comm.).

Conservation implications

The Grey Falcon appears to have a maximum brood size of four (Schoenjahn 2013a). Possible factors in the success of the large brood at Sturt NP include the above-average rainfall in autumn 2003, and its effect on prey resources and populations in the following months (i.e. the falcon's pre-laying and breeding season). In addition, Sturt NP is a conservation reserve (~30 years in 2003), and the removal of stock and the positive effects of the rabbit calicivirus pandemic (since 1995) on vegetation recovery probably worked in concert to maximise the availability of avian prey resources. Similar conclusions on the positive influence of rainfall, habitat reservation and reduction of rabbit numbers on Grey Falcon productivity have been suggested for other parts of the arid zone (Falkenberg 2011; Sutton 2011).

There are no data on fluctuations in the reproductive success or prey profile of the Grey Falcon in arid New South Wales in response to seasonal conditions (weather or prey fluctuations). As recommended by Garnett *et al.* (2011), better ecological and baseline demographic information is still required for the conservation of this species. On present information, it appears likely that large, de-stocked conservation reserves in the arid zone could be a significant contribution to the management of the Grey Falcon and its prey base, and therefore of the other threatened or declining species that share its environment.

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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.

Baker-Gabb, D. J. (1984). The breeding ecology of twelve species of diurnal raptor in north-western Victoria. *Australian Wildlife Research* **11:** 145–160.

Baylis, T. and van Gessel, F. (2011). Observations and sonograms of calls of Grey Falcon *Falco hypoleucos*. *AudioWings* **14(2):** 8–9.

Bell, D. T., Luyer, J. R. and Agar, P. K. (2013). Birds of the Doolgunna and Mooloogool rangelands, northeast Gascoyne region, Western Australia. *Amytornis* **5:** 1–13.

Burbidge, A. A. and Fuller, P. J. (2007). Gibson Desert birds: responses to drought and plenty. *Emu* **107:** 126–134.

Croft, D. B., Montague-Drake, R. and Dowle, M. (2007). Biodiversity and water point closure: is the grazing piosphere a persistent effect? In 'Animals of Arid Australia: Out there on their Own?' (Eds C. R. Dickman, D. Lunney and S. Burgin), pp. 143–171. (Royal Zoological Society of New South Wales: Sydney.)

Czechura, G. V. and Debus, S. J. S. (1985). The Grey Falcon *Falco hypoleucos*: a summary of information. *Australian Bird Watcher* **11:** 9–16.

Denny, M. (1975). Mammals of Sturt National Park, Tibooburra, New South Wales. *Australian Zoologist* **18:** 179–195.

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.)

Hannagan, T. (1997). 'Mastering Statistics', 3rd edn. (Macmillan: London.)

Harrison, R. (2000). Observations on the Grey Falcon *Falco hypoleucos*. *Australian Bird Watcher* **18:** 267–269.

Higgins, P. J. (Ed.) (1999). 'Handbook of Australian, New Zealand and Antarctic Birds, Volume 4: Parrots to Dollarbird'. (Oxford University Press: Melbourne.)

Higgins, P. J., Peter, J. M. and Cowling, S. J. (Eds) (2006). 'Handbook of Australian, New Zealand and Antarctic Birds, Volume 7: Boatbill to Starlings'. (Oxford University Press: Melbourne.)

Higgins, P. J., Peter, J. M. and Steele, W. K. (Eds) (2001). 'Handbook of Australian, New Zealand and Antarctic Birds, Volume 5: Tyrant-flycatchers to Chats'. (Oxford University Press: Melbourne.)

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

Montague-Drake, R. and Croft, D. B. (2004). Do kangaroos exhibit water-focused grazing patterns in arid New South Wales? A case study in Sturt National Park. *Australian Mammalogy* **26:** 87–100.

NPWS (1996). 'Sturt National Park: Plan of Management'. (NSW National Parks and Wildlife Service: Sydney.)

NPWS (2003). 'The Bioregions of New South Wales: Their Biodiversity, Conservation and History'. (NSW National Parks and Wildlife Service: Sydney.)

NSW Scientific Committee (2009). Grey Falcon *Falco hypoleucos*: Review of current information in NSW, July 2009. Unpubl. Report. Review of the Schedules of the *Threatened Species Conservation Act 1995*. NSW Scientific Committee, Sydney [www.environment.nsw.gov.au/resources/nature/schedules/GFalcon.pdf].

NSW Scientific Committee (2010). Grey Falcon *Falco hypoleucos* endangered species listing [www.environment.nsw.gov.au/determinations/greyfalconFD.htm].

Olsen, J., Fuentes, E., Rose, A.B. & Trost, S. (2006). Food and hunting of eight breeding raptors near Canberra, 1990–1994. *Australian Field Ornithology* **23:** 77–95.

Olsen, P. (1995). 'Australian Birds of Prey'. (University of New South Wales Press: Sydney.)

Olsen, P. D. and Olsen, J. (1986). Distribution, status, movements and breeding of the Grey Falcon *Falco hypoleucos*. *Emu* **86:** 47–51.

Paltridge, R. and Southgate, R. (2001). The effect of habitat type and seasonal conditions on fauna in two areas of the Tanami Desert. *Wildlife Research* **28:** 247–260.

Schoenjahn, J. (2010). Field identification of the Grey Falcon *Falco hypoleucos*. *Australian Field Ornithology* **27:** 49–58.

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

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

Schoenjahn, J. (2013b). Why do some young Grey Falcons *Falco hypoleucos* stay with their parents into the next breeding season? [abstract]. *Boobook* **31:** 72.

SPSS (2009). PASW Statistics for Windows, Version 17.0.3. (SPSS Inc.: Chicago.)

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.

Thackway, R. and Creswell, I. D. (1995). 'An Interim Biogeographic Regionalisation for Australia, Version 4.0'. (Australian Nature Conservation Agency: Canberra.)

Van Dyck, S. and Strahan, R. (Eds) (2008). 'The Mammals of Australia', 3rd edn. (Reed New Holland: Sydney.)

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