AUSTRALIAN FIELD ORNITHOLOGY 2007, **24**, 137–157

Breeding Biology and Diet of the Little Eagle *Hieraaetus morphnoides* in the New England Region of New South Wales

S.J.S. DEBUS[1], T.S. HATFIELD[2], A.J. LEY[3] and A.B. ROSE[4]

[1]Zoology, University of New England, Armidale, New South Wales 2351 (Email: sdebus@une.edu.au)
[2]3 Denchley Street, Tannum Sands, Queensland 4680
[3]19 Lynches Road, Armidale, New South Wales 2350
[4]Associate, The Australian Museum, 6 College Street, Sydney, New South Wales 2010 (Present address: 61 Boundary Street, Forster, New South Wales 2428)

Summary

The breeding biology, behaviour and diet of the Little Eagle *Hieraaetus morphnoides* were studied throughout 110 hours of observation from nest-renovation until early in the nestling period, and by analysis of prey remains and pellets, at three nests in the New England region of northern New South Wales in 2006. Supplementary observations and collections of food remains were made at a fourth nest, which was also monitored through the nestling and post-fledging periods. Egg-laying occurred in September (n = 4 clutches). At two nests, incubation (by both sexes, but mostly by the female) lasted 37–39 days, and at one nest the post-fledging dependence period lasted at least 8 weeks. Sex-roles, parental behaviour and time-budgets in each phase (week 1 only of the nestling period) are described and quantified. Fledgling productivity was 0.4 young per pair (1.0 per successful pair) in 2006 (n = 5 pairs). The breeding diet at three nests near Armidale (on the Northern Tablelands of NSW) was 78% mammals (70% Rabbits *Oryctolagus cuniculus*), 13% birds and 4% reptiles by number (plus 4% unidentified bird/mammal), and 94% mammals (80% Rabbits), 5% birds and 1% reptiles by biomass (n = 23 prey items). Hunting and attack behaviour are described; one of four observed strikes was successful.

Introduction

The biology of the Little Eagle *Hieraaetus morphnoides* has been studied, though much less comprehensively than for the Wedge-tailed Eagle *Aquila audax* (see Debus *et al.* 2007 on the latter species). Since the summary of the Little Eagle's biology by Marchant & Higgins (1993), there have been studies of its foraging, breeding biology and diet in the arid zone (Aumann 2001a,b,c), cursory studies of its breeding success and diet (Falkenberg *et al.* 2000; Olsen *et al.* 2006a), a population study in the Australian Capital Territory (Olsen & Fuentes 2005; Olsen & Osgood 2006), and several anecdotal accounts of prey items or behaviour (Say 1993; Aumann 1995; Whelan 1995; Conole 1996a,b; Johnstone & Storr 1998; Morris & Burton 1999; Morris 2003, 2004, 2006; Lenz 2004; Schoenjahn 2005; Courtney 2006; Debus 2006a,b,c, 2007). Although previous behavioural studies have quantified aspects of the Little Eagle's nestling period (Debus 1983, 1984a,b; Bollen 1989, 1991), there have been major gaps in knowledge of the nest-building, prelaying, incubation and early nestling periods, with no quantification of sex-roles and parental time-budgets in these phases, and no description of a complete breeding cycle from nest-building to independence of the young. There has been little information available on nest-building and prelaying behaviour, no description of copulation, few precise determinations of the incubation period (Marchant & Higgins 1993 gave an improbable range of 'at least 33–41 days', cf. ~36 days as determined by Bollen 1991), and some debate over sex-roles in nest-building or

nest-lining activity (Marchant & Higgins 1993). The need for knowledge of the biology of the Little Eagle, for conservation and management purposes, is increasing because the species is declining in parts of south-eastern Australia (Australian Capital Territory: Olsen & Fuentes 2005, Olsen & Osgood 2006; New South Wales Central Tablelands: S. Tredinnick pers. comm.).

The genera *Aquila* and *Hieraaetus*, as traditionally constituted, are now known from DNA studies to be paraphyletic, with some in one genus more closely related to those in the other, and vice versa (Wink & Sauer-Gürth 2004; Helbig *et al.* 2005; Lerner & Mindell 2005). They could thus either be merged, or each genus (in a narrower sense, with some species transferred between these genera or to other genera) could continue to be recognised. A comparative behavioural study of the Wedge-tailed Eagle (a 'core' *Aquila* eagle) and the Little Eagle could identify any differences, and thus shed light on the validity of separating the small, 'pied', plumage-dimorphic eagles in *Hieraaetus* (cf. Helbig *et al.* 2005; Lerner & Mindell 2005).

This study describes and quantifies behavioural aspects of the breeding cycle of four pairs of Little Eagles for parts of the cycle from nest-refurbishment to independence of a juvenile. Our study was supplemented by observations at one other nest, and the Eagles' breeding diet was quantified at three active nests. We also compare aspects of the breeding behaviour and ecology of the Little Eagle (*Hieraaetus*) with those of the Wedge-tailed Eagle (*Aquila*) studied in the same area in the previous year (Debus *et al.* 2007).

Study area and methods

The main part of the study was conducted at Armidale (30°30′S, 151°40′E), on the Northern Tablelands of New South Wales, in 2006 (a drought period). The area is an undulating plateau at 1000 m elevation, with remnant eucalypt woodland (mainly on ridges) amid cleared pasture and farmland (see Debus *et al.* 2006 for further details and references). The two primary Eagles' nests (Armidale nests 1 and 2), from which most data were collected, were located in remnant eucalypt woodland on private property. A third nest (Armidale nest 3), also in remnant eucalypt woodland on private property, provided data only on the nest-building period. A fourth nest (Armidale nest 4) was located on private land adjoining a woodland reserve (Imbota Nature Reserve, formerly Eastwood State Forest) of 220 ha (see Debus 2006d for further details and references). These four nests were at the same locations as a previous study on the Little Eagle (Debus 1983, 1984a,b, 1991).

Observations at the Armidale nests were conducted from unconcealed positions, using binoculars and telescopes (25×, 20–40× zoom), from distances at which the adult Eagles ignored human activity (generally ~100 m), i.e. the parent Eagles did not stare fixedly at the observers or appear reluctant to leave or return to the nest while observers were present. If females flushed or appeared nervous the viewing distance was increased, so that observer presence did not affect the Eagles' behaviour. Three nests were watched (mostly in the mornings) in the month leading up to laying; two nests throughout the 5-week incubation period (daily in the latter half of the final week, to pinpoint the hatching day); and these two nests also through the first week of the nestling period until both nests failed. A fourth Eagle family was checked through the latter half of the nestling period and through the post-fledging period. Nest-based observations at nests 1 and 2 totalled 99 h, distributed through the day (Table 1). Most nest-watches were for an hour, rarely 0.5 h (around sunset). Watches were opportunistic, but start times were varied and the observers independently watched nest 1 sequentially or on different days around hatching time.

Nest 1 was observed for 24 h over 21 days through the 5-week nest-building and prelaying period; 33 h over 27 days in the incubation period; and 10 h over 7 days in the first week of the nestling period until nest failure on day 8 (total 67 h). Nest 2 was observed (for 4 h) or checked over 7 days in the 2 weeks leading up to incubation; 24 h over 23 days in the incubation period; and 8 h over the first 4 days of week 1 of the nestling period, before nest

Table 1

Hours of observation at Little Eagle nests in nest-building (nest 1 only), incubation and nestling periods (August–November 2006), Armidale, NSW (two nests: see text), during each 2-hour interval of daylight. For each stage, nest 1 = upper row, nest 2 = lower row; subtotals for each stage in bold (nestling period = week 1 only, until nest failure).

0600–0800	*0801–1000*	*1001–1200*	*1201–1400*	*1401–1600*	*1601–1800*
Nest-building:					
5.6	6.7	4.3	2.5	1.8	3.2
Incubation:					
3.7	6.7	8.0	4.8	4.4	5.0
3.5	4.5	4.0	3.7	4.3	4.3
7.2	**11.2**	**12.0**	**8.4**	**8.8**	**9.3**
Nestling period:					
2.0	2.3	1.0	1.0	1.0	3.0
2.0	2.0	2.0	1.0	1.0	–
4.0	**4.3**	**3.0**	**2.0**	**2.0**	**3.0**

failure by week 2 (total 36 h). Nest 3 was observed for 5.5 h over 4 days in the nest-building period (nest already partly built), until the pair abandoned the attempt. Nest 4 was checked on 13 days over the final 6 weeks of the nestling period, and intermittently through the post-fledging period; the nest could not be approached through dense woodland to a suitable viewing point without the female flushing, so the chick's progress was viewed briefly and no sustained nest-watches were conducted.

A secondary study, of one Little Eagle nest in 2006, was conducted at Torryburn (30°25′ S, 151°12′E) ~50 km west of Armidale. It was visited by SD casually through the incubation, nestling and early fledgling periods, to monitor progress and collect food remains.

Incubation, hatching, and brooding/feeding of new chicks were inferred from parental behaviour (see descriptions of behaviour in the relevant Results sections). Parental time-budgets were quantified by continuous focal-animal sampling, i.e. observing and recording the start and finish times (duration) of each behaviour, to the nearest minute. With familiarity, at nests 1 and 2 the adults (all of them light morph) were readily sexed by subtle differences in moult pattern; when together, the sexes were identified by relative size (cf. Marchant & Higgins 1993). Distances between focal points in nesting territories were measured with a range-finder; heights of nests above the ground were estimated from a 2-m person standing beside the tree-trunk; and tree diameter at breast height was calculated from the circumference measurement.

Pellets and prey remains (orts) were collected from below the three Armidale nests and surrounding roosting perches during the nestling period. Prey items were identified by ABR, by microscopic examination of fur if necessary, from comparison with a reference collection. For each nest, the minimum number of prey individuals was calculated from orts, pellets and observed prey items pooled, i.e. species in pellets were counted only if they were not represented in orts, and items observed to be brought to nests were counted only if they were not represented in orts or pellets, taking into account the age distribution of items in orts and pellets, and the number of sight records compared with orts. We did not assume that one pellet equals one prey individual, and we did not double-count items that were represented in both orts and pellets (see Olsen *et al.* 2006a; Debus *et al.* 2007).

Results

Eagle population

Of the five pairs of Little Eagles last surveyed around Armidale city in 1990

(Debus 1991), four remained in 2006 (no implication that the same individuals were involved). The north Imbota pair (both pale birds) was displaced in 2004 by a pair of Wedge-tailed Eagles that built a nest within 800 m of the Little Eagles' nest; many Rabbit *Oryctolagus cuniculus* warrens in Imbota had been fumigated and ripped around 2003. In spring 2005 a new (dark), apparently unpaired male Little Eagle displayed above and on a rudimentary nest ~1 km away from the Wedge-tailed Eagles' nest, but this Little Eagle territory was not occupied in 2006. Otherwise, the remaining four pairs (1–4 of this study) all nested in 2006 within 0.5–1.5 km of respective nests used in 1990. Pair 1 had been displaced ~1.3 km when Wedge-tailed Eagles built a nest ~500 m from the Little Eagles' original nest; pair 2 still nested within ~500 m of nest(s) used in the 1990s; and pair 3 had moved ~500 m after their pre-2006 nest-tree died (the pair having earlier, pre-1990, been displaced ~1.5 km by urban expansion). The Rabbit population in the pre-2006 nesting territory of pair 3 had also been controlled by pindone baiting (R. Hatch pers. comm.), perhaps contributing to the Eagles' recent move. During the nestling period in 2001, a new house and shed were built ~100 m from the active nest of pair 4, including trees felled to within ~50 m of the nest-tree; the breeding cycle was completed (D. Moffitt pers. comm.), but the pair subsequently relocated 1.5 km away.

Of two additional pairs known around Armidale city in the 1980s and 1990s, the pair in Armidale State Forest ('Pine Forest') had, by 2006, moved ~1 km east, apparently as pairs 2 and 3 gradually encroached from the north-west and south-east respectively, but also possibly because the nest-tree and surrounding pines were harvested in the 1980s. The former territory of another pair, between north Imbota and the city in the early 2000s, was occupied by an unpaired, apparently immature male in 2006. The site had meanwhile been disturbed by subdivision, new fencing and roadworks that encroached to within 300 m of the nest-tree, and in 2006 the nest was derelict.

Nest-sites

All four active nests around Armidale in 2006 were high in tall living trees in patches of eucalypt woodland of a least 25 ha. Nests were built in common local eucalypts (Broad-leaved Stringybark *Eucalyptus caliginosa*, Yellow Box *E. melliodora* and Manna Gum *E. viminalis*), on southerly aspects, and sometimes in mistletoe (Table 2). The Torryburn nest west of Armidale was in a horizontal fork high in the crown of a mature Eastern Grey Box *E. moluccana*. Nest dimensions were not determined, but nests were about the size of crow/raven (*Corvus* sp.) nests, i.e. small for the size of the Eagles, and inconspicuous.

Breeding chronology

Nest 1 was used in 2005. On 11 August 2006 it was not yet refurbished and there was no whitewash below it, although the nearby roost-trees were occupied. By 15 August some sticks had been added, therefore rebuilding started on or about 13 August. The pair was still in prelaying mode on 15 September and the female was sitting on 17 September, with incubation in progress by 19 September. Therefore, laying occurred on 16 or 17 September (probably the latter date). At nest 2 the pair copulated on 8 September, when the female sat on the nest intermittently, but also soared. Incubation was in progress on 9 September, so laying must have occurred on 8 or 9 September. At nest 3 building was in progress over 5–8 October, but was subsequently abandoned and the breeding attempt did

Table 2

Nest-site characteristics of Little Eagle nests at Armidale, NSW, 2006: characteristics of nest-tree and position of nest. For tree species, 1 = Broad-leaved Stringybark *Eucalyptus caliginosa***, 2 = Manna Gum** *E. viminalis***, 3 = Yellow Box** *E. melliodora***; dbh = diameter at breast height; nest height = height of nest above ground.**

Pair/nest	*Tree species*	*Tree height (m)*	*Tree dbh (cm)*	*Nest height (m)*	*Position*
1	1	20	75	18	S slope, flank of minor gully
2	2	21	68	18	S slope, in slight gully; nest in mistletoe *Amyema* sp.
3	3	24	70	18	SE slope; nest in mistletoe
4	1	24	60	20	S slope, flank of minor gully

not proceed. At nest 4 fledging occurred on 25 December ± 2 days, and at the Torryburn nest fledging occurred on 21 December (i.e. laying at both also in September, from incubation and nestling periods of ~5.5 weeks and ~2 months respectively: Marchant & Higgins 1993; this study).

Nest-building and prelaying phase

At nest 1 both sexes collected material and built the nest; they brought sticks at a rate of 0.6/h (n = 14: five by the male, one by the female, eight when the sex of the adult was unknown). The female brought one sprig of green foliage (at 0740 h) to the nest in 24 h of observation, but there were three other mornings when fresh foliage was already on the nest by the start of early- or mid-morning watches (i.e. before 0735 h, 0805 h and 1000 h). All material was carried in the bill. On one morning the male, in the female's absence, brought a stick to the nest, then formed the cup by sitting, raking with his feet, turning and raking again. On another morning, the female brought greenery then remained on the nest while the male brought four sticks during 12 minutes. The male placed the sticks then departed, while the female arranged them and, on one occasion, formed the cup by sitting, raking and turning; if he was slow to depart, she gently pecked his bill. Most building occurred in the mornings, before 1000 h, but on one afternoon two sticks were delivered after 1630 h. There were no observed deliveries between 1000 and 1600 h (cf. Table 1), but on one morning of intensive building activity six sticks and one green spray were delivered in the hour from 0710 h, and on four other mornings 1–3 sticks were delivered per hour between 0730 and 0950 h. During the building phase, the nest was attended by either adult for 7% of observation time (1% by male, 3% by female, 3% by adult of unknown sex); in the early mornings one or both birds often perched on or beside the nest. The nest-building and prelaying phase lasted 5 weeks (~13 August to ~16 September), but no building activity was seen after 9 September when there was fresh greenery on the nest, and no sticks were seen to be added after 2 September. That is, there was little or no building in the last 2 weeks before laying.

For pair/nest 2 the male was seen to bring one stick (in his bill) to a flimsy stick platform, but thereafter the pair's focus shifted to another, more substantial, existing nest ~450 m away (apparently the pair's 2005 nest) that was subsequently built up and used in 2006. At the latter nest, renovation and laying occurred within a fortnight of the male placing a stick on the initial (alternative) nest.

At nest 3, the male brought four sticks to the nest in 5.5 h over five mornings (= 0.7/h). He plucked dry sticks from neighbouring stringybarks by sidling along a branch, pulling the stick with his bill and sometimes flapping, then carried the stick in his bill to the nest where he placed it and, on one occasion, he also formed the cup by sitting, raking and turning. On one morning, at 0700 h when there was fresh foliage on the nest, the female perched on the nest-branch then the neighbouring tree while the male fetched and placed sticks. The male attended the nest for 5%, and the female for 6%, of observation time.

In early August, before nest-building activities started for the season, males sometimes soared high and gave three-note calls while females flew or soared lower, over the tree-canopy, and replied with three-note calls (see Marchant & Higgins 1993 for descriptions of calls). Throughout the building phase, males often soared high and performed an undulating display with two- or three-note calls, and females sometimes soared and called. The adults were vocal around the nest, with much two- or three-note calling, piping and squealing. At nest 1, the male once flew past the nest with rapid, short-amplitude wing-beats. At nest 3, the male called from the nest in the female's absence, and he perched, calling, with his carpals slightly extended to display the pale upperwing-band prominently. He also flew around the top of the nest-tree and of the neighbouring tree, where the female was perching conspicuously on a bare branch above the nest and calling, with her white breast facing the sun. Subsequently, the high-soaring and displaying male stooped to the treetops, calling excitedly, where the female was perched.

During the prelaying days the female at nest 1 often perched in the nearby roost-trees and sometimes interacted vocally with the arriving male; although they were obscured from view and details of behaviour were not visible, her increasingly excited calling at such times suggested courtship feeding or copulation. At nest 2, in the immediate prelaying days, the high-soaring male gave two-note calls and stooped vertically to the tree-canopy around the nest. Two days later, he was soaring, then stooped rapidly in a long, shallow dive, with two bursts of wing-beats, to arrive swiftly among the treetops around the nest. After soaring again and calling, he stooped to the nest-branch, calling excitedly and bobbing and peering at the sitting female; as he edged closer she stood up, then he alighted on her back and they mated for ~5 seconds on the nest-rim, with the male flapping his wings while one of them gave a repeated soft, hoarse mewing call.

Although not seen during the prelaying phase, a rolling and talon-presentation display was observed at the Torryburn nest during the incubation period: the sitting female rose and soared above the tree-canopy, whereupon the high-soaring male stooped vertically at her with his feet lowered, and she made a complete sideways roll to parry with her extended feet as he pulled away.

Territory and nest defence

The adults at nests 1 and 2 defended their territories against intruding Little Eagles and Wedge-tailed Eagles, though more strongly in the prelaying phase than subsequently. For instance, during the building phase at nest 1, when two other male Little Eagles (by size) soared over the nest area the resident male soared and called, then performed vigorous undulating dives culminating in a descent to the nest area, with much calling. During the incubation period the sitting male craned and peered up while his mate was soaring and an intruding Little Eagle soared and called distantly, but otherwise he took no action. However, next day the resident male and the neighbouring male were soaring together,

Table 3

Tolerance of nesting Little Eagles to proximity of farmhouses and observers: distances of nests of each pair from occupied rural dwellings, and distance at which Eagles accepted unconcealed observation. Nests 1–4 numbered as in text and Table 2.

Nest	*Distance from dwelling(s) (m)*	*Distance from observers (m)*
1	~250	90
2	~400 × 2	140
3	240	50
4	330	-[a]

[a]Did not accept observation at 120 m (the maximal unobstructed viewing distance)

both in the display soaring posture with wings slightly drooped and turned back at the carpals and the tail furled (as described by Debus 1991); the sitting female was calling from the nest, then she left and soared. At nest 2 during the incubation phase, the perched female called frequently from the nest-tree, but the sitting male took no action, as a Wedge-tailed Eagle glided high overhead, pursued by a third Little Eagle. Also at nest 2, over the ensuing fortnight of incubation (a) the sitting male watched but took no action as the female soared with an intruding male; (b) the male soared and called over the nest area when a Brown Falcon *Falco berigora* soared over; (c) the sitting female stood and left the nest, calling, and the perched male called then soared, assuming the display soaring posture, as a third Little Eagle soared and called high overhead.

Interactions between two other rival male Little Eagles were observed: a dark bird (individually recognisable by a bent primary) that was unpaired, and a pale bird that (from behaviour and calling earlier in the season) possibly had a mate and active nest. In early October (local incubation period) the two males were soaring together over their mutual hunting grounds; the pale bird feinted then stooped at the dark bird (past his head, without visible response), and both drifted apart towards their respective territories, soaring and calling, before the pale bird returned to soar and call in the dark bird's territory. Subsequently, in mid November (local nestling period), the dark bird was deep in the pale bird's territory; the dark bird soared and performed an undulating display, then the pale bird stooped at him and he retreated to his own territory while the pale bird soared.

During the chick phase at nest 2, on day 1 (female brooding), the soaring male feinted towards an approaching, harassing Australian Raven *Corvus coronoides* (that had fledglings) in the Eagles' nest area; the Raven retreated, and the Eagle assumed the display soaring posture then performed undulating dives as a third Little Eagle soared high overhead.

Reaction to disturbance

Pairs 1–4 nested at distances of 250–400 m from, and often (pairs 1, 3 and 4) in view of, occupied rural residences, and accepted unconcealed observation from 50–140 m away (Table 3). The incubating female of pair 2 was initially wary of human approach within 120 m of the nest (alert, in the flattened intruder posture, at that distance, and flushing at human activity within that radius), so the viewing distance was increased to 140 m and she no longer reacted to observers. Pair 3 was confiding, and had previously nested 90 m from an occupied hut (R. & S. Hatch pers. comm.). The female of pair 4 was wary and generally could not be approached to within unobstructed viewing distance (120 m) without flushing.

The pair between Imbota and Armidale city nested 150 m from, and in view of, an occupied rural residence; the breeding cycle and initial post-fledging days were readily observed from the house (B. Scott pers. comm.). This nest was in a mistletoe in the top of a mature Yellow Box (cf. Table 2).

Incubation

At nests 1 and 2, both sexes shared daytime incubation; routines and behaviour were similar at these nests. At nest 1 the female incubated for 80% of observation time (33 h), the male for 11%, and the eggs were uncovered for 9% (unattended for 7%, when neither adult was standing on or beside the nest or in the nest-tree, for periods of up to 26 min., commonly 2–7 min.). Female incubation stints usually extended beyond the start or finish (or both) of observation sessions (i.e. commonly >60 min.; also >75 min., >105 min.), except for two short stints of 6 minutes each in the restless final days before hatching. The male incubated for seven timed stints of 4–24 minutes, but there were occasions when his stints extended beyond observation sessions (>26, >47 and >51 min.). At nest 2 the female incubated for 89% of observation time (24 h), the male for 7%, and the eggs were uncovered for 4% (unattended for 3%, for periods of 5–20 min.). Female incubation stints always extended beyond the start or finish (or both) of watches (i.e. usually >60 min.); the male incubated for stints of 20, 29 and >52 minutes.

At nest 1, when the male relieved the female, changeover routines were of two main types. Either the calling female left the nest to be replaced by the male 2–8 minutes after she departed, or the female left the nest to collect food from the incoming male in neighbouring trees where she ate while he incubated. On one occasion the male brought food to the nest and then incubated when the sitting female stepped aside and preened on the nest-branch. There were also occasions when the incoming male arrived at the nest with or without food and once with greenery, and the female stayed sitting; he deposited the item and left. On one occasion the food-bearing male touched bills with the sitting female, which stood and ate on the rim, and he left. When relieving the male, the calling female arrived on the nest-branch and he immediately departed before she jumped to the rim. On one occasion the male, which had been incubating for ~1 h, left spontaneously in the female's absence.

At nest 2, when the male took an incubation shift, the calling female left the nest and he came to it 5–10 minutes after she departed. Observed food deliveries to the nest did not result in a changeover: she either stayed sitting and he left (once with old prey remains), or once she took food from his foot and ate on the rim, and he left. Also, on two occasions the calling male (without food) arrived at the nest or elsewhere in the nest-tree, but she stayed sitting and he left. When relieving the male, the calling female arrived at the nest and he departed immediately.

Both returning females commonly stooped to the nest from a soaring position. Males sometimes initiated (or attempted to initiate) a changeover of incubation, but females appeared to determine whether males took an incubation shift and when they were relieved; incubating males always deferred promptly to incoming females.

At nest 1, from laying on 16 or 17 September to pipping or hatching on 25 October meant an incubation period of 38 or 39 days. At nest 2, from laying on 8 or 9 September to pipping or hatching on 16 October gave an incubation period of 37 or 38 days. At each nest, pipping or hatching was indicated by the female

sitting slightly hump-backed (compared with the low, flat incubation posture), periodically twitching at something happening beneath her. In each case there was clearly a chick present next day (26 and 17 October, respectively): the parent sat higher, apparently on its tarsi, with dorsal plumage fluffed, and periodically rocked gently from side to side.

Nestling period

At nests 1 and 2 data were obtained only for the first week after hatching, until nest failure. At nest 1 only the female brooded by day, for 88% of observation time (10 h); she stood on the nest for 5%, fed the chick for 4%, and was away from the nest for 3% (for periods of 2 and 16 min.). At nest 2 the female brooded for 85% of observation time (8 h) and the male for 6%; the adults also stood on the nest (female for 4%, male for <1%), the female fed the chick for 4%, and the nest was unattended for 2% (for one period of 8 min.). At each nest, the pair was together on the nest for <1% of time.

At both nests, the female's brooding stints extended beyond the start or finish (or both) of nest-watches. At nest 2 during one observation session, the calling female left the nest and the relieving male arrived there 8 minutes later for a brooding shift of 27 minutes. When she returned, he stood, but she left again for a perch elsewhere in the nest-tree, and he resettled; when she returned to the nest and he stood again, she gently pecked at his bill and he briefly preened her nape. Then both stood looking into the nest for ~1 minute until he left and she settled to brood. This was the only observation of allopreening by mates. Deliveries of greenery were not observed during the nestling period, but on the hatching day there was fresh greenery on nest 2, and on day 5 there was fresh greenery on nest 1 at 0650 h.

Nest 2 failed sometime between days 4 and 9 (during a lapse in observations), for unknown reasons. Nest 1 failed on the morning of day 8, when a Pied Currawong *Strepera graculina* took the chick when the female was away soaring. Four minutes after the female left, the Currawong went to the Eagles' nest, initially interested in prey remains, but opportunistically seized the chick. The Currawong made a long, shallow glide to the ground with the chick in its feet, at which point the pursuing observer caught up and rescued the chick before the Currawong could peck it. The chick was too heavy for the Currawong to carry far, and appeared uninjured apart from slight skin damage near one eye, but its breathing was laboured. The Currawong then returned and took prey remains from the Eagles' nest. Within 30 minutes the female Eagle returned to the nest and brooded (nest contents unknown, and at no time was there any indication of a second chick). She was also brooding or standing on the nest on later checks through the day, but subsequently abandoned the nest. (It was impractical to try to return the chick to the nest).

Despite surviving for 6 weeks in care, the rescued chick died at 43 days when it suffered convulsions and an inability to breathe or swallow. Healthy raptor chicks are usually at little risk by that age; poisoning (e.g. in road-kill given as food) or mismanagement were ruled out because the chick was not fed road-kill, it had access to direct daily sunlight, was given fresh whole-animal food, and was observed regularly for proper digestion (e.g. crop impaction, whish is easily detected and did not occur). The symptoms suggested early neurological impairment (G. Kaplan pers. comm.). Apparently a female, this eaglet gained weight steadily from 90 g, at 7 days old when rescued, to 700 g at 35 days old (Table 4). Although the progeny

Table 4

Weight gain of captive Little Eagle chick (data: G. Kaplan).

Age in days	*Weight (g)*
7	90
12	135
17	240
21	330
25	440
35	700

of light × light parents, its first down was tinged rusty (Plate 30, above); at 35 days old its remex tips had emerged and the pins of its upperwing-coverts and scapulars had burst (see Plates 28–30 which show age-specific growth stages).

Nest 4 was checked regularly from the time the chick was ~3 weeks old. Over the next fortnight, while the chick was still mostly downy, the female was usually on the nest, in one case standing and shading the chick. Subsequently, when the chick was feathering, the female was off the nest at all check times. When the chick was ~4 weeks old, the female fed it 122 pieces of prey, bill to bill, in 16 minutes (= 7.6 pieces/min. or one piece every 8 sec. on average).

Fledging

On the fledging day at the Torryburn nest, the juvenile was initially perched beside the female at the nest (Plate 31, above), then later in the morning it was perched in a leafy tree ~50 m away. The female was perched on a more exposed branch in that tree, apparently guarding the juvenile.

Post-fledging period

Casual observations, mainly at the Torryburn nest in 2005 and 2006 and other nests in the region (including nest 4 and a neighbouring nest in north Imbota in previous years since 2000), revealed that when juveniles attain adult proportions and can fly well, they often practise soaring in the nest area (low over the tree-canopy at first), and soar to food-beg from high-soaring parents. Within ~1 month from fledging, a north Imbota juvenile fed on a road-killed Rabbit ~500 m from the nest.

In summer 2006–07, ~56 days after fledging, the juvenile from nest 4 was initially begging stridently (i.e. still dependent on parental feeding) from a tree ~200 m from the nest; it flushed and soared, then begged high in the air (apparently to a soaring parent) ~1 km from the nest. Thereafter, it was not detected in the nest area.

New fledglings (n = four closely observed since 2000) of the light morph had lightly marked, rich-rufous head and underparts (see Plate 31, above), rich-brown upperparts with a dull, non-contrasting upperwing-band, pale tips to the greater upperwing-coverts, forming a pale medial line along the spread upperwing, and translucent pale trailing edges to the wings and tail. At ~2 months after fledging, the nest 4 juvenile's rufous belly was starting to fade.

Rescued Little Eagle chick, 3.5 weeks old, 20 November 2006

Plate 29 Photo: Gisela Kaplan

Breeding productivity

Only one chick fledged from four monitored breeding attempts around Armidale city in 2006, and two from five known attempts including that at Torryburn (= 0.25 and 0.4 young per pair, respectively; 1.0 per successful nest). Both of these were males by their size, as was the 2005 Torryburn juvenile. Over several years to 2002, near Tamworth (~100 km south-west of Armidale), one pair has raised a single fledgling in alternate years (G. Olde pers. comm.) or 0.5 young per year.

Feeding rates

During the incubation period, the male at nest 1 delivered four prey items to

Table 5

Breeding diet of Little Eagle at Armidale, NSW, 2006 (three nests: N1 = nest 1 etc. as in text): minimum number of prey individuals and percentage (% n) from orts, pellets and observations pooled (rabbits and hares by jaw, bone or claw count). [O] = observed, [R] = orts, [P] = pellets. For biomass, figures are minus the appropriate wastage factor for the species' body weight(following Baker-Gabb 1984). Prey weights from Debus (1984a) and Olsen *et al.* (2006a).

Prey species	*Weight (kg)*	*N1*	*N2*	*N4*	*Total*	*% n*	*Biomass (kg)*	*% biomass*
[ORP]Rabbit *Oryctolagus cuniculus* (juvenile)	0.4	6	6	4	16		4.3	80
[O]Brown Hare *Lepus capensis*	4	1[a]			1		0.5	9
[RP]juvenile	0.4		1		1		0.3	6
Total mammals		**7**	**7**	**4**	**18**	**78**	**5.1**	**94**
[O]Noisy Friarbird *Philemon corniculatus*?	0.1	1			1		0.1	
[P]Common Starling *Sturnus vulgaris*	0.07			1	1		0.07	
[O]Unidentified bird	0.09[b]	1			1		0.09	
Total birds		**2**		**1**	**3**	**13**	**0.26**	**5**
[O]Tree Dragon *Amphibolurus muricatus*	0.05		1		**1**	**4**	**0.05**	**1**
Subtotal							**5.4**	**100**
[O]Unidentified (bird/mammal) ?		1			**1**	**4**		
Total		**10**	**8**	**5**	**23**	**100**		

[a]Carrion

[b]Mean of identified birds

the female in 32.5 h (= 0.1 item/h); at nest 2 the male delivered two items in 24.3 h (= 0.1 item/h). During the nestling period, the male at nest 1 made two prey deliveries in 10 h (= 0.2/h), and the male at nest 2 made two prey deliveries in 8 h (= 0.25/h).

Diet and hunting

Eight intact pellets averaged 31 × 21 mm (23–38 × 19–24 mm), and 12 pellets averaged 1.6 g (0.8–2.4 g). The Eagles' diet at the three Armidale nests consisted of 78% mammals (70% Rabbits), 13% birds and 4% reptiles by number (with 4% unidentified bird/mammal), and 94% mammals, 5% birds and 1% reptiles by biomass (Table 5, which gives scientific names). Introduced lagomorphs contributed 94% of prey biomass (80% Rabbits).

Observed prey items delivered to the three nests (n = 20 items) were 16 Rabbits (80%), two birds (10%), one lizard (5%) and one unidentified vertebrate (bird/mammal, 5%); most of these prey types (other than birds at nest 1 and lizard at nest 2) were also represented in orts or pellets. Items in orts or pellets, but not observed being brought to nests, were juvenile Hare at nest 2 and subadult Common Starling at nest 4. Of 12 pellets, Rabbit occurred in 10 (83%), juvenile Hare in

Rescued Little Eagle chick, above: in first down, 1 week old, 2 November; below: with major dorsal feather tracts sprouting, 5 weeks old, 30 November 2006.

Plate 30 Photos: Gisela Kaplan

one (8%) and bird in one (8%). At nest 1, six Rabbit kittens observed being brought to the nest were matched by juvenile Rabbit in eight pellets. However, six Rabbits observed being brought to nest 2 were not found in orts or pellets; this pair (or perhaps scavengers) left little trace of prey items under the nest (one pellet and one ort, both of juvenile Hare), and the pair's roost-trees were not found. An additional item observed eaten in the nest area of pair 1, but not taken to the nest nor found in orts or pellets, was one road-killed adult Hare scavenged by the female in the nest-building phase.

Incidental prey items found below the Eagle nest at Torryburn were Galah *Cacatua roseicapilla* and two Eastern Bearded Dragons *Pogona barbata* (one adult, one subadult). The Torryburn Eagles were also observed with prey twice: a Peaceful Dove *Geopelia striata* (Plate 31 below) and a Magpie-lark *Grallina cyanoleuca* (S. Mitchell pers. comm.). At Tamworth (100 km south-west of Armidale) in spring 2004, a male Little Eagle was flushed from a freshly killed Galah, having started to eat it at the head; as the site was beside a minor road, scavenging on a road-killed or road-injured bird could not be ruled out.

At Armidale the adult Eagles were observed attacking prey on five occasions in the incubation and nestling periods. In spring 2006 foraging Little Eagles were often seen high quartering and poising (= 'kiting'or wind-hanging), or soaring and prospecting. For example, one male over a period of 30 minutes alternated between quartering and higher soaring, with one abortive stoop to the treetops before soaring again. The following attacks were observed, all by male Eagles and launched from soaring flight:

1. An aborted stoop at White-winged Choughs *Corcorax melanorhamphos* that were disturbed by the observer; the Choughs were milling on the ground and in trees, but were alerted to the Eagle's approach so the Eagle pulled out at about treetop height.

2. A long, slanting stoop at 45° to the tree-canopy (unsuccessful), then the Eagle resumed soaring.

3. A drop-attack into woodland, apparently to the ground (outcome unseen).

4. A drop-attack into woodland; the Eagle rose clutching a Tree Dragon *Amphibolurus muricatus* and took it to the nest.

5. A quick vertical stoop at birds foraging and milling in a treetop, becoming a short chase around the tree, between treetops, as the intended prey (a Noisy Friarbird *Philemon corniculatus*) flushed and escaped. A bird, apparently a Friarbird, was subsequently a prey item at this nest (nest 1, Table 5).

Discussion

Breeding biology and behaviour

Egg-laying dates and nest-site characteristics were consistent with previous information on the Little Eagle for the region, and for south-eastern Australia generally (cf. Debus 1984a; Mallinson *et al.* 1990; Marchant & Higgins 1993; Olsen 1995). This study confirmed that males contribute to nest-building, which may be expected as with males of other aquiline eagles, and indeed of most accipitrid raptors (e.g. Marchant & Higgins 1993). It was apparent that, although both sexes collected sticks and greenery and formed the nest, males did most of the stick-collection and females did much of the arranging of material, 'dismissing' the male if he lingered after placing a stick. However, males also arranged material in the female's absence.

This study has added hitherto unrecorded detail on the Little Eagle's nest-building and copulatory behaviour, and some aspects of courtship and display. It was apparent that the Little Eagle's displays, associated calls, and precopulatory behaviour are more noisy and vigorous than in the Wedge-tailed Eagle (cf. Marchant & Higgins 1993; Debus *et al.* 2007). This difference may be partly a function of the Little Eagle's smaller size, and hence greater agility and perhaps need to supplement long-range displays vocally. The small nests of Little Eagles and Booted Eagles *Hieraaetus pennatus* are best located by listening for the birds' calls, whereas the relatively larger (for the size of the bird) nests of the quieter Wedge-tailed Eagle and Golden Eagle *Aquila chrysaetos* are best located by sight (J. Olsen pers. comm.; SD pers. obs.). Aerial courtship displays by male Little Eagles appear to be demonstrations of speed and agility. The pale upperwing-band of adult males, enhanced by an apparently deliberate posture when perched, is prominent ('shiny') in sunlight and may be highly reflective in ultraviolet light (as suggested for the adult Wedge-tailed Eagle's bronzy upperwing scalloping: Olsen 1995). This possibility deserves investigation. Although juveniles of these species also have a pale upperwing-band, it is duller than in adults and may not be as reflective.

Territorial and nest defence by Little Eagles were much as previously described (cf. Debus 1983, 1991; Marchant & Higgins 1993; Lenz 2004; Olde 2006). There is evidently much interspecific conflict between Little Eagles and Wedge-tailed Eagles, with the latter dominant in competition for nest-sites and readily displacing pairs of Little Eagles (this study; Debus 1991; Olsen & Fuentes 2005; Olsen & Osgood 2006). Wedge-tailed Eagles also rob and prey on Little Eagles (Debus 2004, 2006c; Ley 2006; Olsen *et al.* 2006a).

This study has clarified the estimated incubation period of the Little Eagle (37–39 days, cf. Marchant & Higgins 1993), which is similar to that of its close relative, the Booted Eagle (36–40 days: Ferguson-Lees & Christie 2001). It was apparent that female Little Eagles are dominant and control the male's behaviour at the nest. It was also evident that incubating females are alert to males being available (i.e. visible or vocal in the nest area) to take an incubation shift, and that males are alert to opportunities to incubate. Male incubation shifts were not limited to relieving the female when she ate food provided by the male, but also occurred when a female left the nest for reasons other than feeding on his kills.

This study also confirmed that at least some male Little Eagles share the brooding of small chicks. Although more complete data are required, it appears that the proportion of time spent on the nest by the female steadily declines through the nestling period, from almost constant brooding in the early downy stage, to standing on the nest with the chick during the later downy stage, and being mostly absent other than at feeding times during the feathering stage (cf. Debus 1984a,b; Bollen 1989). It also appears that the size of nestling meals increases with chick age (cf. Debus 1984b), although further data are required.

Little Eagle chicks usually have white down; the captive chick's rusty-tinged first down was hitherto unrecorded in this species. A previous report of cream down was rejected by Marchant & Higgins (1993), but may have been correct as down colour is apparently variable. With further investigation, dark down might be found in some dark-morph Little Eagle chicks. Growth of the captive eaglet was generally similar to that previously reported (cf. Marchant & Higgins 1993), with this study adding some detail, although the captive chick's growth rate may have differed from that of a healthy wild chick. It is worth noting that the

photograph of an 'immature' Little Eagle on p. 76 of Olsen *et al.* (1993) shows a prematurely fledged juvenile. Aspects of the post-fledging dependence period were much as previously described, and a duration of ~2 months is also in agreement with previous data (cf. Debus 1984a; Bollen 1989).

There were subtle differences evident in the breeding behaviour of the Little Eagle compared with that of the Wedge-tailed Eagle, mainly concerning relations between the sexes. For instance, in Little Eagles allopreening seems to be rare. Male Wedge-tailed Eagles appear to have a more equal status in nest-formation and many aspects of nest-based parental care, with females not so clearly dominant (cf. Debus *et al.* 2007), whereas in Little Eagles the female is dominant and the male submissive. This difference may be partly a function of the Little Eagle's greater size dimorphism. The Little Eagle's calls are also more complex and musical than the Wedge-tailed Eagle's simple yelping calls. However, unquantified observations by Hollands (1984) suggest that, in some Little Eagle pairs, relations between the sexes may be amicable and *Aquila*-like during the incubation and early nestling periods. There are marked differences in behaviour and temperament in the Little Eagle versus Wedge-tailed Eagle in captivity or falconry, extreme for two species supposedly in the same genus, and greater than between *Aquila* and *Buteo* (J. Olsen pers. comm.).

Little Eagle breeding productivity at Armidale was low in 2006: among the lowest values recorded for this species (cf. Mallinson *et al.* 1990; Debus 1991; Marchant & Higgins 1993; Aumann 2001b; Olsen & Fuentes 2005; Olsen & Osgood 2006), perhaps related to drought conditions. Currawongs were previously suspected in one case of nest failure at Armidale (Debus 1984a); this study confirmed the Pied Currawong as a nest-predator, although the eagle chick may have already been debilitated. Although a small sample size, all three known juvenile Little Eagles in the drought period of 2005–06 were males. In the Lesser Spotted Eagle *Aquila pomarina* male fledglings (the less expensive sex to raise) predominate in poor seasons, and female fledglings (the more expensive sex to raise) predominate in good seasons (Väli 2004). A similar variation in offspring sex-ratio according to seasonal conditions may occur in the Little Eagle (and other eagles), and deserves investigation.

Eagle population

There is little evidence of a decline in the Little Eagle population in New England. However, some early trends are showing in the form of the disappearance of one known pair, an unpaired male in the former territory of a breeding pair, an apparent decline in breeding productivity, and the displacement of some pairs by urban expansion and by Wedge-tailed Eagles. The situation in the Southern Tablelands (Olsen & Fuentes 2005; Olsen & Osgood 2006) may predict future trends in New England; Little Eagles were a common sight on the Central Tablelands 10 years ago, but are now very uncommon (S. Tredinnick pers. comm. 2006). Furthermore, the sighting frequency of the Little Eagle declined by 14% overall between the first and second national bird atlases, with >20% decline in parts of eastern and southern Australia (Barrett *et al.* 2003); this frequency declined between the first and second national Bird of Prey Watch Scheme (Steele 1998); and it has declined in the Western Australian wheat belt (Johnstone & Storr 1998). Poor breeding productivity at Armidale in 2006 was similar to that around Canberra in 2005–06 (cf. Olsen & Fuentes 2005; Olsen & Osgood 2006). There is a need for studies of threats and their causes, and the impacts of mortality (especially non-natural) on the Eagle population. That is, the reasons why populations are declining

Little Eagles (light morph), Torryburn, NSW, above: adult female and juvenile male beside nest on fledging day, 21 December 2006; below: juvenile male feeding on Peaceful Dove, January 2007.

Plate 31 Photos: Sigrid Mitchell

need to be determined. There could usefully be further study and substantiation of competition with the Wedge-tailed Eagle, including whether such interaction is related to habitat loss. Meanwhile, retention of woodland remnants with large trees appears important for maintaining nesting habitat.

Diet and hunting

The Little Eagles' diet at Armidale in 2006 was similar to that recorded in 1980 (Debus 1984a), and similar to that recorded elsewhere in southern Australia, i.e. primarily Rabbit (cf. Marchant & Higgins 1993). This study was the first to confirm juvenile Hare as a prey item, which may be expected as the Eagles are unlikely to distinguish between a leveret and a Rabbit kitten. In lower-elevation, warmer and drier, bird-rich woodland west of Armidale, Little Eagles took birds and reptiles (Debus 2006c; this study). Where Rabbits are scarce, Little Eagles take many birds and reptiles (Aumann 2001c).

Dietary sample sizes for the Little Eagle at Armidale in 2006 were small, and obtained in a different year from those for the Wedge-tailed Eagle (Debus *et al.* 2007). Therefore, direct quantitative comparison is not possible. Nevertheless, it is clear that breeding Wedge-tailed Eagles (male ~3 kg, female ~4 kg) take many large mammals (adult Rabbits and Hares and small macropods) and large birds (e.g. ducks), whereas Little Eagles (male ~0.6 kg, female ~1 kg: Marchant & Higgins 1993) take juvenile Rabbits, few (juvenile) Hares, and smaller birds (passerines, parrots). Similar results were obtained by Baker-Gabb (1984) and Aumann (2001c). We predict that these eagles' respective geometric mean prey weights will differ substantially, when compared statistically for contiguous territories in the same breeding season (cf. Aumann 2001c; Olsen *et al.* 2006a). Given the greater size difference between Wedge-tailed and Little Eagles, one would expect an even greater difference in prey size than for the Wedge-tailed Eagle and White-bellied Sea-Eagle *Haliaeetus leucogaster* (cf. Olsen *et al.* 2006b).

Conclusions

Cumulative sample sizes from previous studies (Cupper & Cupper 1981; Debus 1983, 1984a,b; Hollands 1984; Bollen 1989, 1991) and the present study suggest that results to date on breeding behaviour, sex-roles and parental time-budgets of the Little Eagle are typical for the species. Aspects of the breeding biology and behaviour of the Little Eagle seem typical of small *Hieraaetus* species (in the strict sense), especially the Booted Eagle (cf. Ferguson-Lees & Christie 2001), although more comprehensive data are required. For the Little Eagle there is much scope for more systematic, detailed and quantified studies that might include, for instance, observation of plumage-dimorphic pairs (i.e. readily sexed partners) from the start of nest-building through to independence of juveniles; individual marking and radio-tracking (e.g. for home-range and habitat use or juvenile dispersal, cf. Real *et al.* 1998; Real & Mañosa 2001; Cadahía *et al.* 2005; Martínez *et al.* 2007); breeding habitat and nest-site characteristics (e.g. Suárez *et al.* 2000; Pepler *et al.* 2001; Martínez *et al.* 2006); focus on the post-fledging period; and comparative dietary studies of intraspecific prey partitioning (cf. Martínez & Calvo 2005) and interspecific prey partitioning with the Wedge-tailed Eagle (cf. Baker-Gabb 1984; Aumann 2001c; Olsen *et al.* 2006a). Further ecological studies are warranted, in order to understand and remedy the Little Eagle's decline in south-eastern Australia, given the 'umbrella' role of top predators in the conservation of threatened ecosystems such as the temperate woodlands of Australia (cf. Sergio

et al. 2006). Furthermore, with climate change the calicivirus may affect Rabbit populations in cool, humid areas such as the New South Wales tablelands, and the Little Eagle (and some other raptors) may become increasingly dependent on native prey and healthy woodland: a situation like that before European settlement.

The results of this study and that on the Wedge-tailed Eagle (Debus *et al.* 2007) lend some support to the separation of the genera *Hieraaetus* and *Aquila*, in the revised sense (following Helbig *et al.* 2005 and Lerner & Mindell 2005). *Hieraaetus* thus consists of the Booted Eagle, Little Eagle, Papuan Booted Eagle *H. weiskei* (genetically closer to the Booted than Little Eagle), Wahlberg's Eagle *H. wahlbergi* and Ayres' Eagle *H. ayresii*, with the larger Bonelli's Eagle '*H.*' *fasciatus* transferred to *Aquila* and the Rufous-bellied Eagle '*H.*' *kienerii* in its own monotypic genus (which would be *Lophotriorchis* Sharpe 1874). *Aquila* therefore includes the Wedge-tailed Eagle, its sister species Gurney's Eagle *A. gurneyi* and several other close relatives—Golden, Verreaux's *A. verreauxii*, Bonelli's, and African Hawk-Eagle *A. spilogaster*—among others (but not the spotted eagles, separable genetically as *Lophaetus*). *Hieraaetus* can be characterised as small, plumage-dimorphic and strongly size-dimorphic eagles ('pied' in the pale morph) with slight occipital crests and melodious whistling voices, versus larger, uncrested, less size- or plumage-dimorphic *Aquila* eagles with yelping or barking voices. *Hieraaetus* in the revised sense thus becomes a much tighter group morphologically and in some other aspects of biology.

Acknowledgements

We thank Norm & Janet Butt, Brian Chetwynd, Andrew Gasbarri, Suzanne & Rick Hatch, David Hegarty, Keith Hiscox, Julie Knox, Rose McCarthy, Berenice Scott, and Brian & Sue Wilson for permitting observations or nest searches on their land, and in some cases also providing information on eagles that nested on their land. Bill Clark (of Harlingen, Texas, USA), Lachlan Debus and Sofia Dodds shared some of the nest-watches or checks with us, and Gisela Kaplan kindly provided photographs and weights of the captive chick. We thank Jerry Olsen for a copy of Martínez & Calvo's paper, Tom Aumann, Jerry Olsen and Penny Olsen for comments on a draft, Graham Cam for editing, and Sigrid Mitchell for photographs.

References

Aumann, T. (1995), 'Little Eagle nest near Rapunga' [*sic*; = Papunya], *Australasian Raptor Association News* **16**(2/3), 29.

Aumann, T. (2001a), 'Habitat use, temporal activity patterns and foraging behaviour of raptors in the south-west of the Northern Territory, Australia', *Wildlife Research* **28**, 365–378.

Aumann, T. (2001b), 'Breeding biology of raptors in riparian environments in the south-west of the Northern Territory, Australia', *Emu* **101**, 305–315.

Aumann, T. (2001c), '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.

Barrett, G., Silcocks, A., Barry, S., Cunningham, R. & Poulter, R. (2003), *The New Atlas of Australian Birds*, RAOU, Melbourne.

Bollen, C. (1989), 'Notes on Little Eagles breeding on the Southern Tablelands of New South Wales', *Australian Bird Watcher* **13**, 65–66.

Bollen, C. (1991), 'Further notes on the Little Eagle breeding on the Southern Tablelands of New South Wales', *Australian Bird Watcher* **14**, 110–111.

Cadahía, L., Urios, V. & Negro, J.J. (2005), 'Survival and movements of satellite-tracked Bonelli's Eagles *Hieraaetus fasciatus* during their first winter', *Ibis* **147**, 415–419.

Conole, L. (1996a), 'Attempted capture of honeyeaters and lorikeets by Little Eagle', *Australasian Raptor Association News* **17**(1), 21–22.

Conole, L. (1996b), 'Little Eagles and rabbits', *Australasian Raptor Association News* **17**(2), 22–23.

Courtney, J. (2006), 'Little Eagle takes White-faced Heron', *Boobook* **24**, 19.
Cupper, J. & Cupper, L. (1981), *Hawks in Focus*, Jaclin Enterprises, Mildura, Vic.
Debus, S.J.S. (1983), 'Behaviour and vocalisations of nesting Little Eagles', *Australian Bird Watcher* **10**, 73–78.
Debus, S.J.S. (1984a), 'Biology of the Little Eagle on the Northern Tablelands of New South Wales', *Emu* **84**, 87–92.
Debus, S.J.S. (1984b), 'Further notes on nesting Little Eagles', *Australian Bird Watcher* **10**, 196–201.
Debus, S.J.S. (1991), 'Further notes on territory, breeding and plumage of the Little Eagle', *Australian Birds* **25**, 1–10.
Debus, S. (2004), 'Wedge-tailed Eagle grappling with Little Eagle', *Boobook* **22**, 11.
Debus, S. (2006a), 'Little Eagle and Wood Duck', *Boobook* **24**, 19.
Debus, S. (2006b), 'Wedge-tailed Eagle robs Little Eagle', *Boobook* **24**, 43.
Debus, S. (2006c), 'Avian food items of Little Eagle', *Boobook* **24**, 44.
Debus, S.J.S. (2006d), 'Breeding and population parameters of robins in a woodland remnant in northern New South Wales, Australia', *Emu* **106**, 147–156.
Debus, S. (2007), 'Little Eagle and lorikeet', *Boobook* **25**, 14.
Debus, S.J.S., Ford, H.A. & Page, D. (2006), 'Bird communities in remnant woodland on the New England Tablelands, New South Wales', *Pacific Conservation Biology* **12**, 50–63.
Debus, S.J.S., Hatfield, T.S., Ley, A.J. & Rose, A.B. (2007), 'Breeding biology and diet of the Wedge-tailed Eagle *Aquila audax* in the New England region of New South Wales', *Australian Field Ornithology* **24**, 93–120.
Falkenberg, I.D., Hurley, V.G. & Stevenson, E. (2000), 'The impact of Rabbit Calicivirus Disease on raptor reproductive success in the Strzelecki Desert, South Australia: A preliminary analysis', pp. 535–542 in Chancellor, R.D. & Meyburg, B.-U. (Eds), *Raptors at Risk*, Hancock House, Surrey, Canada, and World Working Group on Birds of Prey & Owls, Berlin.
Ferguson-Lees, J. & Christie, D.A. (2001), *Raptors of the World*, Helm, London.
Helbig, A.J., Kocum, A., Seibold, I. & Braun, M.J. (2005), 'A multi-gene phylogeny of aquiline eagles (Aves: Accipitriformes) reveals extensive paraphyly at the genus level', *Molecular Phylogenetics and Evolution* **35**, 147–164.
Hollands, D. (1984), *Eagles, Hawks and Falcons of Australia*, Nelson, Melbourne.
Johnstone, R.E. & Storr, G.M. (1998), *Handbook of Western Australian Birds*, vol. 1, WA Museum, Perth.
Lenz, M. (2004), 'Advertising of territory by Little Eagles very late into the day', *Canberra Bird Notes* **29**, 89–90.
Lerner, H.R.L. & Mindell, D.P. (2005), 'Phylogeny of eagles, Old World vultures, and other Accipitridae based on nuclear and mitochondrial DNA', *Molecular Phylogenetics and Evolution* **37**, 327–346.
Ley, A. (2006), 'Wedge-tailed Eagles preying on other raptors', *Boobook* **24**, 42.
Mallinson, D., Olsen, P. & Olsen, J. (1990), 'A note on the breeding of the Little Eagle *Hieraaetus morphnoides* and other raptors in the Mt Mugga area, ACT', *Corella* **14**, 88–91.
Marchant, S. & Higgins, P.J. (Eds) (1993), *Handbook of Australian, New Zealand and Antarctic Birds*, vol. 2, Oxford University Press, Melbourne.
Martínez, J.E. & Calvo, J.F. (2005), 'Prey partitioning between mates in breeding Booted Eagles (*Hieraaetus pennatus*)', *Journal of Raptor Research* **39**, 159–163.
Martínez, J.E, Pagán, I. & Calvo, J.F. (2006), 'Factors influencing territorial occupancy and breeding output in the Booted Eagle *Hieraaetus pennatus*', *Ibis* **148**, 807–819.
Martínez, J.E, Pagán, I., Palazon, J.A. & Calvo, J.F. (2007), 'Habitat use of Booted Eagles (*Hieraaetus pennatus*) in a special protection area: Implications for conservation', *Biodiversity and Conservation* **16**, 3481–3488.
Morris, A.K. (2003), 'New South Wales annual bird report for 2001', *Australian Birds* **33**, 85–160.
Morris, A.K. (2004), 'New South Wales annual bird report for 2002', *Australian Birds* **33**, 165–242.
Morris, A.K. (2006), 'New South Wales annual bird report for 2004', *Australian Birds* **34**, 1–69.
Morris, A.K. & Burton, A. (1999), 'New South Wales annual bird report for 1996', *Australian Birds* **31**, 86–137.
Olde, G. (2006), 'Little Eagles harassing Wedge-tailed Eagle', *Boobook* **24**, 42.
Olsen, J. & Fuentes, E. (2005), 'Collapse in numbers of breeding Little Eagles in the Australian Capital Territory', *Canberra Bird Notes* **30**, 141–145.
Olsen, J. & Osgood, M. (2006), 'Numbers of breeding Little Eagles in the Australian Capital Territory in 2006', *Canberra Bird Notes* **31**, 178–182.
Olsen, J., Fuentes, E., Rose, A.B. & Trost, S. (2006a), 'Food and hunting of eight breeding raptors near Canberra, 1990–1994', *Australian Field Ornithology* **23**, 77–95.

Olsen, J., Fuentes, E. & Rose, A.B. (2006b), 'Trophic relationships between neighbouring White-bellied Sea-Eagles (*Haliaeetus leucogaster*) and Wedge-tailed Eagles (*Aquila audax*) breeding on rivers and dams near Canberra', *Emu* **106**, 193–201.
Olsen, P. (1995), *Australian Birds of Prey*, University of New South Wales Press, Sydney.
Olsen, P., Crome, F. & Olsen, J. (1993), *Birds of Prey & Ground Birds of Australia*, Angus & Robertson, Sydney.
Pepler, D., Martin, R. & van Hensbergen, H.J. (2001), 'Estimating the breeding population of Booted Eagles in the Cape Province, South Africa', *Journal of Raptor Research* **35**, 15–19.
Real, J. & Mañosa, S. (2001), 'Dispersal of juvenile and immature Bonelli's Eagles in northeastern Spain', *Journal of Raptor Research* **35**, 9–14.
Real, J., Mañosa, S. & Codina, J. (1998), 'Post-nestling dependence period in the Bonelli's Eagle *Hieraaetus fasciatus*', *Ornis Fennica* **75**, 129–137.
Say, M. (1993), 'Little Eagle takes Crested Pigeon', *Australasian Raptor Association News* **14**, 52–53.
Schoenjahn, J. (2005), 'Little Eagle drowns cormorant', *Boobook* **23**, 42.
Sergio, F., Newton, I., Marchesi, L. & Pedrini, P. (2006), 'Ecologically justified charisma: Preservation of top predators delivers biodiversity conservation', *Journal of Applied Ecology* **43**, 1049–1055.
Steele, W. (1998), 'Birds of prey and the rabbit calicivirus', *Wingspan* **8**(3), 23.
Suárez, S., Balbontín, J. & Ferrer, M. (2000), 'Nesting habitat selection by Booted Eagles *Hieraaetus pennatus* and implications for management', *Journal of Applied Ecology* **37**, 215–223.
Väli, Ü. (2004), 'Sex ratio of Lesser Spotted Eagle *Aquila pomarina* nestlings in good and poor breeding years', *Bird Study* **51**, 189–191.
Whelan, D. (1995), 'Follow-up observation on Little Eagle', *Australasian Raptor Association News* **16**, 21.
Wink, M. & Sauer-Gürth, H. (2004), 'Phylogenetic relationships in diurnal raptors based on nucleotide sequences of mitochondrial and nuclear marker genes', pp. 483–498 in Chancellor, R.D. & Meyburg, B.-U. (Eds), *Raptors Worldwide*, World Working Group on Birds of Prey & Owls, Berlin, and BirdLife Hungary, Budapest.

Received 24 May 2007 ■

Footnote: The body of the rescued Little Eagle chick has been lodged with the Australian Museum.