

DIET AND BREEDING BIOLOGY OF THE WEDGE-TAILED EAGLE *Aquila audax* AT THREE NESTS IN NORTH-EASTERN NEW SOUTH WALES

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The diet and breeding biology of the Wedge-tailed Eagle *Aquila audax* were studied by observation and collection of prey remains and pellets at three active nests in the Richmond Valley in north-eastern New South Wales, during July to November 1997. The nests successfully fledged one young each after estimated incubation and nestling periods of 40–47 days and 75–85 days respectively. The diet consisted of 29 species of vertebrates: 27 per cent birds, 50 per cent mammals and 23 per cent reptiles by number, including a variety of native mammals but few rabbits in this region of high biodiversity and generally low rabbit numbers. Hunting behaviour, parental roles and nestling growth are described.

INTRODUCTION

The diet of the Wedge-tailed Eagle *Aquila audax* has been studied in various parts of Australia, mainly southern and inland pastoral regions (Leopold and Wolfe 1970; Brooker and Ridpath 1980; Baker-Gabb 1984; Hull 1986). The eagle preys on a variety of mammals, birds and reptiles but mainly on the introduced Rabbit *Oryctolagus cuniculus* or, in its absence, small macropods. Recent studies have confirmed such a pattern in additional localities (Sharp 1997; Richards and Short 1998; Debus and Rose 1999).

Little is known of the diet of the eagle in coastal eastern Australia. One study in southern Victoria found the diet to consist mostly of rabbit and Common Ringtail Possum *Pseudocheirus peregrinus* (Hull 1986); one in Tasmania mostly rabbits and small macropods (Marchant and Higgins 1993); and another in north-eastern Queensland a diet that included arboreal marsupials taken in rainforest (Burnett *et al.* 1996).

Since the introduction of the Rabbit Calicivirus Disease (RCD) to control rabbits, questions have been raised about the future of some of the Australian raptors (e.g. Baker-Gabb 1996; Steele 1997). A concern is that RCD will cause a population decline in some raptors through reduced breeding success and perhaps starvation. Previous control of rabbits by myxomatosis resulted in a decline in the clutch size and presumably the breeding success of several rabbit-eating raptors, including the Wedge-tailed Eagle (Olsen and Marples 1992).

The breeding biology and parental behaviour of the Wedge-tailed Eagle are well known in general terms, though with little quantification (Marchant and Higgins

1993). Incubation and nestling periods, parental roles and nestling growth are known approximately or from few data.

The aim of this study was to describe the diet and breeding behaviour of the Wedge-tailed Eagle at three nests over one breeding season, including an area where rabbits were scarce, in north-eastern New South Wales. This may throw some light on the eagle's alternative food sources and its possible response to the effects of RCD in regions of high biodiversity.

STUDY AREA AND METHODS

The study sites were located in far north-eastern New South Wales. This area of New South Wales once supported one of the largest areas of lowland subtropical rainforest in Australia. Today many low-lying areas have been cleared and are used for the production of sugar cane and dairy products, and plantations such as teatree and, in the more elevated areas, macadamia nut. Of ten known eagle nesting territories in the study area, three nest sites were selected for intensive study on the basis of their accessibility and likelihood that they would not be disturbed or interfered with by the public during the breeding season.

One nest was located on private property west of Kyogle (28°38'S, 153°00'E) on the Mt Afterlee Road. The habitat surrounding the nest, in the hunting range of the breeding pair, was predominantly eucalypt forest on the fringe of rainforest, with little disturbance. There were low densities of rabbits in this area (densities determined by this study). Another nest was located on Skyline Road 5 km from Lismore (28°49'S, 153°16'E). The predominant habitat was farmland, mostly for dairy and cattle production and small hobby farms, with patchy eucalypt forest on the slopes. This area had medium densities of rabbits. The third nest was located on the property of the Main Camp Teatree Plantation east of Rappville (29°05'S, 152°57'E). The habitat consisted mainly of teatree plantation surrounded by eucalypt forest. This site had a high density of rabbits.

Nests were visited at least once per week during the breeding season and observations were conducted from 15 June until 5 October 1997. A total of 40 hours was spent observing the behaviour of parent and young eagles, mainly at Skyline Road where the nestling period was

observed intensively on three days in week 1, and one day per week in weeks 3, 4, 6, 7, 8 and 10. Prey remains were collected at all three nest sites. General nesting habits were observed for periods of between 1 and 7 hours at various times of the day, more so in the later stages of the development of the young eagles.

A telescope (at 300 m) and a spotting scope (at 25 m, from a hide) were used in daily observations to record parental and young feeding habits, both at the nest and at the main feeding trees (which were usually within 20 m of the nest tree). The eagles were sexed in the field by display, relative size and plumage colouring.

Collection of food remains

Regurgitated pellets and prey remains were collected from underneath roost and nest trees at the three nest sites from 15 June until 5 October 1997. A tarpaulin was positioned underneath the main roosting trees to capture any food remains and pellets dropped by the eagles.

Prey items such as pellets and food fragments were sent to A. B. Rose for hair analysis and identification. The minimum number of individuals of each prey species represented in the prey items was calculated. Further analyses of feathers and bones for identification were completed in the laboratory using a hair analysis kit (Kanowski 1993) and reference to Brunner and Coman (1974). Prey was also identified from Cogger (1996), Slater *et al.* (1986), Swahan (1995) and Triggs (1996).

Rabbit warrens within the area of the eagle home ranges were counted, and rabbit populations were estimated at each site on the assumption that each warren contained more than 10 rabbits.

RESULTS

Nest sites

The Skyline Road and Mt Afterlee nests were situated in the largest trees in the area, in eucalypt forest with a southerly aspect overlooking a valley, and located one-third up the slope. At Main Camp the nest was located in a dead tree on the edge of the plantation and forest. Table 1 shows the characteristics of the nests.

Nesting period and parental behaviour

Suspected breeding and courtship behaviour, such as undulating dives by the male, were observed at all three sites in late June and early July. Approximate hatching dates at each nest were 24 July, and 17 and 22 August. Incubation periods for the three breeding pairs were 40–47 days, as estimated from the condition of nests and from parental behaviour (40–45 days at Skyline Road, 45–47 days at Mt Afterlee; 42–45 days at Main Camp). At all three nest sites, the female did most of the incubation. At Skyline Road, the adult eagles changed incubation roles four times in 10 hours (Table 2). The male incubated for four observed stints of 24–26 minutes (mean 26 min), 20 per cent of the time that the eggs were covered, and the female for four stints of 100–110 minutes (mean 105 min), 80 per cent of the time that the eggs were

covered. The changeover periods usually lasted only a few minutes until the other eagle was settled. The egg was uncovered (for 13% of observation time) only while the adult gathered a spray of leaves to lay on the nest, or went to a nearby roosting tree to excrete. At the Skyline Road nest, fresh leaves from the nest tree (*Eucalyptus tereticornis*) were taken and placed on the nest each day, by the female only. This behaviour was observed mostly between 11:00 and 13:00 h.

Once the young had hatched, the female eagle reduced her time at the nest whereas the male increased his share of parental care (Table 2), by sometimes tearing up and giving food to the young bill to bill. Once, after feeding it, he also brooded the chick for 360 minutes (one six-hour brooding stint, 38% of observed brooding time). The female brooded for six observed stints of 92–99 minutes (mean 96 min), 62 per cent of observed brooding time. Both sexes, but mostly the male, brought food to the nest; the female was seen tearing up and giving food to the young twice compared with four times for the male. At the Skyline Road nest, the male delivered four and the female delivered two prey items in 30 hours of observation (Table 2). On arrival they immediately fed the young. Once the young had hatched, one adult eagle stayed at the nest or in the nest area while the other hunted for food or soared above, sometimes lost to view. Both parents used the nest as a feeding platform, for themselves and to feed the nestling.

Feathers began to be visible on the young eagles at about three weeks. At five weeks, secondary and body feathers were appearing and the young were able to stand and move around in the nest. At 10 weeks the young were fully feathered, and the parents dropped food into the nest for them to tear up themselves (see Table 3 for stages of growth). The nestling period at Skyline Road was 75–80 days, that at Mt Afterlee 75–80 days, and that at Main Camp 80–85 days, in each case for a single nestling.

Foraging behaviour

Opportunistic observations of adult eagles hunting, either gliding attacks or pouncing, were made. At Main Camp and Skyline Road, surprise attacks from behind vegetation were observed. Once, below the nest at Skyline Road, the male eagle swooped down and caught a Cattle Egret *Ardea ibis* in his talons, then took it back to the nest tree to feed to the young. One eagle at Main Camp was seen chasing a rabbit, catching it after a pursuit of 20 metres along the ground. The eagle proceeded to eat it on the ground, attracting more eagles to the area. After the other eagles arrived, the disturbed eagle flew off to a nearby tree with

TABLE 1
Characteristics of three nests of the Wedge-tailed Eagle in north-eastern New South Wales. Human habitation = occupied dwelling.

Site	Height of nest above ground (m)	Tree species in which nest found	Width/depth of nest (m)	Forest type	Distance from human habitation (km)
Skyline Road	20	<i>E. tereticornis</i>	1.5/0.4	Dry sclerophyll	0.4
Mt Afterlee	30	<i>E. tereticornis</i>	1.2/0.6	Wet sclerophyll	10
Main Camp	25	unknown	0.9/0.5	Dry sclerophyll	5

TABLE 2

Percentage observation time (total 40 hours) spent by both sexes of Wedge-tailed Eagle at the Skyline Road nest site. For the incubation period, observations were made on different days in the later stages of incubation. For the nestling period, observations were spread throughout.

Stage/sex	Percentage of observation time (changeover and prey-delivery rates per hour).
Incubation (10 h):	(changeover rate 0.4/h)
female	70
male	17
female and male at nest	11
egg unattended	2
Nestling period (30 h):	(prey-delivery rate 0.2/h)
female	32
male	20
female and male with young	3
young unattended	45

TABLE 3

Growth of nestling Wedge-tailed Eagle*. Day = day of nestling period.

Day	Remarks
3	Downy, unable to move about nest.
4	Head wobbly; unable to sit up.
7	Able to stand; size increased by half. Swallowed all food offered to it: feathers, bone and flesh.
15	Doubled in size from last inspection; primaries not visible.
24	Primaries visible along edge of wing. Stood up without wobbling, walked over to female. Preening.
37	Picked at remains of prey, after being fed by male.
48	Well feathered on wings and body, down still on forehead and breast; same size as parents. Flapped wings. Took food from female's bill as she tore prey, before female raised her head to offer food. Young then fed itself from prey.
55	Fully feathered except small patch on breast and throat. Continually jumping around on nest, sometimes flapping wings.
70	Fledging imminent.

* The remarks are based on observations of growth at one nest.

the rabbit still in its claws. At Main Camp it was common to find more than five individual Wedge-tailed Eagles in the one day. At Mt Afterlee, one of the eagles took a fledgling Grey Butcherbird *Cracticus torquatus* from a nest (J. Rogers, pers. comm.).

On four different occasions, eagles were observed feeding on carrion at Main Camp. Two adults fed on the remains of a Red-necked Wallaby *Macropus rufogriseus*. The remains of a Common Wallaroo *Macropus robustus* had marks on it suggesting that Wedge-tailed Eagles had eaten it (A. B. Rose, pers. comm.). An eagle fed on a dead rabbit, and another eagle fed on the remains of an Eastern Grey Kangaroo *Macropus giganteus*.

Food items

The eagles took a large variety of mammals, birds and reptiles (29 species; Table 4). The overall diet at the three nests consisted of 27 per cent birds, 50 per cent mammals and 23 per cent reptiles by number. Of 29 pellets (from all three nests combined), birds occurred in 21 per cent, mammals in 76 per cent and reptiles in 45 per cent. Seventeen intact pellets measured 29–92 × 20–50 millimetres (mean 65 × 34 mm). The mass of these 17 pellets was 3.4–13.6 grams, mean 8.8 grams.

There were some differences in dietary proportions between the three nests. Diet at the Skyline Road nest consisted of 36 per cent birds, 36 per cent mammals and 28 per cent reptiles by number. Diet at the Mt Afterlee nest consisted of 14 per cent birds, 53 per cent mammals and 33 per cent reptiles by number. Diet at the Main Camp nest consisted of 29 per cent birds and 71 per cent mammals by number, with no reptiles recorded.

Bird species most often preyed on were Cattle Egret and Laughing Kookaburra *Dacelo novaeguineae*. Other avian prey were mostly medium to large non-passerines, especially waterbirds (Table 4).

The most frequent mammalian prey were rabbits, which were preyed on at all three sites. Overall, the rabbit constituted 18 per cent of the diet by number (37% of mammalian prey items) and occurred in 28 per cent of pellets. Of the mammalian prey, the rabbit constituted 18 per cent at Mt Afterlee, 44 per cent at Skyline Road and 50 per cent at Main Camp. Neither rabbits nor warrens were recorded in the nest area at Mt Afterlee. There was a small population of about 40 rabbits (four warrens) near the nest at Skyline Road. Within 2 km of the Main Camp nest more than 10 separate warrens were counted, with the population estimated to be greater than 100 rabbits. The conditions were optimal for rabbits and the teatree plantation officials reported pest proportions of them in the area.

The second most frequent mammalian prey was the Long-nosed Bandicoot *Perameles nasuta*. Noteworthy mammalian prey were flying-foxes *Pteropus* spp. The remains of an Echidna *Tachyglossus aculeatus* consisted of the spines attached to a thin piece of skin. The neatness of the separation of the spines from the body suggested an attack by another predator, but Echidna hair was later found in an eagle pellet under the nest. Cattle *Bos taurus* was probably eaten as carrion.

The most frequent reptilian prey was the Eastern Bearded Dragon *Pogona barbata*, followed by the Common Bluetongue *Tiliqua scincoides*. Most of the reptiles were detected only in pellets.

DISCUSSION

Nesting behaviour for the Wedge-tailed Eagles observed was similar to that reported in previous studies (Leopold and Wolfe 1970; Ridpath and Brooker 1986). In contrast, Cupper and Cupper (1981) observed only the male eagle hunting, and seldom coming to the nest. Individual variation in parental roles is apparent from the limited data available on nesting behaviour, as Ridpath and Brooker (1986) also observed feeding of young by both sexes. Brooding of young by the male has not previously been reported for the Wedge-tailed Eagle (Marchant and Higgins 1993).

Estimated incubation and nestling periods were similar to those previously reported (in Marchant and Higgins 1993). Growth and development of the young eagles was also similar to that previously reported (in Marchant and Higgins 1993).

Wedge-tailed Eagles prefer to breed in areas remote from roads and settlements (Marchant and Higgins 1993). However, one pair in this study (Skyline Road) successfully

TABLE 4

Food remains from three Wedge-tailed Eagles nests, north-eastern New South Wales, 1997 breeding season: minimum number (n) of individuals in prey remains and pellets and percentages of total items. *Prey species not listed by Marchant and Higgins (1993).

Species	Skyline Road (n)	Mt Afterlee (n)	Main Camp (n)	%
White-faced Heron <i>Egretta novaehollandiae</i>			1	
White-necked Heron <i>Ardea pacifica</i>	1		1	
Cattle Egret <i>Ardea ibis</i>	2	1		
Australian White Ibis <i>Threskiornis molucca</i>	1			
*Pacific Baza <i>Aviceda subcristata</i>	1			
*Dusky Moorhen <i>Gallinula tenebrosa</i> ^a			1	
Tawny Frogmouth <i>Podargus strigoides</i>	1			
Laughing Kookaburra <i>Dacelo novaeguineae</i>	1	1	1	
Grey Butcherbird <i>Cracticus torquatus</i>	1	1		
Torresian Crow <i>Corvus orru</i>	1			
Total birds	9	3	4	27
Echidna <i>Tachyglossus aculeatus</i>		1		
*Northern Brown Bandicoot <i>Isodon macrourus</i>		1		
*Long-nosed Bandicoot <i>Perameles nasuta</i>	1	3		
Koala <i>Phascolarctos cinereus</i>		1	1	
Common Brushtail Possum <i>Trichosurus vulpecula</i>			1	
*Black-striped Wallaby <i>Macropus dorsalis</i>		1		
*Pademelon <i>Thylogale</i> sp.		1		
*Black Flying-fox <i>Pteropus alecto</i>		1		
*Grey-headed Flying-fox <i>Pteropus poliocephalus</i>	1		1	
Fox <i>Vulpes vulpes</i>	1		1	
Rabbit <i>Oryctolagus cuniculus</i>	4	2	5	
Hare <i>Lepus capensis</i>	1		1	
Cattle <i>Bos taurus</i>	1			
Total mammals	9	11	10	50
Bearded Dragon <i>Pogona barbata</i>	4	6		
Lace Monitor <i>Varanus varius</i>		1		
Common Bluetongue <i>Tiliqua scincoides</i>	3			
Total reptiles	7	7	0	23
Total	25	21	14	100

^aFound and identified at the nest tree by David Readen.

breeds 5 km from a rural city and only 400 metres from a busy road, which is not unusual (P. Olsen, pers. comm.). This tolerance may be related to the scarcity of suitable nesting trees and the high concentration of Wedge-tailed Eagles in the region, forcing breeding adults to accept sites closer to human habitation. Other reasons may include prey availability, and the likelihood that in coastal (non-sheep) areas Wedge-tailed Eagles are not persecuted as much as in the inland.

In their hunting and feeding, the Wedge-tailed Eagles observed were similar to those of previous studies (Fleay 1952; Leopold and Wolfe 1970; Debus 1978; Brooker and Ridpath 1980; Cupper and Cupper 1981; Baker-Gabb 1984).

Ten bird species, 16 mammals species and three reptile species were recorded as prey items. Mammals were the most frequent food items at both Main Camp and Mt Afterlee, whereas at Skyline Road food items included many birds. Overall, these eagles displayed highly opportunistic feeding behaviours and captured a wide variety of prey. This study added eight new species to the list of prey reported taken by the Wedge-tailed Eagle (Table 4; cf. Marchant and Higgins 1993). Apart from flying-foxes, equivalent congeneric mammals have been recorded in the eagle's diet in other regions of Australia (Marchant and Higgins 1993). The dietary diversity in this study

reflects the species richness in this region of coastal New South Wales.

Some other studies have also recorded a diverse diet or low incidence of rabbit in the eagle's diet in some regions (e.g. Brooker and Ridpath 1980, Marchant and Higgins 1993). Another study in north-eastern New South Wales found a high incidence of rabbit and a moderately diverse diet (Debus and Rose 1999), but in a pastoral landscape on the tablelands where rabbits were abundant.

Rabbit populations approximately reflected the number of rabbits preyed upon by the eagles at the three sites in this study. Only two rabbits were recorded at the Mt Afterlee nest, where rabbits were not recorded in the field. At the Skyline Road and Main Camp sites, however, warrens were recorded in the area, and more rabbits were recorded as prey at those nests.

Although rabbits were the single most frequent prey species of the eagles in this study, they were not the primary food and the eagles did not rely entirely on rabbits. This non-reliance on rabbits indicates that if RCD does eradicate rabbits, coastal Wedge-tailed Eagles might not be greatly affected. This may be attributed, partly, to the many native species such as birds, wallabies and reptiles that are available to Wedge-tailed Eagles in north-eastern New South Wales.

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BOOK REVIEW

Field Guide to Tasmanian Birds

Dave Watts, October 1999. New Holland Publishers Pty Ltd, Australia. RRP \$29.95

Dave Watts' 'Field Guide to Tasmanian Birds' is a concise, much needed handbook specific to the birds of the Island State. Its publication is certainly justified, for as Sally Bryant states in the book's introduction, 'Few locations in the world offer over 220 species of resident or regular visitor, including 12 endemic species, all within two to three hours travel of a major centre and nestled among breathtaking wilderness and world heritage scenery.' Each species has a separate page devoted to it, with the usual brief text covering 'identification, habits, habitat, breeding, distribution', and finally, a 'where to see' section. Surprisingly, this last crucial piece of information has been omitted for some species which in unfortunate, particularly for those birders who may be just visiting Tasmania on a short trip. There is however, a clear distribution map given for each species.

Paradoxically, I feel the magnificent accompanying photographs are both the book's great strength and yet weakness at the same time. Dave Watts' bird photographs are exceptional, although it should be pointed out that over 60 images included here are by other similarly talented photographers who perhaps could have received a little more acknowledgment for their work rather than simply the Photo Credits *en masse*. The stunning images are what really makes this book, yet to describe it as a field guide is debateable. A field guide surely should contain an accurate, visual depiction of plumage variations for each species covered, particularly with regard to the bird's sex or adult/immature status. They should also clearly show the entire bird, and in a manner that enables the guide's user to differentiate between similar species. These necessities become obvious when 'in the field', and for this reason I think the Slater or Simpson and Day style field guides

are still way ahead in practical terms compared to photographic guides. For example, the Australian Owllet-nightjar photograph is stunning, and certainly typical of how it may be seen secreting itself in the wild, but it provides little indication to a novice birdwatcher as to what the whole bird actually looks like.

The layout is clear and uniform throughout, and an interesting attempt has been made to simplify the book's use by colour coding the top corner of each page, each colour representing a specific group of birds. In reality, unless you can quickly recall which colour relates to which group (there are 7) then it is unnecessary. Perhaps if the publishers has printed a key to these groups on the cover then the code would be far more speed efficient.

Overall, a 'Field Guide to Tasmanian Birds' is an attractive, worthwhile addition to Australian bird literature and its succinct format should appeal to a broad range of readers. For serious birdswatchers, however, it should be seen as a useful accompaniment to the "traditional" field guides, rather than as a replacement.

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