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BREEDING DIET OF THE WEDGE-TAILED EAGLE *Aquila audax* IN SOUTHERN VICTORIA

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The breeding diet of the Wedge-tailed Eagle *Aquila audax* was investigated in the Bacchus Marsh district of southern Victoria in 1999–2000, by collection and analysis of prey remains and pellets from six territories (including five active nests, all of which fledged young). The eagles' diet (*n* = 111 prey items) consisted of 95.5 per cent mammals (89.2% European Rabbits *Oryctolagus cuniculus*) and 4.5 per cent birds by number, and 99 per cent mammals (86% Rabbits, 12% Brown Hares *Lepus capensis*) and 1 per cent birds by biomass. Although the contribution of rabbit may have been overestimated, it was still of overriding importance. No reptiles, sheep or lambs were recorded.

INTRODUCTION

The diet of the Wedge-tailed Eagle *Aquila audax* has been well documented for many parts of Australia, particularly the southern arid and temperate zones, but also recently in some northern regions (Olsen 2005; Collins and Croft 2007; Olsen *et al.* 2006a; Debus *et al.* 2007; Fuentes *et al.* 2007; Parker *et al.* 2007; Silva and Croft 2007; Winkel 2007). The eagle is a generalist predator and opportunistic scavenger, taking a wide range of mammals, birds, reptiles and carrion, but it preys particularly on rabbits, hares and juvenile kangaroos (Marchant and Higgins 1993; Olsen 2005). In the southern half of Australia the introduced European Rabbit *Oryctolagus cuniculus* is commonly taken. The eagle's dietary profile, breeding density and fledgling productivity are often linked to rabbit abundance or, since the rabbit calicivirus disease, the abundance of alternative mammalian prey (see Marchant and Higgins 1993 and Olsen 2005 for reviews, and recent studies by Sharp *et al.* 2002; Dennis 2006; Olsen *et al.* 2006a,b; Collins and Croft 2007; Debus *et al.* 2007; Fuentes *et al.* 2007; Parker *et al.* 2007; Silva and Croft 2007 and Winkel 2007). The prevalence of rabbit in the eagle's diet (e.g. Olsen 2005) may simply reflect the local abundance of rabbits, and the historical decline of similarly sized native mammals in southern and central Australia (e.g. Strahan 1995).

As well as being well populated by Wedge-tailed Eagles, Victoria has many naturalists with strong birdwatching interests and community 'ownership' of eagles. Nevertheless, there have been only two previous studies of the diet of the Wedge-tailed Eagle in that State; in the arid north-west (Baker-Gabb 1984) and temperate south-east (Hull 1986). Both studies, pre-calicivirus, found a high proportion of rabbit in the eagle's diet. The aim of this study, conducted since the spread of the calicivirus, was to describe the diet of the Wedge-tailed Eagle in southern Victoria, with particular reference to the importance of rabbit.

STUDY AREA

The study area was the Bacchus Marsh district (37º41'S, 144º26'E), approximately 50 kilometres west of Melbourne, Victoria. The area is semi-rural, with diverse land uses including many extractive industries (coal, clay and sand) and agriculture (vegetables crops, orchards, wool and dairy), as well as containing some large areas of native vegetation at Werribee Gorge State Park and Lerderderg State Park. The climate and vegetation are described in Foster and Wallis (2010).

Historically, rabbit densities around Bacchus Marsh reached 200 per square kilometre (DNRE 2000). In recent times, rabbit control measures and the calicivirus have reduced rabbit numbers in the area by 40 per cent (Cooke 2002), but in spring 1999 densities were still estimated at 12–17.6 per kilometre of transect (DNRE 2000; S. Beani pers. comm.). The present study found a mean of 11 rabbits per kilometre along 22 kilometres of transect. Overall numbers have recovered since 1996 to 50 per spotlight kilometre in the region (Cooke 2002).

METHODS

The usual methods of raptor dietary analysis were restricted in this study, owing to concerns by the then Department of Natural Resources and Environment about adverse effects of human disturbance on the eagles' breeding success (e.g. Mooney and Holdsworth 1991). Accordingly, two collection strategies were employed over the two years (1999–2000). Ground-level nets were installed to collect prey remains (orts) and pellets beneath the active nests in three eagle territories. The nets were set up before the onset of the 1999 breeding season, and remained in position throughout the study. Recovery of items in the nets began on a monthly basis immediately after eagle chicks were first sighted in the nests, and were timed to coincide with the voluntary absence of both parent eagles from the nest. For three other eagle territories, where the use of collection nets was impractical (owing to ground-level vegetation or steep slopes), items were collected manually from beneath the nests only after the incubation stage and only if both parent eagles were away from the nest voluntarily. Collection of remains from beneath identified roost trees away from the nest tree was conducted fortnightly, with no apparent disturbance to nesting pairs of eagles (see Table 1 for number of nests per territory). Items were collected from

beneath old and current nests; for Territory 1, most items were collected from beneath a frequently used roost tree, whereas for Territory 2 no regular roost/feeding tree was identified. The active nests in Territories 1–5 (Table 1, i.e. all breeding pairs) reared young to the fledging stage during the study.

Collection nets were synthetic anti-bird orchard netting in commercial four by four metre sheets. A nylon rope (3.9 m per side) was woven into each edge, to facilitate tensioning, and to allow sag so that items collected in the middle and did not bounce out. Nets were positioned approximately 1.5 metres above ground level, to forestall terrestrial predators.

Orts were identified by comparison with reference material. Pellets were air-dried before separation of components, which were identified by comparison with reference material, using a microscope (Chandler 1916; Day 1966; Brunner and Coman 1974). At the time this analysis was undertaken (2000) the occurrence of a species in a pellet was assumed to represent one prey item (Errington 1932; Glading *et al.* 1943). However, for diurnal raptors this assumption has since been questioned (e.g. Olsen *et al.* 2006a,b; Debus *et al.* 2007; Fuentes *et al.* 2007). In this study, the minimum number of individuals per prey species was calculated by taking into account their representation in both orts and pellets. Biomass ingested per prey item was calculated according to the wastage factors adopted by Brooker and Ridpath (1980) (20% for prey ≤1 kg; 30% for prey between 1 and 5 kg). Prey weights were taken from Strahan (1995), Olsen *et al.* (2006a) and Fuentes *et al.* (2007), and data were pooled across nest sites and time for analysis.

RESULTS

Many of the orts and pellets were collected from two nests in Territory 1 (Table 1). However, no prey items were found beneath the pair's unused nest. The suspended collection nets provided 31 prey items (52%) out of a total of 60 items collected from Territory 1, and out of 111 items (28%) across all sites. Nets captured 40 and 84 per cent, respectively, of items from Territories 1 and 2, but no regular roost or feeding tree was found in Territory 2, whereas most items in Territory 1 were collected from beneath a frequently used roost tree. No prey items were found in autumn (March–May). The number of prey items found peaked in spring (September–November), during the eagles' nestling period, before declining in summer (December–February) around the fledging stage, when the parent eagles spent increasing time away from the nest (Table 2). No items were found in nets, or beneath nests or roost trees, after the first week in January, by which time young eagles in the district had been fledged for 3–4 weeks (Foster and Wallis 2010).

Of the 111 individual prey items identified, 52 (46.8%) were identified from pellets. Only two pellets contained more than one identifiable prey species. Mammals (95.5%), mainly rabbits (89.2%), were the major prey items by number, with one Bush Rat *Rattus fuscipes* and one Common Ringtail Possum *Pseudocheirus peregrinus* (Table 3). Medium-sized, ground-feeding birds of more than 100 grams represented a minor component of prey items (4.5%). No reptiles were recorded, and although the district is agricultural, no lambs or sheep were recorded in the eagles' diet. By biomass, diet was 99 per cent mammals (86% rabbit, 12% hare) and 1 per cent birds. The contribution of rabbit was possibly overestimated by number (see Methods), and therefore by biomass, but the importance of rabbit is nevertheless clear.

TABLE 1

Number of prey items in orts and pellets collected from each Wedge-tailed Eagle territory, Bacchus Marsh district, Victoria, 1999–2000. Includes multiple eagle nests (i.e. old and current) per territory. For description of collection nets, see Methods. No breeding in Territory 6, but main nest (lined with fresh foliage) netted.

Territory	Nests	Active nest netted (Y/N)	Items in nets	Prey items	% items in nets
1	2	Y	18	45	40
2	1	Y	11	13	84
3	3	N		13	
4	4	N		24	
5	1	N		14	
6	3	Y	2	2	100
Total			31	111	28

TABLE 2

Seasonal collection of orts and pellets from Wedge-tailed Eagle nests, Bacchus Marsh district, Victoria, 1999–2000.

Season	Prey items	%
Autumn	0	0
Winter	14	12.6
Spring	58	52.3
Summer	39	35.1

DISCUSSION

Collection nets were of limited effectiveness in this study, owing to topography, ground vegetation, height of nests (hence difficulty of estimating the drop zone), and damage by falling branches. At one nest, a net was damaged twice over the two-year study, necessitating removal and replacement between breeding seasons. Damage to nets may have allowed some orts and pellets to be lost to weathering or scavengers. Nets may be more effective where trees are lower, and vegetation and topography are more conducive.

The seasonal pattern of ort and pellet accumulation was as expected, consistent with little activity at nests during autumn, resumption of attention to nests by winter, incubation in late

TABLE 3

Breeding diet of Wedge-tailed Eagle, Bacchus Marsh district, Victoria, 1999–2000: minimum number (*n*) and percentage (*%n*) of prey individuals in orts and pellets. For biomass and percentage, figures are minus the appropriate wastage factor for the species' body weight (following Brooker and Ridpath 1980). Prey weights from Strahan (1995), Olsen *et al.* (2006a) and Fuentes *et al.* (2007). Weight of unidentified bird = mean of other bird species.

Prey species	Mass (kg)	*n*	*%n*	Biomass (kg)	% Biomass
Rabbit *Oryctolagus cuniculus*	1.5	99	89.2	104	86
Brown Hare *Lepus capensis*	4	5	4.5	14	12
Common Ringtail Possum *Pseudocheirus peregrinus*	0.9	1	0.9	0.7	1
Bush Rat *Rattus fuscipes*	0.1	1	0.9	0.1	<1
Total mammals		106	95.5	118.8	99
Rock Dove *Columba livia*	0.3	2	1.8	0.5	<1
Australian Magpie *Cracticus tibicen*	0.3	1	0.9	0.2	<1
Australian Raven *Corvus coronoides*	0.7	1	0.9	0.6	<1
Unidentified bird	0.4	1	0.9	0.3	<1
Total birds		5	4.5	1.6	1
Total		111	100	120.4	100

winter, nestlings in spring, and fledging in early summer (Foster and Wallis 2010). The spring peak is consistent with feeding of nestlings, and the summer decline with departure of fledglings from the immediate nest area (see Debus *et al.* 2007).

The collection of remains only from beneath nests is a potential source of bias in studies of eagle breeding diet. However, for the Wedge-tailed Eagle there is close agreement between orts and pellets collected from the ground and from within nests (Parker *et al.* 2007), and thus there is no need to disturb eagles at critical stages of their reproductive cycle. Dietary studies can usefully include remote observations (by telescope) of prey deliveries to nests, to detect prey items missed in orts or pellets (Debus *et al.* 2007).

The dietary results are similar to those obtained elsewhere, in terms of the importance of mammals and especially rabbits, particularly in temperate southern Australia (Marchant and Higgins 1993; Olsen 2005; Dennis 2006; Olsen *et al.* 2006a; Debus *et al.* 2007; Fuentes *et al.* 2007). However, the eagles around Bacchus Marsh took fewer birds than in many previous studies, and no reptiles, and their diet was generally less diverse than in other temperate regions, at least during the seasons studied. The eagles' diet at Bacchus Marsh was more similar to that in arid north-western Victoria (Baker-Gabb 1984) than at Yellingbo in temperate south-eastern Victoria (Hull 1986).

The lack of diversity in the eagles' diet at Bacchus Marsh, and small number of birds taken despite the apparent abundance of magpies and ravens (AF pers. obs.), is probably attributable to the high abundance of rabbits in the area, even since the calicivirus outbreak. The lack of arboreal mammals in the diet is probably related to the limited wooded areas in the district: a contrast with the number of possums taken in a partly forested landscape at Yellingbo (cf. Hull 1986). In neighbouring eagle territories around Bacchus Marsh, with extensive wooded areas (e.g. Lerderderg State Park), the proportion of arboreal mammals in the eagles' diet may be higher.

The lack of diversity in the eagle's diet at Bacchus Marsh appears not to have adversely affected its breeding density or fledgling productivity (cf. Foster and Wallis 2010). This result may be related to rabbit density in the study area, which is well above the minimum 1.6 rabbits per spotlight kilometre, or 60 rabbits per square kilometre, required for eagle breeding where rabbits are primary prey in the arid zone (Ridpath and Brooker 1986). The latter figure is low compared with densities in semi-arid and southern temperate regions (2.4–8.5 rabbits/spotlight

km: Mutze *et al.* 2005). Indeed, high rabbit densities may have permitted the higher eagle nesting density and smaller estimated territory sizes at Bacchus Marsh than in some other studies (cf. Foster and Wallis 2010). However, if rabbit numbers are permanently reduced to low levels, the availability of alternative prey will become more important and, in the absence of adequate alternative prey, the eagle's breeding density and fledgling productivity can be expected to decline. Studies elsewhere in temperate southern Australia suggest, though, that where kangaroos are abundant the eagles can readily switch to taking more juvenile kangaroos (Fuentes *et al.* 2007).

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