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Diets of Wedge-tailed Eagles *Aquila audax* and Little Eagles *Hieraaetus morphnoides* breeding near Canberra, 2008–2009

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In the Australian Capital Territory during 2008–09, the diet of breeding Wedge-tailed Eagles *Aquila audax* consisted of 65 per cent mammals, 33 per cent birds and 1 per cent reptiles by number (*n* = 94 prey items from 10 nests), of which 19 per cent consisted of macropods, 34 per cent rabbits (mostly adults, plus 4% hares), and a range of other large mammals, many probably eaten as carrion. Breeding Little Eagles *Hieraaetus morphnoides* took 52 per cent mammals, 45 per cent birds and 3 per cent reptiles by number (*n* = 58 prey items from six nests), of which 2 per cent consisted of macropod (one small joey kangaroo) and 50 per cent rabbits (mostly juveniles). Both eagle species took more rabbits in 2008–2009, compared with two earlier periods in 2002–2003 and 2004–2007. By biomass Wedge-tailed Eagles took 93 per cent mammals (20% rabbits, 45% macropods); Little Eagles took 73 per cent mammals (almost entirely rabbits) and 24 per cent birds. Geometric Mean Prey Weight for Wedge-tailed Eagle prey was 1650 grams, for Little Eagles 337 grams. Standardised food niche breadth was 0.205 for Wedge-tailed Eagles, and narrower (0.143) for Little Eagles. The Shannon Index for Wedge-tailed Eagles was 2.75, for Little Eagles 2.28. Although a Pianka Index suggests 46 per cent overlap in prey used by the two eagles, the great difference in GMPW and heavy use of rabbits by Little Eagles suggest that there is little interspecific competition for prey. Little Eagles may be declining in the ACT because rabbits, their main prey, are poisoned, and this poisoning may affect Little Eagles more than some other raptors.

INTRODUCTION

The diets of the Wedge-tailed Eagle *Aquila audax* and Little Eagle *Hieraaetus morphnoides*, breeding in contiguous territories over the same period, were contrasted by Olsen *et al.* (2010). That study sought to compare the geometric mean prey weight (GMPW), standardised food niche breadth, Pianka Index (dietary overlap) and Shannon Index (dietary diversity) for the two eagle species, from data collected between July 2002 and January 2008. They concluded that dietary niche breadth and diversity were similar, but there was little overlap in prey sizes and types used by the two eagle species, and a fivefold difference in geometric mean prey weight (reflecting the eagles' respective body sizes). However, the sevenfold skew in sample size for the two species (1421 and 192 prey items for Wedge-tailed Eagles and Little Eagles respectively) meant that further samples of Little Eagle prey were needed.

Because relatively little is known about the Little Eagle's diet, and there is concern about the Little Eagle's conservation status in south-eastern Australia (e.g. Olsen *et al.* 2010; Debus 2011), JO continued dietary studies on Little Eagles and Wedge-tailed Eagles breeding in sympatry in and near the Australian Capital Territory. This paper reports on the same comparative aspects of the two eagles' diet, in contiguous territories in the ACT, using new data for the period January 2008 to January 2010 (i.e. the 2008 and 2009 calendar years, with some spillover to January 2010 for Little Eagle samples from spring–summer 2009). These samples (94 Wedge-tailed Eagle vs 58 Little Eagle prey items) show less disparity in respective sample sizes than in the study by Olsen *et al.* (2010).

METHODS

The study area and methods were as previously described for studies of the comparative ecology of raptors around Canberra in the ACT (Fuentes *et al.* 2007; Olsen *et al.* 2006a, 2008, 2010). Collections of prey remains and pellets from occupied nests and nearby roosts were made as follows.

Wedge-tailed Eagle: 18 collections over 10 sites (12 nest-years) January 2008–November 2009, mostly in the breeding season (August–January), with two collections from an occupied roost in April.

Little Eagle: 15 collections over six sites (eight nest-years), in the breeding season (November 2008–January 2009; October 2009–January 2010).

The methods for identifying prey items, calculating the minimum number of prey individuals and their adjusted biomasses, and statistically treating the data, are described elsewhere (Olsen *et al.* 2010). Adjusted biomass of prey (consumed) takes into account wastage factors of different-sized prey, and the maximum amount of usable tissue the respective eagles can carry (see Olsen *et al.* 2010 for explanation and references). The sources of prey weights were as for other papers in this series (Fuentes *et al.* 2007; Olsen *et al.* 2004, 2006a,b, 2008, 2010). As in those prior studies, a mean weight of 1.5 kilograms for adult rabbits and 500 grams for juvenile rabbits was used for statistical purposes, to take account of the range of weights (from hindfoot lengths in remains) for juveniles and immatures. All the aforementioned study area and methods papers are available from the Institute for Applied Ecology website (www.canberra.edu.au/centres/iae) and the Global Raptor Information Network (www.globalraptors.org).

RESULTS

In pellets and prey remains collected in the ACT during 2008–09, Wedge-tailed Eagles took, by number, 65 per cent mammals, 33 per cent birds and 1 per cent reptiles, of which 19 per cent (of the total diet) consisted of macropods, 34 per cent rabbits (plus 4% hares) and a range of other large mammals; many of the last (e.g. macropods, cattle, sheep) were probably eaten as carrion. Wedge-tailed Eagles certainly killed some macropods, although we could not separate live kills from carrion in prey remains. Little Eagles took 52 per cent mammals, 45 per cent birds and 3 per cent reptiles by number, of which 2 per cent (of the total) consisted of macropod (one small joey kangaroo) and 50 per cent rabbits, but no larger mammals. Of the rabbits taken by Wedge-tailed Eagles, most were adults (29, versus three juveniles), whereas most of the rabbits taken by Little Eagles were juveniles (20, versus nine near-adults) (Table 1; Appendix 1). Similarly, most of the birds taken by Wedge-tailed Eagles were large species, including cockatoos and ravens, whereas most of those taken by Little Eagles were smaller species such as parrots and passerines (Appendix 1).

By biomass, Wedge-tailed Eagles took 93 per cent mammals (20% rabbits, 45% macropods) and 7 per cent birds, whereas Little Eagles took 73 per cent mammals (almost entirely rabbits) and 24 per cent birds; reptiles contributed trivial prey biomass for both species (<1% for Wedge-tailed Eagles, 3% for Little Eagles: Table 1).

Table 1

Summary table of dietary parameters of Wedge-tailed Eagles (WtE) and Little Eagles (LE) breeding sympatrically in the ACT, 2008–2009.

Diet	% n		% biomass	
	WtE	LE	WtE	LE
Mammals	65	52	92.6	72.8
Rabbit: adult	31	16	19.4	35.5
juvenile	3	35	0.7	36.2
Birds	33	45	7.2	23.6
Reptiles	1	3	0.2	3.4
Dietary statistics	WtE		LE	
GMPW	1650		336.7	
Shannon Index	2.75		2.28	
Standardised niche breadth	0.205		0.143	
Overlap (Pianka Index)	0.459			

GMPW for Wedge-tailed Eagles was 1650 grams, for Little Eagles 337 grams, this highly significant difference reflecting the fivefold difference in body weight between the two eagle species (Table 1; Wilcoxon rank sums test: Z = –5.75, *P* <0.0001). For the Wedge-tailed Eagle, standardised food niche breadth was 0.205; for the Little Eagle, 0.143. The Shannon Index for Wedge-tailed Eagles was 2.75, for Little Eagles 2.28, indicating that the Little Eagle's diet was slightly narrower and less diverse than was the Wedge-tailed Eagle's diet. A Pianka Index of 0.459 suggests some overlap in prey used by the two eagles, but the great difference in GMPW and heavy use of rabbits by Little Eagles suggest that there is little competition for prey between the two eagle species.

DISCUSSION

The breeding diets of both eagle species were, by number, similar to the larger dataset obtained in 2002–08. Dietary proportions, by number, species and age-classes of rabbits and other mammals, were similar to those found previously for the respective eagle species in the study area (see Olsen *et al.* 2010), although both eagle species took slightly more rabbits (and Little Eagles more juvenile rabbits) in 2008–09 than in 2002–08 (Table 2). This difference may reflect the resurgence of the rabbit population in the ACT region after 2006 (Olsen *et al.* 2013). Wedge-tailed Eagles took more Eastern Grey Kangaroos, as live kills and carrion, but Little Eagles were too small to kill macropods and avoided macropod carrion. Our results apply mainly to the breeding season, with some autumn samples for the Wedge-tailed Eagle, and comparative dietary metrics may vary in the non-breeding season. Study of the Little Eagle's non-breeding diet would be difficult other than by direct observation, as these eagles leave the nest area during the non-breeding season (our pers. obs.).

Dietary metrics for 2008–2009 differed, to varying degrees, from 2002–2008. For the Wedge-tailed Eagle, GMPW was similar in both periods (~1300 g vs 1650 g), but dietary diversity and food niche breadth were greater in the latter period (3.16 vs 2.75, and 0.205 vs 0.16, respectively). For the Little Eagle, GMPW was greater in the latter period (337 vs 249 g), but food niche breadth was the same (0.14) and dietary diversity was slightly narrower (2.28 vs 2.94). Dietary overlap between the two species was much less in the latter period (46% vs 69%),

Table 2

Percentage of rabbits in the diet of Wedge-tailed Eagles and Little Eagles near Canberra during three periods: 2002–2003, 2004–2007 and 2008–2009, as rabbit availability increased (see Olsen *et al.* 2013). *n* = number of prey items collected during each period for each eagle species (J. Olsen unpubl. data).

	2002–2003		2004–2007		2008–2009 (this study)	
	n	%	*n*	%	*n*	%
Wedge-tailed Eagle	531	16.6	98	26.8	94	34
Little Eagle	106	23.6	86	41.9	58	50

although both studies took place during an extended drought, and rabbits were likely more available in the latter period. These differences in dietary metrics may reflect the changes in dietary proportions noted above, i.e. in the latter period both eagle species took more rabbits (Table 2) in keeping with the increasing rabbit population; Wedge-tailed Eagles took proportionally fewer birds in the latter period, and Little Eagles took proportionally fewer reptiles and invertebrates.

There are several possible reasons why Wedge-tailed Eagles took mainly adult rabbits (and Little Eagles took mainly juveniles) in the present study, in contrast with some prior studies (e.g. Western Australia: Brooker and Ridpath 1980) in which Wedge-tailed Eagles took all age-classes of rabbits, including many juveniles. These relate partly to the eagles' respective body sizes and breeding seasons, i.e. Little Eagles are smaller than Wedge-tailed Eagles, and breed later in the year (e.g. Marchant and Higgins 1993). Other reasons relate partly to the breeding seasons of rabbits in the upland ACT versus more lower-elevation areas, and to rabbit population structure during the eagles' breeding seasons in relation to rabbit diseases. That is:

(i) In the ACT, rabbits are seasonal breeders, with kittens emerging in spring (N. Webb pers. comm.), whereas Wedge-tailed Eagles start breeding well before kittens emerge, and therefore there would be a higher proportion of adults in the available prey population before rabbits peak;

(ii) Rabbit breeding peaks ~6 weeks earlier in Western Australia, with higher rabbit breeding productivity (owing to a longer growing season) and likely more autumn breeding in the west, than in the ACT (Gilbert *et al.* 1987), hence more juveniles are available to breeding Wedge-tailed Eagles in the west;

(iii) The epidemiology of flea-borne, winter-transmitted myxomatosis, and of the rabbit calicivirus, means that young rabbits now form a smaller proportion of the rabbit population during the Wedge-tailed Eagle (winter) breeding season than formerly (B. Cooke pers. comm.).

Therefore, it may be more a matter of relative availability of rabbit age-classes through winter–spring, than selection of specific age-classes, particularly for Wedge-tailed Eagles. Weather may also influence the seasonal availability of rabbit kittens, e.g. drought versus effective rainfall, but (a) both of our studies took place during drought, and (b) the rabbit population generally increased over the period occupied by both studies (Olsen *et al.* 2013), despite the drought.

The Little Eagle has declined in the ACT from 12 pairs in the early 1990s to two pairs in 2010 and one in 2011 (Olsen *et al.* 2009, 2012; Debus *et al*. 2013). Suggested possible reasons include urban expansion displacing breeding pairs, and competition with Wedge-tailed Eagles for remaining breeding habitat (e.g. Olsen and Fuentes 2005; Debus 2011; Olsen *et al.* 2010, 2012), and a supposed decline in primary prey (rabbits) through the impact of the calicivirus (COG 2008). However, rabbits have been increasing in the ACT since about 2006–07 (Olsen *et al.* 2013), and form an increasing proportion of Little Eagle prey (this study), but are now aggressively controlled in Canberra, including the Nature Parks, by official poison baiting (Williams 2011; further discussion by Olsen *et al.* 2013).

If rabbit control measures are continued in the ACT using Pindone and 1080, these poisons may kill more Little Eagles than Wedge-tailed Eagles, because Little Eagles take proportionally more rabbits or may be physiologically more sensitive to these poisons. Australian raptors are unlikely to ingest harmful or fatal doses of 1080 at the concentrations in pest baits or bodies, although eagles seem more sensitive than some other raptors (e.g. see McIlroy 1984; Martin and Twigg 2002). However, Pindone is a much higher risk to birds, and eagles and other raptors seem particularly susceptible (Martin *et al.* 1994). Furthermore, 1080 requires only one application in a given control event, whereas Pindone requires up to three applications, thus heightening the risk to raptors. There may also be a seasonal interaction between baiting and the eagles' breeding versus non-breeding diet, and their population dynamics. For instance, if baits are applied mainly in late summer and autumn then juvenile eagles (i.e. potential recruits) may suffer high mortality, if they rely heavily on carrion or moribund animals while developing hunting skills (e.g. see Martin *et al.* 1994 for discussion of differential mortality in nestling or juvenile raptors, versus adults, from Pindone). In co-operation with ACT Parks and Conservation, we are exploring the question of Pindone poisoning (Olsen *et al.* 2013; J. Olsen *et al.* unpubl. data).

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REFERENCES

Brooker, M. G. and Ridpath, M. G. (1980). The diet of the Wedge-tailed Eagle, *Aquila audax*, in Western Australia. *Australian Wildlife Research* **7:** 433–452.

Canberra Ornithologists Group (2008). Nomination of a Vulnerable species to the ACT Flora and Fauna Committee – Little Eagle. *Canberra Bird Notes* **33:** 84–95.

Debus, S. J. S (2011) Parental time-budgets and breeding behaviour of the Little Eagle *Hieraaetus morphnoides* in northern New South Wales. *Corella* **35:** 65–72.

Debus, S. J. S., Olsen, J., Judge, D. and Butterfield, M. (2013). Numbers of breeding Little Eagles *Hieraaetus morphnoides* in the Australian Capital Territory in relation to atlas counts. *Corella* **37:** 30–32.

Fuentes, E., Olsen, J. and Rose, A. B. (2007). Diet, occupancy and breeding success of Wedge-tailed Eagles *Aquila audax* near Canberra, Australia, 2002–2003: four decades after Leopold and Wolfe. *Corella* **31:** 65–73.

Gilbert, N., Myers, K., Cooke, B. D., Dunsmore, J. D., Fullagar, P. J., Gibb, J. A., King, D. R., Parer, I., Wheeler, S. H. and Wood, D. H. (1987). Comparative dynamics of Australasian rabbit populations. *Australian Wildlife Research* **14:** 491–503.

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

Martin, G. R. and Twigg, L. E. (2002). Sensitivity to sodium fluoroacetate (1080) of native animals from north-western Australia. *Wildlife Research* **29:** 75–83.

Martin, G. R., Kirkpatrick, W. E., King, D. K., Robertson, I. D., Hood, P. J. and Sutherland, J. R. (1994). Assessment of the potential toxicity of an anticoagulant, Pindone (2-pivalyl, 3-indandione), to some Australian birds. *Wildlife Research* **21**: 85–93.

McIlroy, J. C. (1984). The sensitivity of Australian animals to 1080 poison. VII. Native and introduced birds. *Australian Wildlife Research* **11:** 373–385.

Olsen, J. and Fuentes, E. (2005). Collapse in numbers of breeding Little Eagles *Hieraaetus morphnoides* in the Australian Capital Territory. *Canberra Bird Notes* **30:** 141–145.

Olsen, J., Debus, S. J. S., Rose, A. B. and Hayes, G. (2004). Breeding success, cliff characteristics and diet of Peregrine Falcons at high altitude in the Australian Capital Territory. *Corella* **28:** 33–37.

Olsen, J., Debus, S. J. S. and Judge, D. (2013). Declining Little Eagles *Hieraaetus morphnoides* and increasing rabbit numbers near Canberra: is secondary poisoning by Pindone the problem? *Corella* **37:** 33–35.

Olsen, J., Fuentes, E., Bird, D. M. Rose, A. B. and Judge, D. (2008). Dietary shifts based upon prey availability in Peregrine Falcons and Australian Hobbies breeding near Canberra, Australia. *Journal of Raptor Research* **42:** 125–137.

Olsen, J., Fuentes, E., Judge, D., Rose, A. B. and Debus, S. J. S. (2010). Diets of Wedge-tailed Eagles (*Aquila audax*) and Little Eagles (*Hieraaetus morphnoides*) breeding near Canberra, Australia. *Journal of Raptor Research* **44:** 50–61.

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

Olsen, J., Fuentes, E. and 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, J., Osgood, M., Maconachie, M, Dabb, G. and Butterfield, M. (2009). Numbers of breeding Little Eagles *Hieraaetus morphnoides* in the Australian Capital Territory in 2008. *Canberra Bird Notes* **34:** 81–85.

Olsen, J., Osgood, M., Maconachie, M, Dabb, G. and Butterfield, M. (2012). Little Eagles, Whistling Kites and Swamp Harriers in the Australian Capital Territory 2010. *Canberra Bird Notes* **36:** 155–157.

Williams, K. (2011). Managing rabbits in Canberra Nature Park. Report to the Commissioner for Sustainability and Environment, Canberra.

Appendix 1

Diets of Wedge-tailed Eagles (WtE) and Little Eagles (LE) breeding sympatrically in the ACT, 2008–2009. For sources of prey weights, and adjusted biomasses, see text.

Species	Mass (kg)	*n*		% *n*		Adj. biomass (kg)		% biomass	
		WtE	LE	WtE	LE	WtE	LE	WtE	LE
Eastern Grey Kangaroo *Macropus giganteus*	35	5		5.3		19		12.58	
juv.	17.2	9		9.6		34.2		22.65	
joey	0.25		1		1.7		0.21		1.12
Common Wallaroo *Macropus robustus*	29	4		4.3		15.2		10.07	
Rabbit *Oryctolagus cuniculus*	1.5	29	9	31	15.5	29.3	6.67	19.41	35.52
juv.	0.5	3	20	3.2	34.5	1.01	6.8	0.67	36.21
Hare *Lepus capensis*	4	4		4.3		10.7		7.09	
Sheep *Ovis aries*	50	4		4.3		15.2		10.07	
lamb	15	1		1.1		3.8		2.52	
Cow *Bos taurus*	200	1		1.1		3.8		2.52	
Fox *Vulpes vulpes*	9	2		2.1		7.6		5.03	
Total mammals		**62**	**30**	**66.3**	**51.7**	**139.81**	**13.68**	**92.73**	**72.85**
Domestic Fowl *Gallus gallus*	2	1		1.1		1.6		1.06	
Pacific Black Duck *Anas superciliosa*	1.036		1		1.7		0.74		3.94
Hardhead *Aythya australis*	0.87	1		1.1		0.7		0.46	
Tawny Frogmouth *Podargus strigoides*	0.326	1		1.1		0.26		0.17	
Galah *Eolophus roseicapillus*	0.335	4	1	4.3	1.7	1.07	0.27	0.71	1.44
Sulphur-crested Cockatoo *Cacatua galerita*	0.804	2		2.1		1.28		0.85	
Crimson Rosella *Platycercus elegans*	0.135	2	2	2.1	3.4	0.24	0.24	0.16	1.28
juv.	0.131		2		3.4		0.24		1.28
Eastern Rosella *Platycercus eximius*	0.106	3	1	3.2	1.7	0.27	0.09	0.18	0.48
Red-rumped Parrot *Psephotus haematonotus*	0.061		2		3.4		0.12		0.64
Southern Boobook *Ninox novaeseelandiae*	0.283	1		1.1		0.25		0.17	
Laughing Kookaburra *Dacelo novaeguineae*	0.345		1		1.7		0.28		1.49
Australian Magpie *Cracticus tibicen*	0.329	3	6	3.2	10.3	0.78	1.56	0.52	8.31
juv.	0.3	2		2.1		0.48		0.32	
Pied Currawong *Strepera graculina*	0.27	2		2.1		0.48		0.32	
Australian Raven *Corvus coronoides*	0.645	2		2.1		1.04		0.69	
Little Raven *Corvus mellori*	0.541	1		1.1		0.43		0.28	
Raven sp.	0.593	2		2.1		0.94		0.62	
Magpie-lark *Grallina cyanoleuca*	0.09		2		3.4		0.16		0.85
White-winged Chough *Corcorax melanorhamphos*	0.334	2	1	2.1	1.7	0.54	0.27	0.36	1.44
Common Starling *Sturnus vulgaris*	0.075	1	3	1.1	5.2	0.07	0.21	0.05	1.12
Common Myna *Sturnus tristis*	0.116		2		3.4		0.2		1.06
Bird (Little Raven?)	0.541	1		1.1		0.43		0.28	
Small bird	0.03		2		3.4		0.06		0.32
Total birds		**31**	**26**	**33.1**	**44.4**	**10.86**	**4.44**	**7.2**	**23.65**
Common Bluetongue *Tiliqua scincoides*	0.4	**1**	**2**	**1.1**	**3.4**	**0.32**	**0.64**	**0.21**	**3.41**
Total		**94**	**58**	**100.5**	**99.5**	**150.99**	**18.76**	**100.14**	**99.91**