CORELLA

Volume 37 Number 2 June 2013

Journal of
The Australian Bird Study Association

Registered by Australia Post
Print Post Approved – PP226018/0008

ISSN 0155-0438

AUSTRALIAN BIRD STUDY ASSOCIATION INC.

www.absa.asn.au

OFFICE BEARERS, 2013

Bequests:

The Association welcomes enquiries on how to make a bequest. This is a common way to assist in the work of the Association when you are unable to do so at the present time. Donations to the ABSA Fund for Avian Research are tax deductible in Australia. Please contact the President, either by email: info@absa.asn.au or by mail to PO Box A313, Sydney South, NSW 1235, for more information.

Annual subscriptions for 2013 are as follows: $60.00 (Single), $70.00 (Single Overseas), $75.00 (Household), $80.00 (Household Overseas), $40.00 (Concession), $90.00 (Corporate), $100.00 (Corporate Overseas). Subscriptions are payable in advance and due on 1 January each year. All members of the Association receive *Corella*.

All papers published in Corella are subject to peer review by two referees.

Postal address of the Association is:
PO Box 1867, Penrith BC NSW 2751

Printer: Penrith Art Printing Works, 5 Robertson Place, Penrith, NSW 2750

ISSN 0155-0438

Corella, 2013, 37(2): 25–29

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

Jerry Olsen[1], S. J. S. Debus[2], David Judge[1] and A. B. Rose[3]

[1]Institute for Applied Ecology, University of Canberra, Australian Capital Territory 2601 (Email: Jerry.Olsen@canberra.edu.au)
[2]Honorary Associate, Division of Zoology, University of New England, Armidale, New South Wales 2351 (Email: sdebus@une.edu.au)
[3]Associate, Australian Museum, 6 College Street Sydney, New South Wales 2010
(Present address: 61 Boundary Street, Forster, New South Wales 2428)

Received: 6 February 2012

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).

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.

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			

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).

ACKNOWLEDGEMENTS

Thanks to Sue Trost and Mark Osgood for collecting prey; to Terry Dennis, Jeff Jolly and Chris Davey for generating interest in Little Eagles; to Nick Mooney, Joan Real, Luis Palma, Les Boyd, Marcos Moleón, Jim Hone, Michael Brooker and Bill Mannan for advice; and to Christie Gould, Michael Maconachie, David Mallinson, Frank Barnes, Nick Webb, Geoffrey Dabb and Roger Curnow for finding eagle nests. Thanks also to the ACT Parks and Conservation Service, including Murray Evans, Don Fletcher, Michael Maconachie, Bernard Morris, Brett Macnamara, Paul Higginbotham and Darren Rosso. Particular thanks to Walter Boles and John Disney (Australian Museum) for aid with the identification of some specimens, and to Sean Doody (Institute for Applied Ecology) and Robert Palmer (Australian National Wildlife Collection) for mass estimates of some prey. Special thanks to Ross Bennett, Enzo Guarino, Arthur Georges, Gabriela Peniche and the Kippax Veterinary Hospital for their assistance with prey masses. The study methods were approved by the University of Canberra Animal Ethics Committee, reg. no. CEAE 02/10. Michael Brooker, Chris Davey, Greg Czechura and an anonymous referee kindly reviewed drafts, and Terry Dennis's edits on a companion paper have been adapted herein.

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**

Numbers of breeding Little Eagles *Hieraaetus morphnoides* in the Australian Capital Territory in relation to atlas counts

S. J. S. Debus[1], Jerry Olsen[2], David Judge[2] and M. Butterfield[3]

[1]Honorary Associate, Division of Zoology, University of New England, Armidale, New South Wales 2351 (Email: sdebus@une.edu.au)
[2]Institute for Applied Ecology, University of Canberra, Australian Capital Territory 2601 (Email: Jerry.Olsen@canberra.edu.au)
[3]101 Whiskers Creek Road, Carwoola, New South Wales 2620

Received: 8 February 2012

The Little Eagle *Hieraaetus morphnoides* is undergoing a severe decline in parts of south-eastern Australia, including the Australian Capital Territory, even though atlas reporting rates may suggest that Little Eagle numbers are stable or declining only moderately. We compared trends in atlas reporting rates of the Little Eagle, and the number of occupied Little Eagle breeding territories (active nests), in the ACT during 1988–2011. We found that, although the number of occupied territories or breeding pairs declined from 13 to one (i.e. >90% decline), the number of reported Eagle sightings fluctuated about a rather constant level. Because atlas surveys may not accurately reflect declines, or the severity of declines, in some raptors, we suggest that atlas data are combined with surveys of nesting raptors to assess trends in raptor numbers.

INTRODUCTION

The Little Eagle *Hieraaetus morphnoides* is declining in parts of south-eastern Australia, and is now classified as *vulnerable* in the Australian Capital Territory (ACT) and New South Wales (Olsen and Fuentes 2005; Olsen *et al*. 2008, 2009; Debus 2011). Olsen *et al*. (2008, 2009) showed a decline in active Little Eagle nests from 11 to one in Canberra nature parks and reserves between 1992 and 2007, from a total ACT population of 13 occupied territories at the time (Taylor and COG 1992). In contrast, Barrett *et al*. (2007) reported a 39 percent decrease in the reporting rate for Little Eagles in New South Wales, based on data from the first Atlas of Australian Birds (conducted between 1977 and 1981: Blakers *et al.* 1984) and the New Atlas of Australian Birds (conducted between 1998 and 2001: Barrett *et al.* 2003). Sergio *et al*. (2008) argued that changes in atlas counts of raptors in Europe were not representative of changes in the number of breeding pairs of raptors, because such atlas counts can either over- or underestimate true raptor numbers. However, they presented no data to support this claim.

Owing to this lack of published data on breeding raptors and atlas counts, we sought to compare the number of active Little Eagle nests in the ACT over the period 1988–2010 against trends in reporting rates for the Little Eagle in the Canberra Ornithologists Group (COG) sightings database, to determine whether database sightings for Little Eagles were correlated with the number of active nests.

STUDY AREA AND METHODS

Study area

The study area was the Australian Capital Territory. Field methods and Little Eagle habitats were as previously described for studies on the comparative ecology of raptors around Canberra in the ACT (Fuentes *et al.* 2007; Olsen *et al.* 2006, 2010a). These 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).

Counts of Little Eagle nests

The number of resident pairs of Little Eagles and their active nests (i.e. eggs or nestlings) in the ACT 1988–1992 were taken from broad surveys of raptors in the ACT (Olsen 1992; Taylor and COG 1992). When a decline of Little Eagles was first noted (Olsen and Fuentes 2005), a team co-ordinated by JO and colleagues (e.g., see Olsen and Osgood 2006; Olsen *et al.* 2008, 2012) attempted to find all active Little Eagle nests and occupied breeding territories in the ACT. It was readily apparent when a known pair moved its nest location from year to year (see Olsen *et al.* 2009, 2010b, 2012); that is, if a known site was found to be disused then alternative nests were identified before concluding that a territory was defunct.

Sightings of Little Eagles

Data on the reporting rate for Little Eagles in the ACT during 1988–2011 were obtained from the annual bird reports of the Canberra Ornithologists Group, published annually in *Canberra Bird Notes*, from sightings mainly by amateurs in the ACT. The atlas statistic used (COG's F-value) is a measure of the number of sightings as a proportion of observer effort: the number of sites at which the species was recorded, as a percentage of the total number of atlas surveys sites throughout the ACT (e.g. COG 2012). In the ACT, Little Eagles occur in the wooded and open areas around Canberra, including woodland between suburbs, but not in the rugged, forested south (Namadgi National Park) (e.g. Olsen 1992; Taylor and COG 1992; Olsen and Fuentes 2005).

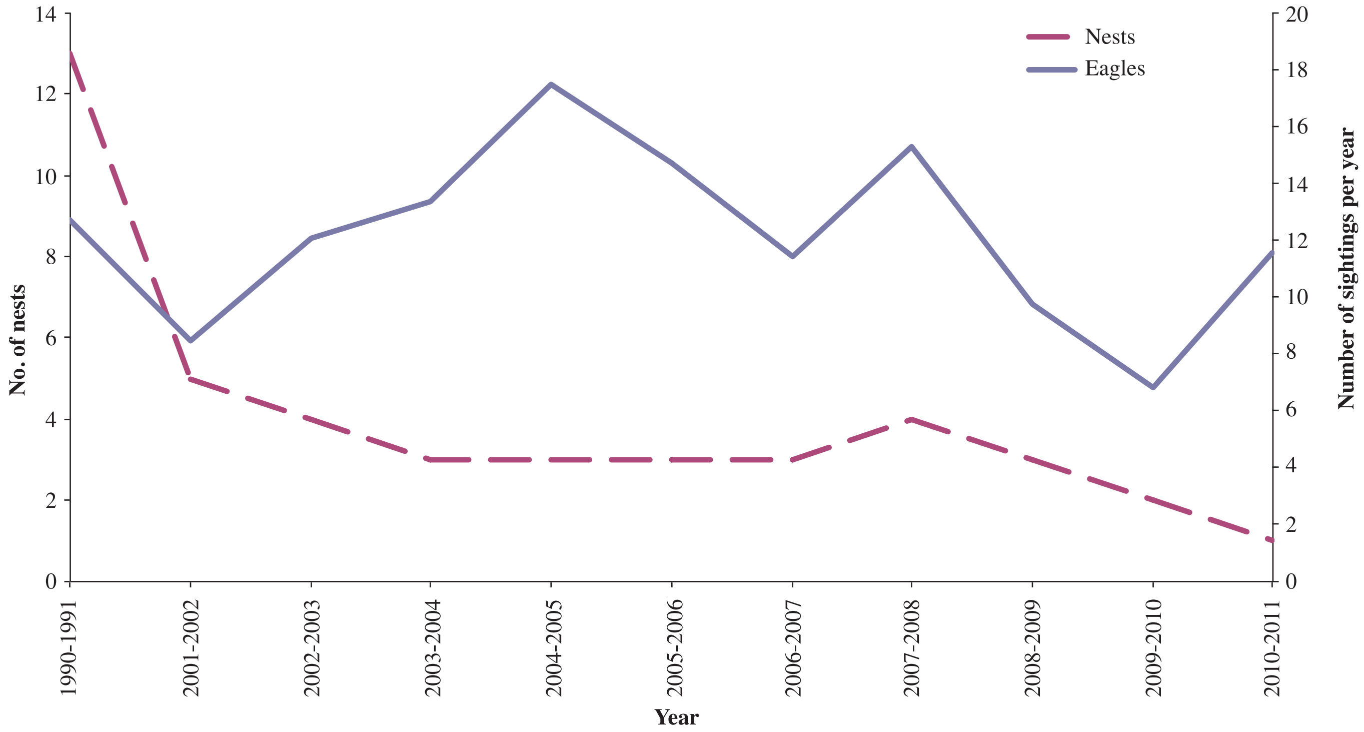


Figure 1. *Relationship between number of active nests (from annual surveys of breeding pairs, = Nests) and atlas reporting rate (from annual COG surveys, = Eagles) for Little Eagles in the ACT, 1990–2010. Right vertical axis scale gives annual atlas reporting rate for Eagle sightings; left vertical axis scale gives number of Eagle nests (regression: F = 0.06; P = 0.81; not significant).*

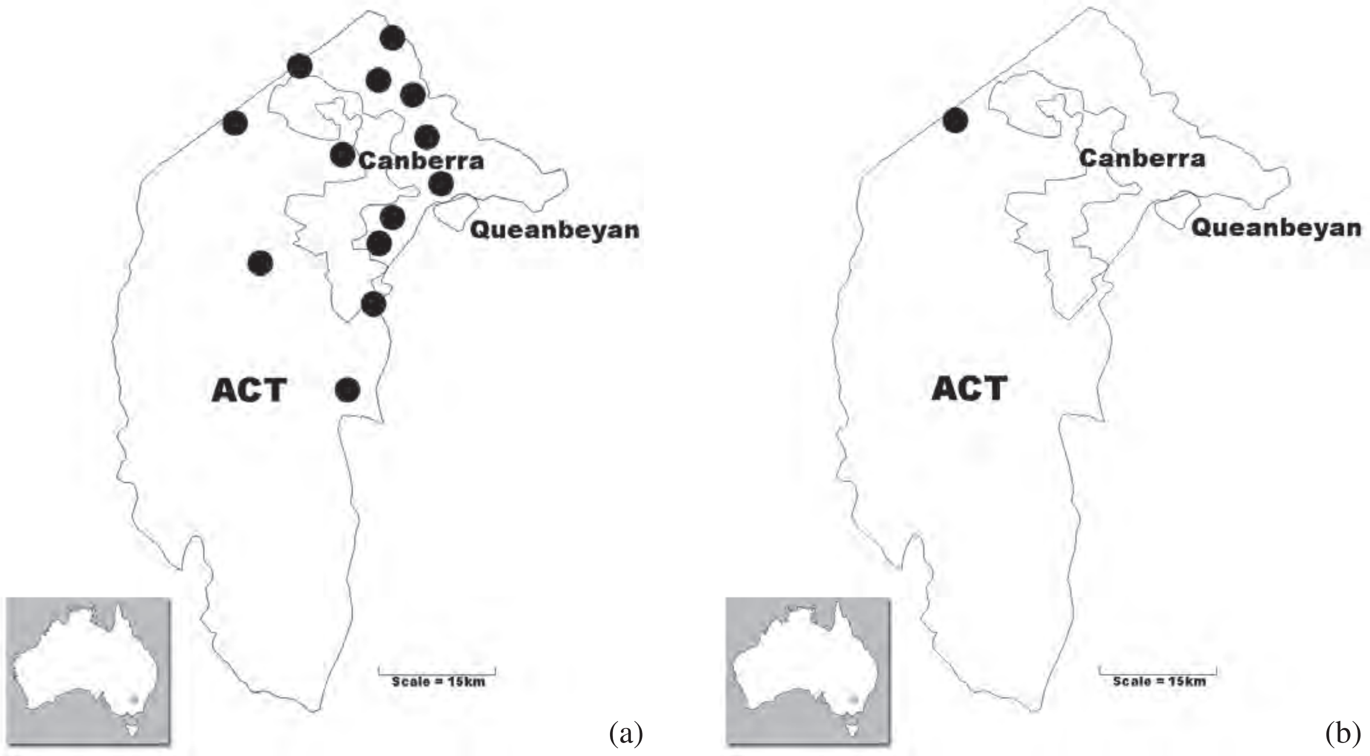


Figure 2. *Breeding Little Eagles found in the Australian Capital Territory: (a) 1992, (b) 2011. Each black dot represents a cluster of up to six alternative nests inside a Little Eagle territory.*

RESULTS AND DISCUSSION

There was no significant relationship between the number of active Little Eagle nests in the ACT and the COG atlas reporting rate for Little Eagles (Figure 1; regression analysis: $F = 0.06$, $P = 0.81$). That is, the number of sightings, although variable, has remained high until recently, but the number of pairs with active nests has declined by at least 90 percent over the same period (Figure 2). The lack of a correlation between sighting rates and active nests may relate to ongoing immigration of Little Eagles from adjoining New South Wales.

Admittedly, there has been variation in the incentive to report Little Eagle sightings, e.g. the national bird atlas in 1998–2001 and encouragement of COG members to report eagle sightings after their decline was first signalled in 2005. Nevertheless, it appears that the ACT has become a population sink for Little Eagles. Furthermore, the number of COG sightings may be inflated by false positives, as there have been several confirmed cases of other raptor species misidentified by COG observers as Little Eagles, including Brown Falcons *Falco berigora*, Whistling Kites *Haliastur sphenurus*, Black Kites *Milvus migrans*, and others. The converse also occurs, e.g. a dead Little Eagle (examined in the hand) misreported as a Powerful Owl *Ninox strenua* (Olsen *et al.* 2012). Recently, several photographs were submitted to JO for identification: (a) a Little Eagle and a Whistling Kite in the same frame, initially suspected as a pair of Little Eagles at Jerrabomberra, and (b) a dark-morph Little Eagle over Canberra, initially suspected as a Whistling Kite or a female Swamp Harrier *Circus approximans*. This case illustrates (a) the high potential among amateurs for confusing raptor species, and (b) the commendable practice of verifying records before submitting them to the COG database, which contrasts with the frequent 'I know what I saw' syndrome that has resulted in erroneous records.

Data in this study, and in Olsen *et al*. (2009), may be the only data comparing sighting records with nest surveys for an Australian raptor, and validate a similar conclusion by Olsen *et al.* (2009) on a smaller dataset. Sighting records may mask the true situation with respect to an eagle's breeding population (e.g. Sergio *et al.* 2008). Surveys of active nests and breeding productivity provide a more reliable yardstick for assessing trends in raptor numbers than do bird atlas reporting rates, hence the need for long-term monitoring of these aspects in sample areas (e.g. Olsen *et al.* 2009), though combining atlas data with nest surveys could provide a better measure of raptor numbers than either method used on its own. The causes of territory desertions and unexpected eagle deaths also require investigation (e.g. Olsen *et al.* 2010b; Debus 2011). Further comparisons of nest surveys with atlas reporting rates, in Australia and elsewhere, are needed to replicate and confirm the findings of this study.

In 2011 we made recommendations to the ACT Government for a Little Eagle Action Plan. These include: retain woodland, begin radio-tracking studies of Little Eagles to determine home-range size and habitat use, and investigate the effects on raptors of the chemicals Pindone (2-pivalyl, 3-indandione) and 1080 (sodium fluoroacetate) used to poison rabbits in the ACT. However, only one breeding pair of Little Eagles was found in the ACT in 2011. Furthermore, we recommend that records of rare, uncommon or threatened raptors in the ACT be verified by photographs referred to experts, before acceptance into the COG database.

ACKNOWLEDGEMENTS

Thanks go to Brian Cooke, Joan Real, Michael Maconachie, Don Fletcher, Nick Webb, Oliver Orgill and Susan Trost for help with various aspects of this study. Thanks go also to Michael Brooker, Chris Davey, Julia Hurley and two referees for helpful comments on a draft. We acknowledge and commend the practice, among a few conscientious observers, of having their photographs verified before submitting the records to COG.

REFERENCES

Barrett, G. W., Silcocks, A. F., Cunningham, R., Oliver, D. L, Weston, M. A. and Baker, J (2007). Comparison of atlas data to determine the conservation status of bird species in New South Wales, with emphasis on woodland-dependent species. *Australian Zoologist* **34:** 37–77.

Barrett, G. W., Silcocks, A.F., Barry, S., Cunningham, R. and Poulter, R. (2003). 'The New Atlas of Australian Birds'. (RAOU: Melbourne.)

Blakers, M., Davies, S. J. J. F. and Reilly, P. N. (1984). 'The Atlas of Australian Birds'. (Melbourne University Press: Melbourne.)

Canberra Ornithologists Group (2012). Annual bird report: 1 July 2010 to 30 June 2011. *Canberra Bird Notes* **37:** 1–88.

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.

Fuentes, E., Olsen, J. and Rose, A. B. (2007). Diet, occupancy, and breeding performance of Wedge-tailed Eagles *Aquila audax* near Canberra, Australia 2002–2003: four decades after Leopold and Wolf. *Corella* **31:** 65–72.

Olsen, J. (1992). 'Raptors in Namadgi, Canberra Nature Parks, the Murrumbidgee River Corridor, and Googong Foreshore'. Report to ACT Parks and Conservation, Canberra.

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. and Osgood, M. (2006). Numbers of breeding Little Eagles *Hieraaetus morphnoides* in the Australian Capital Territory in 2006. *Canberra Bird Notes* **31:** 178–182.

Olsen, J., Fuentes, E., Judge, D., Rose, A. B. and Debus, S. J. S. (2010a). 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. (2006). Food and hunting of eight breeding raptors near Canberra, 1990–1994. *Australian Field Ornithology* **23:** 77–95.

Olsen, J., Osgood, M., Maconachie, M. and Dabb, G. (2008). Numbers of breeding Little Eagles *Hieraaetus morphnoides* in the Australian Capital Territory in 2007. *Canberra Bird Notes* **33:** 77–80.

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. (2010b). Little Eagles, Whistling Kites and Swamp Harriers in the Australian Capital Territory in 2009. *Canberra Bird Notes* **35:** 81–84.

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.

Sergio, F., Newton, I. and Marchesi, L. (2008). Top predators and biodiversity: much debate, few data. *Journal of Applied Ecology* **45:** 992–999.

Taylor, M. and Canberra Ornithologists Group (1992). 'Birds of the Australian Capital Territory, An Atlas'. (Canberra Ornithologists Group and the National Capital Planning Authority: Canberra).

Corella, 2013, 37(2): 33–35

Declining Little Eagles *Hieraaetus morphnoides* and increasing rabbit numbers near Canberra: is secondary poisoning by Pindone the problem?

Jerry Olsen[1], S. J. S. Debus[2] and David Judge[1]

[1]Institute for Applied Ecology, University of Canberra, Australian Capital Territory 2601 (Email: Jerry.Olsen@canberra.edu.au)
[2]Honorary Associate, Division of Zoology, University of New England, Armidale, New South Wales 2351 (Email: sdebus@une.edu.au)

Received: 13 February 2012

The Little Eagle *Hieraaetus morphnoides* is declining in parts of south-eastern Australia, including the Australian Capital Territory (ACT) , even though the number of European Rabbits *Oryctolagus cuniculus* is increasing. A non-pathogenic lagovirus related to Rabbit Haemorrhagic Disease Virus (RHDV) is protecting rabbits from RHD in cooler areas of south-eastern Australia. Consequently, the chemicals Pindone (2-pivalyl, 3-indandione) and 1080 (sodium fluoroacetate) are used to poison rabbits, and Pindone may disable raptors and/or be fatal to them. Little Eagles take proportionally more rabbits than do Wedge-tailed Eagles *Aquila audax*, so Little Eagles may be more affected by secondary poisoning. We recommend that (i) the Little Eagle be uplisted from *vulnerable* to *endangered* in the ACT, and (ii) Pindone be banned in Little Eagle home ranges in the ACT.

INTRODUCTION

In other papers, we refuted two misconceptions about the Little Eagle *Hieraaetus morphnoides* in the Australian Capital Territory (ACT): namely, that Wedge-tailed Eagles *Aquila audax* in the ACT region compete with Little Eagles for prey (Olsen *et al.* 2010a, 2013), and that atlas reporting rates accurately reflect trends in the Little Eagle breeding population (Olsen and Fuentes 2005; Olsen *et al*. 2009; Debus *et al.* 2013). In fact, in the ACT Wedge-tailed and Little Eagles overlap little in prey, and even less so since Eastern Grey Kangaroo *Macropus giganteus* and European Rabbit *Orytcolagus cuniculus* populations have increased (Olsen *et al.* 2010a, 2013). Further, the Little Eagle breeding population in the ACT has crashed even though sightings are still frequently reported in databases (Debus *et al.* 2013). Olsen and Osgood (2006) speculated that Mevinphos, a broad-spectrum organophosphate insecticide, might be implicated in the Little Eagle's decline, although Olsen *et al.* (2009, 2010b) linked the decline to possible secondary poisoning from Pindone and other toxins used to kill European Rabbits *Oryctolagus cuniculus* and other agricultural pests.

There are no published data showing that densities of breeding raptors in Australia increase or decrease in relation to numbers of rabbits. Steele and Baker-Gabb (2009) compared raptor abundance before and after the introduction of Rabbit Calicivirus Disease (RCD) in 1995–96, as a pest-control mechanism that caused severe declines in numbers of rabbits. They found no detectable effect from the introduction of RCD on populations of species of raptors that are dependent on rabbits as a food source.

Rabbit Haemorrhagic Disease Virus (RHDV) escaped from Wardang Island, off South Australia, in October 1995, and may have been widespread in the ACT by late 1996 (B. Cooke pers. comm.). Studies following the arrival of RHDV on mainland Australia showed that the virus caused mortality rates of up to 95 percent in the rabbit populations investigated, but was less effective in some other regions of Australia. Henzell *et al.* (2002) described a cline in the effectiveness of RHDV along a hot-dry to cool-humid gradient, and Saunders *et al*. (1999) showed that the impact of RHDV in the New South Wales Central Tablelands was patchy. Presumably, a similar situation applies in the ACT (B. Cooke pers. comm.). Antibodies against RHDV were found in sera of rabbits sampled before the introduction of RHDV. These two observations, combined, led to the hypothesis that a similar benign virus had already been present in Australian wild rabbits, giving them partial immunity. This virus was discovered, isolated and its genome published (Strive *et al*. 2010) and termed Rabbit Calicivirus Australia 1 (RCV-A1). To counter the decreased effects of biological control in the ACT, the chemicals Pindone (2-pivalyl, 3-indandione) and 1080 (sodium fluoroacetate) are now used to control rabbits. At high doses, Pindone is fatal to raptors, or disables them temporarily (Martin *et al*. 1994), which can be fatal if the raptor is incapacitated and cannot forage or evade predators. If rabbit control measures are thus affecting raptors in the ACT, via secondary poisoning, relatively more Little Eagles than Wedge-tailed Eagles may die, because Little Eagles take proportionally more rabbits (by biomass 52% compared with 13% for Wedge-tailed Eagles, and more recently 73% vs 19%, respectively: Olsen *et al*. 2010a, 2013). Little Eagles may be more sensitive to such poisons than are some other raptors, although we have no evidence yet to support this suggestion.

A better understanding of the numbers, feeding ecology and threatening processes of the Little Eagle is a precursor to understanding this species' decline in south-eastern Australia, and formulating management actions, particularly given the 'umbrella' role of raptors in ecosystem and biodiversity conservation (see Sergio *et al.* 2006, 2008). This paper addresses a third misconception about Little Eagles in the ACT, namely that they have declined because of the effect of the calicivirus on their primary food supply (rabbits). Instead, we demonstrate that rabbit numbers have increased greatly over the period that the Little Eagle breeding population has crashed, and we discuss the possible role of Pindone baiting of rabbits, and hence secondary poisoning of Eagles, in that decline.

Figure 1. *Relationship between number of active nests of Little Eagles (— — from annual surveys of breeding pairs) and abundance index of rabbits (—— rabbits/km, from monthly surveys, see text) in the ACT, 1990-2001 (regression: F = 1.98; P = 0.20; not significant).*

STUDY AREA AND METHODS

The study area was the Australian Capital Territory. Field methods and Little Eagle habitats were as previously described for studies on the comparative ecology of raptors around Canberra in the ACT (Fuentes *et al.* 2007; Olsen *et al.* 2006, 2010a). Surveys of resident pairs and active nests of the Little Eagle were as previously described (Debus *et al.* 2013). 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).

Counts of rabbits

Data on numbers of rabbits (rabbits/km) came from transect counts conducted monthly or bimonthly by the ACT Department of Land and Environment near Glendale in the ACT (D. Fletcher, N. Webb and O. Orgill pers. comm.). These surveys included the years when RHDV arrived in Canberra, around 1996. The method followed protocols outlined by Anon. (2008). Rabbits were counted using a 100-Watt spotlight from the back of a 4WD vehicle travelling at a set low speed along standardised transects, starting one hour after sunset, and counting all the rabbits in a set arc from the vehicle. Three counts were made along the same route on different nights within seven days of the new moon (i.e. the darkest nights, to sample maximum rabbit activity). The mean of the three counts was divided by the combined lengths of the transects on the site, to give the mean number of rabbits per kilometre for each counting session at each site, as an index of relative abundance. This method gave a trend for increase or decrease in numbers of rabbits, rather than a population density.

RESULTS AND DISCUSSION

The decline in the number of active Little Eagle nests in the ACT over the period 1990–2010 (Figure 1) shows no significant relationship with trends in numbers of rabbits, even after the arrival of RHDV by 1996 (regression analysis: $F = 1.98$; $P = 0.20$). Rabbit numbers peaked around 2006–07 to the point of requiring active control, and peaked again in 2010, whereas the number of breeding pairs of Little Eagles has declined to less than 10 percent of what it was in the early 1990s. In recent years (2007–10) there may even be a negative relationship between Little Eagle breeding status and rabbit numbers, and in 2011 there was only one breeding pair of Little Eagles found in the ACT (Olsen *et al.* 2012). There is no sign of a lagged recovery of the Little Eagle breeding population, following the resurgence of rabbits (Figure 1), and rabbit control has increased to counter this resurgence.

The lack of a correlation between the Little Eagle's breeding status in the ACT and trends in rabbit numbers suggests that some reason other than RHDV and loss of prey is causing the Eagle's decline. Various possible reasons have been canvassed, e.g. increasing competition with Wedge-tailed Eagles for decreasing habitat and nest sites (owing to urban expansion), and poisoning (e.g. Olsen *et al.* 2008, 2009), which deserve investigation. We previously refuted the idea that Wedge-tailed

Eagles compete substantially with Little Eagles for prey (Olsen *et al*. 2010a, 2013), although they may compete for nest sites. 'Floater' Little Eagles may continue to appear in the ACT from the wider continental population, but the ACT region may have become a population sink for this species.

Our investigations revealed an apparent link between the distribution of Pindone use and the disappearance of Little Eagle breeding pairs. Pindone is used mainly in peri-urban areas (G. Saunders pers. comm.), because it is much less toxic to dogs than is 1080, and an antidote exists, whereas there is no antidote for 1080. The prevailing pattern found in the ACT is that Little Eagle pairs are disappearing from government peri-urban lands where Pindone is used, but successfully breeding pairs persist on outlying private farms where 1080 or no rabbit baits are used. An example of the latter is the Pegasus pair (see Olsen *et al.* 2009), where there has been virtually no rabbit control except for some warren-ripping three years ago (landholder information). The most recent examples on government land concern (a) the Black Mountain pair, which was not found breeding in December 2011, but there were Pindone panels present (J. Real pers. comm.); and (b) the Mt Ainslie pair, where Pindone was used directly under the nest because the pair was allegedly 'not breeding', but Pindone could equally have been the reason for the Eagles' disappearance. Data on Pindone use in the ACT, e.g. application rates 1990–2010, are needed to investigate any temporal pattern between the Little Eagle's decline and Pindone use.

Adult Little Eagles, Wedge-tailed Eagles and Whistling Kites *Haliastur sphenurus* have been found, inexplicably dead, in or under their respective nests, resulting in nest failure, but these bodies were not analysed for Pindone.

Under the circumstances, we recommend (i) that the Little Eagle be uplisted from *vulnerabl*e to *endangered* in the ACT (a >90% decline in two generations easily meets IUCN criteria for that category), and (ii) that Pindone be banned in the remaining Little Eagle home range(s) with occupied nests, as a precautionary measure, pending the outcome of investigations into Pindone use and any correlations with defunct Little Eagle territories.

Pindone was accepted for use in Australia with almost no toxicity trials or research (e.g. see Martin *et al.* 1994), so the problem may be more widespread than is realised, and might bear on the 50 percent decline in atlas reporting rates for the Little Eagle in south-eastern NSW over the past 30 years (see COG 2008). It would be ironic if Pindone, which appears not to be controlling rabbit populations (Figure 1), is killing off a predator that eats mostly rabbits (Olsen *et al.* 2013).

ACKNOWLEDGEMENTS

Thanks go to Brian Cooke, Joan Real, Michael Maconachie, Don Fletcher, Nick Webb, Oliver Orgill and Susan Trost for help with various aspects of this study. Thanks go also to Michael Brooker, Chris Davey, Julia Hurley, Tom Aumann and an anonymous referee for helpful comments on drafts.

REFERENCES

Anon. (2008). 'Vertebrate Pest Control Manual'. (NSW Department of Primary Industries: Orange.)

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., 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 performance of Wedge-tailed Eagles *Aquila audax* near Canberra, Australia 2002–2003: four decades after Leopold and Wolf. *Corella* **31:** 65–72.

Henzell, R. P., Cunningham, R. B. and Neave, H. M. (2002). Factors affecting the survival of Australian wild rabbits exposed to rabbit haemorrhagic disease. *Wildlife Research* **29:** 523–542.

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.

Olsen, J. and Osgood, M. (2006). Numbers of breeding Little Eagles *Hieraaetus morphnoides* in the Australian Capital Territory in 2006. *Canberra Bird Notes* **31:** 178–182.

Olsen, J., Debus, S. J. S., Judge, D. and Rose A. B. (2013). Diets of Wedge-tailed Eagles *Aquila audax* and Little Eagles *Hieraaetus morphnoides* breeding near Canberra, 2008–09. *Corella* **37:** 25–29.

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., Fuentes, E., Judge, D., Rose, A. B. and Debus, S. J. S. (2010a). 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. (2006). Food and hunting of eight breeding raptors near Canberra, 1990–1994. *Australian Field Ornithology* **23:** 77–95.

Olsen, J., Osgood, M., Maconachie, M. and Dabb, G. (2008). Numbers of breeding Little Eagles *Hieraaetus morphnoides* in the Australian Capital Territory in 2007. *Canberra Bird Notes* **33:** 77–80.

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. (2010b). Little Eagles, Whistling Kites and Swamp Harriers in the Australian Capital Territory in 2009. *Canberra Bird Notes* **35:** 81–84.

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.

Saunders, G., Choquenot, D., McIlroy, J. and Packwood, R. (1999). Initial effects of rabbit haemorrhagic disease on free-living rabbit (*Oryctolagus cuniculus*) populations in central-western New South Wales. *Wildlife Research* **26:** 69–74.

Sergio, F., Newton, I., Marchesi, L. and Pedrini, P. (2006). Ecologically justified charisma: preservation of top predators delivers biodiversity conservation. *Journal of Applied Ecology* **43**: 1049–1055.

Sergio, F., Newton, I. and Marchesi, L. (2008). Top predators and biodiversity: much debate, few data. *Journal of Applied Ecology* **45:** 992–999.

Steele, W. and Baker-Gabb, D. (2009). A national community-based survey of the diurnal birds of prey (BOPWatch). *Boobook* **27:** 23–24.

Strive, T., Wright, J., Kovaliski, J., Botti, G. and Capucci, L. (2010). The non-pathogenic Australian lagovirus RCV-A1 causes a prolonged infection and elicits partial cross-protection to rabbit haemorrhagic disease virus. *Virology* **398:** 125–134.

Corella, 2013, 37(2): 36–40

Analysis of breeding data of the Welcome Swallow *Hirundo neoxena* near Manjimup, Western Australia

Sian Simojoki and S.J.J.F. Davies[1]

Department of Environment and Agriculture, Curtin University of Technology, G.P.O. Box 1987U, Perth, 6845, Western Australia
[1]Corresponding author. E-mail: S.Davies@exchange.curtin.edu.au

Received: 31 July 2012

Breeding data on the Welcome Swallow *(Hirundo neoxena)* collected by Dick and Molly Brown at the Middlesex Field Study Centre, near Manjimup, Western Australia, were analysed and compared with data from Sydney, Tasmania and New Zealand. The mean clutch size in Middlesex (3.06) was considerably lower than in Sydney (3.86), Tasmania (4.03) and New Zealand (4.49). The long, dry Western Australian summer and migration factors may account for the difference between Middlesex and Sydney but migration factors cannot account for those differences with New Zealand. Lack of competition in New Zealand, where the Welcome Swallow is a recent immigrant, may be the explanation for the differences. There was no correlation between latitude and clutch size from the four study sites. The hatching and fledgling success rates were noticeably higher in Middlesex than in the other three studies. Nesting sites close to water were preferred, possibly because they provided the birds with mud for nest building and a rich foraging place. Man-made nesting sites were used much more commonly than natural sites across all studies, perhaps because they were convenient and provide protection. There was no correlation between rainfall and breeding success. There was no evidence that pulli return to breed at the location in which they were reared.

INTRODUCTION

The Welcome Swallow *Hirundo neoxena* was studied for over 20 years by Dick and Molly Brown at the Middlesex Field Study Centre, near Manjimup, Western Australia (Brown and Brown 1991; Brown *et al*. 2005). Between 1974 and 2000, they collected detailed nest records of Welcome Swallows breeding behaviour around Middlesex. The study area covered 22 breeding sites, all within a five kilometre radius of the Centre. The detailed records for the Welcome Swallow cover 894 nests and, in addition, there are data from mist netting and banding of 2260 birds (Brown *et al.* 2005).

Many of the breeding birds and their young were banded with bands supplied by the Australian Bird and Bat Banding Scheme (ABBBS). After the Browns died the data were transferred by their executor Lee Fontinini, to Alma and Perry de Rebiera who released it to the Department of Environment and Agriculture, Curtin University, for detailed analysis by SS. This paper examines the mean clutch size, number of eggs hatched and the number of fledglings in first and second nesting attempts from 1974 to 2000 from the Middlesex area. The hatching and fledging success between each of the nesting sites for clutch one and two and between the years 1974 to 2000 are compared to determine differences between the sites and between the years. In addition the hatching success data are compared between man-made and natural nesting sites and with the rainfall data for the region to examine the effect of an important environmental variable. These results are compared with the results of studies from Sydney, Tasmania and New Zealand and the relationship between clutch size and latitude is investigated.

METHODS

Study sites

The Middlesex Field Study Centre is located eight kilometres south of Manjimup, Western Australia (34° 30' S, 116° 18' E). It was established in 1972 by Molly and Dick Brown on their two hectare property where they recorded every bird that they saw on their land from 1974 to 2000 (Brown *et al.* 2005).

Land use of the district

The Centre is located near the main forest reserves of south-western Australia, where the Karri (*Eucalyptus diversicolor*) forests merge into Jarrah (*Eucalyptus marginata*) and Marri (*Corymbia callophylla*) forests. Much of the large timber has been logged and the area cleared for farming, initially for cattle and sheep grazing, with remnant bushland left for shelter. Later orchards were established. During the period 1972 to 1989, the area experienced much clearing of remnant bush as well as a decrease in orchards and a significant increase in vegetable crops, especially potatoes and cauliflowers. During the following decade, many vineyards were added to these vegetable crops. This change from grazing to horticulture was accompanied by the building of many dams on the streams to ensure water was available for irrigation (Brown *et al*. 2005).

Climate

Manjimup experiences a Mediterranean climate, with cool wet winters and warm, dry summers. From 1971 to 2000, Manjimup recorded a mean maximum temperature 20.4°C, a mean minimum temperature 10.1°C and a mean annual rainfall 963.9mm (Bureau of Meterorology 2011) (Table 1). Unlike

CORELLA

Journal of
The Australian Bird Study Association Inc.

Volume 36
2012

Parts 1 – 4

Honorary Editor:

J. R. Farrell

Supplement to *Corella,* June, 2013

GENERAL INDEX

GENERAL INDEX

INDEX OF AUTHORS

REFEREE PANEL FOR 2012

J. Brazill-Boast	S. Debus	J. Hardy	I. McAllan	G. Smith
M. Brooker	D. Drynan	R. Heinsohn	R. Noske	J. Szabo
N. Carlile	G. Friend	A. Leishman	J. Olsen	D. Watson
L. Corbett	P.-J. Guay	M. Mathieson	L. Shoo	C. Young

SPECIES INDEX

LICHENOSTOMUS
chrysops Yellow-faced Honeyeater: 9,14,28*.
flavescens Yellow-tinted Honeyeater: 94.
fuscus Fuscous Honeyeater: 8,14,85.
leucotis White-eared Honeyeater: 14.
melanops Yellow-tufted Honeyeater: 9,14.
penicillatus White-plumed Honeyeater: 14.

LICHMERA
indistincta Brown Honeyeater: 94.

LIMOSA
lapponica Bar-tailed Godwit: 8,27*,104*.

LONCHURA
punctulata Nutmeg Mannikin: 14.

MACRONECTES
giganteus Southern Giant-Petrel: 9,51*.
halli Northern Giant-Petrel: 8,51*.

MACROPYGIA
amboinensis Brown Cuckoo-Dove: 94.

MALURUS
amabilis Lovely Fairy-wren: 101.
cyaneus Superb Fairy-wren: 9,14,56,85,104*.
lamberti Variegated Fairy-wren: 9,14,56,85,101.
melanocephalus Red-backed Fairy-wren: 85,101.

MANORINA
melanocephala Noisy Miner: 8,85.
melanophrys Bell Miner: 8.

MELANODRYAS
cucullata Hooded Robin: 85.
vittata Dusky Robin: 8.

MELIPHAGA
lewinii Lewin's Honeyeater: 8,14,28*.

MELITHREPTUS
albogularis White-throated Honeyeater: 85.
brevirostris Brown-headed Honeyeater: 8,14.
lunatus White-naped Honeyeater: 9,14.

MEROPS
ornatus Rainbow Bee-eater: 9,85,94.

MICROCARBO
melanoleucos Little Pied Cormorant: 100.

MICROECA
fascinans Jacky Winter: 14,85.

MONARCHA
melanopsis Black-faced Monarch: 14.
trivirgatus Spectacled Monarch: 9.

MORUS
serrator Australasian Gannet: 8,27*.

MYCTERIA
americana Wood Stork: 22.

MYIAGRA
cyanoleuca Satin Flycatcher: 14.
inquieta Restless Flycatcher: 85.
rubecula Leaden Flycatcher: 14.

MYZOMELA
obscura Dusky Honeyeater: 94.
sanguinolenta Scarlet Honeyeater: 14,85.

NEOCHMIA
temporalis Red-browed Finch: 9,14,52*,56,85.

NINOX
novaeseelandiae Southern Boobook: 8,14,86.

NUMENIUS
madagascariensis Eastern Curlew: 100.

ONYCHOPRION
fuscata Sooty Tern: 9.

OREOSCOPUS
gutturalis Fernwren: 8.

ORIOLUS
sagittatus Olive-backed Oriole: 14,85,94.

PACHYCEPHALA
inornata Gilbert's Whistler: 8.
pectoralis Golden Whistler: 8,13,28*,56,85.
rufiventris Rufous Whistler: 9,13,56.

PARDALOTUS
punctatus Spotted Pardalote: 14.
striatus Striated Pardalote: 86.

PASSER
domesticus House Sparrow: 8,14.

PELAGODROMA
marina White-faced Storm-Petrel: 9,45,47,76,97.

PELECANUS
conspicillatus Australian Pelican: 21.

PETROCHELIDON
ariel Fairy Martin: 9.
nigricans Tree Martin: 28*,86.

PETROICA
rosea Rose Robin: 9,14.

PHALACROCORAX
carbo Great Cormorant: 49,77,100.
sulcirostris Little Black Cormorant: 100.
varius Pied Cormorant: 77.

PHAPS
chalcoptera Common Bronzewing: 85,94.

PHILEMON
citreogularis Little Friarbird: 85.
corniculatus Noisy Friarbird: 8,85,101.

Table 1

Total annual rainfall for Manjimup, W.A, from 1974 to 2000

Year	Annual Rainfall (mm)
1974	1040.8
1975	945.5
1976	1021.5
1977	896.6
1978	1052.1
1979	893.9
1980	923.8
1981	1153.2
1982	815.7
1983	967.6
1984	1029.2
1985	915.2
1986	792.4
1987	699.4
1988	1140.7*
1989	887.6*
1990	1053.7*
1991	985.2
1992	1024.7
1993	897.4
1994	724.3
1995	930.8
1996	1092.4
1997	890
1998	996.4
1999	1059.4
2000	1000.9*

*Some rainfall data for Manjimup missing. Missing months were replaced with data from Yanmah, 11km northwest of Manjimup. Data source: (Bureau of Meterorology 2011)

Sydney, Tasmania and New Zealand little summer rain fell during the period of the study.

Collection of data

The following data were recorded for the nest records: date, location of nest, clutch number, number of eggs, number hatched, number of fledglings, fate of the egg (if known), fate of the young (if known) and first egg date. All birds were banded using metal bands supplied by ABBBS and some were colour-banded. For each banded bird, the following data were recorded: band number, date, age, sex, weight, wingspan, colour of the band, shortest tail feather, longest tail feather, whether it was banded as a nestling and whether it was a re-trap.

Hatching Success

The hatching success for each year/nesting sites was calculated as: mean number hatched/mean number of eggs multiplied by 100. To account for the large variation in sample size, the hatchling success rate was added to the count and the highest numbers selected as the most successful. Third and fourth clutches were not included in the analysis due to their small sample sizes.

Statistical analysis

Independent samples t-test was used to determine if the first and second clutches were statistically different. Due to uneven sample sizes, Mann-Whitney U tests were used to determine whether there was a significant difference between man-made and natural nesting sites in each of the size of clutches, the mean number hatched and the mean number of fledglings. This test was also used to determine if there was a difference between the lowest and highest mean size of clutches, mean number hatched and mean number of fledglings. A Pearson Correlation test was carried out to determine whether there was a significant correlation between total annual rainfall for Manjimup and the hatching success of each clutch. This test was also used to determine whether there was a correlation between mean size of clutches and latitude. All tests were conducted with a 95 percent confidence interval.

RESULTS

Data from 894 nests, collected from 1974 to 2000, showed a 78.4 percent success rate to fledging at least one chick. 62 percent of the clutches occurred on the first nesting attempt, considerably more than the second nesting attempt (36.2%). The third and fourth nesting attempts were only recorded six times and once respectively and these were most likely replacement clutches for failed second nesting attempts (Brown and Brown 1991).

Eggs

The incubation period ranged from 14 to 24 days, with an average of (mean ± *sd*) 17.4 ± 0.2 days. (mode=18, *n*=125). Nesting occurred between August and December with the majority of first clutches occurring in September and the majority of second clutches in November.

Clutch size varied between one and six eggs (mode= 3; mean ± *sd* = 3.06 ± 0.023; *n*= 889). The lowest mean clutch size for the first clutch occurred in 1974 (2 ± 0.58, *n*=3) and the highest in 1976 (3.5 ± 0.5, *n*=2) however these were not significantly different (*P*=0.139). The second clutch had the lowest clutch size in 1978 (2.38 ± 0.38 n=8) and the highest in 1975 (4 ± 0, *n*=2), however these were not significantly different (*P*=0.06). There was no significant difference in mean clutch size between first and second nesting attempts for the different nesting sites (df= 30, t=0.21, *P*= 0.833).

Young

An overall mean ± *sd* of 2.44 ± 0.04 hatchlings was calculated from 894 nesting attempts. Brood size at hatchling varied between one and five (mode= 3; mean ± *sd*= 2.93 ± 0.027; *n*= 746). The lowest mean number of hatchlings for the first clutch occurred in 1985 (1.44 ± 0.66, *n*=7) and the highest occurred in 1979 (3.13 ± 0.23, *n*=8), with the 1979 clutches being significantly higher than those in 1985 (*P*=0.04). The second clutch had the lowest mean number of hatchlings in 1983 (1.75 ± 0.67, *n*=5) and the highest number in 1975 (4 ± 0.0, *n*=2), with the 1975 clutches being significantly higher than the 1983 clutches (*P*=0.018). There was no significant difference in the mean brood size at hatchling between first and second nesting attempts for each of the nesting sites (df= 30, t=-0.19, *P*= 0.849).

Table 2

Summary of mean clutch size, hatching success, fledgling success and incubation periods of the Welcome Swallow in four locations from Australia to New Zealand

	Mean clutch size	Hatching success (%)	Fledging success (%)	Mean incubation (days)
Middlesex	3.06	80.2	72.6	17.4
Sydney	3.86	74.65	56.22	16
Tasmania	4.03	nd.	59.4	15.6
New Zealand	4.49	nd.	46.3	16.7

Source of data: Middlesex Field Study Area: this study; Sydney: Marchant and Fullagar (1983); Tasmania: Park (1981b); New Zealand: Tarburton (1993); nd: no data available

An overall mean ± *sd* of 2.21± 0.05 fledglings was calculated from 894 nesting attempts. Fledging rate varied between one and five (mode= 3; mean ± *sd*= 2.83 ± 0.029; *n*= 699). The lowest mean number of fledglings for the first clutch occurred in 1974 (1 ± 0.71, *n*=2) and the highest in 1992 (3 ± 0.31, *n*=21), with 1992 clutches being significantly higher than 1974 (*P*=0.002). For the second clutch, 1983 had the lowest mean number of fledglings (1.38 ± 0.75, *n*=4) and 1975 had the highest (4 ± 0.0, *n*=2), with 1975 clutches being significantly higher than 1983 clutches (*P*=0.028). There was no significant difference in the number of fledglings between first and second broods for each of the nesting sites (df= 30, t=-0.99, *P*= 0.326).

Breeding success

Looking at breeding localities over all years for the first clutches, taking into account both the hatching success and the number of nests, Keegan's Brook (77.02%, n=108) and Bob's old house (84.05%, *n*=81) were the most successful localities.

In the second clutches, taking into account both the hatching success and the number of nests, Home Dam (91.6%, *n*=40) and Bob's old house (80.51% n=63) were the most successful.

Looking at individual years for the first clutch, years 1975 (*n*=2), 1977 (*n*=4), 1979 (*n*=8) and 1992 (*n*=27) had the highest hatching success rate (100%). Years 1988 (hatching success rate 86.72%) and 1989 (hatching success rate 74.14%) had the highest number of nests at 40 each. Taking into account both the hatching success and the number of nests, 1988 (86.72%, *n*=40) and 1992 (100%, *n*=27) were the most successful years.

In the second clutch, years 1974 (*n*=1), 1975 (*n*=2) and 1980 (*n*=4) had a 100 percent hatching success rate. 1988 (80.73%) had the highest number of nests with 34 recorded. Taking into account both the hatching success and the number of nests, 1999 (97.50%, *n*=12) and 1988 (80.73%, *n*=34) were the most successful years.

Environmental effects

There was no significant correlation between total annual rainfall for Manjimup and the hatchling success for clutch one (*P*=0.476, r=-0.143) or clutch two (*P*=0.99, r=0.003). However, the years with the highest hatchling success for clutch one and two (1988, 1992 and 1999) all received above average rainfall (1140.7mm, 1024.7mm and 1059.4mm respectively).

The majority (96%) of the nests were found on man-made sites. There was no significant difference in the clutch size (*P*=0.172), number hatched (*P*=0.324) or the number of fledglings (*P*=0.473) between natural and man-made sites.

DISCUSSION

In discussing these results it is useful to make comparisons with previously published studies from Sydney, Tasmania and New Zealand (Table 2) (Marchant and Fullagar 1983; Park 1981b; Tarburton 1993).

The average incubation period for Middlesex was higher than Sydney, Tasmania and New Zealand (Table 2). The average incubation period for Welcome Swallows is 16 days (Frith H. J. (ed.) 1997; Marchant and Fullagar 1983; Sindik and Lill 2009) with the Sydney, Tasmania and New Zealand studies recording similar incubation times (Marchant and Fullagar 1983; Park 1981b; Tarburton 1993). The difference may be due to different recording and calculating methods (i.e. recording from first egg or last egg laid).

The mean clutch size at Middlesex was considerably below the average of four (Beruldsen 2003). The mean clutch size of this study was lower than that of Sydney and considerably lower than that of Tasmania and New Zealand (Marchant and Fullagar 1983; Park 1981b; Tarburton 1993) (Table 2).

The smaller clutch size found in the Middlesex population compared to Sydney populations may be due to their sedentariness (Brown and Brown 1991). Since the population does not migrate, they are not exposed to some of the dangers associated with migration such as disorientation and predation while *en route* (Alerstam 1990). The migratory populations, such as those in Sydney, may have evolved larger clutch sizes to make up for those individuals lost on migration (Brown and Brown 1991; Hindwood 1934; Tarburton 1993). It is also possible that the long dry Western Australian summers have an effect on clutch size, by limiting the period when food is readily available.

Both the Middlesex and New Zealand population is sedentary so migration cannot account for the considerable difference in clutch sizes. Welcome Swallows have only recently colonised New Zealand and the population has not yet reached the threshold where density limits the breeding success (Evan *et al.*

2003; Higgins *et al.* 2006). There may be a lack of competitors for resources such as nesting sites and food and an increase in food supply can lead to larger clutches (Lack 1947; Tarburton 1993). Disney's (1988) study into Welcome Swallows breeding in captivity (with food provided) found it not uncommon for birds to have four clutches. A good food supply may increase the clutch size of Welcome Swallows breeding in Australia and New Zealand.

There is a recognised trend in the Northern Hemisphere that clutch size, within the same species, increases with latitude (Lack 1947), however there is little evidence that this trend is present within Australia (Marchant and Fullagar 1983). There was no significant correlation between latitude and the mean clutch sizes of the four locations looked at in this paper. This may be due to the lower climatic and photoperiod variation across the four locations compared to studies in Europe and in the tropics.

There was no significant difference in mean clutch size between the years (when comparing the highest and lowest years) which is consistent with Lack (1947), who states that in most species the mean clutch size does not vary between years.

This study found no significant difference between the clutch size of first and second nesting attempts, however there were considerably more first nesting attempts (62% compared to 36.2%). The Sydney study found a small difference between clutch size in first and second nesting attempts (96 for first clutch and 105 for the second clutch) (Marchant and Fullagar 1983).

The majority of the nesting attempts occurred as first or second clutches, with only 0.8 percent occurring in third or fourth nesting attempts, indicating that, at Middlesex, Welcome Swallows have very few clutches after their second.

The hatching success of this study is considerably higher than the study in Sydney (Marchant and Fullagar 1983) (Table 2). There was no significant difference in the number hatched in clutches one and two, similar to the Sydney study where first and second clutches were not considerably different (71 and 77 respectively) (Marchant and Fullagar 1983). As expected, the years with the lowest clutch size were significantly different from the highest years (for clutch one and two).

The fledgling success of this study is considerably higher than that of Sydney, Tasmania, and New Zealand (Marchant and Fullagar 1983; Park 1981b; Tarburton 1993) (Table 2). This study found no significant difference between the number of fledglings in the first and second clutches. In Sydney, there was a considerable difference, with clutch one having 38 fledge and clutch two having 71 (Marchant and Fullagar 1983).

The Browns listed the nesting sites by local names that will be meaningless to most readers. However, if any follow-up work is undertaken it may be useful to have them published because they will be recognised by local people, so they have been used in the following comments. Two of the most successful nesting sites (Keegan's Brook and Home Dam) were located at a major water source. Water sources, such as dams, provide the swallows with mud for nest building (Boehm 1957; Brown and Brown 1991) as well as excellent feeding grounds, attracting many insects, particularly mosquitoes (Boehm 1957). Swallows also use a large amount of energy during foraging which subsequently leads to a large amount of water loss (Bartholomew and Cade 1963). It would therefore be advantageous to the birds to breed near a large dam.

Bob's old house was also a very successful breeding location, most likely used by the swallows because of convenience and the level of protection it provided (Sharland 1943). However it is difficult to conclude as to why certain sites were preferred due to the little data available on each location.

Lack (1947) states that year generally has little effect on the breeding parameters of most species of birds. In the Middlesex study, several years had 100 percent hatchling success rates but these years generally had very small sample sizes. The most successful years were 1988, 1992 and 1999, which had a high hatchling success as well as relatively large sample sizes. From 1986, much more time was devoted to monitoring the swallows, therefore the years following generally had a larger sample size (Brown and Brown 1991).

There was no significant correlation between annual rainfall and hatchling success at Middlesex. Tarburton (1993) also found no correlation between rainfall and breeding success. Serventy and Marshall (1957) found out-of-season rainfall events have no effect on bird breeding patterns in the southwest. The present analysis confirms their view for the Welcome Swallow.

There were substantially more nests built on man-made structures compared with natural sites, as reported in other studies (Brown and Brown 1991; Evan *et al.* 2003; Higgins *et al.* 2006; Marchant and Fullagar 1983). Tarburton(1993) found no natural nesting sites in the study in New Zealand. The clearing of land for agriculture may account for the lack of natural nest sites in Middlesex. Swallows are known to nest in man-made structures for convenience and protection (Sharland 1943) and depend on man for their wide-spread distribution (Boehm 1957; Marchant and Fullagar 1983).

Re-trap data were investigated to determine if individuals banded as pulli returned to breed in the same location. There did not appear to be any trend in the data to support this. Likewise Park (1981a) banded 213 pulli and only one returned to breed in the area.

ACKNOWLEDGEMENTS

We acknowledge with gratitude the tireless work of Dick and Molly Brown at the Middlesex Field Study Centre who collected all the data, and Lee Fontinini, the Executor of their estate who gave us access to the data for analysis. Jared Pedro gave much help and support, especially during the lengthy analysis process. We thank Peter Fullagar and Michael Tarburton for helpful comments on a draft of this article.

REFERENCES

Alerstam, T. (1990). 'Bird Migration'. (University of Cambridge: Cambridge).

Bartholomew, G. A. and Cade, T. J. (1963). The Water Economy of Land Birds. *The Auk* **80**: 504–539.

Beruldsen, G. (2003). 'Australian Birds their Nests and Eggs', (Kenmore Hills: Queensland).

Boehm, E. F. (1957). Perching birds (Passeriformes) of the Mount Mary Plains, South Australia. *Emu* **57**: 311–324.

Brown, R. J. and Brown, M. N. (1991). 'Thirteenth Annual Report of the Middlesex Field Study Centre.' (ed. RAOU). Pp. 10–24, Manjimup.

Brown, R. J., Brown, M. N., Davis, M. J. and Davies, S. J. J. F. (2005). Observations on the changes in status and movements of birds at the Middlesex field study centre, Manjimup, Western Australia, based on twenty-five years of daily records. In: *Bulletin (Curtin University of Technology. School of Environmental Biology)*. No. 26.

Bureau of Meterorology. (2011). Summary statistics for Manjimup. In: 'Climate statistics for Australian locations.' Australian Government.

Disney, H. J. d S. (1988). Notes on breeding of Welcome Swallows in captivity. *Australian Zoologist* **24**: 211–215.

Evan, K. L., Tyler, C., Blackburn, T. M. and Duncan, R. P. (2003). Changes in the breeding biology of the Welcome Swallow (*Hirundo tahitica*) in New Zealand since colonisation. *Emu* **103**: 215–220.

Frith, H. J. (ed.). (1997). 'The Reader's Digest Complete Book of Australian Birds.' (Reader's Digest Services Pty Ltd: Sydney).

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

Hindwood, K. A. (1934). Birds inhabiting mangroves in the neighbourhood of Sydney. *Emu* **34**: 181–189.

Lack, D. (1947). The Significance of Clutch-size. *Ibis* **89**: 302–352.

Marchant, S. and Fullagar, P. (1983). Nest records of the Welcome Swallow. *Emu* **83**: 66–74.

Park, P. (1981a). A colour-banding study of Welcome Swallows in Southern Tasmania. *Corella* **5**: 37–41.

Park, P. (1981b). Results from nesting study of Welcome Swallows in Southern Tasmania. *Corella* **5**: 85–88.

Serventy, D. L. and Marshall, A. J. (1957). Breeding periodicity in Western Australian birds: with an account of unseasonal nestings in 1953 and 1955. *Emu* **57**: 99–126.

Sharland, M. S. R. (1943). Nesting habits of the Tree-Martin. *Emu* **43**: 126–130.

Sindik, A. and Lill, A. (2009). Peripheral Blood Leukocyte Counts in Welcome Swallow Nestlings. *Journal of Wildlife Diseases* **45**: 1203–1207.

Tarburton, M. (1993). A Comparison of the Breeding Biology of the Welcome Swallow in Australia and Recently Colonized New Zealand. *Emu* **93**: 34–43.

Corella, 2013, 37(2): 41–43

SEABIRD ISLANDS No. 19/1

Little Broughton Island, New South Wales

Location: 32°37'S, 152°20'E. Located approximately 15 kilometres north-east of the entrance to Port Stephens, New South Wales (NSW). It is part of the Broughton Group, situated approximately 260 metres east of Broughton Island.

Status: Nature Reserve, part of the Myall Coast Reserves administered by the NSW National Parks and Wildlife Service, Office of Environment and Heritage. The island was gazetted as a Nature Reserve in 1961, principally to protect the breeding habitat of three species of shearwaters.

Description: Little Broughton Island is 27.4 hectares. It is bounded by cliffs with a vegetated area of 19.0 hectares that slopes from 15 metres above sea level in the north-west to 98 metres above sea level in the south-east. The island is composed primarily of Carboniferous volcanic rhyolite rock with basalt intrusions. North-west of the summit, conglomerate rock and indurated mudstones are exposed within a washout area that drains to an ephemeral creek running east. North of the summit is an elevated aeolian sand dune.

Vegetation on Little Broughton Island is dominated by expansive areas of tussock comprising Spiny-headed Mat-rush *Lomandra longifolia,* Blue Flax Lily *Dianella caerulea* or Coast Tussock Grass *Poa poiformis.* Other species not mentioned by Lane[1] and including exotic (*) species are:

*Livistona australis, Asplenium australasicum, Doodia aspera, Histiopteris incisa, Elaeodendron australe, Leucopogon parviflorus, Acmena smithii, Monotoca elliptica, Acacia longifolia ssp. sophorae, Zieria smithii, Duboisia myoporoides, Wikstroemia indica, Tetragonia tetragonoides, Einadia hastata, Sarcocornia quinqueflora, Crassula sieberiana, Hydrocotyle peduncularis, Parsonsia straminea, Geitonoplesium cymosum, Pandorea pandorana, Cayratia clematidea, Marsdenia rostrata, Peperomia leptostachya, Phragmites australis, Imperata cylindrica var major, *Andropogon virginicus, *Chrysanthemoides monilifera, *Conyza sp., *Phytolacca octandra, *Opuntia stricta var stricta, *Solanum nigrum, *Ipomoea cairica and *Ipomoea indica.*

Landing: Onto sloping rocks near a tunnel at the north-west corner; best attempted with minimal southerly swells. An alternative landing is possible onto rocks at the northern end in the absence of an easterly swell.

Ornithological History: Visits up until December 1973 were documented by Lane[1]. Priddel and others visited for two hours on 3 April 1998 in a targeted, but unsuccessful, search for Gould's Petrel *Pterodroma leucoptera*. A preliminary inventory of the vegetation was recorded along with confirmation of the presence of rats. Black Rats *Rattus rattus* were eradicated from the Broughton Group in August 2009[2]. Carlile, Callaghan and others visited overnight on 1–2 October and 20–21 December 2010 to survey vegetation, seabirds and other terrestrial vertebrates.

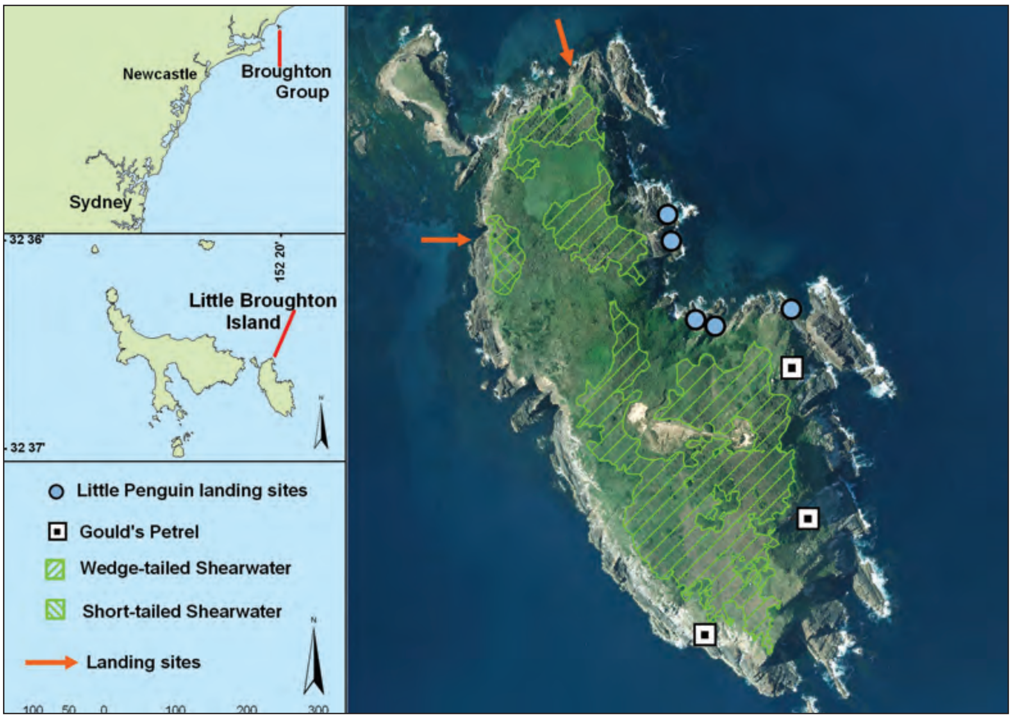


Figure 1. *Little Broughton Island, New South Wales*

Breeding Seabirds and Status

Ardenna pacifica Wedge-tailed Shearwater – Nests over much of the island on deeper soils, with colonies occurring in four distinct habitats based on the dominant vegetation: *Poa, Dianella, Lomandra* and Mixed Species. In one colony, burrows were interspersed with those of Short-tailed Shearwaters *Ardenna tenuirostris*. Burrow density was estimated by counting burrows within a series of random (n = 22) transects (30 x 4 m) that sampled all habitats (3–6 transects per habitat). The extent of each colony, and each habitat within each colony, was recorded by circumnavigating each area with a handheld GPS. Data were then mapped using a geographic information system (GIS), and the area of each colony or habitat calculated. Approximately three percent of the total area of shearwater colonies was surveyed in the transects.

For each colony, the number of burrows within each habitat was calculated as the multiple of mean burrow density for that particular habitat and area of that habitat. Numbers from each habitat were summed to estimate the number of burrows within each colony, and the numbers from each colony summed to estimate the total number of burrows on the island. Total burrow numbers for the island are estimated (± s.e) at 70 526 (± 6265). The number of breeding pairs of Wedge-tailed Shearwater was calculated as the multiple of burrow number and occupancy rate, minus the number of Short-tailed Shearwaters in the mixed colony (see below). Due to time constraints, occupancy rate was not estimated directly, but was assumed similar to that in other shearwater colonies (typically 43–56%)[3,4,5]. Assuming an occupancy rate of 50 percent, the population of Wedge-tailed Shearwaters on Little Broughton Island was estimated to be 34 841 pairs (± 3133). A previous estimate of 3000 to 6000 pairs[1] was made using undisclosed methods.

Ardenna grisea Sooty Shearwater—Despite extensive burrow searches during the incubation period, as well as 1.5 hours of nocturnal spotlighting, audio surveys and camping overnight on the island, the species was not detected. Hindwood and D'Ombrain[6] found two birds ashore in December 1959, and Lane[1] found two pairs incubating eggs in 1972. Lane[1] estimated there to be a few breeding pairs on the island.

Ardenna tenuirostris Short-tailed Shearwater—Nests in a mixed colony with Wedge-tailed Shearwaters on the north-west of the island among Mat-rush, Flax Lily and Sand Couch *Sporobolus virginicus*. In this colony, all burrows within each transect (n = 3) were counted and searched; if occupied, the occupant was extracted and identified. At the time of the survey, adult birds were incubating eggs. Fifty-four percent of the shearwaters sampled were Short-tailed Shearwaters. We estimate the population on the island (± s.e.), confined to this one small colony, to be 422 pairs (± 66). A previous estimate of 1000 pairs was suggested by Lane[1].

Pterodroma leucoptera Gould's Petrel—This species is a cavity nester and suitable nesting habitat (rock scree[7]) is restricted to a few potential sites only. In December 2010, investigation of three such sites returned solicited calls of four adults, presumably on nests. The limited extent of habitat at the southern and eastern sites suggested no more than a few pairs could occupy each site. The south-eastern site of steep rock-scree covered in vines and windswept shrubs, however, is more extensive (~ 600 m^2). One adult was observed here at a formed nest, but without an egg. A second adult was heard, but was unreachable. The total population, subject to confirmation of breeding, is estimated to be approximately 10 pairs. Gould's Petrel has not been recorded previously on this island despite attempts, almost a century ago, to locate them[8].

Eudyptula minor Little Penguin—Limited to the island's eastern edge, where it nests in soil burrows or rock piles. In October 2010, five landing sites, some quite precipitous, were identified from trails of excrement. Penguins landing at each of these sites were counted from dusk (1830 hr) until no penguins arrived within a 30-minute period (2000 hr); a total of 13 birds were observed. During the two-day visit only three nests were found, with adults either incubating eggs (n = 2) or brooding hatchlings (n = 1). We calculated that each arriving bird represented 1.0 nest, and estimated the nesting population to be approximately 13 pairs. This is the first record of this species on the island.

Factors Affecting Status

The population of Wedge-tailed Shearwaters on Little Broughton Island appears to have increased substantially since 1973, in line with similar increases on nearby Broughton Island[9]. Burrow densities ranged from 0.38 to 1.62 burrows per square metre; the highest density, within areas of *Poa* tussock, is more than double that of shearwater colonies (all species) on other NSW islands[4,5,8,9,10,11,12].

The apparent loss of Sooty Shearwaters from Little Broughton is also analogous to the situation on Broughton Island[9]. The reason for the range contraction of this species is unknown, but both increased competition from Wedge-tailed Shearwaters and warmer water as a result of anthropogenic climate change may play a role[14]. The apparent reduction in size and extent of the Short-tailed Shearwater colony on Little Broughton since the previous survey in 1973[1] cannot be fully substantiated because the method used to calculate the original estimate is not documented.

The discovery of small populations of Little Penguins and Gould's Petrel on Little Broughton Island was not unexpected, as both species have been recorded on other islands in the Broughton Group[9,11,12], and previous visits to Little Broughton were of short duration only[1]. The presence of Gould's Petrel is significant as the extensive area of rock scree could support a sizeable population, particularly now that rodents have been removed.

Two invasive weed species—Bitou Bush *Chrysanthemoides monilifera* and Prickly Pear *Opuntia stricta*—are present, but not as prolific here as they are on nearby Broughton Island. The explanation may lay in the absence of European Rabbits *Oryctolagus cuniculus,* their grazing and soil disturbance activities likely to have increased the spread of weeds on Broughton Island.

The taking of an adult shearwater by a White-bellied Sea-eagle *Haliaeetus leucogaster* was observed during the October 2010 survey. Additionally, Peregrine Falcon *Falco perigrinus* and Swamp Harrier *Circus approximans* were seen hunting over the island and would take seabirds if the opportunity arose.

A few feathers of White-faced Storm-petrel *Pelagodroma marina* were found 60 metres south of the main Gould's Petrel nesting area. Spotlighting searches in December 2010 found no evidence of this species using the island. Now that rats have been removed[2] this species may colonise from other islands in the Broughton Group. Hull[8], however, found no evidence of the birds here in 1911, before rats invaded from Broughton Island, but his visit did occur after the storm-petrels would have departed at the end of the breeding season.

Other Seabirds Recorded

White-faced Storm-petrel (body feathers only), Little Black Cormorant *Phalacrocorax sulcirostris,* Eastern Reef Egret *Egretta sacra*, Sooty Oystercatcher *Haematopus fuliginosus* and Crested Tern *Thalasseus bergii*.

Other Vertebrates Recorded

The Yellow-bellied Water-skink *Eulamprus heatwolei* was common, and the Common Blue-tongue *Tiliqua scincoides* was rare.

Banding

First banding	–	20 December 1959
Ardenna pacifica	–	198 adults, with seven recoveries at banding place; six at one year, and one at 13 years after banding.
Ardenna grisea	–	three adults; no recoveries.
Ardenna tenuirostris	–	59 adults, with two recoveries at banding place, both one year after banding.

Bibliography

1. Lane, S.G. (1976). Seabird islands No. 19: Little Broughton Island, New South Wales. *The Australian Bird Bander* **14**: 14–15.
2. Priddel, D., Carlile, N., Wilkinson, I. and Wheeler, R. (2011). Eradication of exotic mammals from offshore islands in New South Wales, Australia. In 'Island Invasives: Eradication and Managemen't. (Eds C.R. Veitch, M.N. Clout, and D.R. Towns). Pp. 337–344. (International Union for Conservation of Nature: Gland, Switzerland.)
3. Dyer, P.K. and Hill, G.J.E. 1992. Active breeding burrows of the Wedge-tailed Shearwater in the Capricorn Group, Great Barrier Reef. *Emu* **92**: 147–151.
4. Carlile N., Priddel, D., Blackmore, C.J., Craven, P. and Jarman, M. (2012). Seabird Islands No. 8/1: Brush Island, New South Wales. *Corella* **36**: 45–47.
5. Priddel, D., Carlile N., Blackmore, C.J., Jarman, M. and Craven, P. (2012). Seabird Islands No. 26/1: Wasp Island, New South Wales. *Corella* **36**: 47–49.
6. Hindwood, K.A. and D'Ombrain, A.F. (1960). Breeding of the Short-tailed Shearwater (*Puffinus tenuirostris*) and other seabirds on Broughton Island, N.S.W. *Emu* **60**: 147–154.
7. Priddel, D. and Carlile, N. (1997). Conservation of the endangered Gould's Petrel *Pterodroma leucoptera leucoptera. Pacific Conservation Biology* **3**: 322–329.
8. Hull, A.F.B. (1911). Avifauna of New South Wales islands. *Emu* **11**: 99–104.
9. Carlile N., Priddel, D. and Callaghan, S. (2012). Seabird Islands No. 18/1: Broughton Island, New South Wales. *Corella* **36**: 97–100.
10. Carlile, N., Priddel, D. and Callaghan, S. (2013). Seabird Islands No. 20/1: North Rock, Broughton Group, New South Wales. *Corella* **37**: 44–46.
11. Carlile, N., Priddel, D. and Callaghan, S. (2013). Seabird Islands No. 21/1: Inner Rock, Broughton Group, New South Wales. *Corella* **37**: 21–22.
12. Carlile, N., Priddel, D. and Callaghan, S. (in press). Seabird Islands No. : Gandja-baa, Broughton Group, New South Wales. *Corella.*
13. Priddel, D., Carlile N., Blackmore, C.J. and Jarman, M. (2012). Seabird Islands No. 25/1: Grasshopper Island, New South Wales. *Corella* **36**: 76–77.
14. Veit, R. R., McGowan, J. A., Ainley, D. G. and Wahl, T. R. (1997). Apex marine predator declines ninety percent in association with changing oceanic climate. *Global Change Biology* **3**: 23–28.

Acknowledgements

Recent surveys of Little Broughton Island would not have been possible without the assistance and support of BirdLife Australia and the Hunter Region of the National Parks and Wildlife Service. Robert Wheeler and Michael Jarman (Office of Environment and Heritage) assisted in the 1998 Gould's Petrel survey. Hannah Morton (Royal Society for the Protection of Birds, Scotland), and Yuna Kim, Anna Lashko, Margarita Steinhardt, Steve Tremont and Brook Whylie (Australasian Seabird Group) assisted in the recent surveys. The Australian Bird and Bat Banding Scheme provided data pertaining to banding and recovery records.

Date complied: 18 November 2011

Nicholas Carlile and David Priddel, Office of Environment and Heritage, PO Box 1967, Hurstville BC, New South Wales 1481, Australia.

Susanne Callaghan, Office of Environment and Heritage, Locked bag 99, Nelson Bay, New South Wales 2315, Australia.

Email: Nicholas.Carlile@environment.nsw.gov.au

Corella, 2013, 37(2): 44–46

SEABIRD ISLANDS No. 20/1

North Rock, Broughton Group, New South Wales

Location: 32°36'S, 152°19'E. Located approximately 17 kilometres north-east of the entrance to Port Stephens, New South Wales (NSW). It is part of the Broughton Island Group, situated approximately1300 metres north of Broughton Island.

Status: Together with nearby Inner Rock, forms Stormpetrel Nature Reserve, gazetted in 1976 for the conservation of seabird nesting habitat. It is part of the Myall Coast Reserves administered by NSW National Parks and Wildlife Service, Office of Environment and Heritage.

Description: North Rock is an irregular-shaped island measuring 260 metres by 130 metres, aligned east–west along its longest axis. It is 2.4 hectares in area, of which 1.0 hectare is vegetated. The island is composed of Carboniferous volcanic rhyolite with basalt intrusions, and has a rocky shoreline. A plateau, reaching 23 metres in height, slopes gently to the west; elsewhere it is surrounded by cliffs. A sand-spit at the western end of the island terminates to the south-west in a small sandy beach amongst rock outcrops. Vegetation is dominated by Spiny-headed Mat-rush *Lomandra longifolia,* with a stand of Tuckeroo *Cupaniopsis anacardioides* at the summit. Other species not mentioned by Lane[1] and including exotic (*) species are:

Asplenium bulbiferum, Histiopteris incisa, Hydrocotyle peduncularis, Diplazium australe, Lepidium sp., *Atriplex cinerea, Monotoca elliptica, Acacia longifolia* ssp. *sophorae, Duboisia myoporoides, Oxalis perennans, Wikstroemia indica, Bromus* sp., *Sporobolus virginicus,* **Chrysanthemoides monilifera* **Rumex* sp., **Conyza* sp., **Solanum nigrum* and **Phytolacca octandra.*

Landing: Onto beaches or rocks at the western end and, depending on prevailing conditions, rocks at the eastern end of the island.

Ornithological History: In December 1973, Lane and others found Wedge-tailed Shearwaters *Ardenna pacifica* and White-faced Storm-petrels *Pelagodroma marina* breeding, and evidence of Little Penguins *Eudyptula minor* recently occupying burrows[1]. Dodkin (NPWS) recorded a Little Penguin ashore in a burrow in February 1974[1]. Priddel and others landed for an hour on 3 April 1998 and searched unsuccessfully for evidence of Gould's Petrels *Pterodroma leucoptera,* but found the remains of a Fluttering Shearwater *Puffinus gavia* amongst a stand of Tuckeroo near the summit. Carlile, Priddel and others visited overnight on 23–24 September and 21–22 October 1999 to survey seabirds and search for further evidence of Fluttering Shearwaters. Callaghan and others visited overnight on 2–3 October and 21–22 December 2010 to search for penguins and to survey shearwaters and storm-petrels.

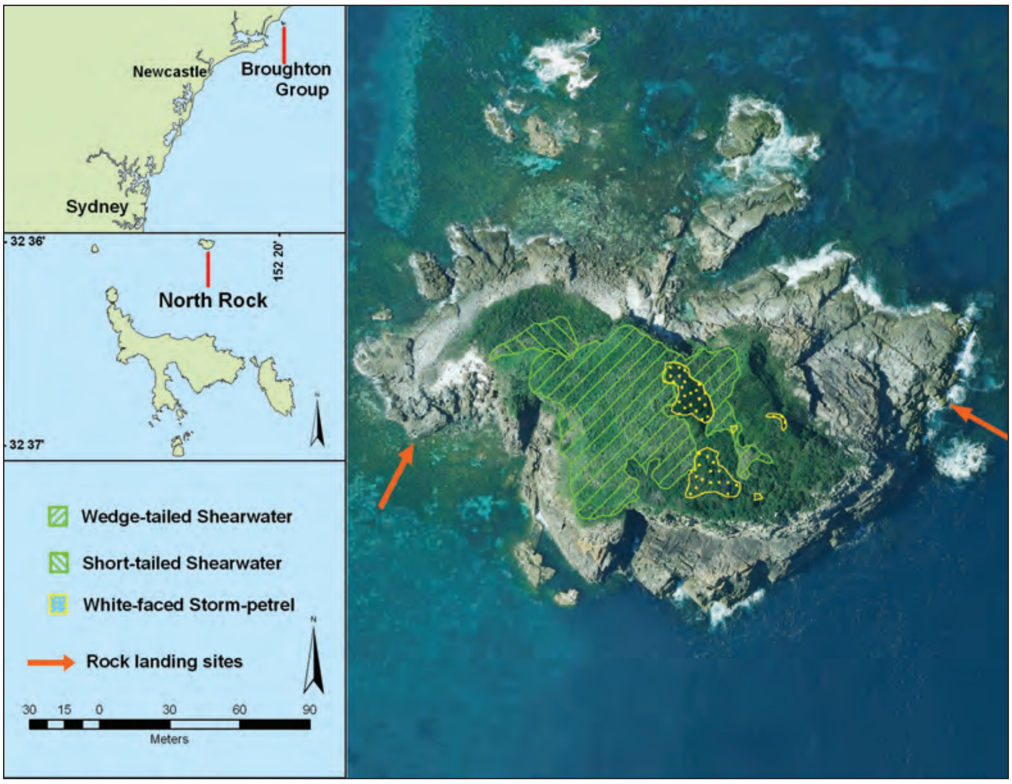


Figure 1. *Little Broughton Island, New South Wales*

Breeding Seabirds and Status

Pelagodroma marina White-faced Storm-petrels—Previously recorded nesting in shallow soils under shrubs and among Wedge-tailed Shearwater burrows[1], but now absent from the shearwater colony. In October 1999, colonies were located within two areas of the plateau covered by shrubs. A quadrat (10 x 10 m) in each area together recorded 55 burrows at a density (± s.e) of 0.28 (± 0.19) burrows per square metre. In December 2010, these two same colonies covered a combined area of 601 square metres and contained 219 burrows at a mean density of 0.36 ± 0.19 burrows per square metre, similar to that recorded a decade earlier. An additional three small colonies were identified, containing 29 burrows in total. Young chicks were found in some of the burrows examined. Although many adults were seen over-flying the island during the evening of 2 October 2010, no adult storm-petrels were seen during one hour of spotlighting (2030–2130 hrs) in December 2010. Based on an occupancy rate of 61 percent[2], a population of 151 breeding pairs was estimated for the island. This is significantly less than the previous estimate of 1000+ pairs made by Lane[1], suggesting the population may have declined.

Ardenna pacifica Wedge-tailed Shearwater – Nests in all vegetated areas of the island that lack shrub canopy. In October 1999, burrows were counted within two quadrats (10 x 10 m) on the western slope leading to the summit. A total of 35 burrows were counted, giving an estimate (± s.e) of 0.18 (± 0.15) burrows per square metre. In December 2010, the boundaries of the colony were mapped using a GPS and geographic information system (GIS). Systematically spaced transects (n = 5; 4 m wide and 20–30 m long) were used to sample the colony. The total area surveyed was approximately 12 percent of the colony. A total of 159 burrows were counted, at a mean density (± s.e) of 0.32 ± 0.10 burrows per square metre (range 0.16–0.71). The number of breeding pairs was calculated as the multiple of mean burrow density, area of the colony and occupancy rate. Due to time constraints an occupancy rate was not estimated directly but was assumed to be similar to that in other shearwater colonies (typically 43–56%)[3,4,5]. Assuming an occupancy rate of 50 percent, the population of Wedge-tailed Shearwaters on North Rock was estimated to be 675 pairs (± 215). This is marginally less than the previous estimate of 1000+ pairs[1] made using undisclosed methods.

Ardenna tenuirostris Short-tailed Shearwater – Nocturnal observations in October 1999 and October 2010 found no evidence of this species. However, *en route* to the summit on the evening of 21 December 2010, occasional calls were heard from an area (345 m^2) of Mat-rush covered in Dusky Coral-pea *Kennedia rubicunda* at the western end of the plateau. Two transects (each 20 x 4 m) contained 11 empty burrows as well as two adult Short-tailed Shearwaters incubating eggs. The population on the island probably does not exceed 10 pairs. This species had not been recorded breeding on this island previously.

Eudyptula minor Little Penguin – No evidence of this species ashore was found during the recent surveys (1999 and 2010). In September 1999, we conducted hourly searches of the island and shoreline between sunset and 0200 hours, and again from 0430 hours until dawn. During this and all subsequent visits, we searched potential nesting areas among rocks and vegetation, without success. In October 2010, we observed no birds visiting the island (one hour nocturnal searching) and found no evidence (excrement trails) of penguin landing or loafing sites. In December 2010 there was no detection of activity. Although, Lane[1] suggested that a few penguins might breed on the island this has never been confirmed.

Chroicocephalus novaehollindiae Silver Gull—Although present on the island during recent surveys, there was no evidence that it nested there. Lane[1] suggested 20 pairs were breeding on the island in December 1973 but no details were given.

Factors Affecting Status

As with all other islands in the Broughton Group, seabirds on North Rock are subject to predation by White-bellied Sea-eagle *Haliaeetus leucogaster* and Swamp Harrier *Circus approximans*.

The possible decline of White-faced Storm-petrel since 1973 may be due to a loss of burrowing habitat as they no longer nest within the colonies of Wedge-tailed Shearwater, despite no evidence that shearwater numbers have increased. However, shearwater colonies on nearby Broughton and Little Broughton islands have increased substantially over the past four decades[6,7] and, if the original population estimate on North Rock was an overestimate, a similar expansion here may have been detrimental to the storm-petrel population. Removal of Black Rats *Rattus rattus* from other islands within the Broughton Island Group[8] will facilitate the expansion of White-faced Storm-petrels from North Rock onto other islands within the Group.

As Lane[1] made no mention of it, Bitou Bush *Chrysanthemoides monilifera* appears to have established on North Rock since 1973. This invasive species, along with Prickly Pear *Opuntia stricta*, will require ongoing management if it is to be contained. The Bitou Bush, if allowed to dominate the vegetation, will be to the detriment of the larger shearwaters and the Prickly Pear could potentially impale the smaller storm-petrels on its spines.

Other Seabirds Recorded

The remains of a Fluttering Shearwater *Puffinus gavia* were found in 1998, but extensive searches since have failed to find any further evidence of this species. Sooty Oystercatcher *Haematopus fuliginosus* was recorded on the island during the recent surveys.

Other Vertebrates Recorded

Yellow-bellied Water-skink *Eulamprus heatwolei* was recorded during the 1999 and 2010 surveys.

Banding

First banding – 10 December 1973

Pelagodroma marina – 1 adult and 4 nestlings, with no recoveries.

Ardenna pacifica – 34 adults, with no recoveries.

Bibliography

1. Lane, S.G. (1976). Seabird islands No. 20: North Rock, Broughton Island, New South Wales. *The Australian Bird Bander* **14**: 16–17.
2. Brothers, N.P. (1981). Observations of breeding success in White-faced Storm-petrel at a newly established colony. *Corella* **5**: 29–33.
3. Dyer, P.K. and Hill, G.J.E. (1992). Active breeding burrows of the Wedge-tailed Shearwater in the Capricorn Group, Great Barrier Reef. *Emu* **92**: 147–151.
4. Carlile N., Priddel, D., Blackmore, C.J., Craven, P. and Jarman, M. (2012). Seabird Islands No. 8/1: Brush Island, New South Wales. *Corella* **36**: 45–47.
5. Priddel, D., Carlile N., Blackmore, C.J., Jarman, M. and Craven, P. (2012). Seabird Islands No. 26/1: Wasp Island, New South Wales. *Corella* **36**: 47–49.
6. Carlile N., Priddel, D. and Callaghan, S. (2012). Seabird Islands No. 18/1: Broughton Island, New South Wales. *Corella* **36**: 97–100.
7. Carlile, N., Priddel, D. and Callaghan, S. (2013). Seabird Islands No. 19/1: Little Broughton Island, New South Wales. *Corella* **37**: 41–43.
8. Priddel, D., Carlile, N., Wilkinson, I. and Wheeler, R. (2011). Eradication of exotic mammals from offshore islands in New South Wales, Australia. In 'Island Invasives: Eradication and Management'. (Eds C.R. Veitch, M.N. Clout, and D.R. Towns). Pp. 337–344. (International Union for Conservation of Nature: Gland, Switzerland.)

Acknowledgements

The recent surveys of North Rock would not have been possible without the assistance and support of BirdLife Australia and the Hunter Region of the National Parks and Wildlife Service. Robert Wheeler and Michael Jarman (OEH) and Lisa O'Neill assisted in the 1998 surveys. Yuna Kim, Anna Lashko, Margarita Steinhardt and Steve Tremont (Australasian Seabird Group) assisted in the recent surveys. The Australian Bird and Bat Banding Scheme provided data pertaining to banding and recovery records.

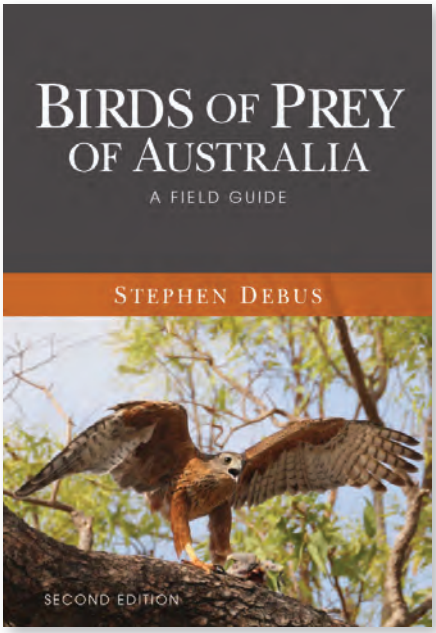
Date complied: 18 November 2011

Nicholas Carlile and David Priddel, Office of Environment and Heritage, PO Box 1967, Hurstville BC, New South Wales 1481, Australia.

Susanne Callaghan, Office of Environment and Heritage, Locked bag 99, Nelson Bay, New South Wales 2315, Australia.

Email: Nicholas.Carlile@environment.nsw.gov.au

Book Review



Birds of Prey of Australia – A Field Guide (Second Edition)

Stephen Debus. 2012. CSIRO Publishing. Paperback, 208 pp. ISBN 9780643104365. RRP $39.95.

The title differs from the first edition solely by dropping "The" as the first word in the title. But there the resemblance ends.

The first edition was basically a rehash of the field identification components of diurnal raptors from Volume 2 of the Handbook of Australian, New Zealand and Antarctic Birds (HANZAB) with the addition of a few colour photographs. Sure, it was in basic field guide style and size, but was it really a specialists' field guide and was it any better for field ID than the general Australian bird field guides of the day? I had my doubts!

Now we have the second edition – well, it wouldn't be appropriate to just say it's "a different kettle of fish" – I believe that Stephen Debus has now created a true specialist field guide to the diurnal raptors of Australia. In the preface we are informed that the impetus for a second edition came from demand for its 2001 predecessor, even though data presented in it were more than 15 years out of date. But Stephen wasn't satisfied with a cosmetic update of the original publication. He did a complete revision, rewrite and reformatting that incorporates new knowledge and a new and impressive concept to compare species that might be confused in flight. The new edition still incorporates a concise overview of raptor biology, but it has also converted the original HANZAB extract into a comprehensive guide to the field diagnostic character of all of Australia's diurnal raptors in a far more useful and informative format.

Each species has a double page spread that presents illustrations, including flight profiles, size and plumage descriptions of age classes and also draws attention to similar species. This concept alone elevates the value of the book to true field guide status. But then the really exceptional concept of "split-images" is introduced to clearly illustrate differences between species that might be confused with each other.

The field guide value is then enhanced even further by the inclusion of diagnostic in-flight photographs of all species. This is followed by a handbook section that presents information on distribution, food and hunting, behavior, breeding, threats to and conservation of each species. The final chapters discuss the broad threats, conservation and the future for raptors and present a glossary and species specific bibliography.

If you acquired the first edition you might be tempted to ignore an updated second edition. FAIL! Retire the first edition to the bookshelf. You *must* have a copy of the second edition in the driver's door pocket of your vehicle.

Jeff Hardy
Ermington, NSW

RECOVERY ROUND-UP

This section is prepared with the co-operation of the Secretary, Australian Bird and Bat Banding Schemes, Australian Nature Conservation Agency. The recoveries are only a selection of the thousands received each year; they are not a complete list and should not be analysed in full or part without prior consent of the banders concerned. Longevity and distance records refer to the ABBBS unless otherwise stated. The distance is the shortest distance in kilometres along the direct line joining the place of banding and recovery; the compass direction refers to the same direct line. (There is no implication regarding the distance flown or the route followed by the bird). Where available ABBBS age codes have been included in the banding data.

Recovery or longevity items may be submitted directly to me whereupon their merits for inclusion will be considered.

Hon. Editor

The following abbreviations appear in this issue:

ABBBS – Australian Bird and Bat Banding Schemes

WBRG - The Wild Bird Rehabilitation Group

Black Swan *Cygnus atratus*

350-02755 (plus Readable Band r+w XCL). Immature (1) female banded by J.T. Coleman at Lake Hugh Muntz, Mermaid Waters, Qld on 8 Dec. 2007. Readable band sighted in field, number on standard band inferred at Western Treatment Plant, Vic on 24 March 2013, over 5 years 3 months after banding. 1371 km SSW.

(This is the longest movement recorded for the species.)

Black-browed Albatross *Thalassarche melanophris*

CF45697*. Adult (1+) banded on Kerguelen Island, Terresaustrales et Antarctiques, France (49º21'00"S 70013’00”E) on 5 Nov. 2010. Recovered dead at Narrawong Beach near Portland, Vic. (38º15'30"S 141042'43"E) by G. Cooper on 15 Aug. 2012. 5646 km ESE

*French Banding Scheme band

Shy Albatross *Thalassarche cauta*

(a) 280-01731. Nestling banded by N.P. Brothers on Albatross Island, Tas. on 31 March 1982, Recovered dead at Salmon Rocks, Flinders Island, Tas. by J. Smith on 10 Dec. 2012, over 30 years 8 months after banding. 286 km E.

(This is the oldest recorded for the species.)

(b) 280-02049. Nestling banded by N.P. Brothers on Albatross Island, Tas. on 28 March 1983. Recovered dead at Fisherman’s Beach, Torquay, Vic. on 19 Nov. 2012, over 29 years, 7 months after banding. 232 km N

(c) 280-11314. Nestling banded by N.P. Brothers on Albatross Island, Tas. on 1 May 1987. Recovered dead at Garie Beach, Royal National Park, NSW on 18 Nov. 2012, over 25 years, 6 months after banding. 894 km NE.

Northern Giant-Petrel *Macronectes halli*

(a) 131-45312. Nestling banded by the Antarctic Division at Handspike Point, Macquarie Island, Tas. on 7 Jan. 1982. Recovered dead at Nuggets Beach, Macquarie Island, Tas. by K. Smith on 18 Sep. 2012, over 30 years 8 months after banding. 4 km ESE

(b) 1456249*. Immature (1) banded on Bird Island, South Georgia, Antarctica (54º00'S 38º02'W) on 7 March 2012. Recovered injured, later died at Stockton Beach, NSW (32º47'00"S 152º01'00"E) by N. Russell on 28 May 2012. 10 314 km S

*British Trust for Ornithology band

Wedge-tailed Shearwater *Ardenna pacifica*

(a) 162-17371. Adult (5+) banded by S.G. Lane on Muttonbird Island, Coffs Harbour, NSW on 14 Dec. 1993. Recaptured, (breeding, incubating egg), released alive with band on 20 Dec. 2012, over 19 years after banding.

(b) 162-26612. Nestling banded by S.G. Lane on Muttonbird Island, Coffs Harbour, NSW on 5 April. 1995. Recaptured, (breeding, incubating egg), released alive with band on 1 Jan. 2013, over 17 years, 8 months after banding.

Australasian Gannet *Morus serrator*

131-64896. Nestling banded by F.I. Norman at Popes Eye off Queenscliff, Port Philip Bay, Vic. on 19 Jan. 1989. Recovered dead at Point Danger, Portland, Vic. by A. Govanstone on 16 Sep. 2012, over 23 years, 7 months after banding. 266 km W.

Buff-banded Rail *Gallirallus philippensis*

083-25739. Immature (1) banded by J.T. Coleman at Chandler, Qld. on 28 Jan. 2013. Recovered sick (currently in care) at The Lake, North Buderim, Qld. on 25 Feb. 2013. 95 km N

(This is the longest movement recorded for the species.)

Common Noddy *Anous stolidus*

062-36913. Nestling banded by J.N. Dunlop on Lancelin Island, WA on 8 Jan. 1996. Recaptured, released alive with two bands at banding place on 5 Nov. 2011, over 15 years, 9 months after banding.

(The bird was also banded with ABBBS band no. 063-49447.)
(This is the oldest recorded for the species.)

Black Noddy *Anous minutus*

062-25369. Juvenile banded by M.V. Preker on Heron Island, Qld. on 15 Jan. 1993. Recaptured, released alive with band at banding place by C.A. Devney on 19 Dec. 2006, over 13 years, 11 months after banding.

(This is the oldest recorded for the species.)

Bridled Tern *Onychoprion anaethetus*

(a) 061-23362. Adult (2+) banded by J.N. Dunlop on Penguin Island, WA (32º18'20"S 115º41'27"E) on 1 Nov. 1986. Recovered sick, later died at Tukuran Zamboanga del Sur, Philippines (07º51'N 123º35'E) on 20 June 1991. 4541 km N.

(This is the longest movement recorded for the species.)

061-23469. Nestling banded by J.N. Dunlop on Penguin Island, WA on 7 Feb. 1987. Recaptured, released alive with band at banding place on 27 Dec. 2011, over 24 years, 10 months after banding.

(This is the oldest recorded for the species.)

Striated Pardalote *Pardalotus striatus*

019-06147. Immature (1) banded by W. Rutherford at Heardsman Lake, Perth, WA on 2 Feb. 2008. Recaptured, released alive with band three times the last occasion by L. Dadour on 16 Feb. 2013, over 5 years after banding.

Australian Raven *Corvus coronoides*

100-99804. Immature (1) rehabilitated bird banded by the WBRG at Birkshire Park, NSW on 4 Aug. 1990. Recovered sick or injured by A. Caruana on 3 Feb. 2013, the bird is alive and currently in care at Blacktown, NSW over 22 years, 5 months after banding. 18 km ESE.

(This is the oldest recorded for the species.)

Notice to Contributors

Manuscripts relating to any form of avian research will be considered for publication. Field studies are preferred particularly where identification of individual birds, as by banding, has formed an integral part of the study. Some broad areas of research which do not necessarily require individual identification include morphometric analyses, techniques, species diversity and density studies as well as behavioural investigations. Behavioural, plumage and breeding studies can be conducted in captivity but must provide basic ornithological knowledge rather than avicultural interest.

Manuscripts are classified as either major articles (more than 1,500 words) or minor articles (500 to 1,500 words). Minorarticles need no summary. Shorter notes relating to almost any aspect of ornithology are welcomed but must adhere to the aims of the Association. Species lists or sightings which are not discussed in relation to historical evidence or scientific parameters are not suitable for publication in *Corella*. Authors proposing to prepare Seabird Island items should contact the Assistant Editor,Seabird Islands, and obtain a copy of the guidelines.

The copyright of material published in *Corella* is assigned to the Australian Bird Study Association.

Contributors are requested to observe the following points when submitting articles and notes for publication in *Corella*.

Manuscripts:

A guide to the format required for tables, figures and manuscripts can be attained by reference to a recent edition of the journal and more specifically to the Publication Style found on the ABSA website.

Articles or notes should be sent via email to the editor as a .doc or .rtf file or typewritten and submitted in triplicate via post. Double spacing is required with typing on one side of the paper only. Margins of not less than 25 mm width at the left hand side and top, with similar or slightly smaller at the right hand side of the page are required.

All pages of the manuscript must be numbered consecutively, including those containing references, tables and captions to illustrations, the latter placed in after the text. No underlining and no abbreviations should be used within the text.

The *Style Manual for Authors,Editors and Printers* (6th edition 2002; John Wiley & Sons Australia, Ltd.) is the guide for this journal. Spelling generally follows the Macquarie Dictionary.

Nomenclature and Classifications follow:

Christidis, L. and Boles, W. E. (2008). 'Systematics and Taxonomy of Australian Birds'. (CSIRO: Collingwood, Victoria).

Proper nouns, particularly place and bird names must commence with a capital letter.

Headings are as follows: **HEADING – capitals and bold** (e.g. **RESULTS**)
Sub Heading – lower case and italics (e.g. *Ecology*)

Referencing:

References to other articles should be shown in the text – '. . . Bell and Ferrier (1985) stated that . . .'or '…. this is consistent with other studies (Jones 1983; Bell and Ferrier 1985).'– and in the Reference Section as:

Bell, H. L. and Ferrier, S. (1985). The reliability of estimates of density from transect counts. *Corella* 9: 3-13.

Jones, J. C. (1983). 'Sampling Techniques in Ornithology.'(Surrey Beatty and Sons: Chipping Norton, NSW.)

Figures (Maps and Graphs) and Tables:

The printable area of the page is 18 cm x 27 cm; double column figures/tables will be 18 cm across; single column figures/tables will be 8.5 cm across; widths between one column and double column can also be accommodated.

The captions for figures should be typed up onto a page separate from the figure.

Maps

Maps should be clear and relevant to the study and can be submitted in a variety of formats (.tif, .eps, .pcx) but there commended one is a high resolution .jpg file (colour is acceptable). In some instances simply listing the latitude and longitude may suffice instead of a published map. Maps should only show necessary information. Excessive labelling(including names of towns, roads, rivers) will clutter the figure making it difficult to locate key place names. Photocopies of original hand drawn maps are not suitable for publication. They should be submitted only initially. When the paper is accepted for publication, the originals must be submitted so that they can be scanned into an appropriate electronic format.

Graphs

Lines should be thick and dark and any fill used should show a clear distinction between sets of data (colour fills are acceptable). Borders around the graph and the key are not necessary. The recommended format is an .xls file – this makes it very easy to adjust fills, thickness of lines etc, if necessary.

Where possible, please present the figure at final size. Figures that seem satisfactory when they are large, can present problems when they are reduced. Remember that if the figure has to be reduced for publication the figure will reduce equally in all dimensions i.e. both width and height will reduce. This can cause some problems, such as: (i) Line graphs where the lines are very close together can lose clarity. (ii) The typeface will reduce. Please ensure that the final typeface size AFTER reduction will be a minimum of 10 times Times New Roman typeface.

Tables

The recommended format is an .xls file but tables created in Word are acceptable. These should normally have a maximum size of one page but larger tables can be accommodated, if necessary.

FOR MORE DETAILED INFORMATION OR ASSISTANCE IN THE PREPARATION OF FIGURES PLEASE CONTACT THE PRODUCTION EDITOR.

CORELLA

Volume 37 Number 2 June 2013

The Australian Bird Study Association Incorporated
ISSN 0155-0438

P.O. Box A313, Sydney South, NSW 2000