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

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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.

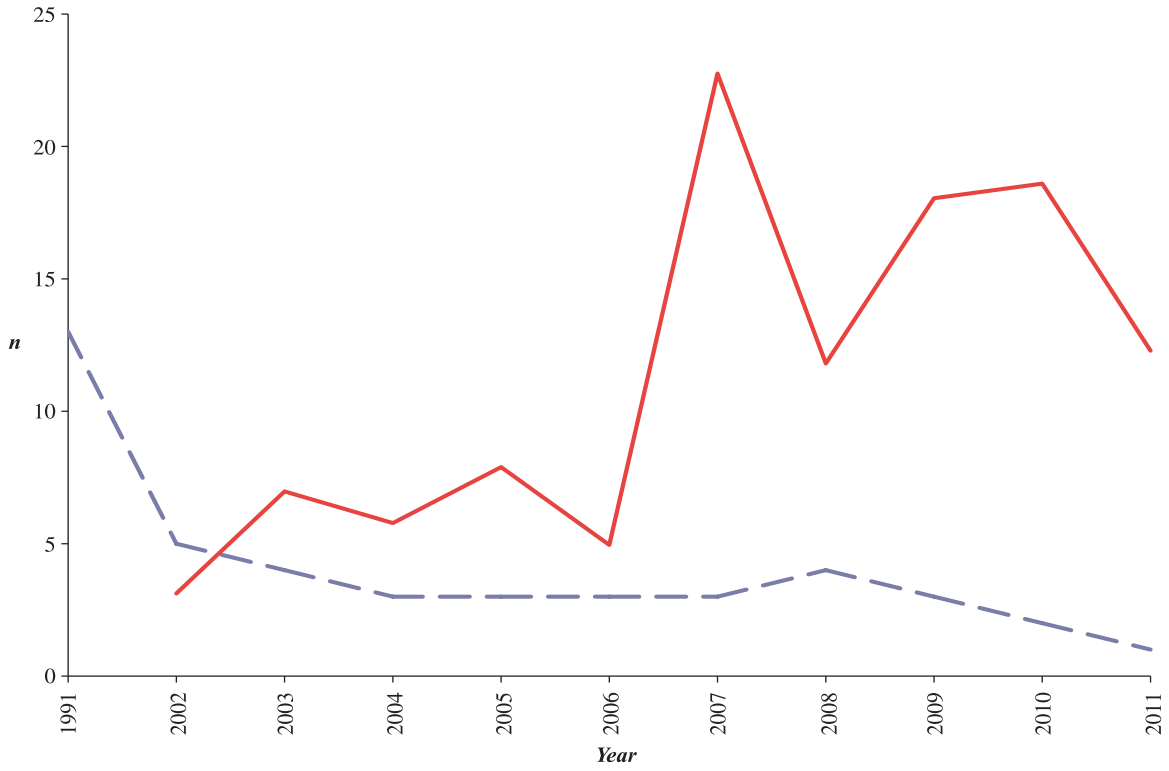

Figure 1. *Relationship between number of active nests of Little Eagles (— — from annual surveys of breeding pairs) and abundance index of rabbits (——— rabbits/km, from monthly surveys, see text) in the ACT, 1990-2001 (regression: F = 1.98; P = 0.20; not significant).*

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 *vulnerable* 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).

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