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Debus, S.J.S. (2015). Assessment of band recoveries for three Australian eagle species. Corella, 39(3), 67-72.

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Assessment of band recoveries for three Australian eagle species

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Received: 18 February 2014

Band recoveries to 2012 were analysed for the White-bellied Sea-Eagle *Haliaeetus leucogaster* (*n* = 11, recovery rate = 6%), Wedge-tailed Eagle *Aquila audax* (*n* = 55, recovery rate = 7%) and Little Eagle *Hieraaetus morphnoides* (*n* = 30, recovery rate = 9%) in Australia (for the Wedge-tailed Eagle, eastern Australia only). Juvenile/immature Sea-Eagles (*n* = 8) were recovered within 3.5 years (0–41 months, mean 13 months), 0–1824 kilometres (mean 268 km) from the banding site. Adults (*n* = 3) were recovered at the banding site; one notable lifespan was 19+ years. Of 60 Sea-Eagles wing-tagged in the coastal Northern Territory, 1978–1994, four (recovery rate = 7%) were juveniles recovered/resighted within 1–4 years, 30–90 kilometres from the banding site, whereas territorial adults were resighted on their territories over the ensuing year. Juvenile/immature Wedge-tailed Eagles (*n* = 55) were recovered 0–821 kilometres from the banding site (mean 130 km, 95% within 300 km), 1–72 months later (mean 11 months); one banded on Kangaroo Island was recovered on the adjacent mainland (13+ km across sea). Little Eagles (mostly aged as 'first year or older' and unsexed) were recovered 0–2884 kilometres from the banding site (mean 219 km, 80% within 200 km), 1–311 months later (mean 60 months); notable lifespans were of 19–26 years, but average lifespan may be ~5 years in the sheep–wheat belt. Human-related mortalities, either deliberate (persecution) or accidental (e.g. collisions, interactions with infrastructure), formed a large proportion of the reported public recoveries of each species.

INTRODUCTION

A banding study has been conducted on the Wedge-tailed Eagle *Aquila audax* in arid Western Australia (Ridpath and Brooker 1986). Available banding data for that species, and for the White-bellied Sea-Eagle *Haliaeetus leucogaster* and Little Eagle *Hieraaetus morphnoides* as at the early1990s, were summarised by Marchant and Higgins (1993). A 20-year update was therefore sought, to ascertain whether further band recoveries had been obtained for these three eagle species, and thus whether their movements could be further elucidated. Meanwhile, post-1986 band recoveries for dispersing juvenile Wedge-tailed Eagles in south-west Western Australia (and elsewhere) were presented by Hatton (2013), and (for WA) are not repeated here. The present paper collates band recoveries to date for all three eagle species (Wedge-tailed Eagle in eastern Australia only). As well as summarising data on dispersal distances and directions, and longevity, this compilation sheds some light on mortality factors.

METHODS

Recovery data for the three eagle species up to 2012 were sourced from the Australian Bird and Bat Banding Scheme (ABBBS). The usable data excluded short-term (<1 month) recoveries of rehabilitated birds (one adult Wedge-tailed Eagle and two juvenile/immature White-bellied Sea-Eagles) where the attempts clearly failed (i.e. birds returned to care), and six cases (equally across the three species) where only the band was found. For distance and direction, only those recoveries at least 5

kilometres from the banding site were mapped (the appropriate resolution for the mapping scale in Figures 1–3). Where the exact recovery date was unknown (given only as month/year), time elapsed was calculated to the nearest month (thus salvaging several cases where the ABBBS database omitted a time elapsed). Distances are simple displacements, with no implication about routes taken or where the birds may have been in the interim; they are therefore minimum distances travelled. Here, 'road-killed' means known to have collided with a moving vehicle (as per the ABBBS definition), i.e. not assumed so if found dead by a road, and 'shot' is as reported by the finder. Ageing is as per ABBBS codes, e.g. 1+ = first year or older, 2 = second year, 2+ = second year or older, etc.

There were 55 usable recoveries for the Wedge-tailed Eagle, 30 for the Little Eagle and 11 for the White-bellied Sea-Eagle. For the Wedge-tailed Eagle, all but two birds were banded before 1990 (most, 80%, from the late 1950s to 1970s); for the Little Eagle, most (90%) in the 1970s to 1990s (only two since 2000); and for the Sea-Eagle, all in the 1970s to 1990s. For the Sea-Eagle, only two juvenile/immature birds were sexed (both as female) when banded, the remainder (six) being unsexed; and three adults were a male and female of a known breeding pair, and a replacement female in the same territory in a later year. For the Wedge-tailed Eagle, only seven birds were sexed (presumably by general size) when banded: five of these as nestlings (four male, one female) by banders in the 1960s/1970s before reliable sexing or growth criteria were available or 'how sexed' was required in the database. For the Little Eagle, only 11 birds were sexed, all as female mostly aged 1+ (one as 2, one as 2+, ones as 3+), which may represent a trapping bias, wintering females perhaps being more likely to come to carrion (pers. obs.), i.e. bait in cage traps. Most recovered

Little Eagles originated from three main centres of banding effort in the agricultural belt: south-western Australia, South Australia and southern Victoria, and almost all free-flying birds were banded in March–July, i.e. usually the eagle's non-breeding season in southern Australia (cf. Marchant and Higgins 1993).

L. Corbett and T. Hertog provided a summary of their unpublished study on White-bellied Sea-Eagles in the Top End of the Northern Territory. They banded, or banded and wing-tagged, 60 White-bellied Sea-Eagles between 1978 and 1994: 11 adults, nine juveniles and 40 nestlings, including some territorial adults (see Hertog 1987). The general capture locations were the Mary River (*n* = 32), South and West Alligator Rivers (at Kapalga, *n* = 23), Humpty Doo (*n* = 3) and Kings Swamp (*n* = 2; see Corbett and Hertog 2011). All captures were in territories at or near an active nest.

RESULTS

White-bellied Sea-Eagle

The ABBBS recovery rate was 11 birds out of 196 banded (6%). Of eight recovered eagles banded as nestlings or juvenile/immature (<3 years old), all were recovered within 3.5 years (0–41 months, mean 13 months), 0–1824 kilometres from the banding site (mean 268 km). Those banded as nestlings or juveniles were recovered 11–1824 km away (mean 306 km, *n* = 7), 1–41 months later (mean 15 months). One banded as immature (<3 years old) was recovered at the banding site within a month. Overall, five young eagles were recovered within 60 kilometres of

the banding site, and six within 140 kilometres. One juvenile was resighted alive in the wild (band number read in the field) 131 kilometres from the banding site, 17 months later, but otherwise these birds were found dead (n = 4, cause unknown), road-killed (n = 1), shot (n = 1, NSW in 1990), and dead entangled in fishing gear (n = 1). There is little discernible pattern to these few recoveries, except that one juvenile dispersed across (or around?) the continent (coastal SA to coastal Qld; Figure 1) within 13 months of being banded as a nestling.

Of two paired adults (age 5+) recovered in Tasmania, the female was shot (in 1994) within two months of banding, and the male was retrapped by the bander one month after banding, at the banding site. The replacement female was another adult (banded at age 5+), retrapped at the banding site 2.4 years and 4.9 years after banding, on the latter occasion her band replaced owing to wear. She was found dead near a highway 3 kilometres from the banding site, 14 years after banding (i.e. at least 19 years old).

In the Corbett and Hertog study in the Top End (NT), there were resightings of some tagged adults and juveniles, all within the capture territory, for up to about 12 months, although three tagged eagles were shot by vandals. Besides the resident territory-holders, there were many transient eagles moving through the trap sites, and these were often caught first while the territorial birds were more cautious and watched. The transients were a mixture of ages, but none established territories in the regularly checked sites. Two banded juveniles were among the above ABBBS recovery dataset (found dead 29 and 42 km from the banding site, 12 and 41 months later). Most other tagged individuals were not resighted, and their fate or

whereabouts were unknown. The only additional records away from the capture site were (i) a nestling tagged at Mary River and resighted at King Creek, Howard River area near Darwin (~90 km away), by a fisherman; and (ii) a nestling tagged at Mary River and resighted as an adult on the McKinley River (~30 km away), four years later (L. Corbett and T. Hertog unpubl. data). In the latter case, it was not known if a territory had been established, as no nest or other eagle was located at the time; the wing tags were still in good condition, and appeared not to bother the eagle (T. Hertog pers. comm.). Collectively, the band returns/tag reports (n = 4) represent a low recovery rate (7%) for 60 eagles marked in the Top End. Marchant and Higgins (1993, p. 84) quoted some other findings from the study as 'territorial adults often moved long distances, [and] all but one of 18 juveniles emigrated or died within three years'.

Wedge-tailed Eagle

The recovery rate was 55 birds out of 822 banded (7%). Almost all 55 eagles recovered had been banded as nestlings (n = 42) or aged 1+ (n = 12), with one aged as 1, one aged as 3 (i.e. all juveniles or immatures, no adults) and one as unknown (in the 1960s), so the results are here pooled for age classes. Eagles were recovered 0–821 kilometres from the banding site (mean 130 km), 1–72 months later (mean 11 months). About one-third (35%) were recovered within 50 kilometres, over half (53%) within 100 kilometres, 80 percent within 200 kilometres, and 91 percent within 300 kilometres. Dispersal appears random in direction, though perhaps with a slight north–south bias along the Great Dividing Range (Figure 2), ridge-lift possibly thus assisting long-range dispersal (e.g. Leopold and Wolfe 1970; Debus *et al.* 2007).

Only two eagles were recovered more than four years after banding (at 4.7 and 6 years, 0 and 84 km from the banding site, respectively), most (>90%) within two years and 82 percent within one year. No further analysis is possible regarding age or sex differences in dispersal distances or longevity.

Of the eagles recovered (all but two dead), 20 (36%) were shot; 16 (29%) were trapped (half of these accidentally in traps for terrestrial animals); five (9%) were found dead, cause unknown; two (4%) were found sick or injured; one (2%) was dead beside a road; one (2%) was electrocuted; two (4%) were found dead near electricity wires; one (2%) was beach-cast (see below); for four (7%), the band was found on the bird and removed, the encounter method and bird's status unknown; and for three (5%), the band was returned to the ABBBS with no details provided. Given the time period (eagle persecution era, 1960s–70s; e.g. Marchant and Higgins 1993) and locations (sheep–wheat belt), and some grazier knowledge of CSIRO research on eagles and lambs (plus the ABBBS return address as 'CSIRO Wildlife' at the time), the last two categories are likely to involve, or include, eagles killed by humans.

One eagle banded as a nestling on Kangaroo Island was recovered dead on the opposite South Australian mainland shore, beach-cast 18 months after banding and decomposed in dunes behind the beach 22 months after banding (the band left on the bird by the first finder, thus generating a dual report). It is unknown whether the eagle made the Backstairs Passage sea crossing (minimum 13.5 km) successfully, or perished in the water and washed ashore. Four others (two nestlings, two aged 1+) banded on Kangaroo Island were recovered there, 6–22 months and 12–56 months later, respectively. The only recovered eagle banded in Tasmania, a third-year

female, was electrocuted and euthanased six months later, 31 kilometres from the banding site within Tasmania.

Little Eagle

The recovery rate was 30 birds out of 332 banded (9%). Almost all 30 eagles recovered had been banded as age 1+ or unknown, with two banded as a nestling and a juvenile, one aged 2, one aged 2+, and one aged 3+, so the results are here pooled for age classes. Eagles were recovered 0–2884 kilometres away (mean 219 km), 1–311 months later (mean 60 months). Over half (60%) were recovered within 100 kilometres of the banding site, and 83 percent within 200 kilometres. Dispersal appears random in direction, 97 percent of recoveries within 600 kilometres of the banding site, with one exceptional bird (unsexed juvenile) travelling 2884 kilometres across the continent (south-west WA to eastern Victoria) and road-killed 14 months after banding (Figure 3). This bird was reported struck by the driver at the recovery site, i.e. it was not transported by an interstate vehicle (D. Drynan pers. comm.). The single bird banded as a nestling was recovered 48 kilometres from the banding site, 78 months later. Some longer dispersals may be assisted by ridge-lift along the Great Dividing Range in south-eastern Australia and the Darling Scarp in south-western Australia (Figure 3). Eagles retrapped by banders (n = 8) were all recovered at the banding site or study area, mostly within a year (one 70 months later, suggesting fidelity to a home range).

Apart from eight retraps at banding sites by banders, of 22 other eagles recovered by the public, nine (41%) were found dead, cause unknown; three (14%)

were road-killed or -injured; four (18%) were dead or injured beside a road; two (9%) were found sick or injured; one (4.5%) was poisoned (unknown if intentionally); one (4.5%) was killed to protect domestic animals; one (4.5%) was trapped by hand and reported as 'dead,' status of band and further details unknown (here suspected to have been killed in e.g. a fowl pen); and for one (4.5%) the band was found on the bird and removed, the encounter method and bird's status unknown (suspected killed). Admitted or suspected killings occurred in the 1970s–early 1980s, as did the poisoning, but 'found dead' persisted until the last such recovery (2004). One female (age 3+) at Perth Airport was retrapped within a month of banding, then translocated (presumably to mitigate aircraft strike).

Eleven females were recovered 0–534 kilometres (mean 128 km) from the banding site (those aged 2, 2+ and 3+ at 0 km, the remainder aged 1+). These, and some other eagles of unknown age/sex, provided some notable longevity records of 10, 15, 19, 24 and 26 years (although 80% of 30 eagles were recovered within 6.5 years). One female (age 1+ at banding) was recovered 6 kilometres from the banding site in north-western Victoria, 9.7 years later: possibly an indication of home-range dimension in one direction. Another female was retrapped within a study area (southern Victoria) a year after banding, 13 kilometres away from the original site: possibly an indication of wintering-range dimension in one direction. Similarly, one eagle of unknown sex in South Australia, and one female in southern Victoria, were recovered almost two years later 13 kilometres away, and six years later 11 kilometres away: again possibly an indication of home-range or wintering-range dimension in one direction, respectively.

DISCUSSION

Recoveries and their interpretation are affected by small sample sizes and various other limitations in the data sets: for the White-bellied Sea-Eagle, by the low recovery/resighting rate for the Top End, despite the large banding/tagging effort there; for the Wedge-tailed Eagle, by the bias in age classes banded and the lack of sexing; for the Little Eagle by banding location and season, and by lack of ageing and sexing (despite the availability of age and sex criteria for the last species since the 1980s, i.e. Baker-Gabb 1984 and Debus 1989). For each species, recoveries are probably biased because those reported by the public are likely to be found near or affected by human activity. That is, eagles dying of natural causes away from humans and anthropogenic landscapes are less likely to be found. Some Wedge-tailed Eagles and female White-bellied Sea-Eagles can remove standard stainless-steel bands, sometimes within hours (D. Drynan, N. Mooney pers. comm.), hence (a) the finding of only a band is inconclusive; (b) some large eagles may 'outlive' their bands; and (c) the now mandatory use of lock-on bands ('clip rings') for the Wedge-tailed Eagle and the White-bellied Sea-Eagle. It is also apparent that band wear on coastal (saltwater) Sea-Eagles may be rapid, requiring band replacement within five years, and that there may be problems with wing-tagging territorial adult Sea-Eagles and perhaps Wedge-tailed Eagles (see Baker-Gabb 1993). The recovery rate for the two large species was rather low for large, persecuted eagles (cf. Newton 1979), perhaps reflecting the low human population density in Australia, whereas the higher recovery rate for the Little Eagle may reflect the fact that some recoveries (27%) were retraps by banders.

The biases and pitfalls of interpreting raptor life-history parameters (e.g. mortality, life expectancy) from band recoveries, especially for persecuted species, are discussed by Newton (1979). Estimates depend on sufficient numbers of birds banded as nestlings (usually only achievable via a dedicated research project), and recovered in subsequent annual intervals: a major shortcoming of the samples in the present study.

White-bellied Sea-Eagle

The small data set means that all one can conclude is that juvenile White-bellied Sea-Eagles are capable of dispersing across the continent, although many disperse lesser distances; that some fall foul of human hazards such as vehicles and fishing gear; and that some eagles may live for at least 20 years. Even today, since legal protection, occasional shooting of this species occurs, including in Tasmania where the species' scheduled *vulnerable* status incurs higher protection and penalties. Sometimes fatal entrapment of this eagle in fish-farm anti-bird nets happens regularly, and adults of this species have been killed by wind turbines at two Tasmanian windfarms ((N. Mooney pers. comm.; see Mooney 2012). A limited colour-banding and radio-tracking study of adult eagles in Tasmania found that they were highly sedentary, with a high turnover of adults at nest sites (N. Mooney pers. comm.), perhaps related to fish-farm deaths.

The limited ABBBS recovery data on juvenile dispersal capability is consistent with the genetic data on minimal population structuring across the species' geographical range (Shephard *et al.* 2005). There is no suggestion that the White-

bellied Sea-Eagle is migratory within or beyond Australia (e.g. Marchant and Higgins 1993). Consequently, this species has been delisted from the 'Migratory' schedule of the federal *Environment Protection and Biodiversity Conservation Act* (D. Drynan pers. comm.). It was initially listed on the basis of its inclusion on the China-Australia Migratory Bird Agreement because it occurs in both countries, but the revised Bonn Convention criteria disqualify it on the grounds that there is no biannual, return migration of a substantial part of the population between the two countries.

Wedge-tailed Eagle

The main conclusion from the data is that many juvenile or immature eagles banded in the sheep–wheat belt in the persecution era were killed by human agency within two years (65% of recovered eagles shot or trapped, up to 78% if data-poor band returns include killings, and up to 87% if 'found dead' is euphemistic for killed). A further seven percent died accidentally from human agency (vehicles, powerlines). A necessary qualifier is the potential source of bias noted above, i.e. eagles shedding bands, or dying away from humans (but perhaps some human-killed banded eagles also went unreported). Persecution continued since legal protection in the eastern states in the 1970s, with two shot recoveries in 1980–83 (SA, Qld) and two suspicious data-poor band returns in 1983–89 (SA, Vic.). Clandestine, illegal persecution continues, notably in South Australia where hundreds of eagles were killed on one inland grazing property (Falkenberg 2011, 2013), and in Tasmania (e.g. Mooney 2011) where the endemic subspecies *A. a. fleayi* is state- and federally listed as *endangered* (though recently reassessed as *vulnerable* by Garnett *et al.* (2011), and its

subspecific status now questioned by Burridge *et al.* (2013)). Other cases of persecution occasionally come to light, and are typically treated lightly by the law (e.g. Smith 2004). Windfarms are an emerging and underestimated threat, especially in Tasmania (Mooney 2012).

For juvenile or immature eagles banded and recovered in eastern Australia, the results are generally similar to those of Ridpath and Brooker (1986) in arid Western Australia regarding apparently random distances and directions, i.e. up to ~800 kilometres from the banding site, and time elapsed (i.e. most recovered within two years). The small sample of juvenile dispersals within south-western Australia, mapped by Hatton (2013, Figure 1.1), shows a similar pattern to that in south-eastern Australia, i.e. random, mostly short- to mid-range dispersal within the Mediterranean zone (southern winter-rainfall zone where people live, and are therefore more likely to find them than in the arid zone/dry tropics). Satellite tracking of a juvenile Wedge-tailed Eagle in the arid Pilbara (WA) by Cherriman (2014) has revealed dispersal to 1 000 kilometres from the nest, in cumulative return and other journeys of 6 800 kilometres in the bird's first two months of independence.

Although a very small sample, the results for Kangaroo Island may parallel the situation in Tasmania, where the eagle population is apparently confined to the island, with little over-sea dispersal from the mainland (see Burridge *et al.* 2013). However, Kangaroo Island is much closer to the mainland than the major Bass Strait islands (King and Flinders) are from Victoria (~90 km for King Is.; ~50 km from Flinders Is. to the Kent Group thence another ~80 km via some islets). Kangaroo Island is visible from the mainland (pers. obs.), and Flinders Island and Victoria are visible from the

Kent Group (which is small and uninviting, and the Strait islands are occupied by Sea-Eagles), whereas King Island is not visible from Albatross Island (S. Garnett pers. comm.), and would not be visible from Victoria.

Little Eagle

It is apparent that Little Eagles are capable of dispersing across the continent, even if most travel much lesser distances (although northward dispersers are unlikely to be recovered in the sparsely human-populated arid zone or tropics). Because this species is not a concern to graziers, the recovery profile probably contains some realistic maximum lifespans (20–26 years). Nevertheless, a few eagles were known or suspected to have been deliberately killed, and almost half of the remaining public recoveries involved human-related mishaps (albeit a recovery bias), with an unknown proportion of sick/injured or 'found dead' also possibly human-related. A mean elapsed time of five years may therefore approximate average longevity in the sheep–wheat belt.

Elapsed distances of 6–13 kilometres between long-term (2–10 years) recoveries, if they represent minimum home-range dimensions, would be consistent with the similar, allospecific (but migratory) Booted Eagle *Hieraaetus pennatus*, the breeding home ranges of which can be up to 10–20 kilometres across in a comparable Mediterranean environment (Spain; Martínez *et al.* 2007). However, home range, dispersal and other aspects of Little Eagle spatial and population ecology remain to be investigated.

Conclusions

Analysis of band recoveries for eagles in Australia is currently limited by the rudimentary and skewed data sets, which lack age and sex details for many birds, the low recovery rates, and the recent decline in banding effort, such that it is not possible to construct life tables. A much greater research effort, with banding, colour-marking, radio- and satellite-tracking, would greatly enhance understanding of the ecology (e.g. home-range size, habitat use, juvenile dispersal) and requirements of these birds, all of which are now at least state-listed as threatened in some Australian states (see Debus 2012 for a summary of their conservation status). For the Wedge-tailed Eagle, such work on the Australian mainland has barely begun (Cherriman 2013; Hatton 2013), where there are arguably higher-priority eagles (i.e. White-bellied Sea-Eagle, Little Eagle) and other raptors. Mooney (2013) has suggested a strategy to address the knowledge deficiencies for the Tasmanian Wedge-tailed Eagle, and Debus (2009, 2011) has suggested some research priorities for the various eagles and other raptors in other states. However, this research will require funding, and perhaps a need to overcome some academic reluctance regarding postgraduate studies on raptors. It is almost certain that eagle mortalities from interactions with human structures (e.g. electrocutions on power poles; collisions with powerlines and wire fences, and now with windfarm turbine blades – see Mooney 2012) to some extent replace persecution as a cause of death, but are greatly under-recorded and deserve closer investigation.

ACKNOWLEDGEMENTS

I thank David Drynan (ABBBS) for providing the recovery data and permission for their use, and I gratefully acknowledge the many banders for their efforts and, as applicable, permission to use the recoveries of their birds. Prominent for effort among the many eagle banders were Max Waterman OAM, and the late Norman Favaloro and Allen Lashmar. I am especially grateful to John Farrell for preparing the maps of eagle recoveries, and Laurie Corbett and Tony Hertog for their unpublished data and permission to use them (and to their informant B. Bowstead for reporting a tagged eagle). I thank Tom Aumann, Nick Mooney and referees Penny Olsen and David Baker-Gabb for comments on drafts.

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Figure 1. *Band recoveries for the White-bellied Sea-Eagle in Australia (>5 km,* n = *7).*

Figure 2. *Band recoveries for the Wedge-tailed Eagle in south-eastern Australia (≥5 km,* n = *49).*

Figure 3. *Band recoveries for the Little Eagle in Australia (>5 km,* n = *22).*