# Video monitoring reveals novel threat to Critically Endangered captive bred and released Regent Honeyeaters

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## 1. Abstract

Nest predation is a primary cause of nest failure in open cup nesting woodland birds and low reproductive success is a common reason that reintroduced species fail to establish in the wild. We used video monitoring to record the breeding outcomes and identify the causes of nest failure in a reintroduced population of the Critically Endangered Regent Honeyeater. We intensively monitored 28 nesting attempts of 13 pairs during the 2015 breeding season, and found that the probability of individual nest success was 0.21 (from egg laying to fledging). We report for the first time Sugar and Squirrel Gliders depredating Regent Honeyeater nests. In addition to losses attributed to predation, a high proportion of chicks died in the nest from unknown causes. Our results show that rates of nest initiation and success are low in reintroduced Regent Honeyeaters, and future reintroductions

should attempt to mitigate the threat of nest predation. Other sources of nest failure and barriers to nest initiation and egg laying are priority areas for future research.

Key words: *Anthochaera phrygia; predation; threatened species; breeding success; nest survival*

## 2. Introduction

Reproduction is a key vital rate determining the demographics of populations. There are numerous external influences that can reduce nest success in birds (here defined as the proportion of nests that fledge at least one young), including extreme weather (Jovani & Tella 2016), limited resources (Sherley et al. 2014), competition (Frei *et al.* 2015), brood parasitism (Wei et al. 2015), parasites (Scott-Baumann and Morgan 2015) and anthropogenic habitat disturbance (Ibáñez-Álamo et al. 2015). However, perhaps the most important driver of nest failure is predation (Ricklefs,1969; Major et al. 2014). Predation risk to eggs, nestlings and attending adults, impact a variety of behaviours (e.g. nest construction and position)(Lee & Lima, 2016) and influences the evolution of life history traits (Martin, 1995) to ultimately shape population dynamics and densities (Lahti, 2001). When predation is the main driver of decline for a threatened species, management actions are often focused on reducing predation risks. For example, predator removal (Armstrong *et al.* 2002) and predator exclusion methods (Major et al. 2014) have been employed to reduce predation and therefore increase adult survival and reproductive output. Seeking to maximise reproductive success is particularly important when attempting to establish or reinforce a population through the release of breeding adults. Predation of nests is known to be a major limiting factor for establishment success in reintroduced populations (Moseby et al. 2015; Ashbrook et al. 2015) and this risk may be further elevated when releasing captive bred individuals due to their naivety to predation pressures in the wild (Moseby *et al.* 2015).

Here, we report findings from nest monitoring of captive bred and released Regent Honeyeaters (*Anthochaera phrygia)* during an initial post-release breeding event in 2015 at Chiltern-Mt Pilot National Park in northeast Victoria. This species has been subject to intensive recovery actions over the last two decades in response to a precipitous decline in population size. Although once widespread across the woodland belt of south eastern Australia, Regent Honeyeaters have lost >85% of their primary habitat through land clearing (Mac Nally *et al.* 2000), and sightings are now largely restricted to regions in New South Wales (Bundarra-Barraba, the Hunter Valley and the Capertee Valley) and north-east Victoria (centred around the Chiltern-Mt Pilot National Park). The total wild population was estimated to number 350-400 individuals in 2010 (Garnett et al. 2010), with further subsequent declines likely. Previous releases at Chiltern-Mt Pilot in 2008, 2010 and 2013, indicated that nest success was low (D. Ingwersen unpubl. data). As the drivers of this low reproductive success have remained largely unknown, here we sought to explicitly identify the factors limiting nest success.

## 3. Methods

### ***Study species and site***

The Regent Honeyeater is a Critically Endangered, nectarivorous passerine endemic to south eastern Australia. The breeding season typically occurs from August to January (the Austral spring and summer). Regent Honeyeaters are open cup nesters, with the nest built solely by the female. Regent Honeyeaters lay 2-3 eggs per clutch and have an incubation period of 14 days and a nestling period of ~16 days (Oliver et al, 1998). Both parents feed the chicks. Although nests are often spatially aggregated, Regent Honeyeaters do not appear to be synchronised breeders (Oliver et al. 1998). Regent Honeyeaters are often associated with riparian habitat during the breeding season (Geering and French 1998; Crates *et al.* 2017).

Chiltern-Mt Pilot National Park ($36^{o}$7'59.00"S $146^{o}$36'4.00"E), was the chosen release site for all releases (2008, 2010, 2013, 2015 and 2017) because wild Regent Honeyeaters have historically used this area for breeding, and wild individuals are occasionally still observed here. It covers 21,600 ha of primarily regrowth open box-ironbark forest of which roughly 4,600 ha in the northern section comprises the core habitat, predominantly Mugga Ironbark (*Eucalyptus sideroxylon*), for Regent Honeyeaters. The northern section of the park also supports Red Stringybark (*E. macrorhyncha*) and box eucalypts (*E. albens, E. macrocarpa and E. polyanthemos*). It is located on the traditional lands of the Dhudhuroa-Waywurru and Pangerang people (Blake and Reid 2002). Seventy-seven Regent Honeyeaters (36 female and 41 male) of mixed ages (39 were < 1 yr, 31 were between 1 and 2 yrs and 7 were between 2 and 3 yrs) were selected for release from birds bred at Taronga Zoo and affiliate zoos. None of the birds had prior breeding experience in captivity.

***Nest location and monitoring***

All released birds were fitted with unique combinations of colour bands. Forty-two of these birds (19 female, 23 male) were also fitted with Holohil systems BD-2 radio transmitters using a backpack style harness incorporating a weak point designed to break when exposed to resistance or wear. The transmitters weighed no more than 5% of the bird's body weight. The release occurred in April 2015, three months prior to any anticipated breeding events, and timed to coincide with the commencement of seasonal flowering of key eucalypt food plants species. The average battery life of functioning radio transmitters was 10-12 weeks, so transmitters were redeployed at intervals during the release such that at any point in time a selection of birds could be tracked. Over the course of the release 59 of the released birds wore a functioning transmitter at least once, with eight of those refitted with transmitters two or three times.

Established pairs were identified on the basis of intense calling and territory defence by the male, both birds displaying courtship positions (lowered straightened body with wings slightly opened), and subsequent close association when foraging, inspecting potential nest sites, and nest building. Once pairs were identified they were monitored daily and their nest attempts followed. Nest building was confirmed when the birds regularly took material to the same place and a clear base of a nest was seen (they often took one or two sticks to a site before ceasing activities at that site). A complete nest was defined as a nest where adult attendance at that nest continued beyond the nest building stage. All nests were discovered during the early nest building stage providing confidence that, amongst monitored pairs, few if any nests were overlooked. For each nesting attempt we recorded the pair ID, the tree species in which the nest was built, height of nest and nest tree height, distance to water, degree of visual concealment, clutch size and nest outcome (Table 1). The degree of visual concealment was assessed by one observer; from each cardinal direction at a distance of 2m from the base of the nest tree, acknowledging that nest height may impact the accuracy of our concealment estimate. We estimated the percentage, to the nearest 5%, of the nest that was concealed by foliage with the mean of these four values providing a relative measure of nest concealment.

**Table 1 near here*

Modified video surveillance cameras (Network 4 Channel AHD DVR Kit with 4 x 720p Cameras) with DVR monitors were used to monitor ten nests (eight that received eggs and two that didn't). Each camera was connected to an 18m cable and fixed to a 6m extendable pole. The batteries and DVR were housed in a 780 x 380 x 380mm cargo box at the base of the tree, minimising the climbing required and therefore disturbance. Cameras were only deployed on completed nests and then only if they were in a position that allowed easy and safe access to the tree with minimal disturbance to the breeding pair. Cameras were always positioned 3-4 metres from the nest, which still enabled quality footage to identify predators. No vegetation or other potential forms of concealment were modified. After a camera had been installed, nests were observed from a distance of 10+ m once per day. If it appeared the nest had been abandoned (e.g. absence of the parents or reduced visitation rates), we scrutinised the video footage to identify the time and cause of predation. Nestlings that were found dead in the nest were stored at ~$4^{o}$C and air-freighted to Taronga Zoo for post-mortem (n=3 chicks from two broods). In one instance, footage showed the adults removing dead chicks and this allowed us to recover those bodies.

### ***Statistical analysis***

An initial basic model for constant daily survival rate (DSR) from laying to fledgling or failure of Regent Honeyeater nests (based on a 30 day nesting period) was estimated using the R-package ‘RMark’ v2.2.2 (Laake et al. 2016), an R- interface for the nest survival model (Dinsmore et al. 2002) in the software program ‘MARK’ (Cooch and White, 2005). We then included concealment and height in a second and third model respectively to calculate if DSR varies with these covariates. Only those nests that reached the egg stage were included in analyses. As two pairs reached the egg stage twice, we first ran all models with the complete data set and then re-ran the models after excluding the second of each of these nests to assess the influence of repeated measures. Akaike’s information criterion corrected for small sample sizes (AICc) was used for model selection (Shaffer, 2004). Means +/_ one standard deviation are presented throughout this paper.

## 4. Results

Twenty-eight nesting attempts by 13 pairs (26 individuals as all pairs remained unchanged through the study) were recorded during the 2015 breeding season (Table 1). There was a mean of 2.2 +/- 1 nests per pair (range 1-4). Ten of these nest attempts, from seven different pairs, were subsequently filmed. Two nests that were filmed never received eggs, and two nests that reached the egg stage were not filmed. In total 10 nests reached at least the egg stage and were used in our DSR analysis.

***Timing of breeding***

The first pairing was confirmed on 1st July 2015, 78 days after the birds were released. At this date 78% of the released individuals (60 of 77 birds), and 86% of those known to be alive (60 of 69 birds) were being regularly sighted. Most pair bonds were confirmed during August (54%, 7/13). By the end of August almost half of all released birds (45%, 35/77) were no longer being detected in the area, most likely due to a combination of mortality, dispersal and transmitter loss. For example by 31st August 2015 10 transmitters had been recovered in settings that indicated the focal bird had died (e.g. a mass of feathers and/or bones). Once a pair had secured a breeding territory, the male typically ceased to call and the pair became increasingly difficult to detect. We therefore assume breeding attempts from additional unmonitored pairs occurred. The first nest to reach the egg stage was recorded on 23rd August 2015, 131 days after birds were released.

***Characteristics of nesting sites***

Nest building typically took 4-5 days, followed by a day with little activity before egg laying took place. The mean height of nests was 7.6 ± 4.8 m (range: 0.7 m in a dead stump to 16 m in a Mugga Ironbark). A total of 13 different tree and shrub species were used as nest sites (Table 1). The most commonly used tree species for nesting were Mugga Ironbark (7 of 28 nests) and Red Stringybark (5 of 28 nests). The mean distance of Regent Honeyeater nests from surface water was 61 ± 76 m.

***Causes of nest failure***

Of the 28 nest attempts monitored (both with and without video surveillance), 18 (64%) were abandoned before eggs were laid, four (14%) failed at the egg stage, four (14%) failed at the nestling stage, and two fledged young. For the 10 active nests (those that reached egg stage) the best supported DSR model was our null model, although a second model with concealment was also equally plausible ($\Delta$AIC < 2; but less than half as well supported based on model weights; see Supplementary Information, Table 1 & 2). Given a lack of influence from our predictor variables we calculated DSR from the null model as 0.95 ± 0.002, giving a nest survival probability over a 30 day nesting period of 0.21 (0.95^30= 0.21).

Five of the pairs abandoned all nest attempts and were never observed to reach the egg stage, whereas eight pairs reached at least the egg stage before failure. Causes of failure or abandonment before an egg was laid could not be ascertained. Three categories of failure at the egg or nestling stage were identified; these were mammalian predation (3/10; Sugar Glider *(Petaurus breviceps)* and Squirrel Glider (*P. norfolcensis*)), avian predation (2/10[1]; Australian Magpie *(Cracticus tibicen*) and House Sparrow (*Passer domesticus*)) (Figures 1a-d) and unexplained nestling mortality (i.e. chicks found dead in the nest or ground: 4/10). (Note that one nest had one chick predated and one chick that escaped and fledged, hence nine nests were subject to predation and two nests that successfully fledged one or more young). The results of post mortems were inconclusive for chicks found dead in nests (Taronga Zoo, unpublished data).

Video monitoring captured important information that would likely have been otherwise missed and/or misinterpreted. Both females whose eggs were predated by nocturnal marsupials returned to the nest the following morning and continued to briefly adopt a sitting position within the empty nest that resembled incubation. Without the camera this behaviour would have inferred that nest failure occurred during subsequent daylight hours. A female Regent Honeyeater was also shown to defend her nest by continuing to incubate despite attempts by a Sugar Glider to get underneath her. The glider eventually abandoned its attempt, but the eggs were predated the following night by Squirrel Gliders.

**Figures 1 near here* 

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## 5. Discussion

This study is the first to provide detail on the breeding outcomes of captive bred and released Regent Honeyeaters. Furthermore, we report the first records of native Sugar and Squirrel Gliders as nest predators of this species. Nest survival was worryingly low at 0.21 and 64% of nest attempts never reached the egg stage. Video footage has provided important information on the impact of predation to the nest success of released bird as well as documenting adult behaviour that would have otherwise been misinterpreted.

Nest abandonment prior to egg laying is not unique to Regent Honeyeaters, yet remains poorly understood (Flegeltaub et al, 2017; Beckman & Martin 2016). This may reflect a mix of inexperienced breeders in the captive-released cohort and the greater intensity of tracking individual captive-released pairs (aided by transmitters) through an entire breeding season. Furthermore, we know from observations in captivity that breeding pairs will frequently initiate multiple nests before settling and completing one (Taronga Zoo pers. comm.). Given that we did not film nests during nest building we are unable to offer additional insight into the drivers of this abandonment. Further monitoring to establish the causes of failure during the nest building phase may have merit.

Predation by native species was the principal cause of nest failure where eggs or nestlings were present. This is consistent with many previous studies that identify nest predation as a substantial threat to open-cup nesting bird species (Beckmann & McDonald 2016; Stojanovic et al. 2014). A single nest failure was attributed to the activities of an introduced avian species when a House Sparrow was filmed destroying eggs. Sugar Gliders have previously been identified as a significant, novel threat to Swift Parrots *(Lathamus discolour)* in Tasmania, where the glider is an introduced species (Stojanovic *et al.* 2014). We are not aware of any observations where Sugar Gliders or Squirrel Gliders have previously been recorded depredating the eggs of bird species within their native range. Stojanovic et al. (2014) also reported that Sugar Gliders killed and ate incubating female Swift Parrots. Whilst no predation of adult Regent Honeyeaters by gliders was recorded in our study, video footage does document two instances where gliders lunge at an incubating female Regent Honeyeater, indicative of a possible predation attempt.

We also recorded nestlings found dead in four nests with no obvious sign of predation or predator-caused nest abandonment. This is common in birds and can be attributed to various factors such as exposure to extreme weather, disease and parasites (Smith et al. 1998) and limited food availability (Jovani & Tella 2016). In order to investigate if nestling mortality could be due to extreme weather conditions we retrieved the daily temperatures for the week prior to chicks dying in the nest. The mean maximum temperature in the week prior to chick death for the first two nests was 26.6º C +/- 3.7º C, (max 32.4º C ), for the third nest it was 27º C +/-2.9ºC (max 32.4º C) and for the fourth nest it was 32.1º C +/-3.3º C (Max 36.6º C)(BOM, 2017). None of these mean maximum temperatures were substantially higher than the means for their respective months (Oct 26.9ºC and December 31.7º C). In addition, whilst post mortems were inconclusive, no apparent sign of disease was detected (Taronga Zoo unpublished data). On this basis limited food availability was considered a more plausible driver of nestling mortality than either extreme temperatures or disease. Assessment of this food limitation hypothesis is the focus of on-going research.

Whilst we acknowledge the role that human disturbance may play in nest failure, we are confident that the presence of researchers and the placement of cameras was not a significant driver of nest abandonment or failure. Cameras were only placed near nests when nest building had been completed. The birds were of captive origin and habituated to the presence of humans since hatching, however we ensured that nest-building attempts were observed from a distance. In addition, there was no evidence from the video footage that visiting predators were aware of, or attracted specifically to, the cameras.

The seemingly poor nest success we have recorded in reintroduced Regent Honeyeaters is concerning. There are no known records of nest success rates prior to significant population declines, however previous studies on the breeding biology of wild Regent Honeyeaters have reported much higher rates than found in this study: 46% (Geering and French 1998) and 38.3% (Oliver *et al.* 1998). It may be that captive bred birds, with no prior breeding experience, are particularly naïve to nest building, nest defence, and feeding of young in wild settings. Surviving birds might therefore be expected to improve in future breeding attempts. However recent observations of wild breeding birds have also reported high rates of failure, seemingly due to predation (R. Crates pers. comm.). Taken together these observations suggest poor reproduction is a proximate limiting factor for the Regent Honeyeater population and not solely related to birds in our study being captive-bred and reproductively naïve.

Knowing that low rates of reproduction may be an important limiting factor in the recovery of Regent Honeyeaters means it can become the focus of management. Our study offers critical insight into the causes of nest failure and suggests targets for possible intervention. We have highlighted two separate areas of concern. Firstly we provide direct evidence for predation by mammals and birds. Secondly, we document nestling mortality that did not appear to be related to disease or temperature extremes and may be due to starvation. Developing interventions and testing their utility requires care and needs to consider the objectives of management (Canessa *et al.* 2016). Furthermore, appropriate interventions need to consider other affected groups and species. For example, control of predators through culling or translocation is unlikely to be acceptable because most identified predators were native species, and some such as the Squirrel Glider are considered regionally threatened. Alternatively, management actions may consider strategies such as predator surveys in the planned release area to assess predation risk (Chalfoun & Martin, 2009) or barriers at nests that prevent or reduce predator access (Homeberger et al, 2017).

Either way, managers of the Critically Endangered Regent Honeyeater are now better informed regarding the causes of poor reproductive success and are thus better positioned to develop, deploy and monitor an appropriate management strategy.

Acknowledgements

This work was conducted under Department of Environment, Land, Water and Planning (DELWP) permit 10007525, DELWP Animal Ethics permit 14.22, Australian National University Animal Ethics permit A2015/28 and the Australian Bird and Bat Banding Scheme. This work was supported through funding by the DELWP Hume Region, the Victorian Government, the Australian Government's National Landcare Program, BirdLife Australia, the New South Wales Government through its Environmental Trust, the Natural Environment Research Council through The Institute of Zoology and The University College London as part of the London Doctoral Training Partnership, and Taronga Zoo. Tree climbing expertise and training was provided by Grant Harris at Ironbark Environmental Arboriculture. Additional support was provided by DELWP, Parks Victoria, other participants in the recovery program and numerous volunteers.

References


Armstrong, D. P., Raeburn, E. H., Powlesland, R. G., Howard, M., Christensen, B., and Ewen, J. G. (2002). Obtaining meaningful comparisons of nest success: Data from New Zealand robin (*Petroica australis*) populations. *New Zealand Journal of Ecology* **26**, 1–13.

Ashbrook, K., Taylor, A., Jane, L., Carter, I., and Székely, T. (2015). Impacts of survival and reproductive success on the long-term population viability of reintroduced great bustards Otis tarda in the UK. *Oryx*, 1–10. doi:10.1017/S0030605315000368

Beckmann, C., and McDonald, P. G. (2016). Placement of re-nests following predation: Are birds managing risk? *Emu* **116**, 9–13. doi:10.1071/MU15064

Beckmann, C., and Martin, K. (2016). Testing hypotheses about the function of repeated nest abandonment as a life history strategy in a passerine bird. *Ibis* **158**, 335–342. doi:10.1111/ibi.12361

Blake, B., and Reid, J. (2002). The Dhudhuroa language of northeastern Victoria: a description based on historical sources. *Aboriginal History 26:(177)-210* **26**, 177–210.

B. O. M. (2017). Climate Summaries [Online]. Available: http://www.bom.gov.au/climate/current/ [Accessed 08 July 2017].

Canessa, S., Guillera-Arroita, G., Lahoz-Monfort, J. J., Southwell, D. M., Armstrong, D. P., Chadès, I., Lacy, R. C., and Converse, S. J. (2016). Adaptive management for improving species conservation across the captive-wild spectrum. *Biological Conservation* **199**, 123–131. doi:10.1016/j.biocon.2016.04.026

Chalfoun, A. D., and Martin, T. E. (2009). Habitat structure mediates predation risk for sedentary prey: Experimental tests of alternative hypotheses. *Journal of Animal Ecology* **78**, 497–503.

doi:10.1111/j.1365-2656.2008.01506.x

Cooch, E. and White, G. (2001). Program Mark. A Gentle Introduction. Available at http://www. phidot. org/software/mark/docs/book.

Crates, R., Terauds, A., Rayner, L., Stojanovic, D., Heinsohn, R., Ingwersen, D., and Webb, M. (2017). An Occupancy Approach To Monitoring Regent Honeyeaters. *The Journal of Wildlife Management* **DOI: 10.10**, 1–9. doi:10.1002/jwmg.21222

Dinsmore, S. J., White, G. C., and Knopf, F. L. (2002). Advanced Techniques for Modeling Avian Nest Survival. *Ecology* **83**, 3476–3488. doi:10.1890/0012-9658

Flegeltaub, M., Biro, P. A., and Beckmann, C. (2017). Avian nest abandonment prior to laying—a strategy to minimize predation risk? *Journal of Ornithology* **158**, 1091–1098. doi:10.1007/s10336-017-1470-7

Frei, B., Nocera, J. J., and Fyles, J. W. (2015). Interspecific competition and nest survival of the threatened Red-headed Woodpecker. *Journal of Ornithology* **156**, 743–753. doi:10.1007/s10336-015-1177-6

Garnett ST, Szabo JK, Dutson G (2010) The Action Plan for Australian Birds 2010. CSIRO Publishing, Melbourne

Geering, D., and French, K. (1998). Breeding Biology of the Regent Honeyeater Xanthomyza phrygia in the Capertee Valley, New South Wales. *Area* **98**, 104–116.

Homberger, B., Duplain, J., Jenny, M., and Jenni, L. (2017). Agri-evironmental schemes and active nest protection can increase hatching success of a reintroduced farmland bird species. *Landscape and Urban Planning* **161**, 44–51. 1 doi:10.1016/j.landurbplan.2017.01.00

Ibáñez-Álamo, J. D., Magrath, R. D., Oteyza, J. C., Chalfoun, A. D., Haff, T. M., Schmidt, K. A., Thomson, R. L., and Martin, T. E. (2015). Nest predation research: recent findings and future perspectives. *Journal of Ornithology* **156**, 247–262. doi:10.1007/s10336-015-1207-4

Jovani, R., and Tella, J. L. (2016). Age-Related Environmental Sensitivity and Weather Mediated Nestling Mortality in White Storks Ciconia ciconia. *Nordic Society Oikos* **27**, 611–618.

Laake, J., Rakimberdiev, E., Collier, B., Rotella, J. & Paul, A., 2016. RMark: R Code for MARK Analysis. R package version 2.2.2. https://cran.r-project.org/web/packages/RMark/index.html

Lahti, D. C. (2001). The 'edge effect on nest predation' hypothesis after twenty years. *Biological Conservation* **99**, 365–374. doi:10.1016/S0006-3207(00)00222-6

Lee, J. K., and Lima, S. L. (2016). Nest building under the risk of predation: Safe nests are not always the best option. *Journal of Avian Biology*, 1–11. doi:10.1111/jav.00958

Mac Nally, R., Soderquist, T. R., and Tzaros, C. (2000). The conservation value of mesic gullies in dry forest landscapes: Avian assemblages in the box-ironbark ecosystem of southern Australia. *Biological Conservation* **93**, 293–302. doi:10.1016/S0006-3207(99)00154-8

Major, R. E., Ashcroft, M. B., and Davis, A. (2014). Nest caging as a conservation tool for threatened songbirds. *Wildlife Research* **41**, 598–605. doi:10.1071/WR14136

Martin, T. E. (1995) 'Avian Life-History Evolution in Relation to Nest Sites, Nest Predation, and Food'.Ecological Monographs 65 (1), pp.101-107

Moseby, K. E., Blumstein, D. T., and Letnic, M. (2015). Harnessing natural selection to tackle the problem of prey naivete. *Evolutionary Applications* **9**, 334–343. doi:10.1111/eva.12332

Oliver, L. D., Ley, J. A., and Williams, B. (1998). Breeding Success and Nest Site Selection of the Regent Honeyeater Xanthomyza phrygia near Armidale, New South Wales. *Emu* **98**, 97–103.

Ricklefs, R. E. (1969). An analysis of nesting mortality in birds. Smithsonian Institution Press.

Shaffer, T. L. (2004). A Unified Approach to Analyzing Nest Success Author. *American Ornithological Society* **121**, 526–540.

Scott-Baumann, J. F., and Morgan, E. R. (2015). A review of the nest protection hypothesis: does inclusion of fresh green plant material in birds' nests reduce parasite infestation? *Parasitology* **142**, 1016–1023. doi:10.1017/S0031182015000189

Sherley, R. B., Barham, P. J., Barham, B. J., Crawford, R. J. M., Dyer, B. M., Leshoro, T. M., Makhado, A. B., Upfold, L., and Underhill, L. G. (2014). Growth and decline of a penguin colony and the influence on nesting density and reproductive success. *Population Ecology* **56**, 119–128. doi:10.1007/s10144-013-0394-1

Smith, R. N., Cain, S. L., Anderson, S. H., Dunk, J. R., and Williams, E. S. (1998). Blackfly-induced mortality of nestling red-tailed hawks. *The Auk* **115**, 368–375. doi:10.2307/4089195

Stojanovic, D., Webb, M. H., Alderman, R., Porfirio, L. L., and Heinsohn, R. (2014). Discovery of a novel predator reveals extreme but highly variable mortality for an endangered migratory bird. *Diversity and Distributions* **20**, 1200–1207. doi:10.1111/ddi.12214

Wei, H., Liang, W., Li, D., Zhang, Z., and Stokke, B. G. (2015). Oriental reed warbler (*Acrocephalus orientalis*) nest defence behaviour towards brood parasites and nest predators. *Behaviour* **152**, 1601–1621. doi:10.1163/1568539X-00003295


Figure1 . Selected video frames showing (a&b) a Sugar Glider *(P. breviceps)* climbing on the branch where a Regent Honeyeater is incubating (circled), before flushing her off the nest and consuming the egg. (c&d) showing an adult male Australian Magpie attacking two Regent Honeyeater nestlings. In the second frame a Regent Honeyeater can be seen defending the nestlings (circled).