Using decision analysis to develop a framework for nest protection for threatened birds

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SUPPLEMENTARY TABLE 1a Number of participants by category at the brainstorm session held online on the 26th April 2022

Audience	**Number of attendees by category**
Advocacy	3
Government	6
Zoological institution	8
Researchers/Academic	8
Industry	2
Total Participants	**27**

SUPPLEMENTARY TABLE 1b Summary of the case-study information presented at the brainstorm session.

Case study 1: Olfactory misinformation training for mammalian predators (Peter Banks, University of Sydney)
Mammalian predators typically follow a sequence of events where predators encounter and detect their prey, identify if it is what they want, approach and subjugate their prey and then consume them. We expect larger gains (for predator success and prey survival) if the interventions are encountered early in the sequence of the events. Several small mammalian predators rely on olfactory cue to find prey, i.e., they find their prey through smell (Bytheway, Carthey et al. 2013). Food is a strong motivator, predators need to sift through vast amounts of information and ignore the unrewarding information, focussing on cues that offer rewards, in this case food. The concept is to make the information that they normally use, unrewarding for them, making it so that they don't get the reward when they pursue that particular component of information, and the information will then blend into the background. The concept is that you are breaking down the strong association between the information that the predators want in order to find their prey. From here, the target food becomes unprofitable for predators, and they have to eat an alternative source of prey.

Case Study 2 – Taste aversion training to protect nesting Hooded Plovers (*Grainne Maguire, BirdLife Australia)*
Hooded Plovers are experiencing population decline and that is largely driven by poor breeding success. A large proportion of human-based threats have been overcome through physical protection of breeding sites, community engagement and behavioural change. However, predation now is the major barrier for the recovery of the species. Across the Victorian coast, 59% of the nests failed and predators were the main cause of failure, with foxes, ravens and magpies being the major predators. Cameras used to monitor nests have inadvertently attracted predators, who have begun to associate cameras with the presence of a nest, so very strict measures have been developed for their use. The agent used in taste aversion training should be odourless and tasteless so predators will avoid the food type, not the agent. The subject animal that you choose must be capable of prey switching obviously for its own survival and the subject animal needs to have a strong negative response or an extended and repeated response to that illness, so that overcomes that memory of a familiar food item like eggs. Condition taste aversion training has had mixed and limited success, with more success reported on a small scale, and in a region dominated by foxes. Condition taste aversion did not produce positive results on a broad scale with mixed predators.
Case study 3: Physical barriers around nests to deter predators (Paul McDonald, University of New England)
There are several bird species that build nests, and then, for whatever reason, the female moves on, and nests are not laid in, and these nest attempts we term 'false' or 'fake nests' and they are commonly seen in Australian birds. These 'fake nests' or 'ancillary nests' (Macqueen and Ruxton 2023) are reported in Regent Honeyeaters. Building physical barriers around nests for bell miners and noisy miners involved using adapter chicken wire and sneaking up on it over the course of three or four stages, starting with a base and putting that in the sides underneath the cup nest and then over the course of every 24 hours, adding another segment, and then you end up with a ball, with a small hole for the female to go through for nest attendance. There were mixed results, from the six nest barriers built, there were two nests that were abandoned for both species, but four were accepted for both, but given these small numbers it is difficult to understand its effectiveness. Overall building a physical barrier around an open cup nest is logistically quite challenging and labour intensive and would need approximately four to six visits to build a nest barrier for Regent Honeyeaters. Importantly, putting a structure around the nest, may potentially attract predators to the area, and is a risk.
Case Study 4: Acoustic deterrent of nuisance animals (Heather Crawford, Murdoch University)
The use of ultrasonic deterrents to prevent nuisance cat activity in people's backyards in urban areas was discussed. Commercial ultrasonic devices, that are not heard by humans, are triggered by motion, and will emit the ultrasound signal. The signal is supposed to elicit fear in animals, making it avoid the area, however, there is the expectation that there is no long-term harm to cats/ animals. The devices are low-cost and accessible to the general public, sold in major hardware stores. Results indicate that it may be a temporary displacement tool, effective for periods of up to two weeks in cats. There is no evidence of birds responding to ultrasound from devices. They are a good first step towards reducing human wildlife conflict in urban areas, but further research is warranted to determine their effectiveness.

SUPPLEMENTARY TABLE 2 Number of participants by category at the pre-expert elicitation meeting held online on the 14th July 2022

Audience	Number of attendees by category
Not-for-profit organisation	1
Zoological institution	6
Researchers/Academic	2
Total Participants	**9**

SUPPLEMENTARY TABLE 3 Number of participants by category at the formal expert elicitation Regent Honeyeater nest protection meeting held online on the 29th July 2022

Audience	Number of attendees by category
Not-for-profit organisation	2
Zoological institution	6
Researchers/Academic	3
Government	4
Total Participants	**15**

SUPPLEMENTARY TABLE 4 Number of participants by category at the future planning meeting held online on 15th August 2022

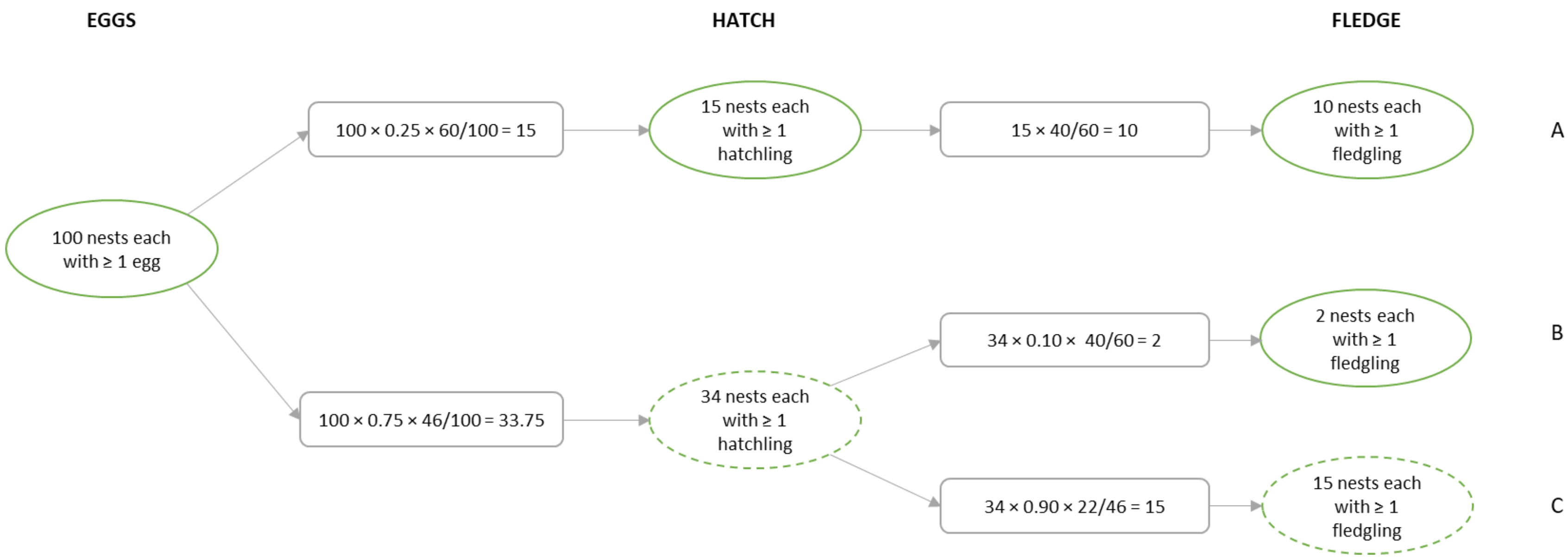
Audience	Number of attendees by category
Not-for-profit organisation	2
Zoological institution	3
Researchers/Academic	1
Total Participants	**6**

Supplementary Material 1 Logic tree for calculation of nest success with imperfect detection

Let’s say we’re interested in calculating the overall success rate of nests for recently released birds under noisy miner control, where the overall rate includes nests that are detected (and targeted for noisy miner control) and those that are not detected (for which no action is implemented). For illustration, we’re interested in the calculation under scenario 3, where 25% of nests are detected up to hatching, and an additional 10% between hatching and fledging.
Outcomes for those that are not detected will be consistent with the base case, where expert judgments estimate that of 100 nests, 46 progress to hatching stage, and 22 succeed to fledging. For those that are detected, and where we deploy noisy miner control, 60 progress to hatching stage, and 40 succeed to fledging. The overall success rate to fledging is the sum of the three branches shown in the logic tree below, where:

- Branch A is the subset of nests detected up to hatching.
- Branch B is the subset of nests that are detected from hatching to fledging, and
- Branch C is the subset of nests that go undetected and unprotected throughout.

The total number of nests expected to succeed to fledging out of 100, is 10 + 2 + 15 = 27, or 0.27.



SUPPLEMENTARY MATERIAL 2 Nest success under multiple actions

Under active protective management, a nest can succeed to fledging at least one individual if,

- it is (partially) protected from avian predation, OR
- it is (partially) protected from mammalian predation, OR
- it is (partially) protected from extreme weather, OR,
- it is (partially) protected from competition, OR,
- it would have succeeded anyway without protection (consistent with the base case success rate).

If two events are independent, then the chance that either one OR the other, OR both, will occur, is

$p(A \cup B) = p(A) + p(B) - p(A \cap B)$,

where

$p(A \cap B) = p(A)p(B)$.

For three events, A, B, and C, the chance of (A, B OR C) is given by

$p(A \cup B \cup C) = p(A) + p(B) + p(C) - p(A \cap B) - p(A \cap C) - p(B \cap C) + p(A \cap B \cap C)$.

Over n events, this expression simplifies to

$$1 - \prod_{i=1}^{n}(1 - p_i).$$

This expression is used to calculate success rates of nests (assuming detection) that are protected through simultaneous deployment of multiple ideas.

References

Bytheway, J. P., A. J. R. Carthey and P. B. Banks (2013). "Risk vs. reward: how predators and prey respond to aging olfactory cues." Behavioral Ecology and Sociobiology **67**(5): 715-725.

Macqueen, E. I. and G. D. Ruxton (2023). "The adaptive function of construction of multiple non-breeding nests in birds." **165**(1): 1-16.