An artificial bird nest experiment in urban environments: Lessons from a school-based citizen science programme

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Abstract Maintaining suitable vegetation within urban environments is crucial for wildlife conservation in the face of anthropogenic habitat change. Here, we report on a citizen science project, involving students from seven schools across south-eastern Australia, that investigated the effectiveness of urban vegetation as habitat for bird nests. The ‘nest concealment hypothesis’ posits that vegetation should obscure the nest from predator detection, thus reducing the likelihood of predation. To test this, participating school-aged citizen scientists constructed artificial nests, which were placed in garden trees within school grounds and monitored for signs of predation. We found no evidence to support the nest concealment hypothesis, with no relationship between the density of vegetation immediately surrounding a nest and its likelihood of predation (binomial model: $\chi^2 = 1.714$, $P = 0.190$). It was observed that 80% of the nests experienced predation. This aligns with mounting evidence suggesting that other factors, such as olfaction and adult defence, may be more important factors in the protection of bird nests. It is important to note that artificial nests are unreliable, and therefore, the veracity of the overall conclusions is limited. However, in conducting this experiment, we demonstrate the suitability of this method as a school-based citizen science activity. This study exemplifies that field-based experiments can used to engage future generations with conservation science.

Key words: artificial nest, citizen science, nest predation, school-based citizen science, urban vegetation.

INTRODUCTION

Anthropogenic habitat change imposes strong selective pressures on nesting success for small open-nesting bird species (Vetter et al. 2013). Urban vegetation can vary considerably along the urban gradient, and nests are more susceptible to predation in areas of reduced vegetation cover (Huhta et al. 2000). The ‘nest concealment hypothesis’ suggests that bird nests obscured from predators’ view, such as among dense foliage, should be protected from predation (Martin 1993). Support for this hypothesis varies, with manipulative experiments using artificial nests finding that nest concealment either decreased the likelihood of predation (Jokimäki & Huhta 2000; Colombelli-Négrel & Kleindorfer 2009; Jokimäki & Huhta 2000; Colombelli-Négrel & Kleindorfer 2009) or provided no significant protection (Borgmann & Conway 2016; Fleverwaub et al. 2017). Given this disparity, understanding how birds in urban environments are affected by the vegetation available for nest placement is critically important for informing ecological urban planning (Garrard et al. 2018). However, as urban environments are dominated by private dwellings and significant infrastructure, applying traditional data collection methods at a large spatial scale is difficult. Data from citizen scientists have the potential to address this, and school-based citizen science programmes provide important educational opportunities for children to engage in science (Kobori et al. 2016; Saunders et al. 2018). Simple study designs, appropriate training and the recruitment of participants that have an active stake in the

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research can potentially generate higher-quality citizen science data (Aceves-Bueno et al. 2017).

Here, we report on a school-based citizen science research programme using a field experiment to investigate two aims. First, we investigated if artificial nests placed within dense foliage would be less likely to show signs of predation compared to nests placed among less dense foliage. Secondly, we determined whether artificial nests placed within dense foliage would survive longer before signs of predation appeared compared to nests placed among less dense foliage. As per the ‘nest concealment hypothesis’, we predicted that artificial nests placed within dense foliage would be less likely to show signs of predation and/or would survive longer before signs of predation appeared. Additionally, we discuss the potential of school-based citizen science programmes to collect robust data to further our collective scientific understanding.

METHODS

Programme details and approach

Six scientists, all recipients of the 2017 Office of Environment and Heritage/Ecological Society of Australia Prize for Outstanding Outreach (Saunders et al. 2018; Soanes et al. 2020), were supported, along with another scientist involved in coordinating the prize (E.R.), to undertake a science outreach project. We recruited seven schools from towns and cities across south-eastern Australia (see Acknowledgements), including Coffs Harbour, Sydney, Canberra and rural Victoria. All schools gave informed consent for their students to participate in the activity. Participating students were in year 3 at one school (aged 7–8), years 3–6 at three of the schools (aged 7–12), year 5 at one school (aged 10–11) and years 7–8 at one school (aged 12–14).

Introducing students to the experiment

Each scientist conducted between two and four visits with their participating school between February and May 2018. The scientists worked with students to conduct the experiment, ensuring that the methods were accurately replicated across schools. Students were first introduced to concepts related to urban ecology of native birds, to stimulate discussions towards understanding the project aims. Next, the scientist explained the experimental methods and assisted students in making and deploying artificial nests in vegetation around their schoolyard. Students then monitored their nests independently, with the scientists only returning after the experiment was concluded to collect data and discuss results.

Experimental design and sampling method

We employed an artificial nest design that is commonly used to simulate the open-cup nests of small birds (e.g. Beggs et al. 2019; Fig. 1a). Up to 30 artificial nests per school (total n = 184) were constructed by cutting a tennis ball in half and covering each half with coconut fibre. Each nest contained two artificial eggs (2 cm diameter) made from white plasticine and were prepared using latex gloves to limit human odour contamination.

Under guidance, students haphazardly placed their nests in trees and shrubs around their schoolyards. The vegetation in which nests were placed varied both within and among each school and included gardens of non-native species and semi-natural plantings of native species. Scientists observed that all sites were potential habitat for rodent and bird species, though some school yards contained enough native vegetation to potentially support large reptile species such as blue-tongued lizards (Tiliqua scincoides). To ensure a more-or-less even spread of vegetation density across the experiment, we instructed students to place their nests in trees with either low, medium or high vegetation cover. Students were instructed to place nests between 0.5 and 1.5 m off the ground. Students estimated the density of vegetation surrounding each nest using a 50 × 50 cm piece of white card marked with a 10 × 10 cm grid (25 squares). The card was held directly behind the artificial nest while an observer, standing 5 m away in front of the nest, counted how many squares were (i) not obscured by vegetation at all, (ii) partially obscured [<50%] by vegetation and (iii) ‘fully’ obscured [%50]% by vegetation. For each square, we ascribed scores of 0, 0.5 and 1 to each of these conditions.

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respectively and summed these values to calculate a continuous variable of percentage ‘vegetation density’.

Students checked their nest daily for signs of predation for up to 10 days. Where a monitoring day occurred on a weekend, either the scientist or a teacher monitored the nests. A predation event was noted when predation marks were observed on either egg, or at least one egg was missing, and the nest was immediately withdrawn from the experiment. On the tenth day, all surviving nests were recorded as receiving ‘no predation’. Where possible, we identified the type of nest predator (i.e. bird or mammal) based on marks left on the predated egg.

Statistical analysis

We tested whether vegetation density affected the overall likelihood of nest predation using a binomial logistic regression model, accounting for ‘study site’ (each individual school) as a random factor. We tested for a relationship between vegetation density and day to predation using a generalised linear mixed model, assuming a Poisson distribution and including ‘study site’ as a random factor. We fitted our models using the ‘lme4’ package (Bates et al. 2014) in R version 3.3.3 (R Core Team 2017).

Ethics statement

All procedures used in this experiment were approved by the Australian National University Animal Ethics Committee (AEC project number A2018/14).

RESULTS

Nest predation experiment

Of the 184 nests that were deployed, 120 were monitored sufficiently to include as data points. The remainder (64 nests) were either lost, not monitored daily due to time or weather constraints, or suffered suspected human interference (Fig. 1b). Of this total, 98 nests (82%) showed evidence of predation, either by predation marks on the eggs, the removal of eggs or movement of nests. The remaining 24 nests showed no signs of predation throughout the entire experiment. Of the 44 nests that were noted as having predation marks, 12 could be confidently attributed to bird beaks and 8 to mammal teeth (Fig. 1c,d). The average number of days until a predation event was 3.99 \pm 3.1 (SD); however, this varied markedly among sites (see Appendix S1). The likelihood of predation was significantly different among sites ($\chi^2 = 23.558$, df = 6, $P < 0.001$).

We found no evidence for an effect of vegetation density on the likelihood of overall predation (binomial model: $\chi^2 = 1.714$, $P = 0.190$; Fig. 2). We detected a positive, although non-significant, relationship between vegetation density and the number of days until nests were predated (GLMER: $\chi^2 = 3.428$, $P = 0.064$; Fig. 3).

DISCUSSION

Vegetation density effects on nest predation

In contrast to the ‘nest concealment hypothesis’, vegetation density did not significantly affect the susceptibility of artificial nests to predation in our study. However, there was a possible trend towards nests in higher-density vegetation being predated later (Fig. 3). Evidence for the ‘nest concealment hypothesis’ is equivocal in the published literature and may depend on multiple factors, including predator type, seasonality and bird plumage (Colombelli-Négrel & Kleindorfer 2009; Borgmann & Conway 2016). A recent meta-analysis of studies on open-cup nesting songbirds concluded that most studies failed to support the hypothesis, with methodological aspects influencing whether such support was found (e.g. many studies failed to standardise a quantitative measure of foliage density; Borgmann & Conway 2016).

Our high rates of nest predation (80%) could be partly attributed to biases associated with artificial
nest experiments. Unlike natural nests, artificial nests cannot account for parental nest defence and are often presented to predators in higher densities than normal, therefore overinflating the proportion of predation (see Fulton 2018). Furthermore, most schoolyard vegetation is confined to isolated patches of habitat in an urban matrix, which tend to harbour higher densities of predators (Haskell et al. 2001; Sorace 2002).

In our study, predator identification from plasticine markings was limited to only a small subset of the data. Additional predator identification techniques, such as camera trapping, could provide important information on the spatial and temporal patterns of nest predators (Kruger et al. 2018). Furthermore, our study did not control for different types of vegetation and diversity of predators. City, peri-urban and rural schools are likely to have different assemblages of predators; thus, these factors likely contributed to both the variability among schools and the non-significant effects of vegetation density on time to predation.

School-based citizen science for artificial nest experiments

Backyard-based citizen science projects often suffer from sampling bias (Evans et al. 2005; Garrard et al. 2018), which we sought to avoid by restricting our study to schoolyards. Schoolyards are not often considered in urban planning, though they could provide critical habitat for wildlife (Evans et al. 2005; Garrard et al. 2018). Our study also allowed us to make research accessible to school-aged citizen scientists. We demonstrate that school-aged citizen scientists can collect scientific data to address questions related to the conservation value of schoolyards, providing the experiments are appropriately designed and students receive adequate support. Collaborating with schools provided a useful way to engage students with conservation issues, along with an introduction to the scientific method. Scientists have consistently recognised the need for more involvement in public education including educating students in data collection and critical thinking, as an ecologically literate public is an important aspect of ensuring a sustainable future.

The number of citizen science publications has grown (Blackawton et al. 2011; Akres et al. 2016; Saunders et al. 2018). However, it is important to design citizen science experiments to ensure that the data collected are accurate and reliable. We designed an experiment that was simple enough to be conducted by students without direct supervision and yet appropriate enough to provide robust data. Nevertheless, we experienced several challenges that were not necessarily unique to working with students. For example, several nests at one school were removed, while some students forgot their nest location, or were unable to check nests consistently. Other complications included students misidentifying predator marks or not recognising predation when it had occurred. This could be remedied in future studies through stricter oversight by scientists or by instructing students to take daily photographs of their nests. Our methods were perhaps better suited to older students (aged 10 to 14) who could more reliably

Fig. 3. Relationship (showing LOESS curve) between vegetation density around nests and the number of days until they showed evidence of predation, with no evidence for a significant correlation (GLMER: $\chi^2 = 3.428, P = 0.064$).

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sample and remember the location of their nests. One school participated in the study as part of their voluntary senior science club, ensuring that all students had an existing interest for science and undertook the experiment with vested student and teacher interest. This school successfully monitored all 30 of their nests. Overall, our monitoring success rate was high (68%), and regular contact with scientists likely contributed to this high level of engagement.

CONCLUSION

We found some support that vegetation density affects the time to predation on artificial bird nests in urban schoolyards. We recommend further study into quantifying native vegetation within Australian schoolyards, at regional, state and national scales, to understand the conservation value of these environments relative to surrounding urban matrices. Using a citizen science approach enabled us to survey across a wide geographic range while also engaging students in scientific research and conservation education. Citizen science projects offer one potential avenue for younger generations to connect with, and form an affinity for, nature conservation (Louv 2008). By engaging with scientists, students can successfully test specific and current hypotheses regarding the conservation of bird nests in urban habitats. Future citizen science projects could include other factors that may affect bird nest predation, such as monitoring the behaviour of predators and observing adult nest defence and vigilance behaviours.

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AUTHOR CONTRIBUTIONS


REFERENCES


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**SUPPORTING INFORMATION**

Additional supporting information may/can be found online in the supporting information tab for this article.

**Appendix S1.** Between-site variation in days to predation on artificial nests. Sites are ordered by increasing latitude (ranging from 37°47’32.0”S to 30°11’20.8”S).

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