Inter-relationships between composition, insulation and water-proofing of domed nests constructed by the long-tailed tit (*Aegithalos caudatus*).

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Abstract

Bird nests are where eggs are incubated and chicks are reared. They exhibit significant variation in design and material composition, often attributed to environmental differences; species might adapt their nests to counteract weather conditions and facilitate offspring survival. The extent to which composition relates to function is not fully understood. Research into the thermal and hydrological properties of nests has been conducted in numerous songbirds, however, more complex, domed nests, such as long-tailed tit nests (Aegithalos caudatus) have not been studied. We examined 15 long-tailed tit nests; temperature loggers obtained insulatory values, while simulated rainfall and nest weighing determined water-proofing capabilities. Nests were then deconstructed, with each region separated and materials individually weighed. They showed clear demarcation; with linings dominated by feathers and outer regions predominantly consisting of moss and lichen. Nest mass and composition did not affect the insulation provided, water absorbed or drying time. These findings contradict those found in other species nests; the reason for this is unclear. Further study could sample long-tailed tit nests from other geographical locations to establish whether variation exists in response to different weather conditions. Additionally, other species with domed nests could be examined, to compare composition and function with long-tailed tits.

Keywords: Avian reproduction, long-tailed tit, nest composition, incubation, waterproofing

Introduction

In February 2022, I approached my programme leader, to show my interest in volunteering opportunities alongside my studies. This was to further develop my skills and gain experience in the field of research, a career path I hope to follow. Through my enjoyment of a recent module in my degree, I had become fascinated by avian reproduction. To facilitate my role in research, I applied for the Undergraduate Research Opportunities Scheme (UROS), which provides funding through the 'Student as Producer' model for participation in research with an academic. In June

2022, with Charles Deeming as my supervisor, we collaborated on a project, looking into bird nests, their composition and how it relates to function. Initial plans were to examine several species of songbird; in the end we decided to focus the study on one species, long-tailed tits (*Aegithalos caudatus*).

Project Background

Bird nests are vital in avian reproduction, providing a location for holding and incubating eggs, while offering protection from weather conditions and predation. Nests constructed by songbirds exhibit substantial variation in size, shape and composition. From basic woven grass cups to complex layered designs, the proportion of materials used and the extent to which diversity relates to function is not fully understood (Deeming and Mainwaring, 2015).

Over 11 years, research at the University of Lincoln has improved understanding of how nest structure relates to function, showing that mass and material proportions relate to nest water-proofing and insulatory properties (Biddle *et al*., 2019; Deeming *et al*., 2020). The nests of only 30 songbird species have been studied, out of approximately 5,000, leaving many questions unanswered about the significant diversity in nest design.

Long-tailed tits build elaborate domed nests, composed of moss and lichen, woven with spider silk and filled with feathers. Without quantifiable data on the materials present, more is needed on how their nest structure impacts incubation or withstands environmental pressures (McGowan *et al*., 2004). Exploring how composition relates to function in this and other species will provide understanding of the evolutionary drivers of nest design and how climate change may impact avian reproduction.

Review of literature

Research by Deeming and Mainwaring (2015) found differences in nest size, structure and composition across songbird species, indicating plasticity in material choice, where variability in design is related to environmental conditions. This plastic response may reflect species-specific effects, such as breeding location.

A study by Gray and Deeming (2017) found species differences in nest mass, diameter and wall thickness, yet no correlation between wall thickness and thermal properties. Nests with a larger mass produced greater insulatory values, indicating that thermal properties are more influenced by nest mass than composition.

Research by Biddle *et al*. (2019) showed significant relationships between nest materials used and the amount of water absorbed, or the time taken to dry. Moss absorbed substantially more water and took significantly longer to dry than other materials. Additionally, larger nests absorbed more water and took longer to dry.

Deeming *et al*. (2020) used similar methodology and found that insulatory values significantly correlated with feather and moss proportions; insulatory values were also significantly influenced by nest base thickness and overall mass.

With long-tailed tits, limited research exists. McGowan *et al.* (2004) examined the structure and function of their nests, including thermoregulatory properties in relation to varying feather proportions. Nests showed clear demarcation and feathers comprised a substantial part of the overall nest mass. Feather mass significantly impacted nest insulation quality; smaller nests with greater feather mass insulated more efficiently. However, mass did not influence insulatory efficiency in larger nests.

Long-tailed tits use lichen extensively on the surface of their nests, but the reasoning for lichen use on birds nests remains a debated topic. Research from Hansel (1996) suggests that it is a means of avoiding predation, concealing nests by background matching.

Methodology

Prior to the research, I built upon my knowledge of avian reproduction and egg incubation from my undergraduate degree content, with particular focus on papers written by Deeming as part of his research conducted at the University of Lincoln.

The nests of 15 long-tailed tits were collected during 2021 and donated by Professor Ben Hatchwell of the University of Sheffield. Methodologies used in this project reflect those previously used by Biddle *et al*., 2019; Deeming *et al*., 2020, with similar results anticipated, despite species differences in nest design.

Firstly, to obtain insulatory values, temperature loggers (iButtons) were heated to 80°C in a water bath, then dried and placed on polystyrene podiums. Each nest was inverted and placed on a podium, with contact between the iButton and the inner cup base. Another iButton and podium without a nest acted as a control. Temperatures were recorded every minute, until loggers had dropped to room temperature. This was repeated 3 times for each nest inside a closed box, to reduce the influence of air movement.

To collect hydrological data, dry nest mass was measured, then nests were inverted and situated in sieves over bowls. 250ml of water was poured over each nest from 30cm above, by rotating a coffee percolator sieve cup to simulate rainfall. To determine the amount of water absorbed and the time it would take them to dry, nest mass was measured after 10 minutes and subsequently every hour for 8 hours.

Finally, to begin deconstruction, feathers that filled the nest were removed, then once the outer nest and lining were distinguished, nests were carefully pulled apart using forceps. Materials from the two regions were stored separately and each material was individually bagged and weighed for composition analysis.

Results

With the long-tailed tit nests, there was clear demarcation present, with distinguishable inner and outer linings. The outer regions had a greater diversity of materials, but were constructed mostly of moss and lichen, woven together by spider silk. The inner cup was lined with many feathers. Material composition, and overall nest mass,did not affect insulatory properties, the amount of water absorbed, or the time taken to dry. The findings from this research will be published in full at a later date, in an ornithological journal.

I will be taking part in further research with my supervisor as part of the research conducted on avian reproduction and nest design at the University of Lincoln. Next, I will examine insulatory properties, water-proofing capabilities and nest composition in another domed nest species, wood warblers (*Phylloscopus sibilatrix*).

Discussion

This summer, studying independently and conducting research, with guidance from a supervisor, has been incredibly rewarding. I have learnt valuable skills, including working collaboratively in a more professional capacity and producing content of a higher standard. Additionally, using a lab throughout the summer provided me with the opportunity to work independently, where I experienced the importance of self-motivation, organisation and time management when working alone.

As part of the UROS experience, workshops provided advice and opportunities to practice presenting skills; instructor and peer feedback gave me confidence in my ability to speak publicly and effectively relay information in a short amount of time. I have been considering a career in research or teaching after my degree, in both cases I would need to be confident and considered in how I present information, which I now feel more experienced in and feel I can build upon due to the guidance provided by UROS and my supervisor. Taking part in UROS has prepared me well for the rest of my degree, particularly regarding data collection and deadlines, poster design and presenting, all of which will be crucial skills for my dissertation and research presentation.

Initially, finding relevant information on my project was more challenging than expected, due to limited research on songbird nests and lack of studies on the species I was examining, therefore, I predominantly utilised research that Charles Deeming had conducted at the University of Lincoln. While doing background research, I was amazed by descriptions of long-tailed tit nests and the complexity of their design, construction and composition. The most challenging aspect of my project was the time it took to complete data collection; each nest deconstruction took several days, insulatory value tests took 3 hours per nest and measuring nest drying times took approximately 8 hours, making data collection significantly time consuming. However, it was a valuable experience; collecting data is something I had not previously completed individually. Designing, writing and presenting my poster was highly rewarding, requiring an evolution of my scientific writing, poster design and presenting skills.

Conclusion

Overall, I am grateful that UROS provided me with a fantastic opportunity to experience completing research, from experimental design to data collection, poster design to presenting. The opportunity to work in a lab space using equipment was hugely beneficial, particularly given how students like myself missed out on practical experience during Covid-19. After his invaluable experience, I have decided to study research Masters and now hope to pursue a career in research. My project also raised questions for me about what subject I want to study after my degree; I have always loved birds and now avian reproduction; evolution and ecology are topics of significant interest to me.

The UROS experience has emphasised to me how important, challenging and rewarding it is to take part in extracurricular work outside of my degree, not just to build my CV and increase my job prospects, but also for character development and transferable skills. I have enjoyed working closely with my supervisor; I have learnt a great deal that I would not have gained from my degree alone and will undoubtedly apply in the future. I have grown as a person, and it has made me a better student. For these reasons, for anyone considering applying for UROS, I would highly recommend it.

References

Biddle, L. E., Dickinson, A. M., Broughton, R. E., Gray, L. A., Bennett, S. L., Goodman, A. M. & Deeming, D. C. (2019). Nest materials affect the hydrological properties of bird nests. *Journal of Zoology*, 309, 161-171.

Deeming, D. C. & Mainwaring, M. C. (2015). Functional properties of nests. In *Nests, eggs and incubation: new ideas about avian reproduction*: 29–49. Deeming, D.C. & Reynolds, S.J. (Eds). Oxford: Oxford University Press.

Deeming, D. C., Dickinson, A. M., Broughton, R. E., Locke, E., Gray, L. A., Bennett, S., Gilchrist, R., Muniz, S., Goodman, A. M. & Biddle, L. E. (2020). Factors affecting thermal insulation of songbird nests as measured using temperature loggers.

Physiological & Biochemical Zoology, 93, 488-504.

Gray, L. A. & Deeming, D. C. (2017). Effect of air movement on the thermal insulation of avian nests. *Bird Study,* 64, 494–501.

Hansell, M. H. (1996). The function of lichen flakes and white spider cocoons on the outer surface of birds' nests. *Journal of Natural History*, 30, 303-311.

McGowan, A., S.P. Sharp, and B.J. Hatchwell. (2004). The structure and function of nests of long-tailed tits *Aegithalos caudatus. Functional Ecology*, 18: 578–583.