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Beetle Boxes in Windsor Forest and Bredon Hill

Key Messages

- Beetle boxes are manmade structures intended to replicate deadwood habitats that support threatened saproxylic invertebrates.
- This project investigated beetle boxes that were designed to mimic hollows that form at the base of trees - the habitat of several rare invertebrate species including the endangered violet click beetle.
- 32 beetle boxes were set up across Windsor Forest and Bredon Hill.
- Different construction materials and content mixtures were trialled in the beetle boxes to determine which combinations were most suitable for future recommended use.
- So far, 41 species of beetle have been identified from samples taken from beetle boxes, 17 of which are obligate deadwood-associates.
- Several beetle species were found in beetle boxes which have particular links to ancient tree hollows. These included *Stenichnus godarti* and *Ptenidium turgidum*.
- No violet click beetles were found in the beetle boxes although this was not surprising given the short timescale of this study.
- Preliminary results suggest that the addition of poultry manure to beetle box contents makes it a more attractive habitat for a greater diversity and abundance of beetles.

Aims and origins of the boxes

When trees reach a particularly old age for their species, they can be defined as 'ancient'. At this stage they tend to develop features associated with decline and decay which are important for woodland biodiversity. Unfortunately, ancient trees and their associated deadwood features are in decline in the UK. Factors contributing to this include general fragmentation and destructive forestry practices (Stockland *et al*., 2012). However, one of the most prominent issues for these habitats is that the extensive harvesting of trees during the 18th and 19th centuries for wartime ship construction and fuel has left an age gap in UK forests (James, 1981). As a result, a whole age category of trees that would now be developing rich deadwood habitats are missing. These habitats including hollows, water-filled rot holes, dead branches, sap-runs and peeling bark are home to a wide range of deadwood associated (saproxylic) insects (Alexander, 2002). One of these is the violet click beetle (*Limoniscus violaceus*) which is considered an umbrella species, inhabiting only high-quality basal rot holes in ancient trees (Gouix *et al*., 2015). The violet click beetle is one of the rarest beetle species in the UK, and is only known to occur at three sites, Windsor Forest, Bredon Hill and a third location in Gloucestershire (Whitehead, 2003).

In the past few years, several of the trees known to have been previously inhabited by the violet click beetle have declined, likely beyond usability for hollow associated insects. The beetle box

project has investigated a novel approach to boosting this diminishing amount of available rot-hole habitat. The work builds upon previous successful experiments in which artificial rot holes were created using boxes filled with mouldy wood substrate (Jansson et al., 2009; Hilszczański et al., 2014; Carlsson *et al*., 2016.). The boxes used in this project have been specifically adapted for the target basal-hollow fauna and the concept has been reimagined through several previously untrialled new construction materials. It was hoped that these boxes could promote the long-term survival of the violet click beetle and other basal-hollow specialist invertebrate species through periods of habitat scarcity.

Experimental set up

With the permission of Natural England, 32 beetle boxes were set up on sites with known populations of the violet click beetle in 2019. Of these, 20 were placed in Windsor Forest and 12 in Bredon Hill. The opportunity was taken to trial different variations of the box construction material and contents with the aim of investigating which features are most important in creating viable beetle habitat. Details of the construction and content variations trialled are outlined below.

Box structure

All boxes constructed as part of this project included common features to make them as similar as possible to the basal tree hollows that they are intended to replicate. These features were:

- A central entrance hole, mimicking the entrance of a basal tree hollow
- A shelf inside the box, positioned over the entrance hole to maintain a hollow area for insects to enter
- An opening in the base of the box, allowing a continuity of the box contents with the soil, promoting natural degradation by soil organisms
- A lid with drainage channels and holes, encouraging rainwater to enter the box with the intention of creating a moist environment that promotes decay

The boxes were partially buried into the soil in the forests so that the base of the entrance hole was flush with the ground as is the case for natural tree hollows.

Box construction materials

- Wooden Boxes

The majority of beetle boxes (n=20) were made from untreated Oak (*Quercus*) wood. Oak wood is easily obtainable and particularly strong and durable, making it a good choice for a structure that must withstand harsh outdoor conditions. Oak is also one of the tree species that the violet click beetle is known to inhabit, making it particularly suitable for this project.

It was thought that a wooden construction would provide hollow conditions that are most similar to that of an actual tree. The wooden box walls have small cracks and areas of rough texture, providing a surface that is more similar to a roughened, decaying tree wall. This will likely provide additional areas for invertebrates to shelter and potentially breed in inside the box.

The drawbacks of using wood as opposed to other materials such as plastic or concrete is that it is prone to warping and deterioration when subjected to consistent adverse weather conditions. As a result, they may be less appropriate for long-term use than some alternatives.

- Plastic Boxes

In addition to wooden boxes, six plastic beetle boxes were also trialled at Windsor Forest. This was done because wooden box structures have been documented to deteriorate over time in previous studies (Approximately 10% of the boxes used by Carlsson *et al*., (2016.) were lost during the 10-year study duration). This is undesirable as basal hollows in real, living trees can persist for hundreds of years. Hence, several tree-hollow specialist beetle species are adapted to prefer long-lived habitats with a low tendency for dispersal.

Plastic beetle boxes have smoother and thinner walls which may influence the temperature stability inside the box and the ability for invertebrates to use the box walls for shelter and oviposition. This trial intended to find out if these physical differences have an observable effect on the beetle communities able to use the box.

- Concrete Boxes

In another attempt to create a long-lived beetle box, a single beetle box was constructed from concrete. This was manufactured by MSc architecture students at the University of East London. Due to the extra planning and assembly time required to create this custom-moulded box, it was completed in 2020 after the initial boxes had already been installed. Because of this, it was decided that the concrete box would be kept separate from the main trials in Windsor Forest and Bredon Hill. Instead, the concrete box was installed in a wildlife garden in South Essex for a preliminary trial of the potential of beetle boxes as saproxylic steppingstones in urban and peri-urban green spaces.

Box contents

Natural tree hollows are often filled with a nutrient-rich wood mould which is credited as the reason that hollows act as such optimal habitat for many species. This mould is usually well-rotted into a moist-crumbly texture and enriched with organic matter such as faeces and carrion which accumulates over time (Ulyshen, 2015). To replicate this wood mould, the beetle boxes were filled with a combination of ingredients and left to degrade for a year in the hope of achieving that the same crumbly texture.

The box contents consisted of soil, sawdust and leaf litter. The lower portion of the box contained a 2:1:1 mixture of soil: sawdust: leaf litter, whilst the upper portion contained a 1:2:2 combination. This was done to reflect the natural gradient of decaying wood down to soil found inside the column created by a basal tree rot-hole.

Some variations of the contents were tested as part of this study to investigate which elements may be recommended as best practice in future. The main variation was the addition of poultry manure to the contents of the plastic boxes and half of the wooden boxes. This was done to increase the nitrogen content of the wood-mould inside, mimicking the conditions found in tree wood mould. Another experimental variation was the use of Beech (*Fagus*) sawdust instead of Oak (*Quercus*) in two of the wooden beetle boxes at Windsor Forest.

Monitoring activities

The beetle boxes in Windsor Forest and Bredon Hill were each sampled twice during the summer of 2020 to investigate which invertebrate species had colonised them during their year of maturation.

During each sampling session, one litre of wood-mould was removed from each beetle box and sorted through on site in a white tray. This sorting allowed larger invertebrates to be collected whilst also providing an opportunity to identify and remove any violet click beetle adults or click beetle larvae and return them to where they were found, preventing any damage to their fragile populations. After initial sorting on-site, the samples of wood-mould were taken away in air-tight pots to be further processed. The wood mould was placed into Winkler extraction traps where it was left to dry out over 6 days. Winkler traps encourage small invertebrates in the substrate to move downwards as the material dries, eventually falling through the trap into a collection pot at the base.

Results Progress

The beetle box invertebrate samples are currently in their final stages of being processed. So far 41 beetle species have been identified from the beetle box contents. Of these, 17 were obligate saproxylic species with strong links to deadwood habitat, while a further 7 were facultatively linked to deadwood habitats (associated to deadwood but also found in other habitat types such as decaying vegetation). Alongside these beetles, saproxylic species of millipedes, worms and pseudoscorpions were also found within the boxes.

Among the saproxylic beetle species found in the beetle boxes, there were some species with particularly strong links to tree hollows. These included:

- *Stenichnus godarti* - a Pselaphine Staphylinid listed as RDB 3 (rare) for Britain. This species has a particular link to crumbly wood mould, found in hollows of oak (*Quercus*) and beech (*Fagus*) trees (Alexander, 2002). A previous study also found *Stenichnus godarti* to be inhabiting aerial beetle boxes in Sweden (Jansson *et al*., 2009).
- *Ptenidium turgidum* – A Ptiliid with a poorly known distribution in Britain (RDB K). It is known from the moist, crumbly mould in broadleaved tree hollows, particularly in beech (*Fagus*) and Elm (*Ulmus*) (Alexander, 2002).

The presence of these species within the beetle boxes suggests that similar conditions to those found in a real tree hollow were achieved within the boxes.

No adult or larval violet click beetles were found inside the boxes during the sampling of this project. This was expected, as violet click beetles are known to prefer particularly mature habitats. Previous beetle box studies have found that the abundance of tree hollow specialist beetles inhabiting boxes increased over time (Carlsson *et al*., 2016). Consequently, it is too early to discern the true success of this long-term conservation measure for the Violet click beetle.

As sample sorting and identification work is ongoing, the results have not yet been subjected to statistical analysis, however initial results demonstrate some observed trends. So far, a greater abundance and diversity of beetles have been found inside boxes that had been enriched with poultry faeces. No strong difference has been observed between the beetle communities inside the wooden and plastic boxes. Initial testing provides a weak indication that using sawdust in the box contents that correlates with the dominant tree species on site may have some positive influence on the diversity of beetle inhabitants. The final testing of these hypotheses will be available in the PhD thesis on this project by September 2022.

Conclusion

This investigation provided evidence that beetle boxes have potential as a conservation tool for supporting threatened saproxylic beetles. The boxes have already proved to be inhabitable for several saproxylic species including tree-hollow specialists. Based on previous research, it is expected that the quality of habitat that they provide will continue to improve over the coming years (Carlsson *et al*., 2016).

It is important to note that, although beetle boxes have promise for the conservation of saproxylic invertebrates, they cannot be considered a replacement for an ancient tree. Ancient trees often have a plethora of habitats, deadwood and otherwise, that support a great diversity of species. At present, beetle boxes only cater to one of these. For this reason, beetle boxes cannot be considered an equivalent to a tree in a development situation where developers might be tempted to replace an inconveniently placed tree with a box. Beetle boxes also require annual/biannual maintenance, involving regular top-ups and occasional structural reinforcement. The cost of this should be considered in the setup of any future beetle box implementation to ensure that there are resources to prevent them becoming prematurely obsolete.

Further study of the basal-hollow beetle boxes used in this study would be worthwhile in determining how the beetle species composition changes with time. In future studies it would also be interesting to profile the progression of fungal colonisation in the box contents. In addition, it would be compelling to explore the potential of beetle boxes for more wide-ranging applications. These boxes provide possible opportunities to study the local saproxylic fauna without disturbing

and potentially hastening the decline of existing basal tree hollows. They may also be useful in aiding the dispersal of vulnerable species across otherwise hostile landscapes and they could even have applications in artificial translocation studies of rare species. Overall, there are many further possibilities worth investigating around the beetle box concept.

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