Ecoacoustics for dormouse surveys: a field test

Jonathan Down, Stuart Newson and Alex Bush

Recently there has been significant growth in studies on ecoacoustics, the branch of monitoring that utilises sound as an indication of which species are present in an area and, as such, a proxy for environmental health. This method has the potential to collect large amounts of data with relatively little effort, and is far less invasive than many other survey techniques. For many species, however, there are no specific guidelines on maximising success of acoustic surveys and limited tools available to aid classification of sounds.

Most acoustic studies have naturally focused on the 'noisiest' animals, such as birds and bats, and there is far less information on how acoustic approaches could be used to monitor more cryptic taxa, such as small mammals (rodents and shrews). If ecoacoustics were a viable method of monitoring for small mammals it could offer a number of benefits, providing ecologists and conservationists with an additional tool for surveying threatened species, while also being non-invasive and less laborious than traditional approaches such as live-trapping. A key step in this direction has recently been made by the BTO (British Trust for Ornithology), which has created an extensive reference library of rodent and shrew calls, carefully recorded from captive individuals, to assist in the identification of small-mammal sounds in the field (BTO 2022).

One rodent for which acoustic surveys could be particularly valuable is the Hazel Dormouse *Muscardinus avellanarius*, a species that is protected in the UK (Wildlife and Countryside Act 1981) because of a 51% drop in numbers since 2000 (Wembridge *et al.* 2019), and which has become locally extinct in 17 counties. The key drivers of this decline have been destruction and fragmentation of natural habitat and the loss of habitat connectivity (Mortelliti *et al.* 2010). Because of its protected status, the Hazel Dormouse is the focus of intense survey effort, both as part of routine monitoring of populations, and also in presence/absence surveys to inform decisions on new developments (PTES 2022). As dormice are nocturnal and elusive, surveys typically rely on proxies for their presence, such as nibbled hazelnuts and footprints captured in footprint tunnels. In some cases, nest-box searches may also be conducted under licence. These approaches can quickly confirm the presence of dormice at a site, but repeat surveys and monitoring over large areas or numerous sites are highly labour intensive. Footprint tunnels also degrade over time if not well maintained, raising some concerns over environmental pollution, and require regular maintenance to replace footprint paper in order to avoid damage to samples. Ecoacoustic monitoring could therefore offer a number of advantages over these methods by offering a simple, repeatable and less time-intensive means of surveying dormice (Middleton *et al.* 2023).

In order to investigate the potential of acoustic methods for surveying dormice, we conducted a field test with the aim of determining how much time a surveyor would need to monitor an area in order to feel confident that any dormice present would have been detected.

As the Hazel Dormouse is a protected species, it is the focus of intense survey effort. Simon Phillpotts Photography/Alamy Stock Photo

Methods

We conducted this study in south Cumbria, in areas known to harbour Hazel Dormouse populations. Dormice had been absent from the county for many years, but as part of the Back on our Map (BOOM) scheme, run by the People's Trust for Endangered Species (PTES), animals were recently reintroduced to two areas of the Arnside and Silverdale AONB and to Gait Barrows NNR (owned by Natural England) in

Recording devices placed adjacent to dormouse nest boxes. Jonathan Down

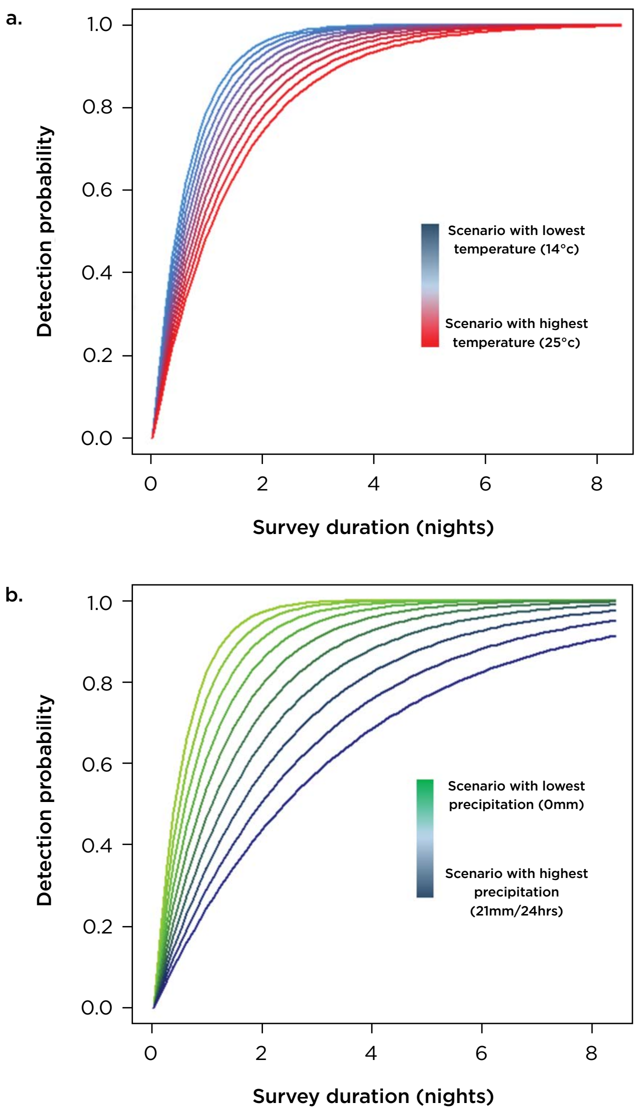

Figure 1. Detection time of dormouse calls plotted against temperature (a) and precipitation (b).

2021, and Eaves Wood (owned by the National Trust) in 2022. This project offered an ideal opportunity to test the use of acoustic recorders for supporting dormouse monitoring, with surveys focused on those areas where releases had taken place. In addition, we were able to deploy recorders adjacent to the cages in which the dormice were initially kept on site, where they were also provided with supplementary food at the time of release. Traditional nest-box surveys were also conducted in each year to confirm if the populations had become successfully established.

We trialled two types of acoustic recorders: the low-cost AudioMoth (Hill *et al.* 2018) and the Song Meter Mini Bat Detector (SMMB) from Wildlife Acoustics. The SMMB is triggered to start recording by sounds in ultrasonic frequencies, whereas the AudioMoths were scheduled to record for one minute in every three. The aim was to use the AudioMoths to test the distances from cages at which calls could be detected but, unfortunately, the devices did not appear suitable for detecting dormice, failing to pick up the majority of calls that were recorded by the SMMBs, even when both recorders were placed next to the release cages. Thus, the remainder of this article focuses on the data obtained using SMMB recorders.

Large numbers of nest boxes had been deployed at each of the release sites, and SMMB recorders were placed within 1m of nest boxes and cages (four recorders in Eaves wood, eight in Gait Barrows) for four weeks at each site. There were not enough SMMB recorders available to conduct stratified sampling across the sites, and we therefore focused on understanding how long it would take to detect dormice in areas where presence was confirmed through nest-box surveys. At least one recorder was situated in an area where dormice were not observed in nest boxes, thereby helping to show that absence of acoustic activity matched the results of nest-box monitoring.

Audio files were classified using the BTO Acoustic Pipeline, which uses machine learning techniques and cloud computing to automate the processing of audio data. In total, we recorded 40,275 ultrasonic calls over 28 nights of recording, of which 66% came from bats and 12% from small mammals (the remainder were not identifiable with confidence).

One challenge highlighted by Newson *et al.* (2020) during development of the BTO call library was the similarity between the calls of Brown Rats *Rattus norvegicus* and Hazel Dormice (see Figure 2), and the associated potential for misclassification. The differences between the two species are relatively nuanced, relating to the quality of the calls – those of Brown Rats are more clear and constant, while those of dormice have an unpredictable vibrating character. Because of the potential for confusion, 20% of the files that the pipeline classified as Brown Rats were manually checked (by looking at the spectrogram and playing the audio files 10× slower in the software SonoBat), and it was concluded that all such calls were in fact produced by dormice.

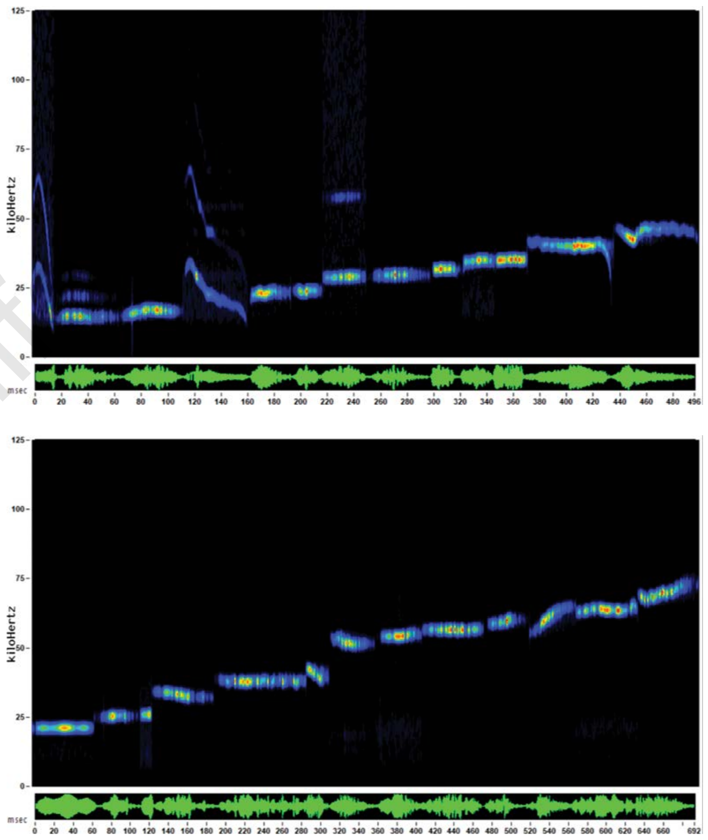

Figure 2. Variation in frequency of recorded calls of Hazel Dormouse (top) and Brown Rat (bottom). From Newson *et al.* (2020)

Estimates of how long a surveyor would need to record to be confident of detecting dormice were produced using an occupancy model adapted from Henry *et al.* (2019). Consider for example a scenario in which a dormouse was detected on only one of many nights of recording. Rather than conclude that the dormouse was only present in the area on that one occasion, occupancy models work on the basis that the animal was in fact present all along, but was simply not detected. The model therefore estimates how the probability of detection is expected to increase as the time spent recording is increased. Our analysis was focused on the time-to-detection (TTD) for each recording device on each night of the study; that is, how long each device had to wait before picking up a dormouse call. We limited analysis to calls with >50% probability of being from a dormouse, but also considered whether the TTD was reduced when calls assigned to Brown Rat were included. We also considered the potential impact of temperature and rainfall on TTD.

Results and discussion

To be confident of detecting dormice by using passive acoustic recorders, we recommend recording for at least five nights (Figure 1). Our study suggests that if Hazel Dormice are not detected within this period it is unlikely that they are making use of that specific location. The likelihood of detecting a dormouse was also influenced by temperature and rainfall (Figure 1). As might be expected, detection probability decreased with increasing rainfall, but if recording is sustained for a week then the cumulative probability of detection is still expected to exceed 80%, even in rainy periods. Temperature was expected to reflect any seasonal differences in activity, possibly reducing TTD as activity might peak on the warmest nights,

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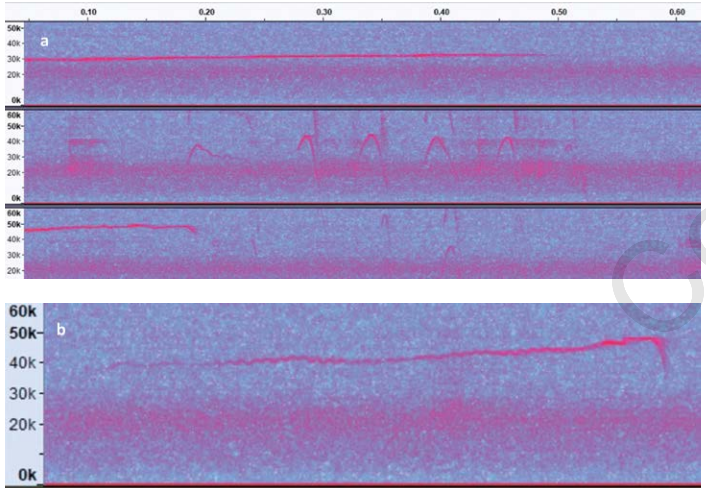
but in fact our analysis suggested that higher temperatures slightly increased the TTD. Even so, when dormice are present the probability of detecting them reached 100% under all modelled temperatures when surveys were sustained for a week or more. Including calls that had been automatically assigned as rats had a relatively small impact overall, slightly reducing TTD under optimal conditions, and also slightly strengthening the effect of environmental conditions on call detection.

These results show the promise of ecoacoustics for dormouse surveys, but some caution is required when interpreting these findings. As recording was primarily done in woodlands where dormice were known to be present and in the vicinity of release cages and nest boxes, our estimated TTD may be lower than that required at a site where presence/absence of dormice is unknown. Our recording devices were deployed at densities between one and four per hectare, but further investigation is needed to determine the number of recorders required to confidently detect dormice at sites of different sizes. Unfortunately, we were unable to simultaneously assess the distance over which calls could be detected, which would go some way towards answering the previous question. However, high-frequency calls do not travel far and so acoustic detection is likely to be restricted to individuals within just a few metres of recording devices.



Spectrograms of dormouse calls recorded during the study, showing characteristic long and upturned 'V' calls (a) and the 'wavering' quality (b) that sets calls of this species apart from those of the Brown Rat.

AudioMoth adjacent to a nest box, in Eaves Wood. Jonathan Down

Practitioners will therefore still need to use their judgement to select which habitats to focus on during surveys. For dormice, dense vegetation close to favoured food sources, such as Hazel *Corylus avellana* and Bramble *Rubus fruticosus*, represents a good feature to target, but acoustics could be used to explore their use of other habitats too.

This case study suggests that acoustic surveys of Hazel Dormice could be a viable monitoring method, and provides a first indication of the degree of survey effort that might need to be applied in order to confirm the presence of these animals. It is crucial to build a manual species-verification step into any acoustic project, but if the uncertainty around detection distance and potential for misclassifying rat calls can be reduced, acoustics could offer a robust approach to monitoring dormice with minimal

Hazel Dormice in their release cage. Jonathan Down

intervention. Wider testing and application of these findings has the potential to substantially improve monitoring efficiency, saving time and effort spent on surveying, which in turn would reduce labour and cost. This would have the secondary benefit of reducing human presence around, and hence disturbance of, dormouse populations. Finally, if monitoring is extended over long periods, this approach could reveal more about how dormice use different habitats through the seasons and shed new light on the habits of these elusive rodents.

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