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The potential of acoustic monitoring to inform and expand common bird monitoring

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Abstract. Acoustic monitoring has the potential to be a very effective method of surveying birds, particularly in remote areas where traditional survey coverage is limited by availability of appropriately skilled surveyors. In order to assess its suitability — particularly for augmenting long-term abundance monitoring — this study compares data collected by acoustic recorders and by surveyors on existing sites (1-km squares) of the UK Breeding Bird Survey (BBS).
Twenty-eight volunteers in Scotland deployed an acoustic recorder on their BBS survey square during spring 2023. An automated classifier (BirdNET Analyzer) was run on all recordings to detect birds and identify them to species. A random subset of recordings was checked manually in order to evaluate classifier performance. We discuss the performance of BirdNET in the context of its suitability for acoustic monitoring in Scotland and compare BirdNET outputs with recent BBS data collected from the same sites. We also consider ongoing and potential future work in this area.

Introduction

The UK Breeding Bird Survey (BBS) is one of over 30 bird monitoring schemes operating in Europe and contributes to the PECBMS (Massimino et al. 2024). Nearly 3,000 skilled volunteers take part in BBS, each monitoring one or more 1-km squares. Each square receives two survey visits per year — an early visit (usually done between mid-April and the end of May) and a late visit (usually done between mid-May and the end of June). During each visit, BBS surveyors record all the birds they see and hear while walking through the square along two parallel, 1-km long transect lines. Surveyors also note the species, number of individuals, distance from the transect and identity of the closest 200m transect section for each detection. The survey and the data collected is used for monitoring of 119 species in the UK during the breeding season, with key outputs including population trends (Heywood et al. 2025) and indicators (Defra 2024). However, there are still species and habitats for which we would like more information. As is the case in many other countries, biological monitoring is more difficult in parts of the UK where there are fewer people and/or where the landscape and terrain is physically challenging. This challenge is especially keen in the north and west of Scotland, which supports several species of breeding bird with narrow distributions at the southern edge of an arctic/northern European range. UK breeding species with populations largely concentrated in Scottish peatlands — e.g. Greenshank *Tringa nebularia* and Dunlin *Calidris alpina* — and montane habitats — e.g. Dotterel *Eudromias morinellus* and Ptarmigan *Lagopus muta* — are challenging to monitor using traditional methods and may require bespoke surveys relying heavily on expensive, professional coverage.

Whilst skilled volunteer bird surveyors are in short supply in upland and montane areas, many of these landscapes are popular with hikers and other outdoors enthusiasts. Most of the people in these groups do not currently have sufficient knowledge or interest to undertake bird surveys, but they might nevertheless be able to make valuable contributions to bird monitoring by deploy-

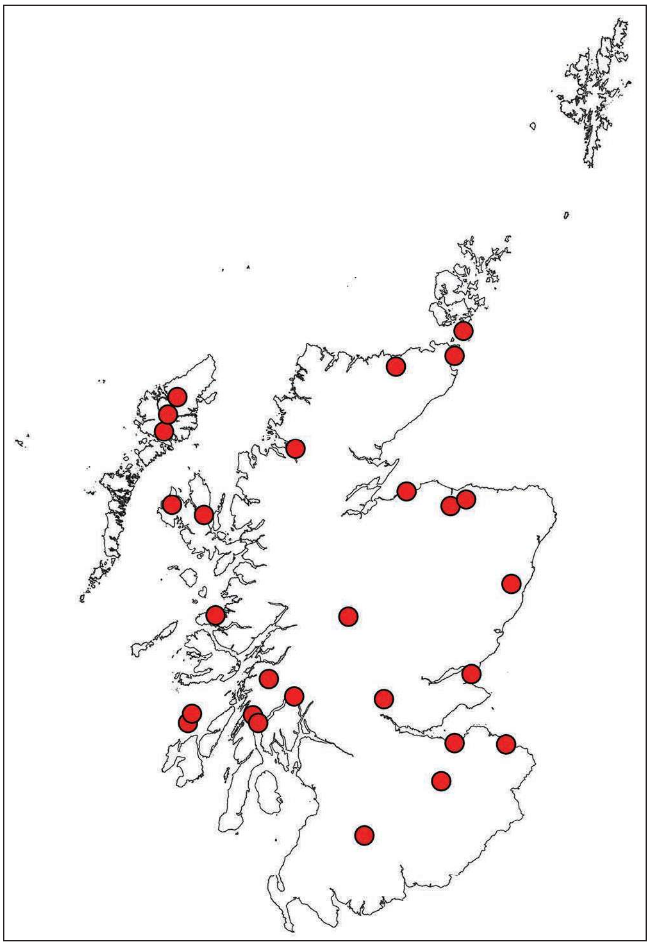

Figure 1. The location of the recorders deployed on BBS squares in 2023.

ing acoustic recording devices in remote areas. To understand the kind of data that could be collected using acoustic recorders in this way, we invited BBS surveyors in Scotland to deploy recorders on their monitoring sites. This allows us to compare data from acoustic recordings with standardised count data collected by human observers at the same locations.

Methods

Recorders

One-hundred and twenty BBS volunteers in Scotland whose squares had been surveyed for at least three of the previous five years (2018 to 2022) were invited to deploy a recorder. Thirty Wildlife Acoustic Song-meter Micro recorders were distributed between the 60 volunteers who responded to this invitation, allowing a wide range of locations and habitat types to be sampled (Fig. 1). Recorders were deployed on 29 squares, with 28 of these successfully generating a large amount of acoustic data. The duration of individual recorders deployments ranged from 28–69 days, during which time they recorded audio for one minute in every 15, yielding a total of 2,077 hours of recordings. The recorders were pre-programmed prior to deployment, and each volunteer was asked to deploy their recorder within 50m of their transect route, between one and two metres from the ground, with sound able to access it from all directions, and with the microphone pointing towards the transect. The deployment was designed to fit around the two survey visits made by BBS volunteers each year — recorders were deployed on early visits and collected during late visits.

Analysis

The automated classifier BirdNET Analyzer v2.3 (Kahl et al. 2021) was used to detect birds and identify them to species in every 3-second segment of each recording. Identifications were constrained by location and date and had a minimum confidence score (a metric that reflects BirdNET's assessment that a classification is correct) of 0.1.

A large sample (10,080) of randomly selected 3-second clips taken from these recordings was manually classified by an expert in bird sound identification (AW) to assess BirdNET's performance.

The BirdNet classifier records were compared with the BBS records in three ways: 1) For each combination of species and BBS square, call rate (defined as the mean number of call detections by BirdNET per hour during the week with the most calls) was compared with counts from BBS surveyors. 2) At the level of the whole BBS square, BirdNET classified call rates were compared with the five-year mean counts (with the count for each year being the highest count from either visit). 3) At a finer spatial scale, call rates were compared with counts from the 200-m section on which the recorder was placed.

Results

Classification performance

BirdNET generated 750,945 detections of 195 species. Classifier precision was generally high, with 79% of BirdNET detections verified by a hu-

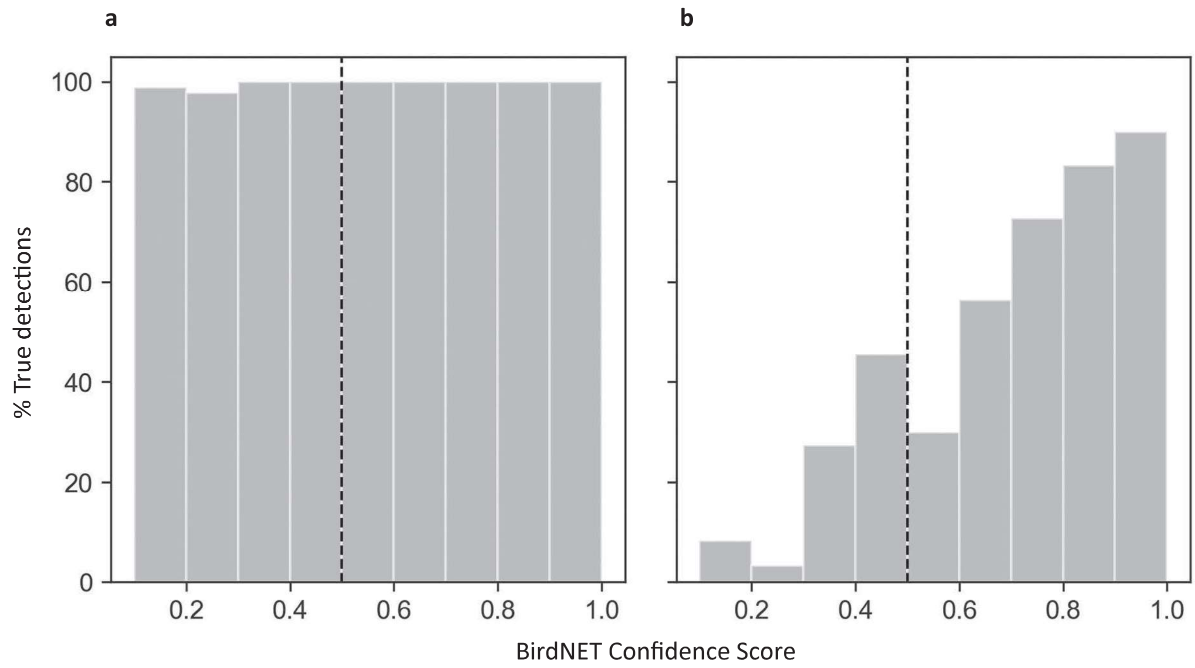

Figure 2. BirdNET-Analyzer precision for Chaffinch *Fringilla coelebs* (a) and Tree Pipit *Anthus trivialis* (b) in relation to true detection, based on manual verification. An arbitrary Confidence Score threshold of 50% (dotted line) would only retain correct Chaffinch detections but would result in 82% of correct Chaffinch detections being unnecessarily rejected. However, the same threshold would likely be too low for robust analysis of Tree Pipit identifications, as it would result in 36% of retained Tree Pipit identifications being incorrect.

man being confirmed as correct. Precision was generally greater for detections with high confidence scores, but this relationship varied substantially between species (Fig. 2). Only 27% of the calls detected and identified by a human expert were detected by the classifier. Among 34 species for which 50 or more calls were manually identified, the proportion of these calls that were also detected by BirdNET varied from 0% to 73%.

Comparison with BBS

During the period 2019 to 2023, 134 species were detected by BBS surveyors on the study squares, with a 60% of the 195 BirdNET species being recorded by the volunteers. When BirdNET data were refined — removing obvious errors and using Bird Atlas 2007–2013 data (Balmer et al. 2013) to exclude species that would not be expected to breed in these locations — 116 BirdNET species remained, of which 85% were recorded by BBS volunteers.

The degree to which BirdNET-derived call rates correlated with BBS counts varied between species and also depended on the number of years and spatial extent that BBS counts were drawn from. For Skylark *Alauda arvensis*, BirdNET call rate was positively correlated with the five-year mean BBS count, regardless of whether or not BirdNET detections were filtered according to confidence score (Fig. 3). However, for other species the correlations were improved by filtering. For common species with relatively small territory sizes that can be detected up to 100m or so away, like Willow Warbler *Phylloscopus trochilus*, BirdNET call rate was more strongly correlated with BBS counts from 200m sections than with counts from the whole BBS square (Fig. 4). For scarcer birds that range over larger distances and can be heard more than 1km away, such as Cuckoo *Cuculus canorus*, the reverse is true.

Discussion

Acoustics and monitoring abundance

We are just starting to learn how acoustic recording, coupled with automated classification technology, could contribute to the information we use to monitor bird abundance. Our 2023 data demonstrate that, at least for some species, the rate of calls classified from recordings reflects the variation in BBS counts across different sites. However, for acoustic monitoring to tell us about long-term changes in population, call rates captured by a recorder at a given location should (in the absence of sudden changes in population) be

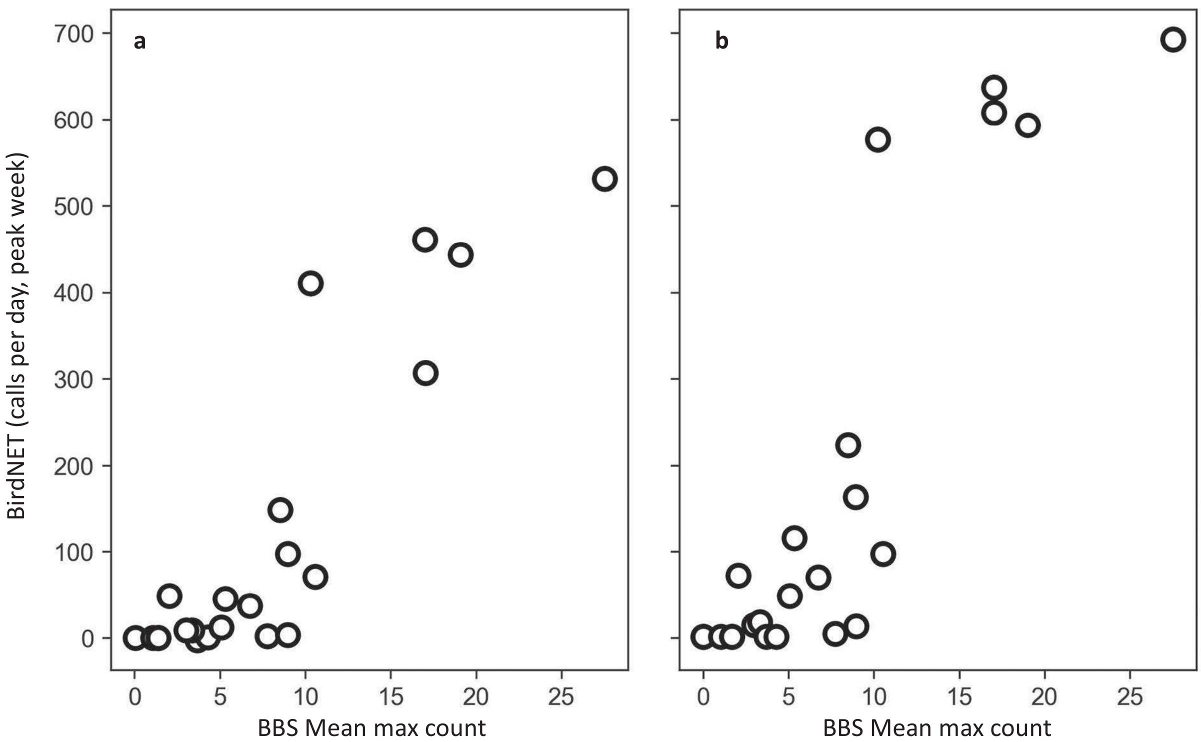

Figure 3. The mean BBS max count of Skylark *Alauda arvensis* over five years (a) correlates relatively well with an index of call output and continues to do so even after filtering by BirdNET confidence score (≥ 0.9) (b). In this case, BirdNET performs well and so relatively few recordings are filtered.

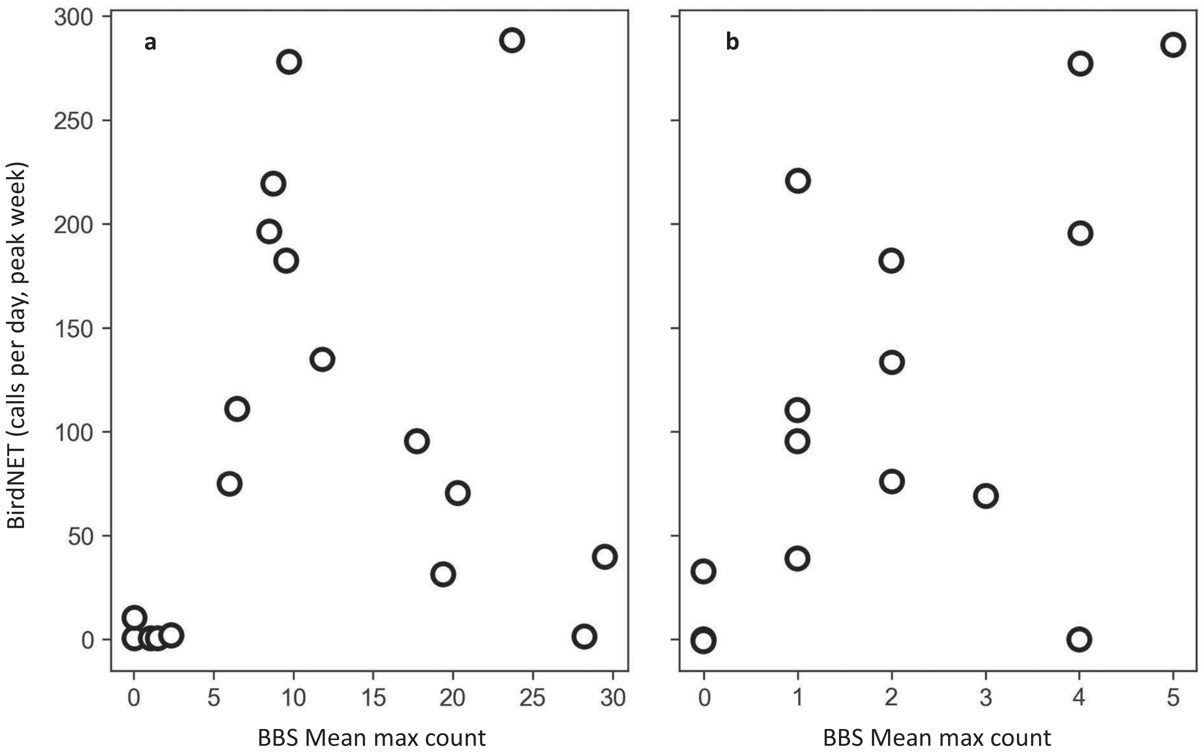

Figure 4. The mean BBS max count of Willow Warbler *Phylloscopus trochilus* over five years (a) does not correlate well with acoustic indices. However, when BBS data is filtered to only include counts from the same year (2023) and 200 m transect section (b), the correlation improves.

relatively consistent from year to year. This year (2025), 20 of the volunteers who took part in 2023 are deploying recorders on their BBS squares again. At 24 of the 28 sites that contributed to this study, this will give us a second year of acoustic data that can be compared directly with BBS counts from the same locations and time period. We can use these data to check how variation in call rates between years compares with inter-annual variability in BBS counts.

Another area of ongoing work aims to improve the ability of acoustic classifiers to correctly identify calls from the recordings. Much of this work focusses on developing single- and multi-species classifiers in the BTO's Acoustic Pipeline (BTO 2024), and we are also collaborating with researchers outside of BTO on various aspects of analysis and interpretation of acoustic data. Among the topics we want to get a better understanding of are:

- Whether classification of calls can be made more robust by drawing on information about other classified calls in the same recording.
- Whether call amplitude can be used to infer the distance of calling birds from a recorder.
- How recorder location and placement, and in particular the background noise this results in, affects the ability of automated classifiers to detect and correctly identify different species in acoustic recordings.
- How variation in recorder type/model influences the data collected. If acoustic recordings are going to contribute to long-term monitoring, we need to consider how improvements in hardware and software will affect the species that can be detected, and how this can be accounted for when working out how populations are changing over time.

Other applications

Acoustic methods could greatly enhance and improve on existing monitoring approaches, particularly in remote areas and/or for nocturnal or cryptic species. For example, acoustic monitoring could contribute information on breeding evidence, along with presence and abundance. As well as identifying calls made by different species, automated classifiers can also be trained to distinguish different sounds made by the same species. If song, alarm calls and juvenile begging calls can all be reliably identified, it may be possible to determine not only that a species was breeding in an area but to get some idea of variation in breeding success — something that is often very difficult and time-consuming to do through more traditional surveys and fieldwork (Jarrett et al. 2024). However, in order to realise acoustic monitoring's potential, further work is needed to improve our guidance for acoustic surveys, the ability of classifiers to identify calls from acoustic recordings and our interpretation of classifier outputs.

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