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Mammal monitoring through bird surveys in the UK

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Introduction

The BTO/JNCC/RSPB Breeding Bird Survey (BBS), and its sister survey on rivers and canals, the Waterways Breeding Bird Survey (WBBS) are the primary monitoring schemes that chart the changes of the UK's bird populations during the breeding season (e.g., Harris et al. 2022). The collection of survey data is undertaken almost exclusively by volunteers and has been running, in its current form, since 1994. Prior to this, the UK's breeding birds were monitored using a separate methodology and sampling regime via the Common Birds Census (CBC). Birds, by being diurnal, often highly visible and audible, make excellent subjects for volunteer-based survey methods, added to which there is a large and dedicated population of skilled birdwatchers able to undertake such surveys.

By contrast, mammals, which occupy a larger range of body sizes than birds, are much less detectable than birds due to their general tendency to nocturnalism and more limited use of human audible vocalisation. Whilst there is no single survey method that would adequately be able to survey all of the UK's birds, to adequately survey the 51 species of terrestrial mammal would require an even broader range of survey methods than is currently used for the UK's birds (Toms et al. 1999), and would undoubtedly need to make more use of non-visual techniques (e.g. passive sound recording, as is already the case for bats; Middleton et al. 2023, Newson et al. 2020).

These contrasting biological constraints between birds and mammals are reflected in the variety of schemes and organisations that are involved in their monitoring. In the case of birds, there are a relatively small number of schemes that are overseen by a small number of organisations that work collaboratively over them; e.g., BBS, The BTO/RSPB/JNCC Wetland Bird Survey (WeBS) and The BTO/JNCC Seabird Monitoring Programme (SMP). In the case of mammals, there are many organisations collecting data on mammal species or taxonomic groups that are relatively disparate in their coordination (Toms et al. 1999, Massimino et al. 2018 and references therein).

One method to increase the coverage of monitoring for any given group is to ask participants in other schemes to make observations of other taxa. The observations collected on the under-reported taxa (in this case mammals) may benefit from any underlying sampling design and statistical methods employed for the original target group. The use of volunteer ornithological surveyors in BBS and WBBS to collect data in the UK, its constituent devolved nations and even regions therein, is one of the few examples of this. Annually, indices of population abundance and trends for nine species of UK mammal are published alongside those of birds (e.g., Harris et al. 2022). These species are:

- Rabbit *Oryctolagus cuniculus*
- Brown Hare *Lepus europaeus*
- Mountain Hare *Lepus timidus*
- Grey squirrel *Sciurus carolinensis*
- Red Fox *Vulpes vulpes*
- Red Deer *Cervus elaphus*
- Roe Deer *Capreolus capreolus*
- Fallow Deer *Dama dama*
- Reeves' Muntjac *Muntiacus reevesi*

Relative to other UK mammals, these species are at least wholly or partly diurnal, or crepuscular, large bodied and readily identifiable, particularly to a group of volunteers who are already skilled in the identification of birds.

This paper describes the field recording methods, statistical approaches to analysis, and uses of mammal data collected by BBS and WBBS, with a view to it acting as inspiration for other similar schemes in other countries.

Methods

Field surveys and data collection

The recording of mammals by BBS surveyors started in 1995, one year after the scheme com-

menced in its present form. The survey protocol for bird recording used for BBS and WBBS are relatively well known and described elsewhere (e.g., Harris et al. 2022). In summary, surveys are conducted using line transects within randomly allocated 1-km squares across the UK. Birds are recorded against one of three distance bands (plus 'in flight'). Two visits are typically undertaken; an 'early' visit between April and mid-May, and a 'late' visit between mid-May and June, with visits commencing at around 0600h local time and lasting approximately two hours.

Mammal recording is an optional extra of the survey, with mammal recording being completed on around 80% of BBS survey sites on average and up to 90% in any given year.

Within field protocols, surveyors are asked with respect to mammals to:

- To count all live mammals seen during the two core bird survey visits, giving rise to count data (recorded as 'C' on field sheets).
- To make notes of any signs of mammals, with dedicated field recording codes for each of: 'F' — field sign; 'D' — dead; 'L' — Local knowledge of presence; 'S' — sightings of live mammals from other visits. These represent non-count data.

Mammal records are submitted within the same 200m transect sections as for birds, but not within distance bands. Surveyors are asked, when submitting records, to indicate whether or not they recorded mammals during their visits to ensure zero counts are interpreted correctly.

Statistical design and analysis

The sampling strategy of BBS and its rationale is detailed elsewhere (e.g., Gregory & Baillie 1994). The survey design uses a regional stratification to allow coverage to vary geographically in a planned manner to capitalise on larger volunteer pools in different areas of the UK. In each of 83 strata defined by administrative boundaries, the number of 1-km squares that were randomly selected was proportional to the number of potential volunteers. Population changes for mammals are estimated using the same methodology as for birds; a log-linear model with Poisson error terms, with counts modelled as a function of year and site effects and weighted to account for differences in sampling densities. For Red Deer and Fallow Deer, a log-linear model with negative binomial error terms is chosen to account for the over dispersed distribution of counts of these two herding species. Confidence intervals around the population changes are estimated via a bootstrap procedure.

Uses of mammal data

Population trends

Population trends of the above listed nine species of UK mammal are published annually alongside data on birds (e.g., Harris et al. 2022). These trends have been periodically updated and published alone, sometimes using modified statistical methods (e.g., Wright et al. 2013). The publication of national trends opens the poten-

Table 1. Changes in the population of nine species of UK mammal over three time periods as derived from data collected from the UK's Breeding Bird Survey. N = mean number of squares per year on which the species was recorded over the trend period in question. Ch = the percentage change in population size over the time period (* indicate a statistically significant change, where the 95% confidence limits do not overlap zero); CI = 95% confidence intervals.

	25-year trend (1996–2021)			10-year trend (2011–2021)			5-year trend (2016–2021)		
Species†	N	Ch	CI	N	Ch	CI	B	Ch	CI
Rabbit	1463	–67*	–73 ... –59	1657	–36*	–43 ... –28	1668	–16*	–24 ... –8
Brown Hare	766	27*	15 ... 40	914	32*	23 ... 43	990	39*	29 ... 48
Mountain/Irish Hare	55	–61*	–79 ... –32	66	–16	–37 ... 8	73	–40*	–53 ... –25
Grey Squirrel	828	30*	16 ... 41	1052	31*	23 ... 40	1169	27*	20 ... 34
Red Fox	282	–48*	–55 ... –39	285	–36*	–44 ... –26	266	–12*	–23 ... –1
Reeves's Muntjac	121	254*	148 ... 407	181	94*	70 ... 128	218	60*	45 ... 79
(Fallow Deer)	69	2545*	35 ... 629	87	168*	66 ... 300	97	152*	75 ... 277
(Red Deer)	74	89*	14 ... 185	94	39	–5 ... 104	109	31	–1 ... 93
Roe Deer	496	124*	92 ... 155	696	55*	42 ... 71	800	29*	20 ... 40

† Species listed in brackets are reported with the caveat that trends from herding species should be interpreted with caution; the presence or absence of a herd during a recording visit may influence counts in any given year.

tial for research on the causes and consequences of these changes at a national scale, which has hitherto only been possible in pre-selected sites or habitats of interest. These trends are now published at an increasingly more regional scale, with trends for subsets of the above species produced at the level of the UK's constituent countries and regions within England (Newson & Noble 2005). Population changes over different times (25-year, ten-year and five-year; Table 1) and population trends (Fig. 1) for the nine above listed species of UK mammal are reproduced here.

Modelling spatio-temporal trends

In addition to the production of temporal trends for nine species of mammal, as published annually alongside trends for UK birds (e.g., Harris et al. 2022), mammal data collected as part of BBS allowed these temporal changes to be modelled spatially (Massimino et al. 2018). These analyses followed an approach previously applied to bird data from the same scheme (Massimino et al. 2015) with the end product being the production of both abundance maps and maps of spatial variation in the change of relative abundance for the same nine species listed above.

Comparisons with other datasets

In 2011 the Joint Nature Conservation Committee (JNCC) funded work to compare BBS mammal trends between 1995 and 2009 with another annual scheme: the National Gamebag Census (NGC), carried out by the Game and Wildlife Conservation Trust (GWCT). The NGC is a voluntary scheme that collects bag statistics from shooting estates, on average about 650 per year. The aim of the project was to produce an overview of trends in abundance and distribution.

Of nine species tested, none differed significantly in their trends between the two schemes (Noble et al., 2012). For four species where BBS indicated significant increases between 1995 and 2009, the NCG trend was either not significant (Red Deer, Roe Deer and Reeves' Muntjac) or also showed a significant increase (Grey Squirrel). Rabbit showed a significant decline on BBS whereas NGC found no significant change.

This work demonstrated the feasibility of producing joint BBS-NGC trends for assessing population change for statutory purposes where a single figure is needed. Results of the spatial mapping were also useful, in showing areas where species are most often detected and where the most marked changes had occurred. However, due to differences in sampling design and methods, the recommendation is to routinely report temporal and spatial results from the two schemes separately.

Discussion

Collecting data for readily identifiable mammals during bird surveys comes at almost no extra cost to surveyors and does not impinge on the core activity of recording birds. Using this shared effort means that mammal counts inherit some of the benefits of BBS, in particular its robust sampling design and recording protocols. This standardisation, coupled with nationwide coverage, makes the resulting data better suited to monitoring long-term changes in time and space than records from unstructured recording schemes for which trends have to be derived with much caution. There are, however, some limitations worthy of consideration (see Wright et al. 2013 and references therein). The protocols for mammals in BBS do not, unlike the counting of birds, require observers to restrict counts to solely adults, thus the counts will reflect productivity as well as adults in a given year. This may lead to large between-year variation, especially with species that may defer breeding based on food availability (e.g., Grey Squirrel). Variation in species counts (cf. herding versus non-herding species) and sample sizes may give rise to large levels of uncertainty for trends in some species. Trends for Red Deer and Fallow Deer are therefore reported with caveats (Harris et al. 2022). The spatial scale of BBS is also not the most appropriate for some species, with home ranges of the larger species being much larger than the 1km^2 scale of BBS.

Notwithstanding these limitations, the collection of data from two taxa on the same survey site does provide a spatially and temporally matched dataset for birds and mammals. An example where spatially and temporarily paired mammal and bird data have been used comes from Newson et al. (2011), who identified negative associations between a growing deer population in lowland England and populations of several woodland bird species which are associated with dense understorey habitats.

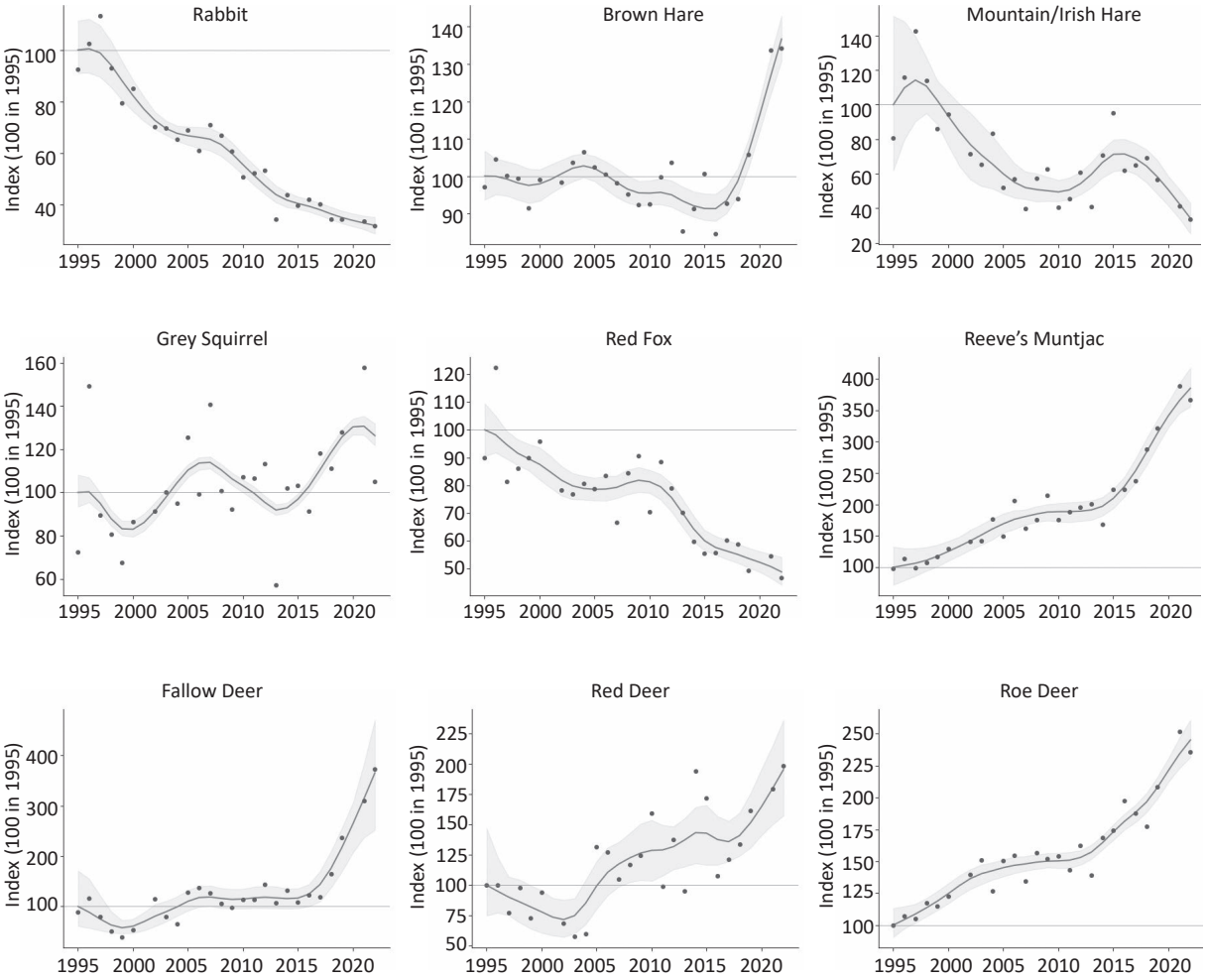

Figure 1. Population trends of the nine species (Rabbit, Brown Hare, Mountain/Irish Hare, Grey Squirrel, Red Fox, Reeve's Muntjac, Fallow Deer, Red Deer and Roe Deer) of UK mammal monitored by BBS since 1995. Plots show unsmoothed indices (dots), smoothed indices (solid lines) and 85% confidence intervals of the smooth index (shaded area). Population indices are set at 100 in the first year of mammal recording (1995).

Another example of where this taxonomic matching occurs, also involving BBS, is the inclusion of BBS squares within the sampling strategy of the UK's Wider Countryside Butterfly Survey (WCBS), which is part of the UK Butterfly Monitoring Scheme (UKBMS). BBS surveyors may visit their square later in the year, using the same transect routes and a similar distance sampling method to record butterflies. The data, alongside those from other surveys within UKBMS, are used to provide population trends of the UK's butterflies (e.g., Fox et al. 2023) and, as for birds, regular updates to Red List status (Fox & Dennis 2022).

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