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Original citation & hyperlink:
Sparks, T, Atkinson, S, Lewthwaite, K, Dhap, R, Moran, NJ & Tryjanowski, P 2017, 'Can bird abundance declines be detected by citizen science programmes?: A case study using Common Cuckoo Cuculus canorus' *Avian Biology Research*, vol 10. Issue 4, pp. 241-245
http://dx.doi.org/10.3184/175815617X15036738758862

ISSN 1758-1567
ESSN 1758-1559

Publisher: Science Reviews 2000

Can bird abundance ~~Cuckoo *Cuculus canorus*~~ declines be ~~confirmed~~ detected by ~~two independent UK~~ citizen science programmes? A case study using Common Cuckoo *Cuculus canorus*

Suggested running title: Citizen science and Cuckoo decline

T.H. Sparks[1,2,*], S. Atkinson[3], K. Lewthwaite[3], R.Dhap[2], N.J. Moran[4] and P. Tryjanowski[1]

[1]Institute of Zoology, Poznań University of Life Sciences, Wojska Polskiego 71C, 60-625 Poznań, Poland

[2]Coventry University, Priory Street, Coventry CV1 5FB, UK

[3]The Woodland Trust, Kempton Way, Grantham, Lincolnshire NG31 6LL, UK

[4]British Trust for Ornithology, The Nunnery, Thetford, Norfolk IP24 2PU, UK

*****Author for correspondence: Faculty of Engineering, Environment and Computing, Coventry University, Priory Street, Coventry CV1 5FB, UK . E-mail: ab1638@coventry.ac.uk

No of words: ~~2100~~ 2300 approx

No of Figures: ~~2~~1(+1?)

No of Tables: 1

Abstract

Using data from two independent UK citizen science schemes we investigate evidence for declines in abundance of Common Cuckoo *Cuculus canorus*, a species that is particularly easy to record. One of the schemes (Nature's Calendar) involves phenological recording across various taxa and is open to the general public, the other (BirdTrack) targets more committed birdwatchers. Results show a very strong correlation between the two schemes and confirm their ability to detect ~~a~~ the marked decline in the abundance of Common Cuckoo in the UK in the 21st century. Furthermore, the first scheme allows some tentative regional comparisons with data from a century earlier, and suggests regional differences in Common Cuckoo decline over the longer term.

Key words: BirdTrack, Nature's Calendar, phenology, population decline, Barn Swallow

1.Introduction

Recently, farmland birds, especially long-distance migrants, have experienced serious declines across Europe, including in the UK. Although the ~~process~~ pattern is well documented (Newton, 2004), there is not a close link between information on population declines and political action, to change farming practices (Hall, 2004). To facilitate political action a better understanding by the general public of the processes driving population decline is necessary. One common practice to increase awareness is to ask non-professionals to collect data on particular species; one of the best examples of what is now known as citizen science (Dickinson *et al.*, 2010). Citizen science can be broadly split into those schemes in which anyone can take part and those which require technical and/or species identification skills (e.g. Newson *et al.*, 2016). In the former, using untrained observers, it is safer to use data on easily identified and detectable species (Dickinson *et al.*, 2010). For these very reasons, we believe that the Common Cuckoo *Cuculus canorus*, hereafter Cuckoo, is potentially a very good candidate to study. This species is characterized by a high rate of detectability during the breeding season (characteristic, loud vocalization or song, which favours surveys), it arrives late in the breeding season and hence can be compared to the distribution and abundance of other species that have already started to reproduce (Saino *et al.*, 2009; Douglas *et al.*, 2010; Jiguet *et al.*, 2012; Tryjanowski and Morelli, 2015).

Moreover, the Cuckoo is an iconic bird of spring in the UK and in many other countries. Its brood--parasitic nature has earned it a place in mythology and its intricate behaviour is still being unravelled (Davies, 2011). It is more often detected by its classic call

than by sight. Urban myth has it that the earliest detection in spring was traditionally reported in the Letters Page of the *London Times* but ~~a~~ our search of the digitised version of that newspaper ~~would~~ produced limited evidence in support of this claim (see also Rusbridge, 2008). There are, however, first arrival records from the Marsham family in Norfolk dating back to 1739 (Sparks and Carey, 1995) and some earlier individual records for the UK.

Recently the decline of this species in the UK has been very marked (Douglas *et al.*, 2010). Harris *et al.* (2015) reported its UK decline to be 46% in the 1995–2013 period. Over a longer period, 1967–2012, the decline across England was estimated as 76% (Baillie *et al.*, 2014). The decline in Cuckoo is much less apparent in Europe as a whole with the 1980–2012 decline estimated at 26%, but only at 6% in the recent decade (2003–2012, PECMBS

2014). Thus the recent change in the UK, where the species has now been red-listed (Eaton *et al.*, 2009), appears to be more serious than at the continent-scale. Because of the large range of the adult birds and the brood--parasitic nature of their life cycle it is difficult to obtain estimates of population size and even more so of reproductive performance. The causes of the decline are equivocal, but could include deterioration of conditions on overwintering grounds and along migration routes, reduced host availability, climate change causing asynchrony with host species, and reduced prey (e.g., Conrad *et al.*, 2004; Douglas *et al.*, 2010; Hewson *et al.*, 2016)

In this paper we examine data from two independent UK citizen science schemes to assess whether these can generate surrogates of population change. Since recorder effort can ~~vary non-monotonically~~fluctuate from year-to-year we have used records of Barn Swallow *Hirundo rustica*, hereafter Swallow, as a "control". The Swallow is another iconic species of spring and is a very numerous, obvious species; even occasionally acting as a host for Cuckoo (Liang *et al.*, 2014). The use of Swallow as a control was determined by the choice of species recorded in Nature's Calendar, both currently and in the historical record, where it is by far one of the most popular species. Given that most bird-active recorders will record Swallow, use of this species as a control will allow estimation of the commonness of Cuckoo

records. We have created a very simple index for Cuckoos, being the number of Cuckoo

records as a percentage of the number of Swallow records, and have examined this for evidence of change in the 21st century and in comparison to records from 70–120 years ago.

2.Materials and Methods

2.1.*Data sources*

Two citizen science programmes were used to provide data on the relative numbers of Cuckoo and Swallow records. The first of these was Nature's Calendar (www.naturescalendar.org.uk), open to the general public, which collates phenological data in the UK. The scheme has been running since 1998, but was quite limited in the first year. In addition, the scheme has backloaded a large number of older records including those collected by the Royal Meteorological Society between 1891 and 1947. Data on first observations of Cuckoo (usually song) and Swallow (usually visual) were abstracted for the periods 1891–1947 and 1999–2014 at the UK level, and component regions. Data were excluded for 1932 because of incomplete records, and insufficient Northern Ireland records were available for the 1891–1947 period. Records from London and for Northern Ireland tend to be less numerous and results may need to be treated with caution. For each year, f~~F~~or the whole of the UK and for each region separately, a simple index ~~of~~ for Cuckoo ~~records~~ was calculated as the ~~percentage~~ number of Cuckoo records as a percentage of~~relative to~~ the number of Swallow records.

The second scheme was the BTO/RSPB/BirdWatch Ireland/SOC/WOS BirdTrack (www.birdtrack.net) which has been running since 2002. This collects numbers of sightings of birds throughout the year as a by-product of general birdwatching activities and as such typically requires more commitment from its recorders. The total number of site visits per

year that included observations of Cuckoo and Swallow was obtained from the website for the whole of the UK. Thus the records used here are based on presence/absence rather than on abundance. An index of Cuckoo records was obtained on the same basis as that used for the Nature's Calendar data above. Because this scheme incorporates records throughout the year rather than just first records, and because Swallows are more numerous and have a longer summer residence than Cuckoos, the index for this scheme is inevitably lower than that from Nature's Calendar.

Between 2002–2006, Nature's Calendar also asked its recorders to note down failure to hear Cuckoo as follows "If you usually hear the Cuckoo but didn't hear it this year, please tick the box" (Woodland Trust, 2005). The numbers of observers recording failure to hear the Cuckoo were abstracted for all years for the UK. For each year and region the percentage of all recorders (heard + non-heard) failing to hear the Cuckoo was calculated.

A population index for Cuckoo from the Breeding Bird Survey (Baillie *et al*., 2014) was obtained for comparison to our Cuckoo indices. ~~Where recorders had volunteered to provide their age we also examined the influence of age on hearing cuckoos.~~

2.2.*Statistical Analysis*

The indices for the two schemes were correlated for their 13 common years (2002–2014). Trends for Nature's Calendar indices (1999–2014) and BirdTrack indices (2002–2014) were calculated by regression on year for the whole of the UK. The indices were $\log_e$-transformed prior to regression so that proportional change, rather than absolute change, was estimated from the slope coefficient. A comparison of the Nature's Calendar indices for UK regions for

1891–1947 and 1999–2014 was made using two sample t-tests (~~un~~equal variances not assumed). The percentage of not-heard recorders was averaged across years for each region and compared to the Nature's Calendar Cuckoo index for the same regions for the common years (2002–2006) using correlation. Correlation was also used to compare our indices with the population index from the Breeding Bird Survey. All analysis and graphs were generated in Minitab 17.

3.Results

The Nature's Calendar Index was highly correlated with that from BirdTrack (r_{11}=0.914, ~~P~~p<0.001) and with national Breeding Bird Survey results (r_{14}=0.723, p=0.002). Both indices show a rapid decline, especially in the middle of the period (Figure 1). Trend coefficients for both schemes were similar and highly significantly negative suggesting a decline of 4.5% per annum (Nature's Calendar: coefficient -0.0458, p<0.001; BirdTrack: coefficient -0.0457, p<0.003). Mean indices for both schemes were highest in the South East and East of England, and lower northwards and westwards.

The comparison with the 1891–1947 period suggested that most regions had an approximately equal ratio (index ~~=~~ 100) of Cuckoo and Swallow records in the earlier period (Table 1). With the exception of the South East, indices were significantly lower in the recent period for all regions. ~~Once again t~~The differences between the two time periods appeared to be greatest in the north and west.

~~For the UK, t~~The percentage of Cuckoo recorders failing to hear Cuckoo averaged across 2002–2006 was 11.8%. This varied substantially between regions from 7.2% for Scotland to 17.6% for London (Table 1). Excluding Scotland, there was a significant correlation between % not heard and mean index (r_9=-0.730, p=0.011; with Scotland r_{10}=0.506, p=0.093. Index based on Nature's Calendar). ~~We were able to detect a greater failure to hear cuckoo among the 60+ age group (Figure 2).~~

4.Discussion

We show a serious decline in Cuckoo for the UK during the current century, which is compatible with a far more detailed study which focused on population size of Cuckoo on farmland (Sanderson *et al.*, 2006). The indices we used are based on Cuckoo records as a percentage of Swallow records, the latter acting as a control. The data submitted to the Royal Meteorological Society's phenology scheme between 1891 and 1947 suggests that most recorders provided first records of both Cuckoo and Swallow since the indices were approximately 100, on average, in each region. The more recent scheme, Nature's Calendar, suggests that parity is only maintained in the South East. Elsewhere, and particularly northwards and westwards, Cuckoo now appears to be less frequently recorded than Swallow. However, this may not be true of Scotland over recent decades (http://app.bto.org/mapstore/StoreServlet?id=276).

More worryingly is that the decline in Cuckoo in the current century seems to be very rapid, with both schemes indicating a very distinct loss in the mid-"noughties". The recent relative stability of the Cuckoo in Scotland is perhaps borne out by the low percentage of people in Scotland who reported that they did not hear ~~'s low not heard~~ Cuckoo ~~percentage~~. ~~Our older age group of recorders experienced a higher probability of not hearing Cuckoo despite them being the age group that was likely to have had greater first-hand experience of nature, and being taught nature study, when younger. We do not know if this reflects reduced hearing or reduced mobility in this group.~~

Our approach, a comparison with a well recorded species (in this instance the Swallow), relies on the "control" species maintaining its population and distribution. The

Swallow is reported to be undergoing a modest population increase (Baillie *et al.*, 2014) but we do not feel this would have a major influence on our results since Swallow is already a very obvious, very numerous and well identified species. Further confidence in this simple Cuckoo index is gained from a comparison with the % not-heard records where, with the exception of Scotland noted above, high % not-heard regions were associated with low mean indices.

Our paper, using Cuckoo as a case study, strongly suggests that citizen science schemes have the potential to provide valuable information about species declines in the absence of more formal population monitoring. This has previously been shown for some citizen science schemes (e.g. Studds *et al.*, 2017), but not all (e.g. Kamp *et al.*, 2016). The UK is very lucky to have ~~the latter~~formal monitoring in place for birds and some other taxa but not all taxa and not all countries are so fortunate. Humans are not very gifted at noticing change around them, particularly when change is taking place at a modest rate (e.g. Simons & Rensink, 2005), for example climate warming (e.g. Bazerman *et al.*, 1997) . Thus, we believe that it is the complete loss of a species rather than a decline in their population size that ~~probably~~ makes most impression on the human brain. The phenological and birdwatching data used here suggest that many of the recorders are no longer encountering Cuckoo in spring, a situation that seems unprecedented compared to a century earlier (see Follett and Strezov, 2015).

To conclude, Cuckoo is a good candidate species by which ordinary members of the public can become involved in surveys to monitor species arrival and presence. A recent study in France has used TV advertisements to encourage young people to volunteer to detect the arrival of Cuckoos in their local area and submit the information to a web-based survey. This method is proving to be an efficient way of collecting high volume data, at relatively low cost (Jiguet *et al.*, 2012)

(http://www.dailymotion.com/playlist/x1yf6c_yannaki_missions-printemps-

2012/1#video=xpon1m). Can these types of strategy be exploited in order to find reliable surrogates of avian diversity in those countries where structured monitoring schemes are not currently in place (Morelli *et al.*, 2015; Tryjanowski and Morelli, 2015)? We believe that the citizen science results shown here, even that which only involves first records, are an excellent warning system but present a worrying picture of the status of this particular species. Widening the involvement of the general public in monitoring taxa is now easier than ever and more likely to lead to effective conservation action (Greenwood, 2005; Follett and Strezov, 2015).

Acknowledgements

We thank the many thousands of committed individuals who submitted data to the Nature's Calendar and BirdTrack schemes. RD received funding from the Nuffield Gold Crest Bursary Scheme. We also thank Stephen Baillie and anonymous referees for providinged critical comments ~~to the previous~~ on earlier versions of the manuscript.

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Figure legends

Figure 1. Cuckoo indices (Cuckoo records as a percentage of Swallow records) from Nature's Calendar (1999–2014; open symbols, black line, left hand axis) and BirdTrack (2002–2014; solid symbols, grey line, right hand axis).

Figure 2. % failure (±SE) to detect cuckoo in spring in three recorder age categories (n=323, 1615, 1491 respectively).

Table 1. Mean±SE Cuckoo indices and the significance of the change (p) from Nature's Calendar (1999–2014 cf. 1891–1947) using a two sample t-test (equal variances not assumed). The percentage of recorders reporting failure to hear cuckoos in 2002-2006 is given in the final column (see text for details).

	1891–1947	1999–2014	t-test	% not heard
	Mean±SE	Mean±SE	p	
UK	101±0.6	67±4.4	<0.001	11.8
South West	103±1.1	53±4.5	<0.001	15.2
South East	105±1.2	107±4.7	0.507	10.5
London	117±6.6	70±16.5	0.003	17.6
Wales	96±1.0	53±3.3	<0.001	14.9
West Midlands	110±3.0	73±5.4	<0.001	11.4
East Midlands	105±2.3	71±5.8	<0.001	10.6
East of England	103±1.0	93±5.0	0.002	8.1
North West	101±1.8	34±4.0	<0.001	17.1
Yorkshire & Humberside	95±2.3	59±5.8	<0.001	13.5
North East	98±2.7	39±3.8	<0.001	15.3
Northern Ireland	Insufficient data	42±3.2		13.7
Scotland	102±1.8	49±2.8	<0.001	7.2

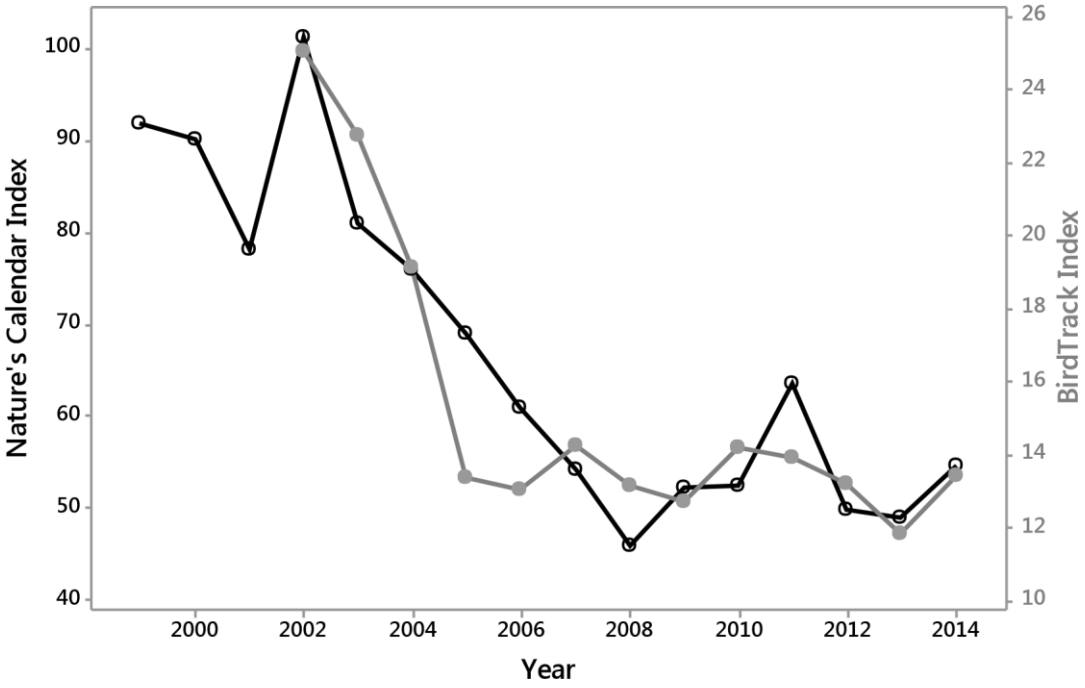

Figure 1. Cuckoo indices (Cuckoo records as a percentage of Swallow records) from Nature's Calendar (1999–2014; open symbols, black line, left hand axis) and BirdTrack (2002–2014; solid symbols, grey line, right hand axis).

Appendix

An interesting by-product from the failure to hear Cuckoo analysis was derived from those records where ~~Where~~ recorders had volunteered to provide their age. ~~we also examined the influence of age on hearing cuckoos.~~ Our ~~older~~eldest ~~age~~ group of recorders experienced a significantly higher probability ($\chi^2_{(2)}$=36.66, p<0.001) of not hearing Cuckoo despite them being the age group that was likely to have had greater first-hand experience of nature, and being taught nature study, when younger. We do not know if this reflects reduced hearing or reduced mobility in this group.

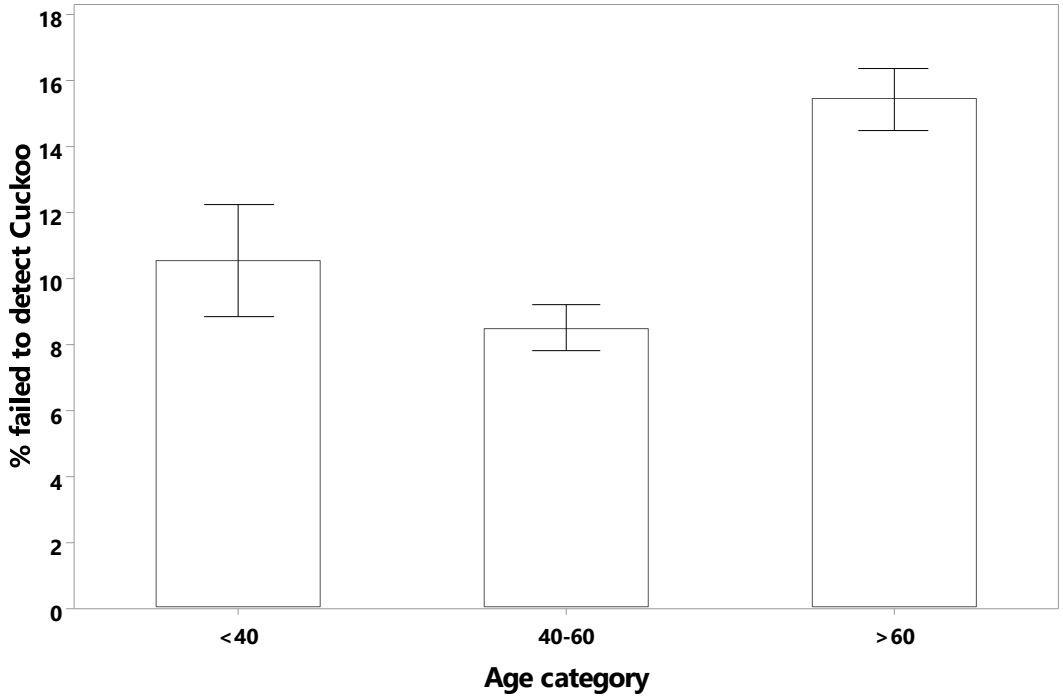

Figure ~~2~~. % failure (±SE) to detect cuckoo in spring in three recorder age categories (n=323, 1615, 1491 respectively).