The results of a major analysis of Fair Isle Bird Observatory's migration census data

The results of a major analysis of Fair Isle Bird Observatory's (FIBO) migration census data were published by the international science journal *Global Change Biology* in September 2016. The study focused on 13 species of songbird that breed in Northern Europe, winter in sub-Saharan Africa and are commonly recorded on Fair Isle on migration every spring and autumn.

Migrant birds have been intensively censused on Fair Isle by staff of the Bird Observatory every year since 1948. The daily spring and autumn migration census was initiated by George Waterson and Ken Williamson and a standard methodology has been in place since 1955. From April to June and from August to the end of October, the three census areas of Fair Isle ('North', 'South-east' and 'South-west', which collectively cover the whole island) have been walked by the Bird Observatory's wardening staff, all migrant bird species have been counted, and total daily counts have been compiled and entered into the Observatory's daily log.

The FIBO log books form a phenomenally rich dataset, comprising over nine million records of nearly 400 species across 70+ years, but for many decades existed only in paper copy. However, digitisation of all historical data for all years was completed in 2013, thanks to a generous grant from The Scottish Ornithologists' Club.

The fully digitised FIBO census dataset presents huge scope for a multitude of different migration studies and analyses. The first major analyses of the dataset by FIBOT, in collaboration with the University of Aberdeen, focused on the migration timing of long-distance migrants. This choice was not *just* because long-distance migration is one of the most staggering and captivating natural phenomena in the world, but also because there is growing concern that climate change is causing major shifts in seasonal, biological events such as migration, at large geographical scales. The key questions to answer were: 1) How has the migration timing of trans-Saharan migrant birds changed in spring and autumn across 60 years? 2) Is the timing of migration in spring and autumn closely linked? 3) Can migration timing be adequately measured across years using just one metric of timing, for example 'first arrival date'?

Initial pilot analyses revealed that these questions could be answered in detail using the FIBO dataset, with few limitations. The data for the 13 study species were of very high temporal resolution (daily data) and covered both spring and autumn, there were very few missing data since 1955, the census methodology and observer coverage of the island had not changed since 1955, and none of the study species bred on Fair Isle - meaning the data represented purely migratory individuals and not a combination of resident breeders and migrants. Furthermore, in each year (1955-2014), the daily census data spanned the full spring and autumn migration periods of each species, thereby fully capturing the whole date range that each species occurred in each season, from first observation date to last observation date. This meant that the timing of the *whole* migration period of each species could be measured, rather than just one aspect of it, such as 'first date'.

For each year and each season, the timing of the full migration period of each species was measured using ten phenology metrics, namely: the first observation date, the 5^{th}, 10^{th}, 25^{th}, 50^{th}, 75^{th}, 90^{th} and 95^{th} percentile dates, the last observation date and the mean date. (Here, a percentile date is just a fixed percentage through the full migration period data – for example for the 5^{th} percentile date, 5% of the dated counts are on or before this date.) These ten metrics were

selected because they collectively span the full migration period and thereby provide a comprehensive, detailed insight into the migration timing of each species.

The results of the analysis revealed considerable and unexpected changes in the migration timing of long-distance migrants that winter in Africa. In most species, in spring and autumn, the early migration phase (measured as the first observation date and the 5th and 10th percentile dates) commonly got earlier, mean spring and autumn migration dates changed little, while the late migration phase (measured as the 90th and 95th percentile dates and the last observation date) commonly got later. Consequently, for most species in both seasons, the duration of the full migration period typically lengthened across years. In some species this lengthening was substantial, for example the spring migration period of Willow Warbler expanded from approximately seven weeks in 1955 to 12 weeks in 2014, and in autumn the migration period of Swallow expanded from approximately eight weeks in 1955 to 13 weeks in 2014.

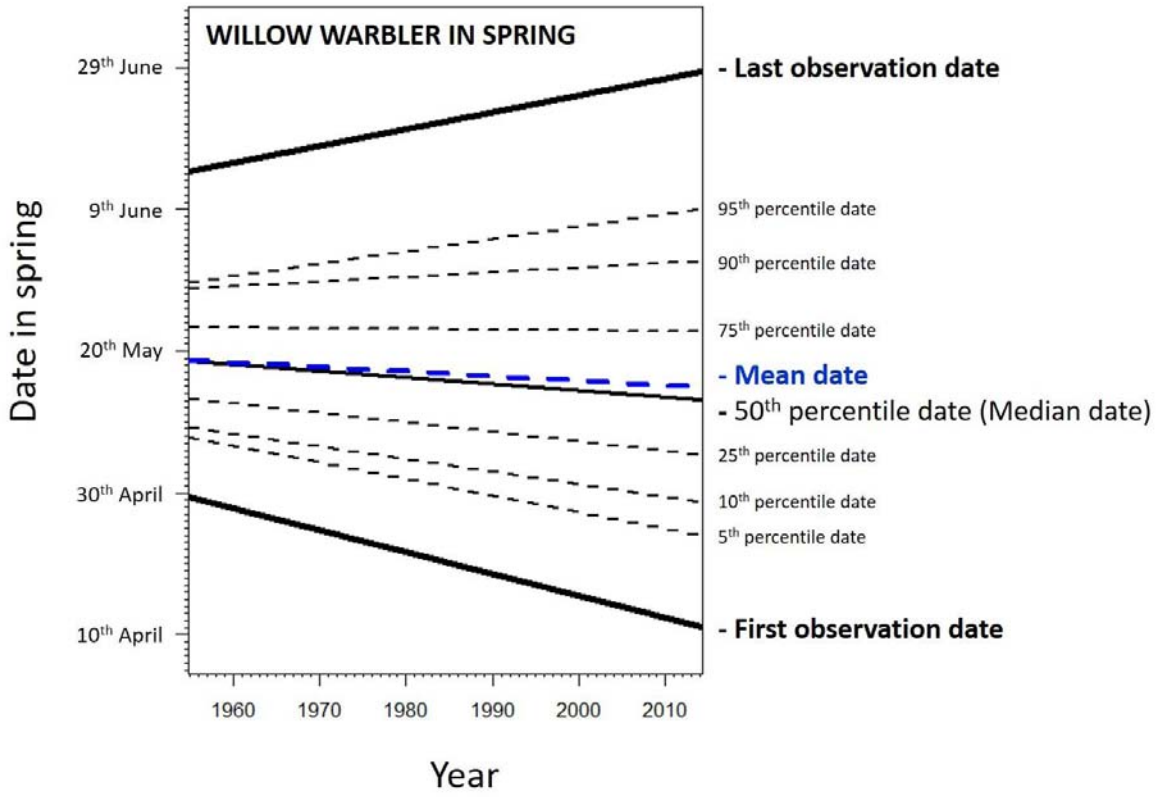

Figure 1. Summary of changes in Willow Warbler migration timing in spring on Fair Isle. Lines represent the linear trend (regression of date on year) for each of the ten phenology metrics across 60 years (1955-2014). Collectively, the 10 metrics span the full migration period, from first observation date to last observation date. Across 60 years, the full migration period has lengthened by approximately five weeks.

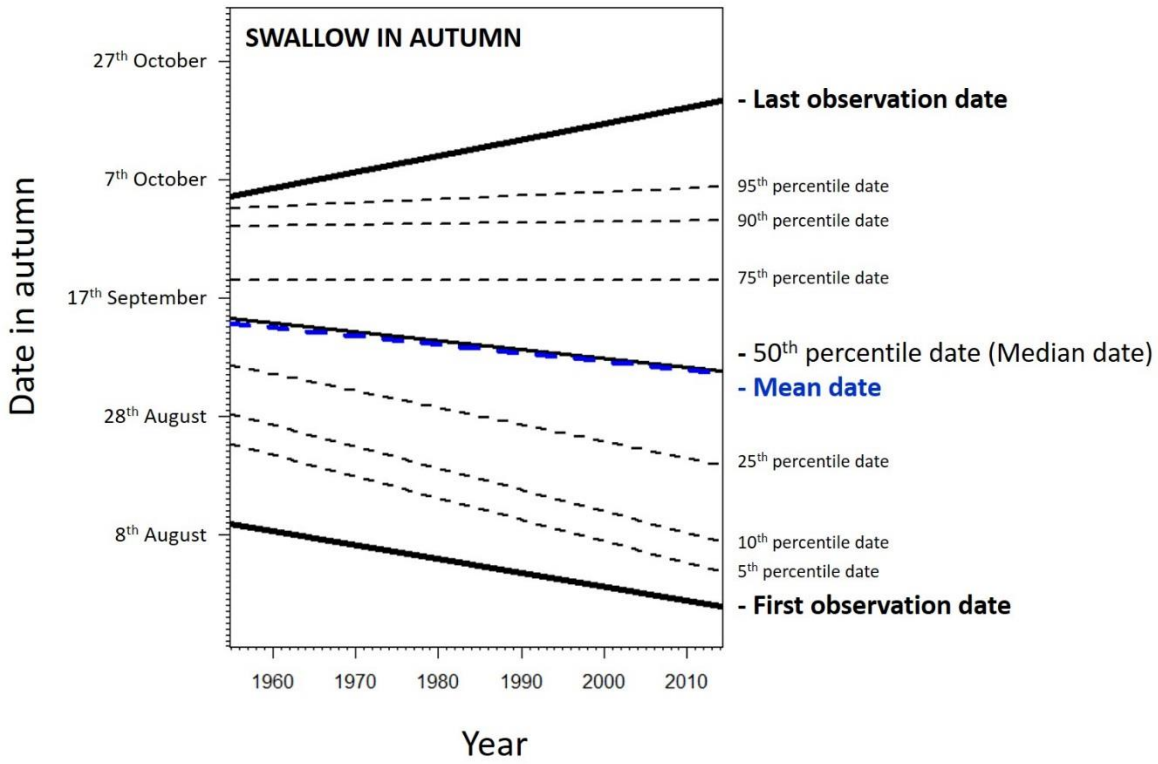

Figure 2. Summary of changes in Swallow migration timing in autumn on Fair Isle. Lines represent the linear trend (regression of date on year) for each of the ten phenology metrics across 60 years (1955-2014). Collectively the 10 metrics span the full migration period, from first observation date to last observation date. Similar to Willow Warbler in spring, across 60 years, the full migration period of Swallow has lengthened by approximately five weeks.

The timing of spring and autumn migration was found not to be closely linked. In any given year, migrant birds that arrive at their breeding grounds early in spring might be expected to depart early in autumn too, as soon as their chicks have fledged. But migration timing in consecutive seasons on Fair Isle occurred independently. For example, if migration timing was early in spring it was not consistently early in the following autumn, and if migration timing was early in autumn it was not consistently early in the following spring.

Furthermore, the ten different metrics measuring migration timing across each full migration period were not strongly correlated with each other, in any season for any species. This means that no single metric adequately described the full pattern of change in migration timing and that the changes in timing could not have been adequately measured across years using just one metric, such as first observation date. For example, had migration timing been measured using just the first observation date, in most species this would have shown advancements in timing, but not revealed the delays that occurred simultaneously in the late phase of the full migration period.

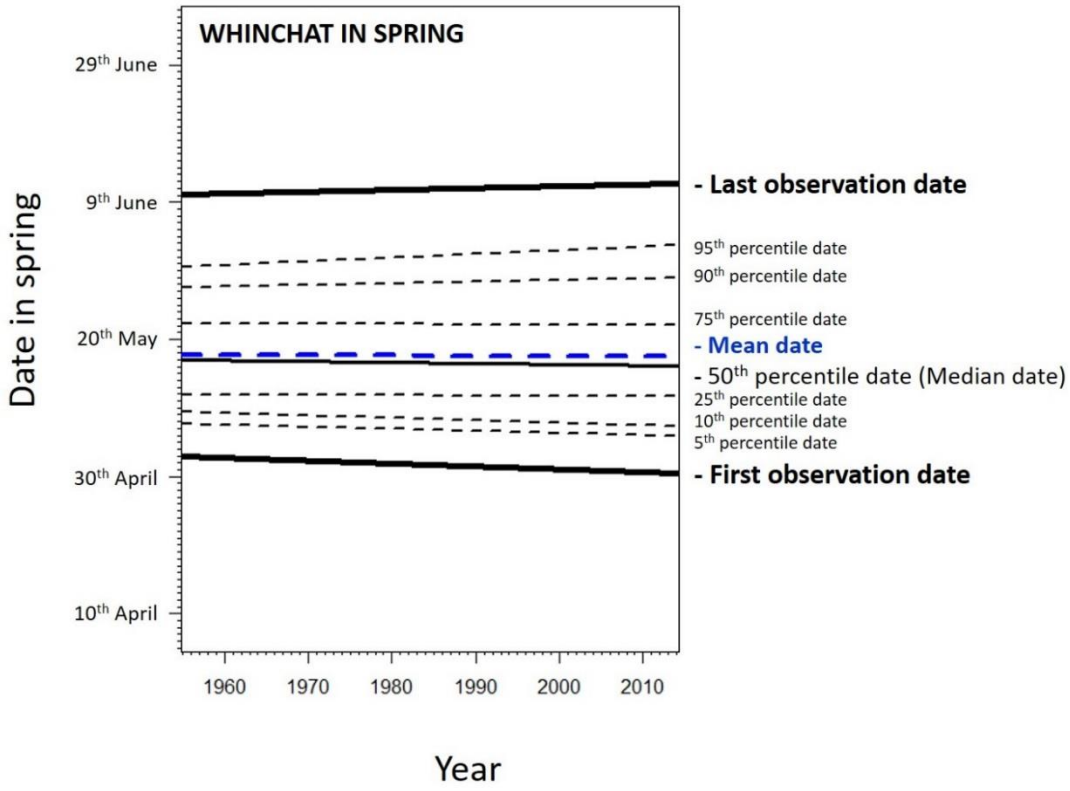

Figure 3. Summary of changes in Whinchat migration timing in spring on Fair Isle. Lines represent the linear trend (regression of date on year) for each of the ten phenology metrics across 60 years (1955-2014). Collectively the 10 metrics span the full migration period, from first observation date to last observation date. Unusually, in this species the full migration period lengthened by very little across years.

Overall, this new analysis of FIBO census data revealed patterns of simultaneous advancement, stability and delay in the spring and autumn migration timing of long-distance migrants. These patterns were unexpectedly complex and for several species included substantial changes in migration timing in both seasons. Such complexity in timing is only revealed if multiple metrics spanning the full migration period, rather than single metrics, are used to measure changes in migration timing. The wider implication of this study is that existing evidence of long-term changes in seasonal, biological events detected using only one or two metrics should be interpreted with caution, because divergent changes occurring simultaneously could potentially have remained undetected.

Full title and authors of research paper:

Quantifying full phenological event distributions reveals simultaneous advances, temporal stability and delays in spring and autumn migration timing in long-distance migratory birds

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The link to Global Change Biology and the Fair Isle research paper online is:

http://onlinelibrary.wiley.com/doi/10.1111/gcb.13486/full