Using the first European Breeding Bird Atlas for science and perspectives for the new Atlas

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SUMMARY

Capsule The first EBCC Atlas of European Breeding Birds (EBBA1) has been widely used in scientific publications.

Aims To quantify how scientific publications have used data from EBBA1, what the topics of these studies have been, and to identify key aspects in which the Second European Breeding Bird Atlas (EBBA2) will provide new opportunities for basic and applied science.

Methods We searched for “EBCC Atlas of European Breeding Birds” in Google Scholar to find papers published in scientific journals that cited EBBA1. We analysed the contents of a random selection of 100 papers citing this atlas. We described the way these papers used EBBA1.

Results EBBA1 has been cited in 3150 scientific publications, and can be regarded as a fundamental reference for studies about birds in Europe. EBBA1 was extensively used as a key reference for the studied bird species. A substantial number of papers re-analysed EBBA1 data to derive new information on species distribution, ecological traits and population sizes. Distribution and ecology were the most frequent topics of studies referring to EBBA1, but this source of information was employed in a very diverse range of studies. In this context, climate change, impact of agriculture and habitat loss were, by order, the most frequently studied environmental pressures.

Constraints in EBBA1 such as the poor coverage in the East of Europe, the lack of information on distribution change and the coarse resolution were identified as issues limiting the use of EBBA1 for some purposes.

Conclusions This study demonstrates the scientific value of European-wide breeding bird atlases. EBBA2, with its almost complete coverage across Europe, the incorporation of changes in distribution between the two atlases and the inclusion of
modelled maps at a resolution of 10x10 km will certainly become a key data source and reference for researchers in the near future.

INTRODUCTION

The collection of biodiversity data over large geographical areas is essential in order to adequately inform conservation policy (Chiarucci et al. 2011, Schmeller et al. 2015).

Great efforts have been made in recent years to integrate biodiversity information from thousands of sources into global data depositories, such as the Global Biodiversity Information Facility (GBIF 2019) and the Map of Life (MOL 2019), among others. These depositories gather a huge amount of open access data, and thus allow scientists to address relevant issues on biodiversity and conservation. However, an aspect that is sometimes neglected is that differences with respect to data sampling, storage and mobilization often lead to bias in large-scale biodiversity patterns (Beck et al. 2014).

Biodiversity data are compiled in very different ways across Europe (Voříšek & Marchant 2003, EuMon 2019). In Western and Central European countries, citizen science - understood as a strong partnership between amateur and professional scientists - has constituted a fundamental pillar for the compilation of biodiversity data (Bell et al. 2008, Dickinson et al. 2010). In contrast, the tradition of data collection in the eastern half of Europe and the Balkans has been often based on professional work directed by academies of science or similar governmental institutions (e.g. Budinski et al. 2010). In addition, methodological differences among countries are influenced by socio-political contexts, specific national targets, fieldwork and data mobilization approaches, and geographical particularities.

Conscious of the value of integrating national data to aid the understanding of large-scale patterns of distribution and abundance in birds, European ornithologists have a long tradition of cooperation among national organizations. Developing from a series of meetings aimed at greater international collaboration in ornithology, the European
Ornithological Atlas Committee (EOAC) was set up in 1972. Its representatives soon realized that a Europe-wide atlas could be produced from national surveys if common standards were adopted (see Greenwood 2017). The EOAC later changed its name and formalized its organizational structure to become the European Bird Census Council (EBCC), the organization that produced the EBCC Atlas of European Breeding Birds (Hagemeijer & Blair 1997), hereafter named EBBA1.

EBBA1 integrated data on the distribution and abundance of breeding birds, compiled at national level, into a single pan-European collaborative work. Thanks to the coordinated efforts of thousands of ornithologists and birdwatchers, accurate information on distribution and abundance was gathered for 495 species in 3,950 50x50 km squares (Figure 1). After publication EBBA1 data were made accessible to researchers, first under direct request to the EBCC Executive Committee and, since 2015, as open access via GBIF. EBBA1 has represented one of the few sources of information concerning distribution of bird populations at a continental scale and consequently has been widely employed in fundamental and applied research and for conservation-oriented publications (e.g. BirdLife International 2004). However, an analysis of the use of EBBA1 in research to assess its impact in the scientific community has not been done.

In this paper we show the potential of using such pan-European distribution data in research. More specifically, we review how EBBA1 was used in scientific literature and what the aims of these studies were. At the moment of writing this article, the Second European Breeding Bird Atlas (EBBA2) (Keller 2014, EBBA2 2019) is finalizing the compilation of updated data on the distribution of all breeding bird species (Figure 1). Following this review of literature we discuss how this knowledge has been incorporated in the aims, organization and methodological choices for the EBBA2 project. Finally, we show our vision of current efforts in the integration of continental bird data and anticipate how EBBA2 will contribute to basic and applied research.
MATERIALS AND METHODS

We considered Google Scholar as our source of information to analyse the use of EBBA1 in scientific publications. This search facility is freely and easily accessible, provides similar results to Thompson’s ISI Citation Index (Pauly & Stergiou 2005), and it has become increasingly popular in recent years (de Winter et al. 2014). We conducted the literature search in December 2016. We queried the sequence of words ‘EBCC Atlas of European Breeding Birds’ and downloaded results in a database. Despite the potential scientific interest of information collected in books, theses, technical reviews and ‘grey’ literature, we removed these types of works from the original database and kept only papers published in scientific journals. Then we performed a random selection of 100 papers from the total available using the Wichmann–Hill number generator (Wichmann & Hill 1982). Selected papers (shown with a symbol * in this article) were read by SH to analyse the general use of EBBA1 in science.

We addressed three specific questions related to how EBBA1 was used in scientific publications:

• Was EBBA1 used only for its information about birds? Or did it also attract researchers’ attention regarding the way the project was organised?
• Were EBBA1 data re-analysed in these scientific publications?
• When new analyses of EBBA1 were performed, what were the purposes?

In addition, we addressed five questions related to the subject matter of the papers that cited EBBA1:

• What were the major research topics of papers that cited EBBA1?
What were the pressures on biodiversity addressed in the papers that cited EBBA1?

Was EBBA1 used more often in papers that studied observed change in the past or predicted future change?

Was EBBA1 more often used in international, national or subnational studies?

Was EBBA1 more often used in studies about a single bird species, multiple bird species or studies that included several groups (birds plus others)?

RESULTS

How EBBA1 was used in scientific publications

Our search in Google Scholar showed that 3150 scientific papers published in journals referred to ‘EBCC Atlas of European Breeding Birds’. From the 100 papers randomly selected for this study 87 papers were in written in English and 13 in nine other languages: German (5), Russian (1), Spanish (1), French (1), Italian (1), Polish (1), Dutch (1), Catalan (1) and Norwegian (1). All these papers are listed in Appendix I.

A total of 96 papers analysed in this study were interested in the EBBA1 data on breeding bird species and four papers focused on the methodology and on how the project was organized. A total of 76 papers referred to the general patterns of species distribution, abundance or ecology shown in EBBA1, but did not use atlas data to conduct new analyses. Nevertheless, 19 papers re-analysed EBBA1 data for three main purposes: analyses of species distribution (8 papers), determining species ecological traits (7) and analyses focusing on population sizes (4).

Subject matter of the papers that cited EBBA1

Main topics

EBBA1 was cited for many different scientific purposes within the field of biodiversity research. Nevertheless, two topics stood out: species distribution (50 papers) and
ecology (44 papers). Other topics such as climate, conservation, trends or abundance were addressed by a smaller number of papers (Figure 2).

Pressures on biodiversity

Climate change was the environmental pressure more frequently reported in papers referencing EBBA1, accounting for a total of 12 papers. Concern on how changes in agricultural practices are affecting farmland birds was the topic of five papers, habitat loss and environmental impact associated with invasive alien species were studied in four papers each and pollution was addressed in three papers.

Temporal focus

EBBA1 was a reference for 22 papers that incorporated an assessment of temporal change in past-to-present approaches. Future projections were at least partly addressed in five papers.

Scale

Our survey showed that 54 of the analysed papers studied patterns at subnational level, 28 papers at national level; 18 papers worked at the European scale (or substantial part of the continent) and five addressed research at the global scale.

Spatial resolution

EBBA1 presented the data in a relatively coarse 50x50 km grid. Among the studies citing EBBA1, 16 studied biogeographical or macroecological patterns at the same spatial resolution used in this atlas. In 25 papers analyses were conducted at finer resolutions, usually using EBBA1 as background information but in few cases re-analysing its data and then applying the results at finer resolution.

Biodiversity focus
EBBA1 was cited predominantly in papers on birds, namely in 48 papers on single species and 46 treating several species. Five papers focused on birds and other biological groups. Only one paper was not interested in birds but exclusively in plants.

**DISCUSSION**

**How EBBA1 was used in scientific publications**

Our analyses show that EBBA1 was used in very different ways. Very often EBBA1 was employed as background information for studies about a particular species, such as that of the status of the Bearded Parrotbill *Panurus biarmicus* in Italy (Brichetti & Grattini 2008)* or the decline of the Red-backed Shrike *Lanius collurio* in Zealand, Denmark (Pedersen *et al.* 2011)*. In other cases, EBBA1 information was viewed in a wider context and represented a general reference for the distribution of groups of bird species, such as for the ranges of boreal birds (Virkkala & Rajasärkkä 2007)*.

A substantial proportion of the sampled papers not only cited EBBA1 data but presented novel analyses using it. Some of the papers that re-analysed the data were interested in deriving information on species distribution. For example, EBBA1 data were used (together with data from the Atlas of Southern African Birds, Harrison *et al.* 1997), to model species distributions at the Last Glacial Maximum and then analyse the contrasting late-Quaternary histories for Southern and Northern Hemisphere bird species (Huntley *et al.* 2013)*. EBBA1 was also used to derive species ecological traits based on the species' respective distributions. For example Gaüzère *et al.* (2015)* used EBBA1 data to calculate species-specific temperature indexes (STI), representing the preferred climate conditions of species based on temperatures within their area of distribution and then showed a fine-scale and short-term adjustment of community composition to temperature changes. An example of EBBA1 data use to derive information on species population size is the study of Møller *et al.* (2011)* who
obtained population sizes from this atlas to determine that migratory divides constitute barriers to dispersal with consequences for ecology and evolution of populations.

**Topics in papers referring to EBBA1**

**Main topics**

EBBA1 was widely used as a reference for bird species distribution, population size and ecology in many scientific publications interested in a variety of scientific topics. Many distributional studies conducted at national or regional scales referred to EBBA1 to provide a wide geographical context for the species of interest. This background information was applied in a variety of circumstances, such as the delimitation of Important Bird Areas (IBAs) in Macedonia (Velevski et al. 2010)* and the distribution of birds of prey in Belarus (Dombrovski & Ivanovski 2005)*. Information from EBBA1 was widely used as a suitable reference in papers on species ecology. A first example is a study that used bird-land cover associations based on EBBA1 data in order to determine the influence of this predictor (and others) on beta diversity for European birds (Keil et al. 2012)*. A second example is the use of EBBA1 as a reference for the habitat preferences of Dartford Warbler *Sylvia undata* in the context of assessing its status in the UK (Wotton et al. 2009)*.

Conservation also emerged as a very relevant topic and information from EBBA1 was used for a wide variety of purposes. For instance, the evaluation of the network of protected areas by Sândor & Domşa (2012)* who determined additional areas to better preserve forest specialist birds on the basis of a thorough analysis of habitat preferences, the assessment of species of conservation concern as described by Keller et al. (2010)* who assessed the international importance of the breeding populations of bird species in Switzerland by estimating the percentage of the national population using EBBA1 as reference, and the evaluation of land use policies as described by
Eggers et al. (2009)*, who used the EBBA1 dataset to evaluate whether biofuel policies were detrimental to biodiversity in agricultural landscapes in Europe.

Pressures on biodiversity

Five out of the six main categories of environmental pressure according to Aichi Target B (Secretariat of the Convention on Biological Diversity 2014) were found as topics in the analysed papers, namely climate change, agricultural practices, habitat loss, invasive alien species and pollution. EBBA1 data had a prominent role in modelling climatic ranges of bird species in the context of predictions of impact of climate change on their populations either at continental (e.g. Huntley et al. 2004)*, national (e.g. Reif et al. 2013, Koleček et al. 2014)* and local level (e.g. Flousek et al. 2015)*. Beyond our random selection of papers in journals, it is noticeable to mention that EBBA1 was essential to model European species distributions under future climatic scenarios (Huntley et al. 2008). Effects of agricultural practices on birds was also addressed by some of the analysed papers. For instance, Meller et al. (2015)* used EBBA1 data and predicted that the magnitude of range shifts due to climate change was far greater than the impact of land conversion to bioenergy plantations within the European Union.

Temporal focus

Since EBBA1 maps provided just a single time reference, and there is no comparable data source for another period yet, no study used the data from this atlas to explicitly analyse temporal changes in bird distribution. However, some authors used the information written in the species accounts in EBBA1 to describe general patterns of distribution or population change, such as in the study of the decline in Tree Sparrow Passer montanus populations in Poland (Tomialojc 2012)*. EBBA1 data were cited in several publications to project species distributions into the future, such as the prediction of a considerable risk of extinction within the Bavarian Forest National Park as a result of global warming (Bässler et al. 2010).
To date EBBA1 is certainly among the most relevant original works that map the occurrence of breeding birds in the whole of Europe. Therefore, it has been widely employed as a key reference for the European distribution of birds in studies carried out at subnational, national, continental and global scales. For example, Chiron et al. (2009)* used EBBA1 data to explore the relationship between the geographical pattern of richness of native bird species and that of exotic bird species in Europe. However, EBBA1 was mostly used as a reference concerning species distribution at subnational level, such as in the study of the impact of radiation from the Chernobyl Nuclear Power Plant on birds by Møller et al. (2010)*.

**Spatial resolution**

The detail at which a geographical dataset defines the location of its features is a key element for studies on species distribution. EBBA1 provided data in a 50x50 km grid and, as shown in many of the examples mentioned so far, this cell size met the needs of many of the analyses required to make progress in diverse fields of the ornithology. For example, Carrascal & Seoane (2009)* aggregated original 10x10 km data for Bonelli’s Eagle *Aquila fasciata* from a Spanish atlas to a coarser 50x50 km resolution because they considered that in the context of analysing of factors affecting its distribution in Spain, the latter provided a higher certainty about the species occurrence in each cell (absences more likely to be real).

**Biodiversity focus**

EBBA1 has undoubtedly created one of the most complete databases on the distribution of birds in Europe. Other large-scale studies have reached a similar status for other taxonomic groups. Together they have conformed an excellent dataset for many studies interested in biodiversity in a broader sense. For example, Huntley et al.
used distribution data from plants, birds and insects to predict that climatic model performance was related neither to major taxonomic group nor to trophic level.

PERSPECTIVES FOR THE NEW EUROPEAN BREEDING BIRD ATLAS

At the moment of compiling information for the analyses shown in this article, a total of 3 150 scientific journal papers referred to the ‘EBCC Atlas of European Breeding Birds’. A new Google Scholar search would find that this is clearly an outdated number. All these values illustrate the recognition EBBA1 has received in the scientific community, but also the very high research potential of an atlas update.

The analysis of publications citing EBBA1 revealed issues that are important to be taken into account for other projects and in particular for the Second European Breeding Bird Atlas, hereafter called EBBA2. Some of the papers analysed in this study made specific comments on the limitations of EBBA1 data, referring especially to deficiencies in the coverage, such as in the eastern part of the continent and the Balkans (e.g. Keil et al. 2012)*. EBBA1 gaps of information resulted mainly from limitations in coordination, fieldwork capacity and data flow at that time. To launch the new project and update in the best possible manner the EBBA1 information, EBCC constituted an EBBA2 steering committee whose members had experience in organising surveys, analysing the data and interpreting the results. These members came from different parts of Europe because bird atlas approaches differ depending on the biogeographical, cultural, traditional and economic contexts (Greenwood 2007). Then, an EBBA2 coordination team was established to deliver the central functions of running the atlas project and of keeping a fluent communication within the network of scientists developing methodologies at the European level, coordinators organising fieldwork at national level and skilled ornithologists doing the fieldwork. This close
The analysis of the papers that cited EBBA1 showed that many studies focused on changes in occurrence. However, none could use that dataset to study changes in distribution (see Temporal focus). Updating EBBA1 information will provide many opportunities to analyse changes in distribution and, thus to investigate the environmental pressures driving these changes. Therefore, one of the most important methodological aspects of EBBA2 was to maximize comparability between the two atlases. Consequently, the same UTM 50x50 km grid, breeding codes and abundance codes as used in EBBA1 were adopted for EBBA2. This grid was also selected in compliance with projects working on other taxonomic groups, e.g. see Sillero et al. (2014) for the new atlas of amphibians and reptiles of Europe, which will provide a good basis for cross-taxa analyses in the future (see Biodiversity focus). However, robust analyses of change do not only depend on the use of the same geographical units but also on the particularities of the fieldwork done in each square in each atlas. To overcome this difficulty, EBBA1-EBBA2 species distribution change was incorporated in the EBBA2 project by means of taking into account information on the fieldwork process for the two atlases. In fact, change was not calculated for all squares but for a subsample that were sufficiently well covered in the two atlases. These squares were determined after a series of analyses that incorporated information on the reported completeness of coverage and the total number of species detected as well as their deviance from modelled expected richness, among others. Finally, in the overall framework of improving the quality of the data, EBBA2 implemented a novel approach by incorporating highly standardised surveys within a sample of 10x10 km squares. The more immediate aim of this survey was to generate detailed maps of species breeding occurrence (see next paragraph), but these standardised surveys
could provide potential added value for robust comparisons in the future (see approach implemented for this purpose in Balmer et al. 2013).

Gaston et al. (2008)* pointed out that, despite the progress made by EBBA1 for the quantitative assessment of species ranges, this coarse resolution limited its direct value for most practical conservation planning exercises. The higher the resolution the better the inferences that can be made concerning issues like distribution (e.g. presence in protected areas) and ecology (e.g. habitat requirements, climatic niches).

Thus, in addition to the compilation of data at the 50x50 km scale, a protocol to collect standardized data across the whole of Europe was implemented in EBBA2 which allowed modelling of species occurrence at a resolution of 10x10 km. This information was mostly derived from timed visits (complete lists of species obtained at a given site and in given time) specifically designed for atlas work and from standardized common bird monitoring schemes. Given the complexity of the data, with many different sources, field methods and intensities of coverage across Europe, the EBCC convened a group of experts in a “Spatial Modelling Group” (SMOG) to approach this pan-European spatial distribution modelling in the best possible way. A final selection of more than 35 000 EBBA2 standard surveys obtained in over 17 000 different 10x10 km squares was available for modelling (Figure 3). This dataset incorporated several elements to allow the robust assessment of the detection probability for many species, i.e. repeated visits at a sample of available squares, date, field method and duration of the survey. A total of 40 environmental predictors, plus detection probability, were used to model species distribution averaging 10 different models (see Figure 4 for an example for Turtle Dove *Streptopelia turtur*). Finally, a cross-validation procedure was conducted in order to quantify the predictive accuracy of the model (Herrando et al. 2017).

Outlook for research
The present study documents the applications of EBBA1 in scientific publications and provides examples of why and how researchers may approach the coming EBBA2 data. This provides the possibility to forge an early connection with future research and encourage new ideas on how the new data can be used and how to increase the use of papers using this data. At the time of writing this article EBBA2 is still an ongoing project. The plan is to publish a book by late 2020 and produce a web-based product some time after publication.

We are convinced that EBBA2 will deliver data and information that will offer excellent and unique opportunities for further scientific analyses and publications. Spatio-temporal comparisons based on the atlas data are a powerful asset that could be applied to understand population dynamics of breeding birds across Europe. We see ample opportunities for use concerning the major topics that already have been addressed using the EBBA1 data, including environmental pressures according to Aichi Target B (see *Pressures on biodiversity*), such as impacts of climate and land-use changes or the spread of invasive (bird) species. Other subjects of interest could be the effects of the Natura2000 network and other conservation policies, identification of new priority areas for conservation, determination of species hotspots (also concerning other taxonomic groups), risks associated with propagation of zoonoses, and flyway research.

Within the context of biodiversity declines across Europe, the new European Breeding Bird Atlas represents a unique opportunity for researchers and policy makers to deliver valuable research to underpin conservation action across the continent. We are confident that, as it happened with its predecessor, EBBA2 will become a landmark for bird conservation in this region.

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areas in Macedonia: sites of Global and European importance.

areas in Finland: consequences for boreal forest bird populations. *Biol.


status of the Dartford Warbler in the UK and the Channel Islands in
APPENDIX

Random selection of 100 papers that cited the *EBCC Atlas of European Breeding Birds* (EBBA1) that were used in this study to analyze the uses of this atlas in research


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   areas in Macedonia: sites of Global and European


   areas in Finland: consequences for boreal forest bird populations. Biol.

   patterns of boreal marshland birds: modelling the relationships to land cover


   status of the Dartford Warbler in the UK and the Channel Islands in


100. Завьялов, Е.В., Табачишин, В.Г., Хрустов, А.В. & Якушев, Н.Н.
    2003. Современное распространение и особенности экологии журавля-
LEGENDS TO FIGURES

Figure 1. 50x50 km squares for which data were reported for EBBA1 (light grey squares) and for EBBA2 (dark grey dots). EBBA1 data came from 3,949 squares and coverage for EBBA2 was 5,095 squares (provisional values yet). These values correspond, respectively, to 74% and 96% of the total number of squares in the area shown in the map. It is very important to highlight that the completeness of the coverage was very low in EBBA1 in the northern half of Russia and in some parts of Caucasus and the Western Balkans. Data collection for EBBA2 was mainly carried out from 2013 to 2017 in the more than 50 participating countries, including much better coverage in the European parts of Russia and Kazakhstan, the Caucasus countries, the Canary Islands, Cyprus and the whole of Turkey.

Figure 2. Number of papers citing EBBA1 that were attributed to each of the analysed main topics.

Figure 3. Location of the 17,000 10x10 km squares with EBBA2 standardized surveys. In the context of this project, all these squares were surveyed in a standardized manner between one and ten times. Each survey have a complete list of all species recorded in a given time frame at a particular site and on a single day.

Figure 4. Pilot map showing the probability of occurrence for the Turtle Dove *Streptopelia turtur* in all 10x10 km squares in Europe based on EBBA2 spatial distribution modelling (light-dark grey indicates low-high probability of occurrence, respectively).
FIGURES

Figure 1.

Figure 2.
Figure 3.

Figure 4.