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

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30

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39 **SUMMARY**

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

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

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

50 **Results** EBBA1 has been cited in 3 150 scientific publications, and can be regarded as
51 a fundamental reference for studies about birds in Europe. EBBA1 was extensively
52 used as a key reference for the studied bird species. A substantial number of papers
53 re-analysed EBBA1 data to derive new information on species distribution, ecological
54 traits and population sizes. Distribution and ecology were the most frequent topics of
55 studies referring to EBBA1, but this source of information was employed in a very
56 diverse range of studies. In this context, climate change, impact of agriculture and
57 habitat loss were, by order, the most frequently studied environmental pressures.
58 Constraints in EBBA1 such as the poor coverage in the East of Europe, the lack of
59 information on distribution change and the coarse resolution were identified as issues
60 limiting the use of EBBA1 for some purposes.

61 **Conclusions** This study demonstrates the scientific value of European-wide breeding
62 bird atlases. EBBA2, with its almost complete coverage across Europe, the
63 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.

118

119 MATERIALS AND METHODS

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

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

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

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

- 141 • 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 3 150 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 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

215 obtained population sizes from this atlas to determine that migratory divides constitute
216 barriers to dispersal with consequences for ecology and evolution of populations.

217 **Topics in papers referring to EBBA1**

218 *Main topics*

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

232 Conservation also emerged as a very relevant topic and information from EBBA1 was
233 used for a wide variety of purposes. For instance, the evaluation of the network of
234 protected areas by Sándor & Domşa (2012)* who determined additional areas to better
235 preserve forest specialist birds on the basis of a thorough analysis of habitat
236 preferences, the assessment of species of conservation concern as described by Keller
237 *et al.* (2010)* who assessed the international importance of the breeding populations of
238 bird species in Switzerland by estimating the percentage of the national population
239 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 (Tomiałoć 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).

266 *Scale*

267 To date EBBA1 is certainly among the most relevant original works that map the
268 occurrence of breeding birds in the whole of Europe. Therefore, it has been widely
269 employed as a key reference for the European distribution of birds in studies carried
270 out at subnational, national, continental and global scales. For example, Chiron *et al.*
271 (2009)* used EBBA1 data to explore the relationship between the geographical pattern
272 of richness of native bird species and that of exotic bird species in Europe. However,
273 EBBA1 was mostly used as a reference concerning species distribution at subnational
274 level, such as in the study of the impact of radiation from the Chernobyl Nuclear Power
275 Plant on birds by Møller *et al.* (2010)*.

276 *Spatial resolution*

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

286 *Biodiversity focus*

287 EBBA1 has undoubtedly created one of the most complete databases on the
288 distribution of birds in Europe. Other large-scale studies have reached a similar status
289 for other taxonomic groups. Together they have conformed an excellent dataset for
290 many studies interested in biodiversity in a broader sense. For example, Huntley *et al.*

291 (2004)* used distribution data from plants, birds and insects to predict that climatic
292 model performance was related neither to major taxonomic group nor to trophic level.
293

294 **PERSPECTIVES FOR THE NEW EUROPEAN BREEDING BIRD ATLAS**

295 At the moment of compiling information for the analyses shown in this article, a total of
296 3 150 scientific journal papers referred to the 'EBCC Atlas of European Breeding Birds'.
297 A new Google Scholar search would find that this is clearly an outdated number. All
298 these values illustrate the recognition EBBA1 has received in the scientific community,
299 but also the very high research potential of an atlas update.

300 The analysis of publications citing EBBA1 revealed issues that are important to be
301 taken into account for other projects and in particular for the Second European
302 Breeding Bird Atlas, hereafter called EBBA2. Some of the papers analysed in this
303 study made specific comments on the limitations of EBBA1 data, referring especially to
304 deficiencies in the coverage, such as in the eastern part of the continent and the
305 Balkans (e.g. Keil *et al.* 2012)*. EBBA1 gaps of information resulted mainly from
306 limitations in coordination, fieldwork capacity and data flow at that time. To launch the
307 new project and update in the best possible manner the EBBA1 information, EBCC
308 constituted an EBBA2 steering committee whose members had experience in
309 organising surveys, analysing the data and interpreting the results. These members
310 came from different parts of Europe because bird atlas approaches differ depending on
311 the biogeographical, cultural, traditional and economic contexts (Greenwood 2007).
312 Then, an EBBA2 coordination team was established to deliver the central functions of
313 running the atlas project and of keeping a fluent communication within the network of
314 scientists developing methodologies at the European level, coordinators organising
315 fieldwork at national level and skilled ornithologists doing the fieldwork. This close

collaboration guaranteed the top-down integration from a bottom-up approach taking the very diverse situation in Europe into account (Herrando *et al.* 2014).

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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548

549 **APPENDIX**

550 **Random selection of 100 papers that cited the *EBCC Atlas of European Breeding***
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843 **LEGENDS TO FIGURES**

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

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

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

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

864

865 FIGURES

866 Figure 1.

867

868 Figure 2.

Figure 3.

Figure 4.

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