European Commission

Guidelines on how to use the existing information in EuroBirdPortal and the regional/national online bird portals to help determine the start of the spring migration period for huntable bird species in the European Union

Environment

Guidelines on how to use the existing information in EuroBirdPortal and the regional/national online bird portals to help determine the start of the spring migration period for huntable bird species in the European Union

A report on behalf of the EuroBirdPortal project and the European Bird Census Council.Authors: Gabriel Gargallo1 (EBP Project Coordination, Catalan Ornithological Institute. Nat - Museu de Ciències Naturals de Barcelona, Pl. Leonardo de Vinci 4-5, 08019 Barcelona (Spain) - anella@ornitologia.org) and Stephen R Baillie2 (British Trust for Ornithology, The Nunnery, Thetford, Norfolk IP24 2PU (UK) - stephen.baillie@bto.org)

Table of contents

1. Introduction to EuroBirdPortal and its relevance for updating the Key Concepts Document

Unlike more traditional monitoring projects, which focus on structured data collection based on standardised recording protocols at a sample of study sites, the online bird data gathering portals aim mainly to obtain data from the relatively unstructured but intensive and widespread activities of birdwatchers. There are nearly 40 national/regional online portals operating in Europe and the main purpose of the EuroBirdPortal (EBP) project is to combine their data in order to describe large scale spatiotemporal patterns of bird distribution and their changes over time. The fact that online bird portals collect data from all bird species and all year-round is what makes them uniquely valuable for determining the periods of migration. However, coverage still remains poor in some areas and complete lists data, from which the most robust phenological patterns can be derived, are not yet collected in sufficient numbers across large parts of Europe.

1.1. Introduction to the Key Concepts Document and the information provided in this report

This document addresses the Key concepts of Article 7(4) of Directive 2009/147/EC on the period of reproduction and prenuptial migration of huntable bird species under the European Union's Birds Directive (2009/147/EC). In line with common usage we refer to this as the Key Concepts Document (KCD). Essentially the onset of spring migration is used to define the end of the hunting season while the end of the breeding period is used to define the start of autumn hunting. Hunting seasons are defined for individual EU Member States, who may set different start and end dates in different parts of their countries where there is regional variation in the timing of migration and breeding, in accordance with Article 7 of the Birds Directive. Thus the relevant government departments and conservation agencies in each country require information on the onset of spring migration and the end of the breeding period for all listed species that are present in their countries. The overall process is co-ordinated by the European Commission who aim to ensure that there is a consistent approach across member states. Much of the information on migration and breeding periods will be gathered within individual member states but because the process relates to migratory species it will often be appropriate to additionally take account of information from other parts of the flyway and particularly from adjacent countries.

Here we concentrate on the use of online bird portal data, primarily for determination of the onset of spring migration, because observational data of the type gathered by national portals and collated by EuroBirdPortal (EBP) are particularly suitable for measuring it. However, the use and relevance of the data on breeding evidence is also briefly covered. Finally, we also discuss how bird ringing data from EURING or other important data sources can be used to complement the information provided by the online portals. Our focus is on large national and regional datasets so we do not discuss data that may be available through detailed scientific studies undertaken at particular locations.

This document addresses three main audiences. First it is intended to inform relevant government agencies within EU Member States of the types of information that are available. Secondly it provides researchers and scientific advisors responsible for advising these agencies with information on the types of data that are available and how they should be interpreted. Finally it will help to provide those operating national portals with advice on what information they may be asked to provide and on issues to be considered when interpreting their data.

1.2. Introduction to the EBP project and the online bird recording portals

Unlike more traditional monitoring projects, which focus on structured data collection based on standardised recording protocols at a sample of study sites, the online bird data gathering portals aim mainly to obtain year-round data from the relatively unstructured but intensive and widespread activities of birdwatchers. However, despite the fact that data are gathered following simple standardised protocols (e.g. complete lists), or in some cases even no protocol (casual observations), the vast amount of data contained in these portals and the sheer amplitude of their combined geographical and taxonomic coverage offer great potential for research on the temporal and spatial distribution of birds across large geographic areas.

The number and diversity of online bird portals operating in Europe is high. Some are based on very specific systems and cover a limited geographical area (e.g. a region or country) while others function across several countries using the same basic package. Although all of them have relatively similar objectives, they essentially work independently of each other.

The main purpose of the EuroBirdPortal (EBP) project is to combine the data collected by the different online bird recording portals operating in Europe in order to describe large scale spatiotemporal patterns of bird distribution (seasonal distributional changes, migratory patterns, phenology) and their changes over time.

The EBP is a project of the European Bird Census Council (EBCC) developed through a partnership of 81 institutions from 29 different countries that mobilizes the data collected by more than 100,000 volunteer birdwatchers. The partnership involves biodiversity data centres and reference ornithological institutions in their respective countries, building on long-term experience of collecting high quality monitoring data from thousands of volunteer birdwatchers and turning this information into sound science.

Overall, the online data gathering portals run by the EBP partners collect c. 40 million bird records every year thanks to the collaboration of more than 100,000 active observers. This is the largest and most dynamic citizen science biodiversity data flow in Europe.

1.3. The national/regional online portals operating in the different Member States of the European Union

There are a total of 36 national/regional online portals operating in the Member States of the European Union (Table 1.1). Many of them are unique solutions solely implemented in a given region or country (15) but the majority (21) share a common basic system or platform that has "regional" (usually country level) versions. These common systems or platforms are BirdTrack, eBird, Observation.org and Ornitho. Their regional versions are locally adapted (e.g. are in the local language, have specific news sections and statistics) but, otherwise, are mostly identical among them or, at least, use the same core database, design and functionalities.

Some portals, particularly those using the common platforms, also collect data outside their main area of activity (i.e. the country/region indicated in Table 1.1) or even have global portals (e.g. BirdTrack, eBird, Observation.org). However, the vast majority of data collected in each country or region comes from the portals primarily operating there.

EU Member State	Online portal	Online system	EBP Partner
Austria	https://www.ornitho.at/	Ornitho	BirdLife Austria
Belgium	http://observations.be	Observation.org	Natagora
	http://waarnemingen.be		Natuurpunt
Bulgaria	https://www.smartbirds.org/	Smartbirds	Bulgarian Society for the Protection of Birds
	https://app.bto.org/birdtrack2/main/data-home.jsp	BirdTrack	
Croatia[1]	http://www.fauna.hr/	Ornitho	Association BIOM
Cyprus[2]	https://app.bto.org/birdtrack2/main/data-home.jsp	BirdTrack	BirdLife Cyprus
			The North Cyprus Society for the Protection of Birds and Nature
Czech Republic	http://birds.cz	Birds.cz	Czech Society for Ornithology (CSO)
Denmark	http://dofbasen.dk/	DOFbasen	Dansk Ornitologisk Forening (DOF)
Estonia	https://plutof.ut.ee/	PlutoF	Estonian Ornithological Society
Finland	https://www.tiira.fi/	Tiira	BirdLife Suomi
France	https://www.faune-france.org	Ornitho	Ligue pour la Protection des Oiseaux (LPO)
Germany	https://ornitho.de	Ornitho	Dachverband Deutscher Avifaunisten (DDA)
Greece	https://app.bto.org/birdtrack2/main/data-home.jsp	BirdTrack	Hellenic Ornithological Society
Hungary	http://map.mme.hu/	MAP	Magyar Madártani és Természetvédelmi Egyesület
Ireland	http://blx1.bto.org/birdtrack/	BirdTrack	BirdWatch Ireland
Italy	https://www.ornitho.it	Ornitho	Lega italiana protezione uccelli (LIPU)
			Centro Italiano Studi Ornitologici (CISO)
			EuroBirdNet Italia
Latvia	http://dabasdati.lv/	Dabas Dati	Latvian Fund for Nature
			Latvian Ornithological Society (LOB)
Lithuania[3]	http://ornitologija.lt/orni/web/	Lietuvos Paukščiai	Lithuanian Ornithological Society (LOD)
Luxembourg	https://ornitho.lu	Ornitho	natur&ëmwelt
Netherlands	http://trektellen.nl	Tektellen	Dutch Centre for Field Ornithology (Sovon)
	http://avimap.nl/	Avimap	
	https://waarneming.nl	Observation.org	
Malta[3]	https://app.bto.org/birdtrack2/main/data-home.jsp	BirdTrack	
Poland	https://ornitho.pl	Ornitho	Polish Society for the Protection of Birds (OTOP)
Portugal	http://ebird.org/portugal	eBird	Portuguese Society for the Study of Birds (SPEA)
			Laboratório de Ornitologia (LABOR)
Romania	http://www.openbirdmaps.ro/	Openbirdmaps	Milvus Group
	http://pasaridinromania.sor.ro/ornitodata	Ornitodata	Societatea Ornitologica Romana
Slovakia	http://aves.vtaky.sk	Aves-Symfony	Slovenská ornitologická spoločnosť/BirdLife Slovensko
Slovenia[1]	http://atlas.ptice.si	Atlas.ptice	BirdLife Slovenia (DOPPS)
Spain	https://ebird.org/spain	eBird	Sociedad Española de Ornitologia (SEO/BirdLife)
	https://app.bto.org/birdtrack2/main/data-home.jsp	BirdTrack	
	https://www.ornitho.cat	Ornitho	Catalan Ornithological Institute (ICO)
	https://www.ornitho.eus	Ornitho	Aranzadi Zientzia Elkartea
Sweden	https://artportalen.se/	Artportalen	Swedish Species Information Centre (SLU)
United Kingdom	http://blx1.bto.org/birdtrack/	BirdTrack	British Trust for Ornithology

Table 1.1. Portals operating in the different Member States and their responsible EBP partner ([1]No data on EBP viewer yet, [2] Data submitted but no formal EBP partner yet, [3] No formal EBP partner yet). Only the primary recording schemes operating in each country are indicated. Note that some portals (e.g. BirdTrack, eBird, Observation.org, Ornitho, Trektellen) collect some data in other areas or even worldwide.

1.4. Main characteristics of the data collected

Online bird recording portals collect data on all bird species year-round thanks to the collaboration of large numbers of volunteer birdwatchers. Data collection protocols are kept reasonably simple while the feedback given back to the participants in the form of maps, lists and tables is, in general, very comprehensive. This attracts maximum participation and ensures that observers use the portal as a kind of online notebook of all their birdwatching activities, promoting widespread data gathering throughout the year.

The basic data collected includes species, date, location, and whether all species detected were reported (i.e. do the data comprise a complete list). Casual records are those that do not form part of complete lists and only provide presence information. In contrast, complete lists contain much more valuable presence/absence data (strictly detection/non detection data). Many observations also include the number of individuals of each species observed (counts) and, in the case of complete lists, some additional contextual data about the whole observational event (e.g. start and end time, distance travelled/area covered). Despite being a very simple protocol, therefore, complete lists not only provide presence/absence data but usually also information about recording effort (see section 6.1). Most portals also allow observers to provide additional detailed information on a given observation (e.g. age and sex, breeding evidence, comments) but always in an optional manner.

Several portals also include data from standard monitoring schemes (e.g. common breeding bird census, winter waterbird counts), but in general, this is only a small proportion of the whole dataset.

1.5. Quality checks and overall reliability of the data collected

All online portals have a data verification process in place. Usually, a combination of automated data filters and a network of local expert reviewers is used. Data filters are most often used to flag the records which are unusual because of the species (e.g. a vagrant is reported), timing (e.g. a summer visitor observed in mid-winter) or location (e.g. a bird observed well outside its known range for a given time period), but some portals can also flag records when observed in a unusual altitude or because the number of birds reported is too high. These filters are mostly set up once, but can be updated from time to time using the new data collected by the system or through additional expert advice.

To further ensure their effectiveness, filters are often fully embedded in the data entry process, warning the observer about potential errors as they are about to be entered (e.g. showing a warning message or preventing data from being submitted before it is double checked). Most errors are due to typing errors (e.g. selecting the wrong species from a dropdown menu or typing the wrong number when indicating the count or the date), therefore, if the observer is conveniently warned many of them are already corrected before being submitted.

Records that end up being submitted and which are flagged are subsequently reviewed by a network of local experts who will be responsible for making a final decision regarding the record's validity. The network of local experts is usually formed by a combination of experts on certain regions or areas and experts on certain groups of species. These experts not only validate the data flagged automatically by the internal filters, they also routinely check the entire database using the different tools and outputs provided by each system (tables, maps, graphs) to flag and review additional dubious records. Such networks of experts are usually big and active enough to detect most of the obvious errors in a matter of hours. In the Ornitho system, for instance, it is estimated that 80% of the errors are detected in less than 72 hours. The reviewers usually have special login credentials that allow them not only to see all flagged records but also to communicate with the observers about their records and to check or intervene in other validation processes.

In the case of national or regional rarities, most portals work closely with the corresponding Regional or National Rarities Committees to ensure that the corresponding records also go through the usual validation process for rarities. In fact, some Regional or National Rarities Committees use the online portals as the sole framework where the whole process related to rarities (submission and verification) is done.

Once a final decision is taken by the corresponding committee or team of reviewers, records in process of validation are either unflagged or marked as unconfirmed (or not-accepted). Unconfirmed records are retained (e.g. for the own use and interest of the individual observer and to be available if future reassessment is required) but, like flagged ones, not shown in public outputs (e.g. listings, graphs, etc.) nor used in any kind of analysis.

For the 105 species shown in the EBP viewer (see section 2), additional data quality checks are conducted using a specific online tool that allows partners to delete any wrong record that still may be apparent in the viewer maps. This tool works in real-time. Therefore, anytime that a wrong record is deleted all affected maps are automatically corrected.

Despite all the efforts directed to ensure data quality, the sheer quantity of records collected by the EBP partner's local online portals (c.50 million new records every year) is too big as to ensure that they are completely error-free. However, the potential existence of a few erroneous records, which anyway is inherent to any big database, does no dismiss the immense value of the data collected. There is now a substantial and growing body of evidence demonstrating that robust ecological conclusions concerning distributions and phenology can be drawn from data of this kind (Baillie et al., 2006; Fink et al., 2010; La Sorte et al., 2018; Newson et al., 2016a).

1.6. Main potential and limitations of data from online portals

The fact that online bird portals collect data from all bird species and all year-round is what makes them uniquely valuable for determining phenological patterns across much of Europe. As explained in detail in the next sections (particularly, sections 2.3, 3.3 and 6), however, this does not come without some limitations or important caveats. These can be summarised as follows:

- Coverage remains poor in some entire countries or significant parts of them (see section 3.1).

- Complete list data, from which the most robust phenological patterns can be derived, are not yet collected in sufficient numbers across large parts of Europe.

- Online bird portals provide huge datasets of observational data but do not provide information on the movements of individual birds. Therefore, specialist expertise in migration ecology or the use of complementary data, particularly those derived from ringing or tracking, are generally required to make sound interpretations of the spatiotemporal patterns derived from them.

2. How to use the maps and graphs available on the EBP to update the KCD?

The EBP online viewer shows a set of different animated maps and phenological graphs depicting the week-by-week distributional patterns of 105 species, 28 of which are huntable, thanks to the 205 million bird records submitted between 2010 and 2016 to the on-line bird recording portals run by the project partners. The geographic coverage of the viewer includes all Member States except Lithuania and Malta plus some non-EU countries (Andorra, Israel, Norway, Switzerland and Turkey). Although some useful country-specific information can be extracted from the EBP viewer maps, their real value resides in their capability to provide a continental overview of the main spatiotemporal patterns of bird distributions. To take into account such large-scale overview can be important when trying to understand the overall progress of migratory movements and to correctly interpret the precise country or regional phenological patterns obtained using other, more suitable, sources of information. Moreover, this continental overview can be particularly useful when trying to define migration periods in countries with poor coverage.

2.1. Introduction to the EBP viewer

The EBP viewer shows animated maps depicting the week-by-week distributional patterns of 105 species, 28 of which are huntable according to the Birds Directive 2009/147/EC (Table 2.1). Currently, the viewer maps show data for the period 2010 to 2016 but by the end of 2018 a new, near "real-time", version of the viewer is expected to be launched. The available species will be the same (at least in the short term), but unlike the current one, this version will be updating its content on a weekly basis and show data from January 2010 up to the previous week, hence the term "real-time" (for more details see this link).

Currently, the geographic coverage of EBP viewer includes all Member States except Lithuania and Malta plus some non-EU countries (Andorra, Israel, Norway, Switzerland and Turkey; Figure 2.1).

Figure 2.1. Geographical coverage of the current version of the EBP viewer (EU Member States are shown in green).

Species available in the EBP viewer				Species not available in the EBP viewer	
Non-huntable		Huntable		Huntable	
English name	Scientific name	English name	Scientific name	English name	Scientific name
Egyptian Goose	*Alopochen aegyptiaca*	Greylag Goose	*Anser anser*	Mute Swan	*Cygnus olor*
Common Shelduck	*Tadorna tadorna*	Greater White-fronted Goose	*Anser albifrons*	Bean Goose	*Anser fabalis*
Great Cormorant	*Phalacrocorax carbo*	Brent Goose	*Branta bernicla*	Pink-footed Goose	*Anser brachyrhynchus*
Great White Egret	*Ardea alba*	Eurasian Wigeon	*Mareca penelope*	Canada Goose	*Branta canadensis*
White Stork	*Ciconia ciconia*	Common Teal	*Anas crecca*	Gadwall	*Mareca strepera*
Eurasian Spoonbill	*Platalea leucorodia*	Northern Pintail	*Anas acuta*	Mallard	*Anas platyrhynchos*
European Honey-buzzard	*Pernis apivorus*	Northern Shoveler	*Spatula clypeata*	Red-crested Pochard	*Netta rufina*
Black Kite	*Milvus migrans*	Garganey	*Spatula querquedula*	Common Pochard	*Aythya ferina*
Red Kite	*Milvus milvus*	Goosander	*Mergus merganser*	Tufted Duck	*Aythya fuligula*
Western Marsh-harrier	*Circus aeruginosus*	Common Quail	*Coturnix coturnix*	Greater Scaup	*Aythya marila*
Hen Harrier	*Circus cyaneus*	Northern Lapwing	*Vanellus vanellus*	Common Eider	*Somateria mollissima*
Pallid Harrier	*Circus macrourus*	Ruff	*Calidris pugnax*	Long-tailed Duck	*Clangula hyemalis*
Montagu's Harrier	*Circus pygargus*	Common Snipe	*Gallinago gallinago*	Common Scoter	*Melanitta nigra*
Eurasian Sparrowhawk	*Accipiter nisus*	Black-tailed Godwit	*Limosa limosa*	Velvet Scoter	*Melanitta fusca*
Eurasian Buzzard	*Buteo buteo*	Eurasian Curlew	*Numenius arquata*	Common Goldeneye	*Bucephala clangula*
Rough-legged Buzzard	*Buteo lagopus*	Common Redshank	*Tringa totanus*	Red-breasted Merganser	*Mergus serrator*
Osprey	*Pandion haliaetus*	Common Greenshank	*Tringa nebularia*	Hazel Grouse	*Bonasa bonasia*
Red-footed Falcon	*Falco vespertinus*	Black-headed Gull	*Larus ridibundus*	Willow Grouse	*Lagopus lagopus*
Eurasian Hobby	*Falco subbuteo*	Mew Gull	*Larus canus*	Rock Ptarmigan	*Lagopus muta*
Common Crane	*Grus grus*	Common Woodpigeon	*Columba palumbus*	Black Grouse	*Lyrurus tetrix*
Little Ringed Plover	*Charadrius dubius*	Eurasian Collared-dove	*Streptopelia decaocto*	Western Capercaillie	*Tetrao urogallus*
Dunlin	*Calidris alpina*	European Turtle-dove	*Streptopelia turtur*	Chukar	*Alectoris chukar*
Green Sandpiper	*Tringa ochropus*	Eurasian Skylark	*Alauda arvensis*	Rock Partridge	*Alectoris graeca*
Wood Sandpiper	*Tringa glareola*	Fieldfare	*Turdus pilaris*	Red-legged Partridge	*Alectoris rufa*
Common Sandpiper	*Actitis hypoleucos*	Song Thrush	*Turdus philomelos*	Barbary Partridge	*Alectoris barbara*
Sandwich Tern	*Thalasseus sandvicensis*	Redwing	*Turdus iliacus*	Grey Partridge	*Perdix perdix*
Common Tern	*Sterna hirundo*	Eurasian Jay	*Garrulus glandarius*	Common Pheasant	*Phasianus colchicus*
Rose-ringed Parakeet	*Psittacula krameri*	Common Starling	*Sturnus vulgaris*	Wild Turkey	*Meleagris gallopavo*
Common Cuckoo	*Cuculus canorus*			Western Water Rail	*Rallus aquaticus*
Short-eared Owl	*Asio flammeus*			Common Moorhen	*Gallinula chloropus*
European Nightjar	*Caprimulgus europaeus*			Common Coot	*Fulica atra*
Common Swift	*Apus apus*			Eurasian Oystercatcher	*Haematopus ostralegus*
Common Hoopoe	*Upupa epops*			Eurasian Golden Plover	*Pluvialis apricaria*
Eurasian Wryneck	*Jynx torquilla*			Grey Plover	*Pluvialis squatarola*
Woodlark	*Lullula arborea*			Red Knot	*Calidris canutus*
Collared Sand Martin	*Riparia riparia*			Jack Snipe	*Lymnocryptes minimus*
Barn Swallow	*Hirundo rustica*			Eurasian Woodcock	*Scolopax rusticola*
Northern House Martin	*Delichon urbicum*			Bar-tailed Godwit	*Limosa lapponica*
Tree Pipit	*Anthus trivialis*			Whimbrel	*Numenius phaeopus*
Meadow Pipit	*Anthus pratensis*			Spotted Redshank	*Tringa erythropus*
Water Pipit	*Anthus spinoletta*			Lesser Black-backed Gull	*Larus fuscus*
Western Yellow Wagtail	*Motacilla flava*			European Herring Gull	*Larus argentatus*
White Wagtail	*Motacilla alba*			Caspian Gull	*Larus cachinnans*
Bohemian Waxwing	*Bombycilla garrulus*			Great Black-backed Gull	*Larus marinus*
Common Nightingale	*Luscinia megarhynchos*			Rock Dove	*Columba livia*
Bluethroat	*Cyanecula svecica*			Stock Dove	*Columba oenas*
Black Redstart	*Phoenicurus ochruros*			Eurasian Blackbird	*Turdus merula*
Common Redstart	*Phoenicurus phoenicurus*			Mistle Thrush	*Turdus viscivorus*
Whinchat	*Saxicola rubetra*			Eurasian Magpie	*Pica pica*
Common Stonechat	*Saxicola torquatus*			Eurasian Jackdaw	*Corvus monedula*
Northern Wheatear	*Oenanthe oenanthe*			Rook	*Corvus frugilegus*
Ring Ouzel	*Turdus torquatus*			Carrion Crow	*Corvus corone*
Sedge Warbler	*Acrocephalus schoenobaenus*				
Marsh Warbler	*Acrocephalus palustris*				
Eurasian Blackcap	*Sylvia atricapilla*				
Garden Warbler	*Sylvia borin*				
Lesser Whitethroat	*Sylvia curruca*				
Common Whitethroat	*Sylvia communis*				
Yellow-browed Warbler	*Phylloscopus inornatus*				
Wood Warbler	*Phylloscopus sibilatrix*				
Common Chiffchaff	*Phylloscopus collybita*				
Willow Warbler	*Phylloscopus trochilus*				
Collared Flycatcher	*Ficedula albicollis*				
European Pied Flycatcher	*Ficedula hypoleuca*				
Eurasian Blue Tit	*Cyanistes caeruleus*				
Eurasian Golden Oriole	*Oriolus oriolus*				
Red-backed Shrike	*Lanius collurio*				
Great Grey Shrike	*Lanius excubitor*				
House Sparrow	*Passer domesticus*				
Common Chaffinch	*Fringilla coelebs*				
Brambling	*Fringilla montifringilla*				
European Serin	*Serinus serinus*				
Eurasian Siskin	*Spinus spinus*				
Common Linnet	*Linaria cannabina*				
Red Crossbill	*Loxia curvirostra*				
Ortolan Bunting	*Emberiza hortulana*				
Reed Bunting	*Emberiza schoeniclus*				

Table 2.1. List of the non-huntable and huntable bird species (Birds Directive 2009/147/EC) currently available in the EBP viewer and those that are huntable but not yet available.

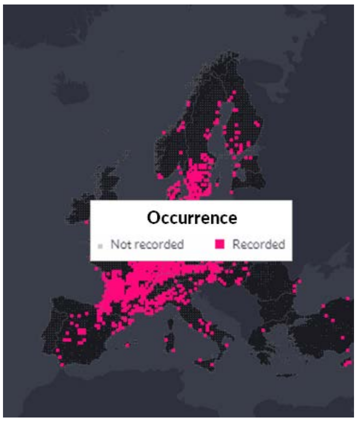
2.2. Description of the maps and graphs available, the kind of information that they contain and its main limitations

A total of five types of animated species maps are shown in the EBP viewer. These maps are formed by 52 frames, each one providing a snapshot of the distribution of birds in each of the 52 weeks of the year. Therefore, moving forward or backward the animation, week by week, it is very easy to grasp the overall year-round changes in bird distribution ("bird movements"). Rather than checking one single static map, it is possible to view an entire chronological series of weekly map snapshots that gives real added value to the EBP viewer visualizations.

Moreover, to facilitate direct comparison, two animated maps of any species, year and type can be selected to be shown simultaneously (Figure 2.2). It is also possible to select "All years" maps, which combine all seven years of available data, to visualize the overall seasonal patterns of bird distribution rather than that of one specific year. Calendar years (for example “2014”) or July to June inter-annual cycles (for example “2015/16”) can be selected. In the latter, the time series starts at week number 27 of the first year (2–8 July), and finishes in week number 26 of the following year (25 June – 1 July). When selecting natural years the time series starts in week number 1 (1–7 January) and finishes in week number 52 (26–30 December). February 29th is included in week 9 (26 February - 4 March) and, currently, December 31st data is not used). To easily learn how to use the EBP viewer and its different functionalities check this users video guide.

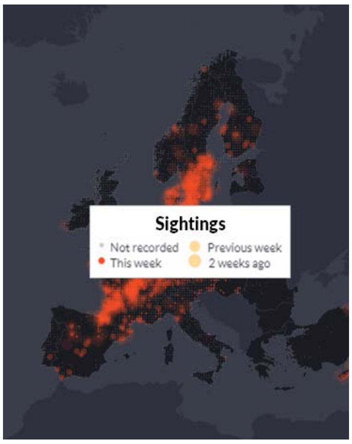
Figure 2.2. The EBP viewer allows easy comparison of the week-by-week distributional patterns of different species or different years of the same species (link).

The species maps shown in the EBP demo viewer are based on 205 million bird records submitted between 2010 and 2016 to the on-line bird recording portals run by the project partners (see section 1). These records were subsequently aggregated by week and 30x30 km square (based on the European Environment Agency reference grid ETRS89-LAEA) summarizing information on the number of observations of each species, the number of counted birds and the recording effort (number of complete lists and total number of records and observers). Four of the species maps (occurrence, traces, counts and phenology) reflect, in different ways, the raw information contained in the aggregated data. A fifth map (corrected regional occurrence), currently unavailable, uses various analytical procedures to account for heterogeneity in observational effort and species reporting rates (it is expected to be available again by the end of 2018). In all cases, only those 30x30 km squares including terrestrial areas are shown in the maps.



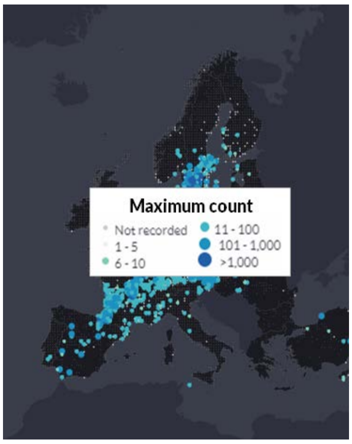
Occurrence map

These maps show the 30x30 km squares where the selected species was recorded or not each week. Note that not all species detected end up being reported and, thus, the absence of records in a given square does not automatically mean that the species was not observed there.



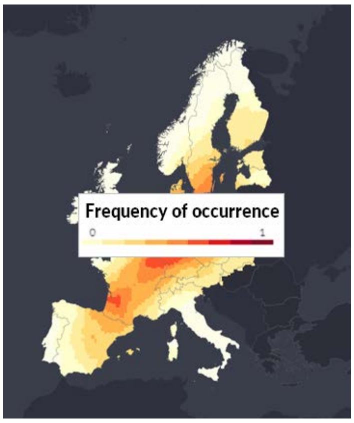
Traces map

These maps show the 30x30 km squares where the selected species has been recorded during each week but also during the two previous ones, enhancing the visualization of rapid temporal changes in distribution and their "traces" over time. The orange symbol indicating that the species was recorded in a given week increases in size and transparency the older the record (i.e. up to 2 weeks ago). Note that not all species detected end up being reported and, thus, the absence of records in a given square does not automatically mean that the species was not observed there.



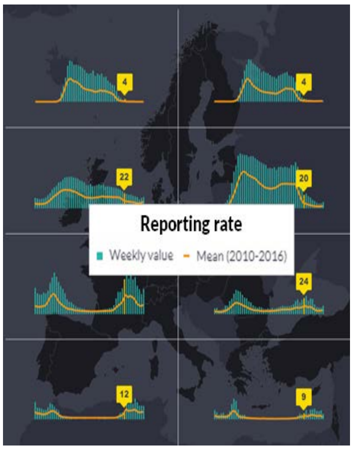
Counts map

These maps show the maximum count recorded for the selected species in each 30x30 km square and week (in "All years" maps, the average of the maximum count of each year is shown). Note that the original counts used to obtain these figures mostly refer to casual counts or rough estimates of the number of birds detected in a given site and date. Only rarely they refer to formal censuses or exhaustive counts. These maps, therefore, only show a rough approximation of the real variability in bird numbers across space and time. Also take into account that not all species detected end up being reported and not all detected species are counted; thus the absence of records in a given square does not automatically mean that the species was not observed there.



Corrected regional occurrence (CRO) map

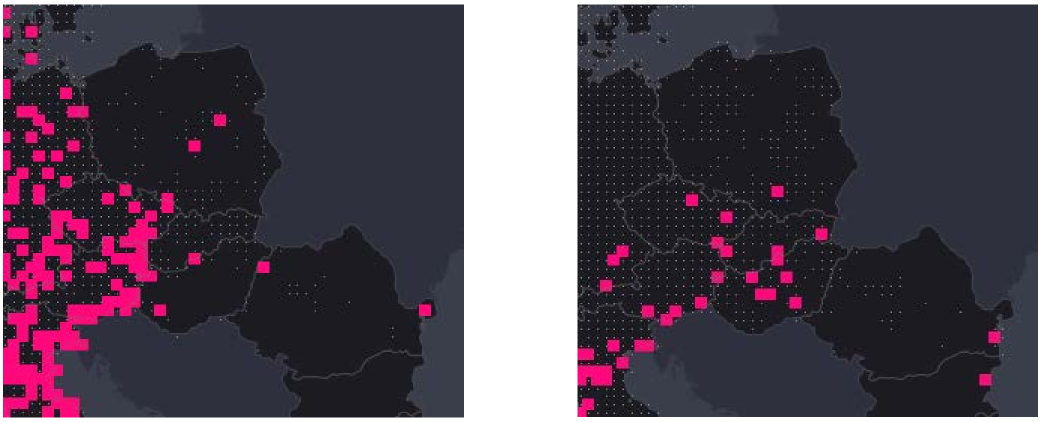
These maps make use of a complex set of spatial and temporal aggregation and smoothing procedures to account for differences in observational effort and reporting activity of the observers (for more details see this link). They are specifically intended to help visualize large-scale temporal changes in bird distributions and thus they should not be interpreted at a local scale. For each 30x30 km square and week these maps depict the estimated regional frequency of occurrence of the selected species. Modelling the spatial and temporal dynamics of bird distributions is one of the main but challenging objectives of the EBP project. This work is underway and, therefore, it has to be stressed that the maps shown here are very preliminary.



Phenological map

These maps depict the phenology of the selected species in eight different geographical sectors according to the percentage of 30x30 km squares where the species was recorded in each sector and week. The weekly value of the selected year ("Weekly value") and the mean for the 2010-2016 period are shown.

It is very important to understand how presence/absence information is depicted in the occurrence, traces and counts maps (see Figure 2.3). All these maps only depict 30x30 km squares that are considered to have been surveyed in a given week (i.e. those where at least some species where recorded). The larger symbols (pink, orange or blue depending on the map type) indicate the existence of records of the selected species in a surveyed square and week while the small grey symbols indicate the lack of them. Therefore, areas not covered at all (no species recorded) in any given week can easily be identified since they appear black in the maps (no symbol is shown). However, note that though, in general, the absence of records of a given species in a surveyed square and week does denote a lack of observations of the species it cannot be completely ruled out that the species was observed but not reported (remember that, as indicated above, most of the data are collected as casual records and, therefore, not all species observed are necessarily reported, unlike in complete lists).



2015 2016

Figure 2.3. Two close-up snapshots of the EBP viewer showing the occurrence of the Garganey in early March (5-11 March) in two different years. The symbols identify the 30x30 surveyed squares (i.e. those where at least some species where recorded in the given week), the large pink square signals the ones where the selected species (the Garganey in this case) was reported and the small grey square the ones where it was not. The areas shown in black (no symbol depicted) signal the 30x30 km squares where no single observation (of any species) was reported. Note how the level of coverage in that particular week has changed from one year to the next, particularly in Poland.

2.3. Guidelines on how to use this information to help define the period of pre-nuptial migration

Although some useful country-specific (or even region-specific within countries) information can be extracted from the EBP viewer maps, their real value resides in their capability to show a continental-wide overview of the main spatiotemporal patterns of bird distribution. To take into account such a large-scale overview can be important when trying to understand the overall progress of migratory movements and to correctly interpret the precise country or regional phenological patterns obtained using other, more suitable, sources of information (cf. sections 3 and 4). Moreover, this overview can be particularly useful when trying to define migration periods in countries with poor coverage.

In any case, before using the information provided by the EBP viewer in relation to the update of the KCD document, the following considerations should be taken into account:

- Only 28 of the 80 huntable species are currently available in the viewer (Table 2.1). Seven of which may be hunted in all Member States (Annex IIa).

- All the maps show the distributional/phenological patterns by week intervals, not decades, therefore, the information cannot be directly translated to the decades format required by the KCD document (see also section 5.4 on the relevance of using daily data).

- The phenological graphs shown in the EBP viewer only show broad regional patterns (not country by country) and do not compensate for observer effort as effectively as those based on complete list reporting rates. Special attention must be paid, therefore, when interpreting these results (see also section 5).

- Coverage is still poor in some entire countries or significant parts of them (cf. Figure 3.1 & Table 3.2), particularly in some seasons or years (Figure 2.3). Moreover, since complete lists are not yet collected in sufficient numbers in large parts of Europe, currently all maps shown in the EBP viewer treat all data as casual records. It is very important, therefore, to take into account how detection/non-detection information is depicted in the maps (Figure 2.3).

- Each on-line bird recording scheme submitting data to the EBP has its own data validation protocols to deal with potentially erroneous observations (section 1). Moreover, additional data quality checks are conducted at the EBP level. However, overall, the EBP demo viewer synthesises more than 205 million bird records in about 44,000 weekly maps. This is too large a number to completely discard the possibility that some erroneous observations could still be present in a few maps. The existence of some erroneous records or counts, however, should not distort the overall large-scale temporal patterns of bird distribution shown in the viewer.

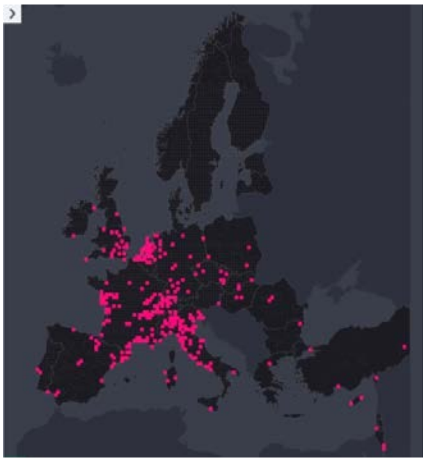
- Despite the overall guidelines given here, some expertise is always required to make sound interpretations of the information provided by the EBP viewer, therefore, we strongly recommended that users should seek advice from local ornithological experts (cf. section 4).

- To overcome the main limitations of the information provided by the EBP viewer (e.g. reduced taxonomic coverage, lack of country-specific information, weekly time periods) it is necessary to use other sources of information, like the tools and outputs provided by the local online portals or, better still, to analyse their raw data (see sections 4-5 for more details).

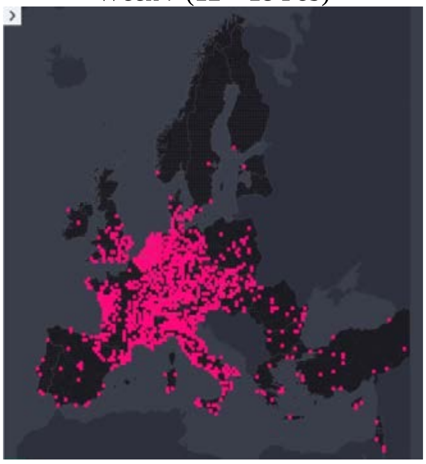
To better illustrate how the information provided by the EBP viewer can best be interpreted, next we describe patterns observed in the chronological series of map snapshots of a few huntable species and give some helpful tips. The examples focus on occurrence, counts and phenology maps since these are the ones that offer more readily interpretable information in relation to the migration periods.

Garganey *Anas querquedula*

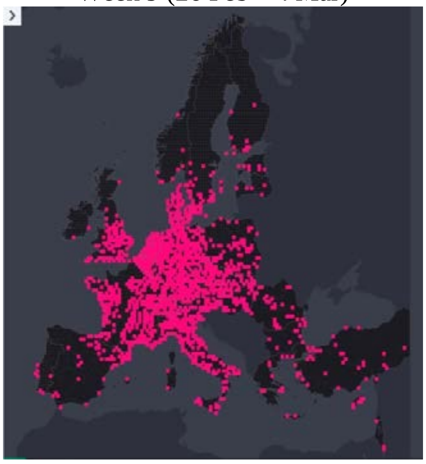
Week 7 (12 – 18 Feb)



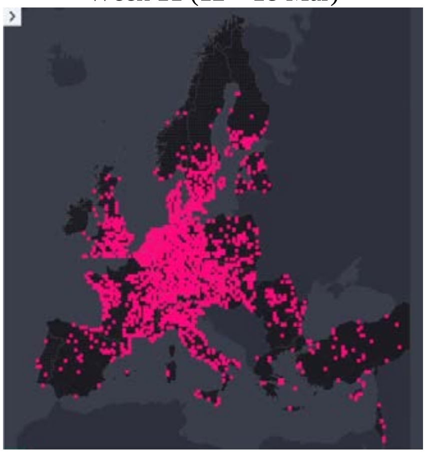
Week 9 (26 Feb – 4 Mar)



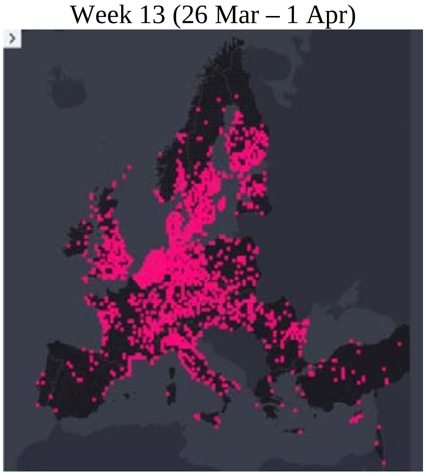
Week 11 (12 – 18 Mar)



Week 13 (26 Mar – 1 Apr)



Week 15 (9 – 15 Apr)



Week 17 (23 – 29 Apr)

Figure 2.4. Snapshots of the occurrence maps of the Garganey for six selected weeks (all years combined; see the complete chronological series here).

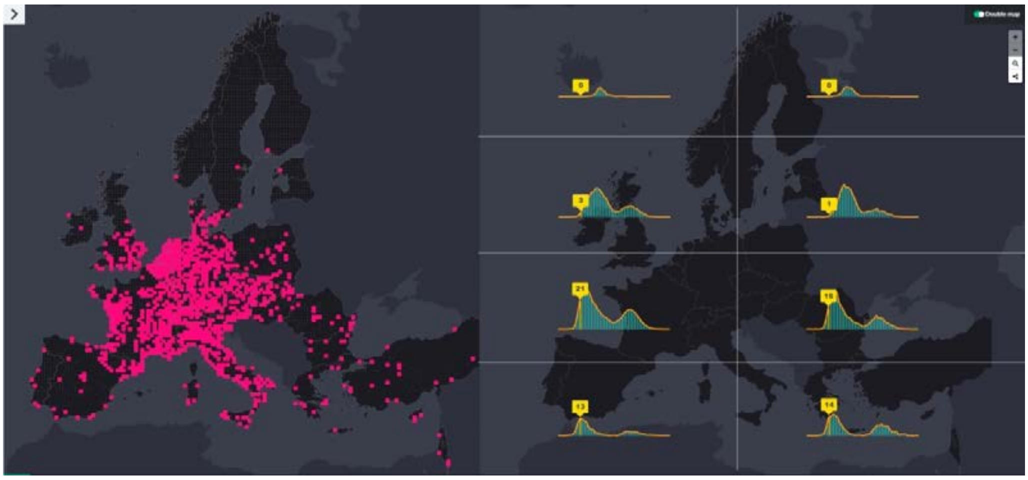
In summer visitors such as the Garganey, the start of the prenuptial migration can be quite easily determined due to the lack of wintering birds. In mid-February (week 7; Figure 2.4) only a very few scattered individuals can be seen in Europe but in late February-beginning of March (week 9) the arrival of the species starts to be very apparent particularly in Spain, France and Italy (see below also). By mid-March (week

11) the species is already widespread through most of central Europe. In late March (week 13) a few birds are detected further north, from Norway to the Baltic countries and southern Finland, where the species is progressively becoming more and more common (cf. weeks 15 and 17).

The all years maps have the advantage of combining all the available information for the period 2010-2016, which is particularly useful for these areas where data or coverage is sparse. However, the combination of several years of data in occurrence maps can sometimes be misleading, for example suggesting that a given species is more common in a given area and time period than it is in reality. Imagine ten records in a given week widespread in different 30x30 km squares of the same country. These can be quite conspicuous in the maps, but taking into account that 7 years of data have been combined, the real frequency of the species in the area and time period would be, really, very low, close to zero. This, therefore, has to be taken into account when interpreting these maps.

Count maps, particularly in some gregarious species such as wildfowl (see below), can be used to overcome this problem since quantity is complementing the coarse occurrence information. Another option is to use the phenology maps, which give an indication of the relative frequency of the occurrence of the species in different sectors of Europe (see above and Figure 2.5). In the case of the Garganey, for example, the occurrence map shows quite a lot of occurrence dots already in late February-beginning of March in the British Isles and around the Netherlands (week 9; Figures 2.4 & 2.5) which may suggest that the arrival takes place in the areas more or less at the same time that in more southern European regions. However the phenological graph clearly indicates that the passage takes place earlier the further to the south (note how the peak of frequency changes from south to north). The size of the sectors used in the EBP viewer, however, very much limits the use of these maps at the country or regional level and this is one of the reasons why it is so important to determine migration periods using reporting rates based on the data available in the local online portals (cf. sections 4 & 5).

Week 9 (26 Feb – 4 Mar)



Week 11 (12 – 18 Mar)

Figure 2.5. Snapshots of the occurrence and phenology maps of the Garganey for two selected weeks (all years combined; see the complete chronological series here).

Checking maps of different years can also help to understand the nature of a given occurrence pattern. For example, to see if the pattern is consistent enough across years, or mostly due to records collected in a very unusual year (Figure 2.6), or the consequence of the combination of small numbers of records collected across many years.

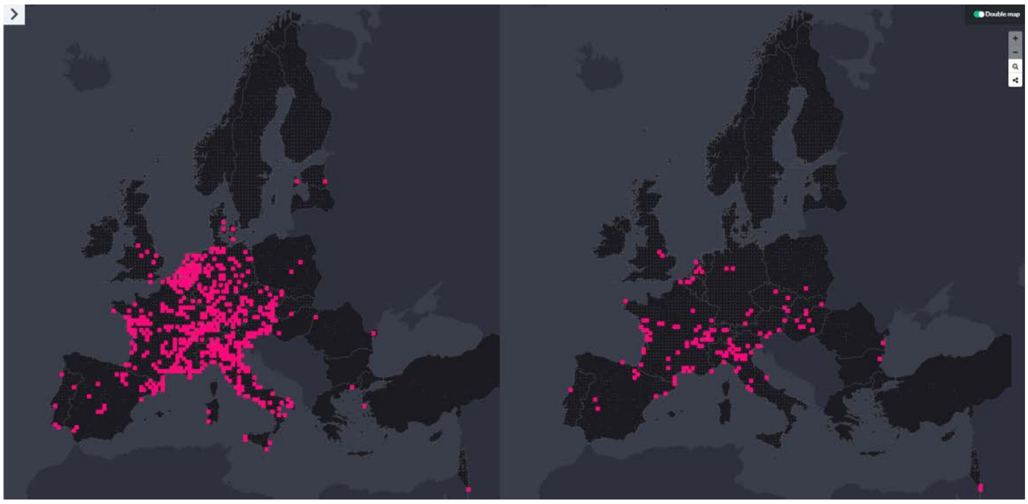
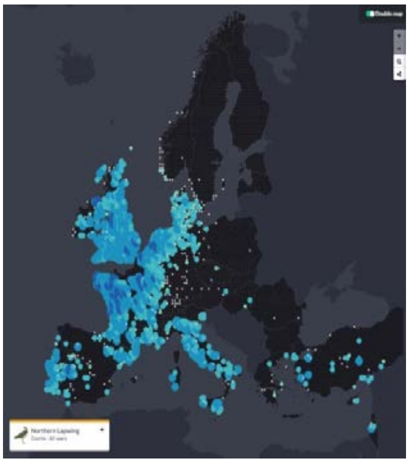
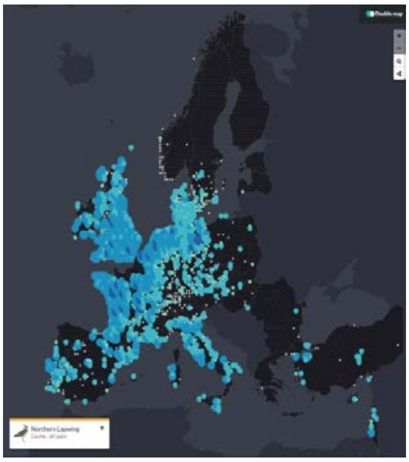


Figure 2.6. Snapshot of the occurrence map of the Garganey on week 10 (5 – 11 March) in 2015 (left) and 2016 (right). Note that in that week of 2015 migration was much more advanced that in 2016 (all years combined; see the complete chronological series here).

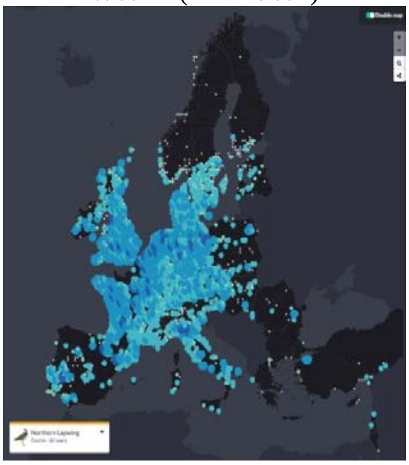
Northern Lapwing *Vanellus vanellus*



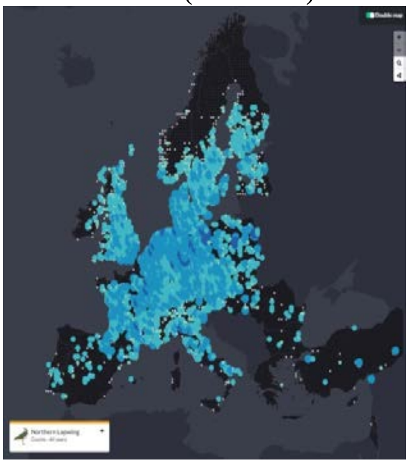
Week 4 (22 – 28 Jan)



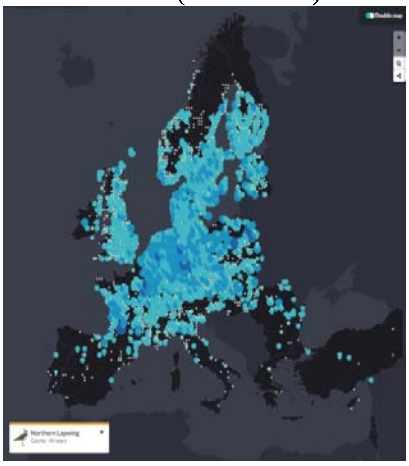
Week 6 (5 – 11 Feb)



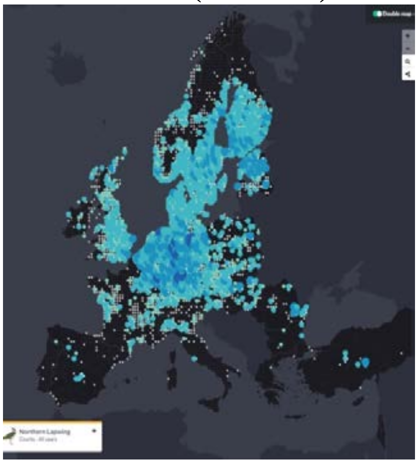
Week 8 (19 – 25 Feb)



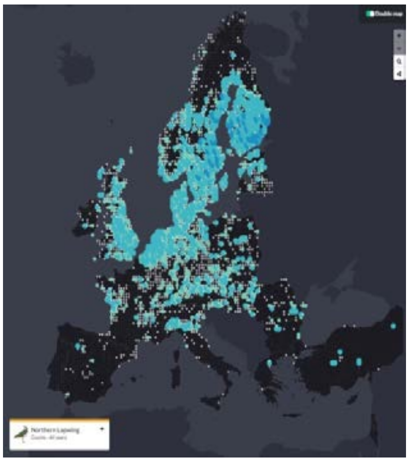
Week 10 (5 – 11 Mar)



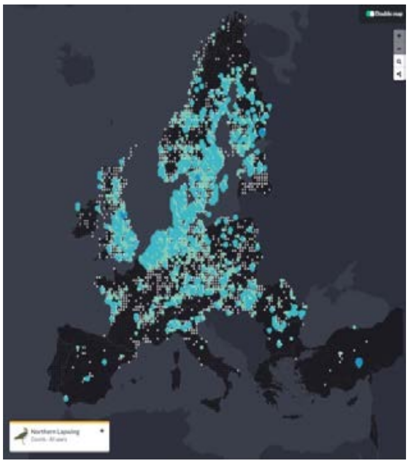
Week 12 (19 – 25 Mar)



Week 14 (2 – 8 Apr)



Week 16 (16 – 22 Apr)

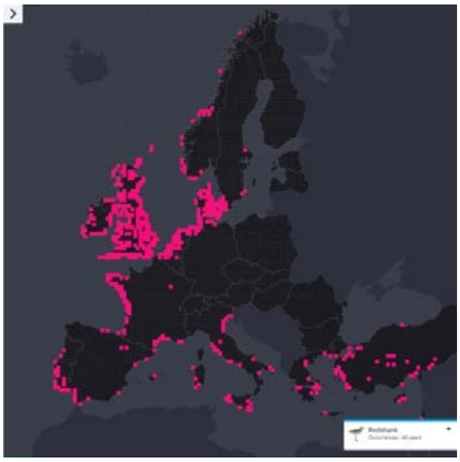


Week 18 (30 Apr – 6 May)

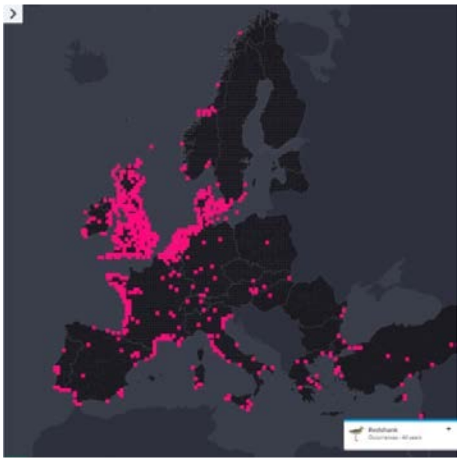
Figure 2.7. Snapshots of the counts maps of the Northern Lapwing for eight selected weeks (all years combined; see the complete chronological series here).

In gregarious species such as the Northern Lapwing, the animated count maps may give a better overview of the progress of the prenuptial migration (Figure 2.7). In late January (week 4) most lapwings are still confined to the main wintering areas and any ongoing movements are difficult to detect. However, by early February (week 6), migrant Lapwings are already present in countries such as Austria, Czech Republic and Slovakia, where the species is mostly absent during the winter. Two weeks later the influx of birds is much greater all over this area, Germany and up to Estonia and southern Sweden and Finland. In early April (week 14), migration is still intense in most of central and northern Europe but it has either finished or is in its last phases in the Iberian Peninsula, Italy and southern France. At the start of the second half of April (week 16), migration is still intense in the very north (e.g. Sweden and Finland) but at the start of May (week 18) it has mostly ceased except, perhaps, in these same more northern areas. Note that in the main wintering areas the start of migration is difficult or impossible to ascertain using these maps due to widespread presence of wintering birds. Also in some of these areas such as western France initiation of breeding behaviour by resident birds may occur before the departure of overwintering birds. Thus measures of breeding behaviour may provide a better basis for ending the hunting season (see section 5.5).

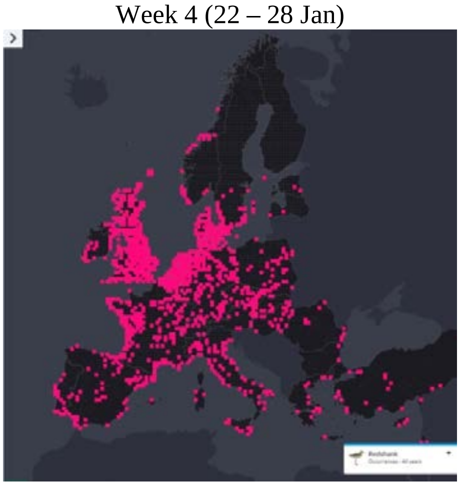
Redshank *Tringa totanus*



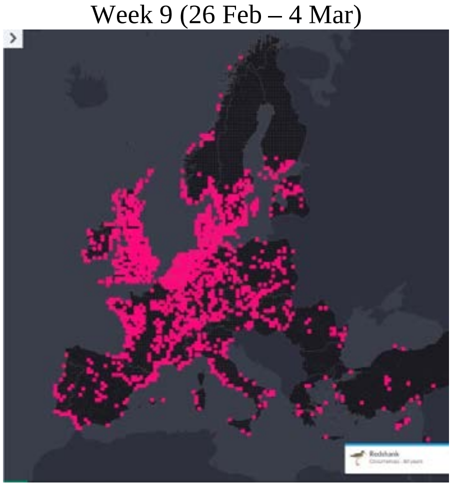
Week 4 (22 – 28 Jan)



Week 9 (26 Feb – 4 Mar)



Week 12 (19 – 25 Mar)



Week 14 (2 – 8 Apr)

Figure 2.8. Snapshots of the occurrence maps of the Redshank for four selected weeks (all years combined; see the complete chronological series here).

The migration activity of some bird species can sometimes be better detected by checking the phenological patterns taking place in adjacent areas not usually occupied during the wintering or breeding periods (Figure 2.8). The Redshank, for example, mainly concentrates in coastal areas of continental western and central Europe during the main wintering period (week 4) but during migration also occurs much more inland. Note how in early March (week 9) a few migrants are already clearly detected in parts of the interior of central Europe and, three weeks later (week 12), passage is very noticeable in countries such as Germany and Poland. In early April (week 14) the migrants are already common further north, in countries such as Latvia and Finland.

3. The relevance of the information shown on the regional/national portals to update the KCD

Most of the observations collected by the online portals include information about the number of individuals detected, not only presence (casual records) or presence/absence data (complete lists), although most of these counts are only rough estimates. Moreover, several portals also collect standard monitoring data (e.g. breeding atlas, common breeding bird census) and breeding evidence information though, in general, these datasets only represent a small part of the entire data collected. Nearly all online portals have search engines that easily allow querying all these data using different set of filters (e.g. species, location, time period). These tools are mostly unrestricted expect for sensitive species or records. The output of the queries usually consists of maps, lists or tables but in several portals (including some of the most widely used) data can be summarized in phenological graphs or diagrams which are particularly useful for determining phenological patterns for whole countries or regions. The exact way in which the phenological patterns are depicted varies greatly across the portals, but overall these cover a large area of the continent and, therefore, allow comparison of the patterns among neighbouring areas and can give an overall view on how spring migration progresses across its main SW-NE axis. These graphs can also be used to provide complementary supporting evidence to more detailed analyses undertaken in any given country. Data quality and coverage issues, however, should always be taken into account when interpreting these graphs. Most of the data currently collected follows no standardized protocol at all (i.e. casual records) and, although the collection of complete lists is increasing steadily, it still represents only c. 25% of all the data. Overall data collection is also increasing markedly across Europe, but coverage is still particularly poor in parts of E Europe and, particularly SW Europe.

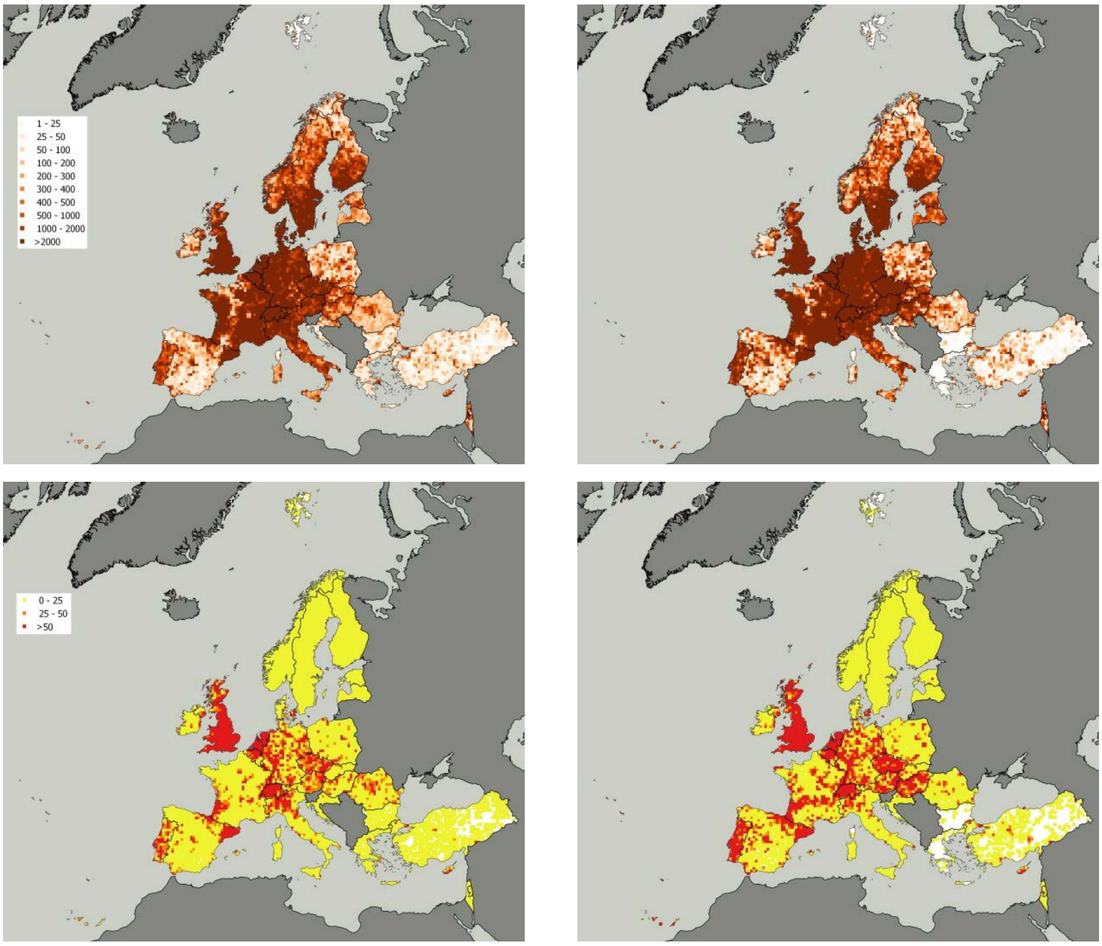
3.1. Main characteristics of the data collected by the different online portals operating in the Member States

Online bird recording portals collect data all year-round thanks to the relatively unstructured but intensive and widespread activities of birdwatchers. This coverage of the entire annual-cycle is what makes online bird portal data so valuable for quantifying phenological patterns.

This complete seasonal coverage, however, is accomplished by collecting data in a much simpler and less structured way. In fact, most of the data currently obtained by the online bird portals operating in Europe is collected using no standardized protocols at all (i.e. casual records; Figure 3.1 & Table 3.1). The collection of complete lists is increasing steadily across the EBP partnership, however, still represents only c. 25% of all data collected. In fact, though most of the portals allow and promote complete lists recording, only in a few of them is the majority of the data collected in this way (Table 3.1). In a few countries complete lists are still too scarce (if not completely non-existent) to be used to estimate phenological patterns (e.g. Scandinavia, Finland; Table 3.1 & Figure 3.1).

Not only the relative quality of the data changes quite markedly across countries, data collection in general also varies greatly from country to country and across different areas within the same country (Figure 3.1 & Table 3.2). In general, coverage is much better in S Finland and Scandinavia, most of central and west Europe and parts of the Iberian Peninsula and still particularly poor in parts of SE Europe. There is, however, a marked increase in data collection across Europe and except for some areas with very low human population densities (e.g. N Finland and Norway and parts of Ireland and Spain), overall coverage is expected to improve substantially in the next few years.

Most of the observations collected by the online portals include information about the number of individuals detected, not only presence (casual records) or presence/absence data (complete lists). Although most of these counts are only rough estimates (particularly when referring to high numbers), they give a very useful insight on the relative abundance of the species across time and space. Several portals also include standard monitoring data (e.g. common breeding bird census, winter waterbird counts) and their corresponding more precise and exhaustive counts (Table 3.1), but in general, these datasets only represent a small part of the entire data collected by them (note that standard monitoring data is widely available in Europe but it is often stored in other, more specific, databases; cf. section 4.2).



Average 2010-2016 Total 2016

Figure 3.1. Number of records (above) and complete lists (below) collected in each 30x30 km square across the EBP partnership (figures are based on the data used for the current version of the EBP viewer). Bulgaria figures will be much higher once data from the Smartbirds portal have been uploaded (only BirdTrack data has been used so far).

Online system	Portal url	Member State	Records collected (2017)	Types of data collected: Complete lists	Types of data collected: Breeding evidence	Types of data collected: Counts	Types of data collected: Standard monitoring data	Available outputs: Search engine	Available outputs: Phenological graphs
Artportalen	https://artportalen.se/	Sweden	3,184,086	No	Yes	Yes	Yes	Yes	Yes
Atlas.ptice	http://atlas.ptice.si	Slovenia		No	Yes	Yes	Yes	Login required	No
Aves-Symfony	http://aves.vtaky.sk	Slovakia	96,821	Yes**	Yes	Yes	Yes	Yes	No
Avimap	http://avimap.nl/	Netherlands	2,586,056	Yes**	Yes	Yes	Yes	Login required	No
Birds.cz	http://birds.cz	Czech Republic	659,367	Yes***	Yes	Yes	Yes	Yes	No
BirdTrack	https://app.bto.org/birdtrack2/main/data-home.jsp	Bulgaria	979	Yes***					
	https://app.bto.org/birdtrack2/main/data-home.jsp	Cyprus	33,401	Yes****					
	https://app.bto.org/birdtrack2/main/data-home.jsp	Greece	4,536	Yes***					
	http://blx1.bto.org/birdtrack/	Ireland	64,271	Yes***	Yes	Yes	No	Yes	Yes
	https://app.bto.org/birdtrack2/main/data-home.jsp	Malta	300	Yes***					
	https://app.bto.org/birdtrack2/main/data-home.jsp	Spain	33,660	Yes***					
	http://blx1.bto.org/birdtrack/	United Kingdom	6,956,383	Yes****					
Dabas Dati	http://dabasdati.lv/	Latvia	174,656	Yes***	Yes	Yes	Yes	Yes	No
DOFbasen	http://dofbasen.dk/	Denmark	1,538,952	Yes*	Yes	Yes	Yes	Yes	Yes
eBird	https://ebird.org/portugal	Portugal	828,628	Yes****	Yes	Yes	Yes	Yes	Yes
	https://ebird.org/spain	Spain	1,575,482	Yes****			No		
Lietuvos Paukščiai	http://ornitologija.lt/orni/web/	Lithuania	4,773	No	Yes	Yes	No	Yes	No[1]
MAP	http://map.mme.hu/	Hungary	281,297	Yes****	Yes	Yes	Yes	Login required	No
Observation.org	http://observations.be http://waarnemingen.be	Belgium	2,219,753	Yes*	Yes	Yes	Yes	Yes	Yes
	https://waarneming.nl	Netherlands	4,181,956				No		
OpenBirdMaps	http://www.openbirdmaps.ro/	Romania	105,163	Yes***	Yes	Yes	Yes	Yes	No
Ornitho	https://www.ornitho.at/	Austria	944,652	Yes**			Yes		
	http://www.fauna.hr/	Croatia	22,092	Yes**			No		
	https://www.faune-france.org/	France	12,404,085	Yes**			Yes		
	https://ornitho.de	Germany	6,135,155	Yes**			Yes		
	https://www.ornitho.it	Italy	1,708,597	Yes*	Yes	Yes	Yes	Login required[2]	Login required
	https://ornitho.lu	Luxembourg	67,425	Yes**			Yes		
	https://ornitho.pl	Poland	489,720	Yes**			Yes		
	https://www.ornitho.cat	Spain (Catalonia)	592,874	Yes****			Yes		
	https://www.ornitho.eus	Spain (Basque Country)	123,205	Yes****			No		
Ornitodata	http://pasaridinromania.sor.ro/ornitodata	Romania	22,717	Yes****	Yes	Yes	Yes	Yes	No
PlutoF	https://plutof.ut.ee/	Estonia	105,953	Yes*	Yes	Yes	Yes	Login required	No
Smartbirds	https://www.smartbirds.org/	Bulgaria	88,626	Yes**	Yes	Yes	Yes	No	No
Tiira	https://www.tiira.fi/	Finland	1,652,126	No	Yes	Yes	Yes	Login required	No
Trektellen	http://trektellen.nl	Netherlands	608,981	Yes****	No	Yes	No	Yes	Yes

Table 3.1. Types of data collected and outputs offered by the online portals operating in the different Member States (Percentage of records collected in complete lists: *<10%, **10-25%, *** 25-50%, **** >50%; [1] Data not collected all year-round; [2] In some portals a minimum number of contributions are required to search the entire database). Only the primary recording schemes operating in each country are indicated. Note that some portals (e.g. BirdTrack, eBird, Observation.org, Ornitho, Trektellen) collect some data in other areas or even worldwide.

English name	Scientific name	Austria	Belgium	Bulgaria	Croatia	Cyprus	Czech Republic	Denmark	Estonia	Finland	France	Germany	Greece	Hungary
Greater White-fronted Goose	*Anser albifrons*	2972	26254	344	88	88	2811	193813	3243	23619	4455	93934	109	718
Greylag Goose	*Anser anser*	16998	112572	178	387	21	12812	3060027	2142	49464	45390	322169	78	2222
Brent Goose	*Branta bernicla*	98	6985				50	279635	651	8741	37909	5872		11
Eurasian Wigeon	*Mareca penelope*	6149	70703	187	58	185	4136	938809	4219	65620	48048	88982	568	472
Common Teal	*Anas crecca*	12793	80167	1	157	230	7977	509548	4364	73755	118442	169587	17	1154
Northern Pintail	*Anas acuta*	2551	25949	1	34	82	1742	127836	1960	30858	31732	41829	3	323
Garganey	*Spatula querquedula*	5919	18543	297	96	411	3631	55913	1469	11017	24060	45155	524	904
Northern Shoveler	*Spatula clypeata*	7625	105237	273	92	853	4188	484742	2776	35039	94341	95200	847	803
Goosander	*Mergus merganser*	16284	32455	19	48		9358	619599	5725	97079	38002	132551	20	165
Common Quail	*Coturnix coturnix*	2541	13890	82	20	185	13266	35555	269	3250	28841	18891	58	2685
Northern Lapwing	*Vanellus vanellus*	23287	124404	332	207	262	20568	782653	6733	86599	198332	212627	511	4190
Ruff	*Calidris pugnax*	8868	20407	141	13	829	4094	254103	301	52809	27107	47443	1406	713
Common Snipe	*Gallinago gallinago*	6247	52395	1	26	119	6407	196633	3539	48401	84331	89560	12	494
Black-tailed Godwit	*Limosa limosa*	2958	31460	78	3	144	457	67841	1036	5294	30740	18778	310	439
Eurasian Curlew	*Numenius arquata*	7503	43729	63	25	162	1389	302020	2391	55290	69877	65194	1079	502
Common Redshank	*Tringa totanus*	4801	56534	119	23	504	2274	715616	2349	27925	61873	32396	3152	1060
Common Greenshank	*Tringa nebularia*	5283	29121	107	43	285	3386	297970	2634	53329	51843	51344	2542	301
Black-headed Gull	*Larus ridibundus*	24471	168862	668	357	765	34770	1083251	5380	59951	303711	187033	3606	3327
Mew Gull	*Larus canus*	5137	62968	48	10	8	3011	627596	4985	68486	23723	64403	85	397
Common Woodpigeon	*Columba palumbus*	34617	302973	297	530	2746	21084	1877245	3707	66059	752749	372417	175	9737
Eurasian Collared-dove	*Streptopelia decaocto*	26348	90796	276	1392	2835	13385	97394	374	7473	521868	107524	5709	8609
European Turtle-dove	*Streptopelia turtur*	4788	12586	218	174	565	4859	2392	523	709	121884	15729	1087	5923
Eurasian Skylark	*Alauda arvensis*	17459	121908	12	118	134	19050	714842	3877	41780	266874	181699	16	8580
Fieldfare	*Turdus pilaris*	14463	54267	157	60	19	15403	394681	4842	100850	85418	211345	98	1762
Song Thrush	*Turdus philomelos*	27515	88958	256	247	1527	29343	240588	2396	26240	306839	159192	1157	7608
Redwing	*Turdus iliacus*	1029	41531	15	1	3	1136	86289	1465	34751	51077	43251	50	170
Eurasian Jay	*Garrulus glandarius*	23291	153797	523	359	400	17825	404561	2792	71575	455048	227142	1625	6742
Common Starling	*Sturnus vulgaris*	37558	155823	736	1214	329	32046	1006872	5686	64717	558381	299388	2884	11958

English name	Scientific name	Ireland	Italy	Latvia	Luxembourg	Netherlands	Poland	Portugal	Romania	Slovakia	Spain	Sweden	United Kingdom
Greater White-fronted Goose	*Anser albifrons*	207	2402	626	97	241673	2021	35	846	775	469	34321	7349
Greylag Goose	*Anser anser*	605	11437	329	472	494424	6658	800	1141	1635	8688	122040	177498
Brent Goose	*Branta bernicla*	1367	28	149		70193	51	158	1	5	618	9276	27512
Eurasian Wigeon	*Mareca penelope*	1488	14357	527	312	183138	3201	1410	1030	856	7254	60053	125657
Common Teal	*Anas crecca*	2024	38722	592	1190	255522	4714	4736	1905	2151	18574	156368	180758
Northern Pintail	*Anas acuta*	180	7399	232	81	101405	1182	1113	525	371	4316	43936	29820
Garganey	*Spatula querquedula*	116	17262	207	78	81883	2343	248	1624	1366	3675	22463	17009
Northern Shoveler	*Spatula clypeata*	848	24357	254	207	175891	2573	4947	1192	767	20235	33655	110260
Goosander	*Mergus merganser*	78	9751	1293	612	82407	6664	21	400	1216	233	98285	54463
Common Quail	*Coturnix coturnix*	13	8742	171	217	23025	864	4231	5040	1440	4967	10083	3272
Northern Lapwing	*Vanellus vanellus*	1939	39382	2578	1881	602849	9775	6611	5280	3153	19439	170308	217141
Ruff	*Calidris pugnax*	263	14212	303	57	120516	2223	1860	1635	622	5950	72112	25180
Common Snipe	*Gallinago gallinago*	1492	21348	1019	734	212569	2824	4741	745	1086	15274	90415	81636
Black-tailed Godwit	*Limosa limosa*	1276	4644	102	8	334199	1068	1423	700	103	6359	13124	54342
Eurasian Curlew	*Numenius arquata*	2648	14317	299	51	239046	938	1984	630	165	5574	93719	124973
Common Redshank	*Tringa totanus*	2095	10620	208	91	248422	2072	7625	770	463	12139	41971	112988
Common Greenshank	*Tringa nebularia*	895	20122	226	119	115695	1650	5122	916	509	11999	88664	32549
Black-headed Gull	*Larus ridibundus*	4159	107069	1465	923	318075	19543	17497	4653	3235	41638	92525	423842
Mew Gull	*Larus canus*	1787	9902	749	48	161939	7165	512	563	793	1023	112854	141470
Common Woodpigeon	*Columba palumbus*	6357	139753	3210	4715	407369	20027	14990	5375	5786	109593	129437	715394
Eurasian Collared-dove	*Streptopelia decaocto*	1984	159592	164	1668	187593	19041	29597	5186	3221	73288	41463	258551
European Turtle-dove	*Streptopelia turtur*	66	32671	283	433	31724	671	3599	3095	2542	10347	1792	11811
Eurasian Skylark	*Alauda arvensis*	1658	41100	3276	3602	243075	10738	6034	16889	5274	12498	74413	175462
Fieldfare	*Turdus pilaris*	871	17161	2194	3638	180620	15942	194	2200	4475	1566	173327	105365
Song Thrush	*Turdus philomelos*	3669	44465	2753	2603	398270	8747	8803	6531	6951	32725	108479	271409
Redwing	*Turdus iliacus*	1335	4470	638	440	165161	654	950	69	245	2861	92188	132022
Eurasian Jay	*Garrulus glandarius*	952	131898	2543	3114	199082	20573	17206	5135	4230	46024	90547	183145
Common Starling	*Sturnus vulgaris*	5135	189672	3611	4492	344078	23069	4901	11321	8156	70795	105588	387319

Table 3.2. Number of records of the 28 huntable species (Bird Directive 2009/147/EC) available in the EBP viewer collected in each Member State by the partner's online portals

(2010-2016 total). Figures have been calculated using the data submitted to the EBP project (note that local portals have data for all or most of the huntable species, not only those listed here). On the other hand, the figures shown for Bulgaria only reflect the data collected through BirdTrack and will be considerably higher once data from the local Smartbirds portal will be uploaded.

Nearly all portals collect breeding evidence information, mostly using Atlas breeding bird codes which allow observations to be assigned to such key activities as territorial bird singing, nest building and to the laying/rearing breeding periods. In fact, several European online portals, particularly in E Europe, started as tools for recording breeding bird atlas data that were later adapted to collect data yea-round. Despite most observers only reporting breeding evidence during the years of fieldwork associated with breeding bird atlas projects, several portals may have large enough numbers of records with breeding evidence as to help define breeding phenological patterns, particularly when no other data sources (e.g. nest record schemes, nestling/chick ringing dates) are available (cf. Figure 3.2). Where sufficient data of this kind exist they may be helpful for determining the start and end of the breeding period.

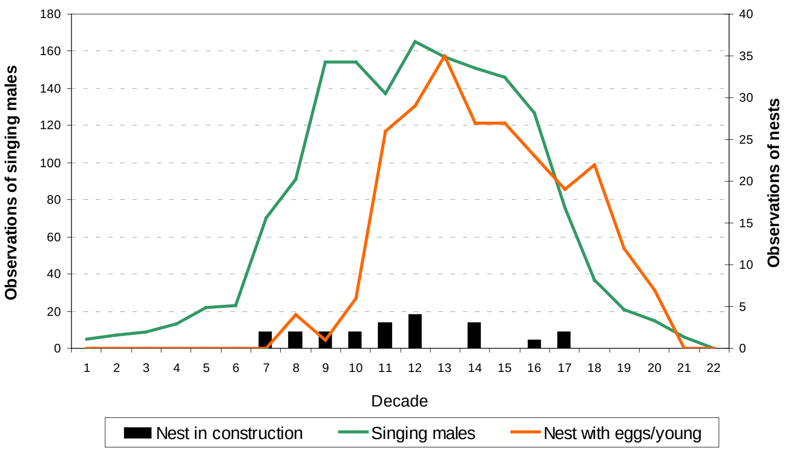


Figure 3.2. Phenology of the singing and breeding activity of the Song Thrush in Catalonia (NE Spain) based on breeding evidence data (atlas breeding bird codes) collected through ornitho.cat.

3.2. Brief description of the types of data visualizations offered by these portals that could be useful in relation to the update of the KCD

Nearly all portals have search engines that allow users to query the corresponding database using different set of filters (Table 3.1). In general, data can be filtered by species, location (e.g. a given region) and time period (e.g. a given year), but in most cases a wider range of options is available, allowing data to be filtered using several additional variables (e.g. age/sex of the bird, behaviour (e.g. breeding evidence), type of data (e.g. casual or complete lists records), etc.). The output of the queries usually consists of lists or tables showing all the observations that match the selected criteria but in some portals maps or graphs showing the distribution of the observations are also provided.

The search tools of several portals are mostly unrestricted (except, for example, for records of sensitive species or records hidden during sensitive time periods such as during nesting). In some cases, the search tool (e.g. Ornitho portals) is somewhat restricted (e.g. to the last 15 days) for unregistered users or to those that are registered but do not contribute a certain minimum amount of data (usually, as low as one record is enough). In any case, since all queries and their associated outputs always have some intrinsic limitations even in the most accessible systems (e.g. not necessarily all variables of interest are shown in a given output), many portals have put in place special access arrangements that can be used to allow access to the whole dataset or to more internal outputs for certain users or institutions (e.g. environmental agencies, natural parks, etc.).

Although the listings, tables and maps provided by the search tools can be of great help when checking specific issues, the outputs that are usually most useful for assessing the periods of migration are those that summarize the data in the form of phenological graphs or diagrams. Several online systems (including some of the most widely used in Europe) offer such outputs (Table 3.1 & 3.3), therefore, given their potential usefulness they are described in some detail below. These tools are useful both for determining phenological patterns for whole countries and for regions within countries. The latter feature may be particularly useful for larger countries where it is considered necessary to define the start and end of the hunting season on a regional basis.

System	Registration required	Time periods	Occurrence graph	Counts graph
BirdTrack	No	Weeks	Complete lists reporting rates	Maximum count
Trektellen	No	Weeks		Mean count per hour
Observation.org	No	Weeks	Complete lists reporting rates	
eBird	No	Weeks	Complete lists reporting rates	Maximum/mean count/mean count per hour
Artportalen	No	Weeks	Total number of records	Total count
DOFbasen	No	Decades		Mean count per observation
Ornitho	Yes	Decades	Total number of records	

Table 3.3. The information shown in the phenological graphs provided by different online systems, the time periods used and the degree of accessibility.

BirdTrack (primary countries of operation in EU: Bulgaria, Cyprus, Greece, Ireland, Malta, Spain, United Kingdom)

The BirdTrack portal has one of the most directly accessible tools to show species-specific phenological graphs. This can be found at the bottom of the frontpage of the portal, where a graph depicts the phenological pattern of a given species at random each time you access it (you can use the species selector located next to the graph to change the species; Figure 3.3). A blue line shows the weekly reporting rate (the percentage of complete lists that contain each species) for the current year and a red one the average reporting rate for all previous years. Hovering over a data point reveals the specific statistics for that week. These phenological graphs provide particularly robust measures since are based on complete lists reporting rates (see section 5 for more details).

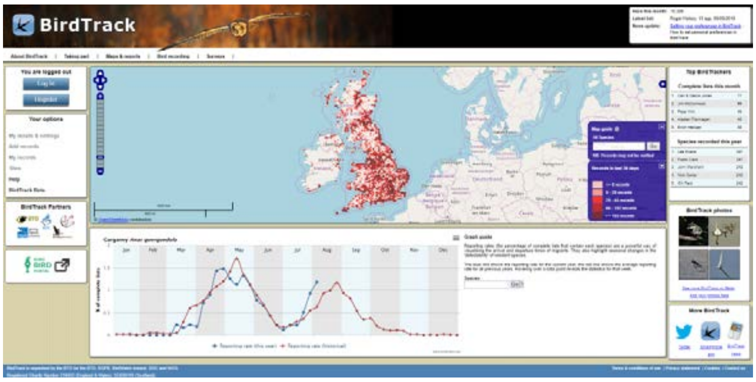


Figure 3.3. The year-round phenological pattern of the Garganey in Britain and Ireland as shown in the frontpage of the BirdTrack portal (link).

A more refined tool can be found in "Reports by species" in the "Maps & reports" menu or in "BirdTrack Beta", accessible from "Your options" menu. The tool section "Reporting rates" visualizes phenological graphs like those shown in the frontpage but with additional fine-tuning options. Data can, for example, be filtered by country or region and one or more time series can be shown (typically for different years; Figure 3.4). Another section of the tool, "Peak count by week", depicts the maximum count for the given species and week.

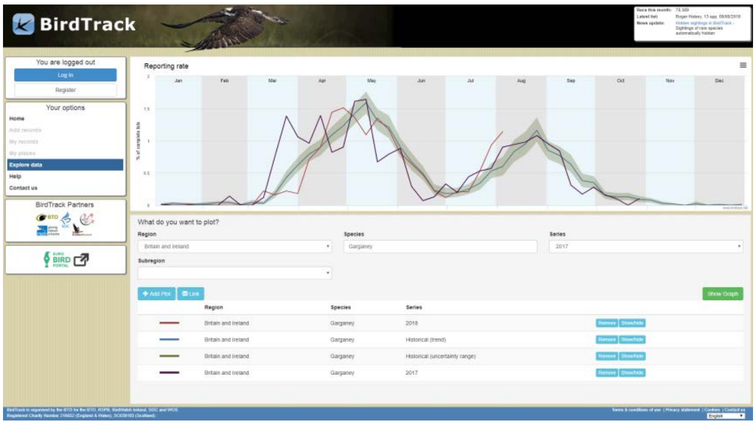


Figure 3.4. The year-round phenological pattern of the Garganey in Britain and Ireland in different years as shown in the "Reports by species" section of BirdTrack (link 1; link 2).

Trektellen (primary countries of operation in EU: Netherlands)

The Trektellen portal has a very useful tool where phenological patterns can easily be depicted. In the frontpage, select "Graph" from the "Analysis" dropdown menu and the webpage of the tool will open. This tool has a nice set of filters, including country, species and year. Data is summarized in terms of the average number of birds per hour and week (Figure 3.4) and different years can also easily be compared (Figure 3.5). Note that Trektellen focuses mainly on migration sites so interpretation of these graphs may be different to those based on data from national portals.

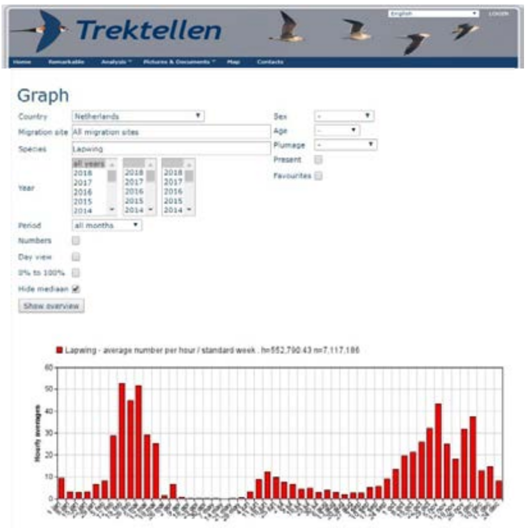


Figure 3.5. The year-round phenological pattern of the Northern Lapwing in the Netherlands as shown in the Trektellen portal (link).

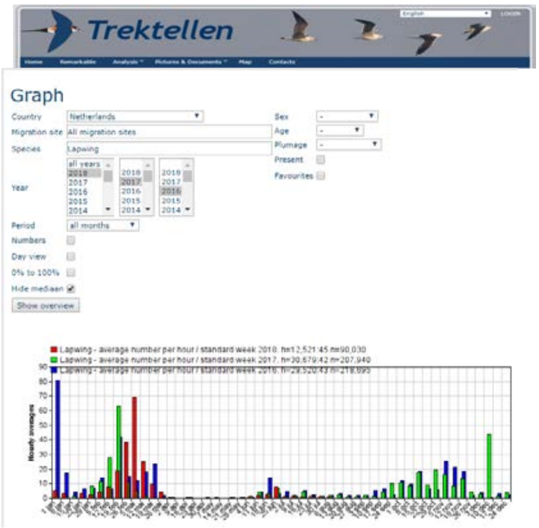


Figure 3.6. The year-round phenological pattern of the Northern Lapwing in three different years in the Netherlands as shown in the Trektellen portal (link).

Observation.org (primary countries of operation in EU: Belgium and Netherlands)

All observation.org portals (cf. Table 3.1) also have a nice tool to visualize the phenological patterns of any bird species of interest. Just click on "Species calendar" in the Species dropdown menu and a nice diagram summarizing the phenological patterns of all bird species will be shown (a blue colour scale depicts the percentage of records of each given species in each week; Figure 3.7). Data can be filtered by year, region or bird family. Moreover, further details on any given species can be obtained by clicking in its name. This will open a new webpage with two graphs showing the historic phenological patterns and that of the current year for the selected species (Figure 3.8). The upper graph shows the percentage of records based on complete lists and the bottom one the percentage based on all the records. The year selector on the top left can be used to change the current year.

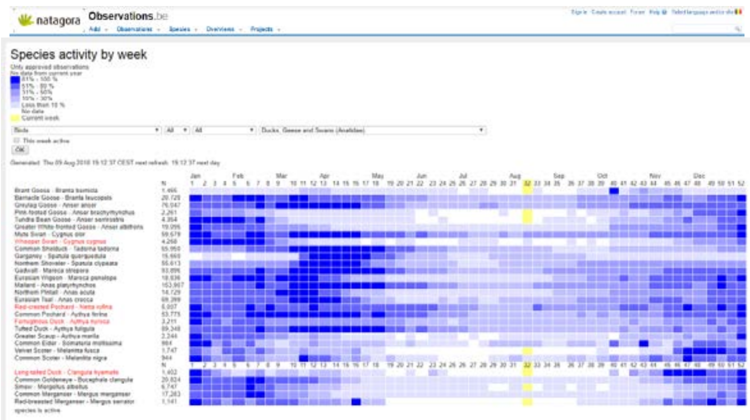


Figure 3.7. The year-round phenological patterns of the bird species of the family Anatidae (Ducks, Geese and Swans) in Belgium as shown in observations.be portal (link).

Figure 3.8. The year-round phenological patterns of the Greylag Goose in Belgium as shown in observations.be portal based on complete lists (upper graph) and all records (bottom graph; link).

eBird (primary countries of operation in EU: Portugal and Spain)

The regional eBird portals (cf. Table 3.1) offer a very complete set of tools to depict the phenological patterns of bird species. From the frontpage, click on "Explore" and then on "Bar charts", a new webpage will be shown where you can select the country, region or even a smaller area of interest. Once the area is selected, click the "Continue" button and a diagram summarizing the phenological patterns of all bird species in the given area will be shown (the size of the green rectangles depict the frequency of observation in each week; Figure 3.9). To get further information for any given species just click on its name and another webpage will be opened (Figure 3.10). In addition to the above diagram, this page shows also a frequency graph depicting the reporting rate in each week (i.e. the percentage of complete lists that contain each species). Being based in complete lists, these graphs are very informative, however, you can also select other graphs which are based on counts (e.g. "Abundance" and "Average Count" graphs) and which can give useful complementary information (Figure 3.11). "Abundance" graphs show the average number of birds reported on all checklists within a specified date range and region, while "Average Count" graphs show the average number of birds seen only in checklists where the species was observed. You can also compare the pattern among different years (Figure 3.12). To do so, click the "Change date" button, select a range of up to 5 years and check the "Separate years" check-box. Then click the "Continue" button to show the resulting graph.

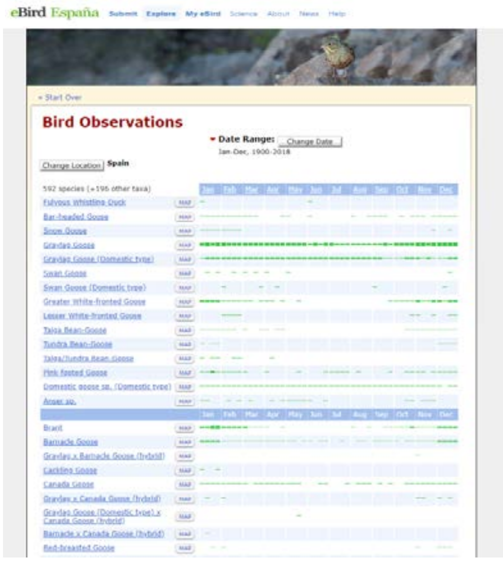


Figure 3.9. Diagram showing the year-round phenological patterns of the bird species recorded in eBird Spain according to complete list data ([link]()).

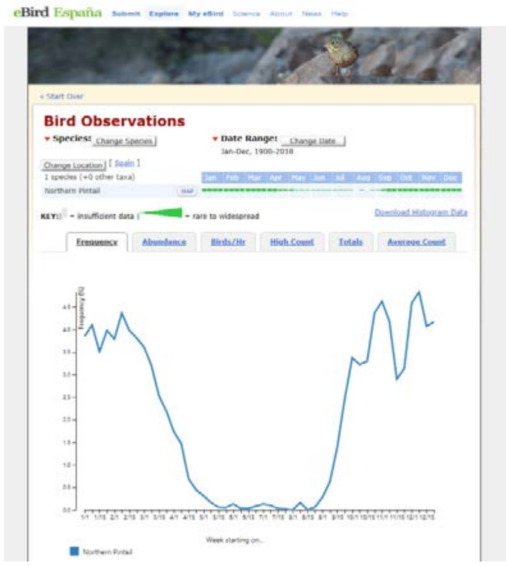


Figure 3.10. Graph showing the year-round phenological pattern of the Pintail in eBird Spain using weekly reporting rates ([link]()).

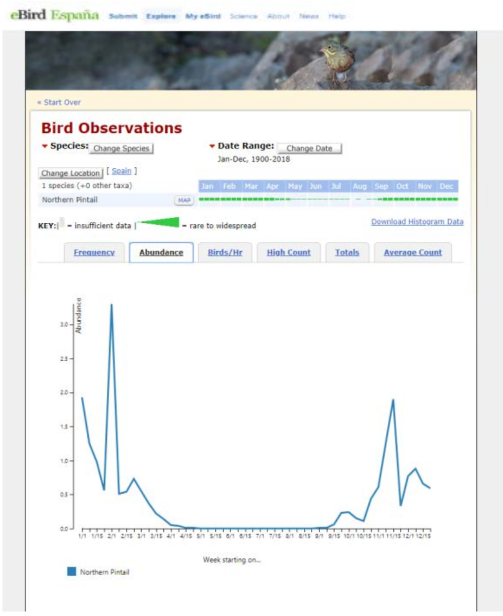


Figure 3.11. Graph showing the year-round abundace pattern of the Pintail in eBird Spain using the weekly average number of birds reported in complete lists ([link]()).

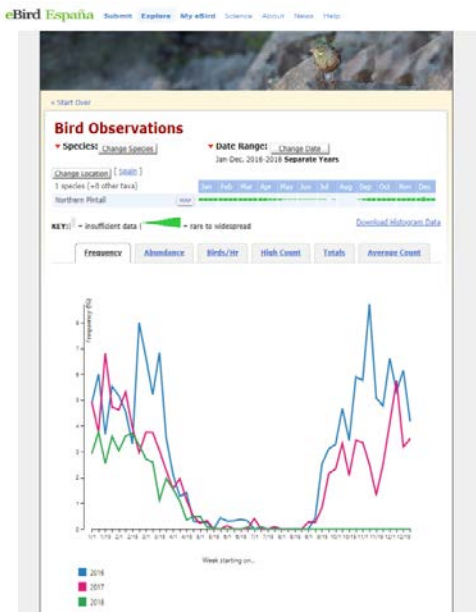


Figure 3.12. Graph based on weekly reporting rates showing the year-round phenological pattern of the Pintail in eBird Spain in three different years ([link]()).

Artportalen (primary countries of operation in EU: Sweden)

The [Artportalen]() system has a quite complete tool to depict phenological patterns. Click "Search" in their frontpage main menu and in the [search webpage]() select the desired species and time period (many more filtering options are available; Figure 3.13). Then click on "Histogram" in the "View sightings" menu to show the phenological graph (Figure 3.14). The graph depicts the number of observations by week but you can also choose to see the number of individuals in order to have some indications about numbers. The main drawback of the phenological patterns shown by this tool is that they do not compensate for variation in observer effort in any way. Recording of complete lists is being planned and, therefore, this should change in the near future.

Figure 3.13. The search engine in Artportalen has many options to filter the data to be shown in the phenological graph (Figure 12; link).

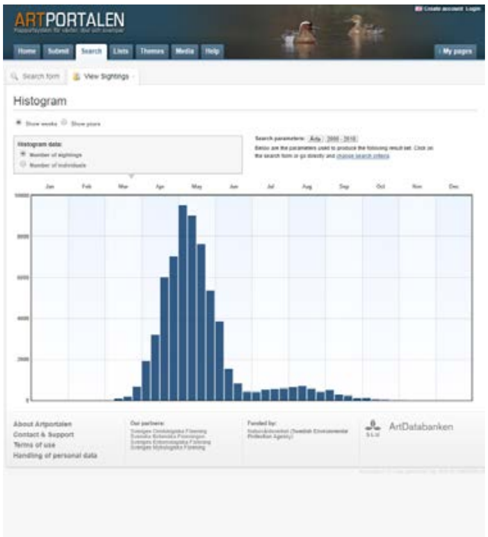


Figure 3.14. The year-round phenological pattern of the Garganey in Sweden as shown in Artportalen (link).

DOFbasen (primary countries of operation in EU: Denmark)

DOFbasen also provides very useful phenological graphs. Go to the Birds of Denmark section (in the frontpage, select "Danmarks fugle" in the "Links" menu), select the species of interest using the dropdown menu "Vælg art:" (Danish vernacular names have to be used) and finally click the "Vælg art" button (Figure 3.15). A new webpage with information on several aspects of the biology of the selected species will be shown, including a phenological graph depicting the average number of individuals reported in each decade (Figure 3.16). Counts are mandatory in DOFbasen, thus the dataset is large and gives good overall information on differences in relative abundance across the year. The graphs are currently based on the data collected in the 2008-2014 period but they will be updated on an annual basis in the near future (with data up to 2017). Moreover, they have the advantage that the data is grouped by decades, the same time periods as those used in the KCD document.

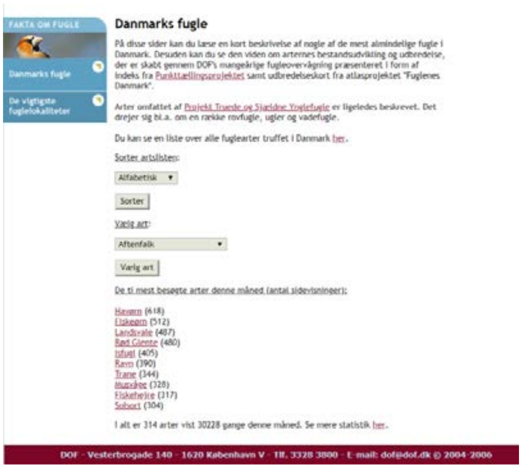


Figure 3.15. The search engine of the Birds of Denmark section of DOFbasen (link).

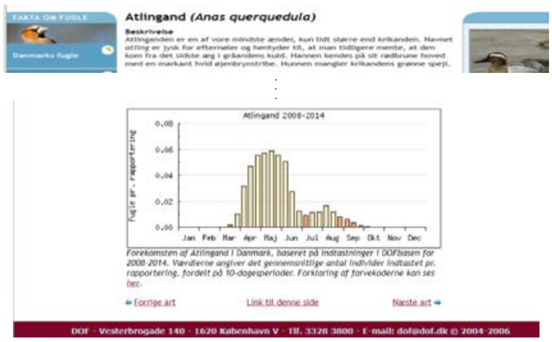


Figure 3.16. The year-round phenological pattern of the Garganey in Denmark as shown in DOFbasen (link).

Ornitho (primary countries of operation in EU: Austria, Croatia, France, Germany, Italy, Luxembourg, Poland, Spain)

All ornitho portals (cf. Table 3.1) have a tool that is particularly useful since, like DOFbasen, it depicts the phenological patterns of any bird species also by decades. You have to register to the system since login is required to access the tool, but this is a very simple procedure. Moreover, once registered in any given ornitho portal you can already login to all other ornitho portals. Once logged in, go to the "Consulting" menu (on the left of the frontpage) and click on "The past 2 days" or "Recent observations" in the "Sightings" section. A new webpage showing a list of observations will be opened. The phenology tool (Figure 3.17) is accessed by clicking any of these symbols appearing to the right of any species name. The tool consists, essentially, of a species search/selector menu and a graph showing the total number of observations of the selected species in each decade (all years of available data are combined). Similar to Artportalen, the main problem with these phenological patterns is that they do not compensate for observer effort. However, an improved version depicting also phenological patterns based on complete lists reporting rates is expected to be implemented by the end of the year.

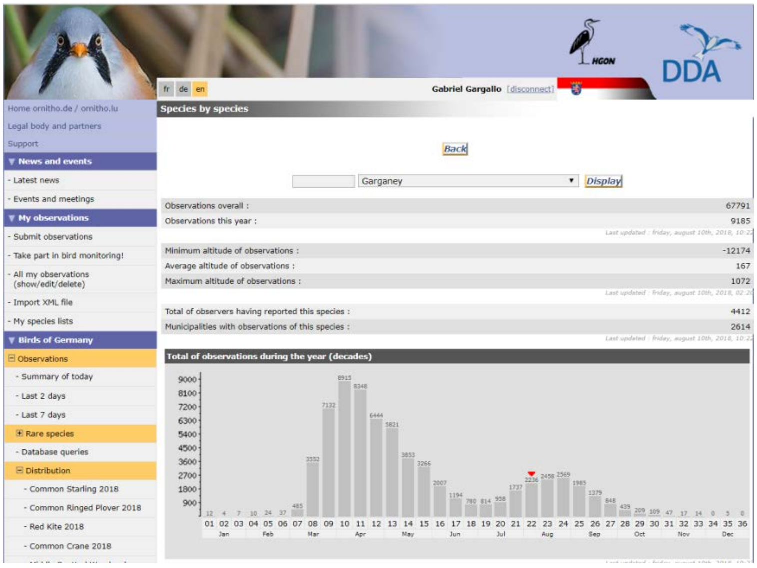


Figure 3.17. The year-round phenological pattern of the Garganey in Germany as shown in the ornitho.de tool (link; login is required).

3.3. Guidelines on how to use this information in order to help define the period of pre-nuptial migration

Phenological graphs and diagrams are powerful tools for visualising the arrival and departure times of migrants. However, it's important to note that the phenological patterns of any given species is the results not only of the temporal variation in the abundance of the species but also of seasonal changes in its 'detectability' (e.g. many summer migrants are easily detectable when they arrive to the breeding grounds and singing activity is highest but later on, during late spring or summer, they are progressively less conspicuous as a result of the reduction in singing activity). Moreover, detectability is also affected by observer effort (which varies greatly across the year and space) and not all the phenological graphs depicted in the online portals equally compensate for this effect.

For a detailed description of the potential and limitations of phenological graphs and how to properly interpret them see section 5. Here, we will only highlight some of the main advantages and drawbacks that are specifics of using the phenological information provided by default in the different online portals.

Advantages

- Three online systems present phenological patterns based on complete lists reporting rates (BirdTrack, observation.org and eBird), which are the ones that better compensate for observer effort (cf. section 5).

- Two online systems depict the phenological patterns by decades (DOFbasen and ornitho), the same time periods used in the KCD document. But unfortunately none of them uses complete lists reporting rates.

- Some systems show both occurrence and count graphs, giving two complementary views that can help to better understand the underlying patterns (see also section 5).

- Despite the differences in the way phenological patterns are depicted, the systems with phenological tools cover a large area of the continent and, therefore, allow comparison of the patterns among neighbouring areas and can give an overall view on how migration progresses across its main SW-NE axis. These graphs can also be used to provide complementary supporting evidence to more detailed analyses undertaken in any given country (for example, to check that in a neighbouring country just to the south the arrival of migrants matches what should be expected from the more local analyses).

Drawbacks

- Most online systems depict the phenological patterns by weeks intervals, not decades, therefore, the information cannot be readily translated to the decades format required by the KCD document.

- Several of the phenological patterns depicted by the online portals are not based on complete list reporting rates and, therefore, do not compensate for variation in observer effort or do so less efficiently. Special attention must be paid, therefore, when interpreting these results (see also section 5).

- The available phenological tools will show phenological graphs for all species even when sample sizes are clearly too small to provide robust results. Sample size should always be taken into account when interpreting these graphs. Note, in particular, that for some Member States the data currently available can still be too sparse (cf. Table 3.2).

- Even when the graphs depicted by default in the different online portal tools give solid information, some expertise is required to make sound interpretations (cf. section 5), therefore, it is always recommended to ask for local expert advice before drawing final conclusions (cf. section 4).

4. The role of EBP local partners to make the best use of the online portals data

To get the most of the information collected by the online portals it is necessary to have access to the raw data and to undertake specific analysis. The support of the EBP partner organisations is, therefore, essential. Most of the EBP partners are well established ornithological institutions within their respective countries or regions and have long-term experience collecting and/or analysing citizen science data.

4.1 Brief presentation of the EBP partner organizations and their background

The information shown in the local online portals can be quite extensive (cf. section 3), but as these results are presented using a given format and time resolution they rarely contain the exact information required to determine the periods of migration as required to update the KCD (e.g. in decades). To make the most of the information collected by these portals it is necessary, therefore, to have access to the raw data and to undertake specific analysis such as those described in section 5. It is essential, therefore, to obtain the support of the EBP partner organisations.

Most of the EBP partners are well established ornithological institutions within their respective countries or regions and have long-term experience collecting and/or analysing citizen science data. Section 5.2 lists all EBP partners and gives some indications of their expertise and field of work (check the relevant websites to obtain further details of each partner). However, in general, the key overall benefits of using EBP partners' expertise can be summarized as follows:

1) Direct access and knowledge of the data collected.

On average, the online portal have been running for more than 10 years, and therefore, in general the EBP partners already have extensive experience of dealing with these kinds of data sources. They are, therefore, in the best position to know which are the real possibilities and limitations of this kind of data. Moreover, EBP partners have direct access to the raw data stored in their corresponding online portals.

2) Experience collecting and managing standard monitoring data.

Most of the EBP partners are also running long-term regional or national standard monitoring schemes and participate in the Pan-European Common Bird Monitoring Scheme (PECBMS), a joint initiative of the European Bird Census Council (EBCC) and BirdLife International (see section 5.2). Moreover, some EBP partners are also operating EURING bird ringing schemes. To run ringing and monitoring schemes requires important and sustained organizational efforts and expertise in managing, summarizing and interpreting citizen science data. Those partners that also run EURING schemes also benefit from having direct access to data that can be particularly well suited to defining migration periods either alone or in combination with online portal data (see section 6).

3) Networking.

EBP partners can count on the support of the EBP coordinator, who has been directly involved with the preparation of these guidelines, regarding advice on the preparation and analysis of their raw data in the context of the KCD update. Moreover, EBP partners also form part of other important ornithological partnerships (e.g. the BirdLife partnership) and, in many cases, they share a common online system (e.g. all those using BirdTrack, eBird, Observation and Ornitho portals) therefore, they can quite easily share expertise and information (e.g. from neighbouring areas; cf. section 5). On the other hand, since the kinds of analyses required are expected to be quite similar across countries they can also collaborate as necessary.

4.2. List of contacts of the local EBP partners in each Member State and their corresponding online portals (version 1.0.

The following table lists the name, website and contact details of all the EBP partners grouped by Member State and their corresponding online portal. For each EBP partner, it is also indicated whether it is a EURING scheme, a participant in the Pan-European Common Bird Monitoring Scheme (PECBMS) or a BirdLife partner. When none of the EBP partners in a given Member State are also a EURING or PECMBS scheme, the relevant contacts of the later are also given. For completeness, the very few countries where there are still no formal EBP partners are also included. To ensure that you have the most up-to-date version of this table you can access the current version here.

EU Member State	Portal	EBP Partner	EBP Partner website	EBP Partner contact	EURING scheme	PECBMS scheme	BirdLife partner	EURING scheme contact	PECBMS (EBCC) scheme contact
Austria	https://www.ornitho.at/	BirdLife Austria	http://www.birdlife.at/	Norbert Teufelbauer (norbert.teufelbauer@birdlife.at): Museumplatz 1/10/8, A-1070 Wien, Austria.	No	Yes	Yes	Leonida Fusani (Leonida.Fusani@vetmeduni.ac.at): Konrad Lorenz Institute of Ethology, Savoyenstraße 1A, A-1160 Vienna, Austria.	EBP partner
Belgium	http://observations.be	Natagora	http://www.aves.be/	Jean-Yves Paquet (jean-yves.paquet@aves.be): 98 rue Nanon, B-5000 Namur, Belgium.	No	Yes	Yes	Didier Vangeluwe (dvangeluwe@naturalsciences.be): Royal Belgian Institute of Natural Sciences, Vautierstreet 29, B-1000 Brussels, Belgium.	EBP partner
	http://waarnemingen.be	Natuurpunt	https://www.natuurpunt.be/	Marc Herremans (marc.herremans@natuurpunt.be): Diensthoofd Studie, Coxiestraat 11, 2800 Mechelen, Belgium.	No	Yes	Yes		
Bulgaria	https://www.smartbirds.org/ https://app.bto.org/birdtrack2/main/data-home.jsp	Bulgarian Society for the Protection of Birds	http://bspb.org/	Svetoslav Spasov (svetoslav.spasov@bspb.org): P. O. Box 50, Sofia BG-1111, Bulgaria.	No	Yes	Yes	Boris Nikolov (lanius.bg@gmail.com): Bulgarian Ornithological Centre, Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences, 1 Tsar Osvoboditel Blvd., 1000 Sofia, Bulgaria.	EBP partner
Croatia	http://www.fauna.hr/	Association BIOM	http://www.biom.hr/	Ivan Katanović (ivan.katanovic@biom.hr): Preradovićeva 34, 10 000 Zagreb, Croatia	No	No	No	Vesna Tutiš (vtutis@hazu.hr): Zagreb Ringing Scheme Institute of Ornithology, Croatian Academy of Sciences and Arts (HAZU), Gunduliceva 24/2, HR-10000 Zagreb, Croatia.	latka Dumbovic Mazal (vlatka.dumbovic@haop.hr): Dept. for wild and domesticated taxa and habitats, Croatian Agency for Environment and Nature, Radnicka 80/7, 10 000 Zagreb, Croatia.
Cyprus	https://app.bto.org/birdtrack2/main/data-home.jsp	BirdLife Cyprus	https://birdlifecyprus.org	Christina Ieronymidou (christina.ieronymidou@birdlifecyprus.org.cy): P.O. Box 12026, Nicosia 2090, Cyprus.	Yes	Yes	Yes	EBP partner (BirdLife Cyprus)	EBP partner (BirdLife Cyprus)
		The North Cyprus Society for the Protection of Birds and Nature	http://www.kuskor.org/	Damla Beton (damlabeton@gmail.com): PK 10, Nicosia, Cyprus.	No	No	No		
Czech Republic	http://birds.cz	Czech Society for Ornithology (CSO)	http://www.birdlife.cz/	Zdeněk Vermouzek (verm@birdlife.cz): Na Belidle 34, 150 00 Prague 5, Czech Republic.	No	Yes	Yes	Jaroslav Cepák (birdringczp@vol.cz): Bird Ringing Centre, National Museum, Hornoměcholupská 34, 10 200 Praha 10-Hostivař, Czech Republic.	EBP partner

EU Member State	Portal	EBP Partner	EBP Partner website	EBP Partner contact	EURING scheme	PECBMS scheme	BirdLife partner	EURING scheme contact	PECBMS (EBCC) scheme contact
Denmark	http://dofbasen.dk/	Dansk Ornitologisk Forening (DOF)	http://www.dof.dk/	Timme Nyegaard (timme.nyegaard@dof.dk): Vesterbrogade 140, DK 1620, Copenhagen V, Denmark.	No	Yes	Yes	Kasper Thorup (kthorup@snm.ku.dk): Copenhagen Bird Ringing Centre, Zoological Museum, Natural History Museum of Denmark, Universitetsparken 15, DK-2100 Copenhagen, Denmark.	EBP partner
Estonia	https://plutof.ut.ee/	Estonian Ornithological Society	http://www.eoy.ee/	Andres Kalamees (andres.kalamees@eoy.ee): P.O. Box 227, 50002 Tartu, Estonia.	No	Yes	Yes	Olavi Vainu (olavi.vainu@envir.ee): Matsalu Bird Ringing Centre, 90305 Läänemaa, Estonia.	EBP partner
Finland	https://www.tiira.fi/	BirdLife Suomi	www.birdlife.fi	Peter Uppstu (peter.uppstu@gmail.com): Annankatu 29 A 16, 00100 Helsinki, Finland	No	No	Yes	Jari Valkama (jari.valkama@helsinki.fi): Ringing Centre, Finnish Museum of Natural History, PO Box 17, FI-00014 University of Helsinki, Finland.	Päivi Sirkiä (paivi.sirkia@helsinki.fi): Zoological Museum, Finnish Museum of Natural History, P.O. Box 17, FI-00014, Helsinki, Finland.
France	https://ornitho.fr	Ligue pour la Protection des Oiseaux (LPO)	https://www.lpo.fr/	Philippe Jourde (philippe.jourde@lpo.fr):	No	Yes	Yes	Frederic Jiguet (fjiguet@mnhn.fr): CRBPO, Muséum National d'Histoire Naturelle, 55 rue Buffon, 75005 Paris, France.	EBP partner
Germany	https://ornitho.de	Dachverband Deutscher Avifaunisten (DDA)	http://www.dda-web.de/	Johannes Wahl (johannes.wahl@dda-web.de): An den Speichern 6, D-48157 Münster, Germany.	No	Yes	No	Franz Bairlein (franz.bairlein@ifv-vogelwarte.de): Institut für Vogelforschung, An der Vogelwarte 21, D-26386 Wilhelmshaven, Germany. Christof Herrmann (christof.herrmann@lung.mv-regierung.de): Beringungszentrale Hiddensee, Agency for Environment, Nature Conservation, and Geology (LUNG), Mecklenburg-Western Pomerania, Goldberger Str. 12, D-18273 Güstrow, Germany. Wolfgang Fiedler (fiedler@orn.mpg.de): Bird Ringing Centre, Max-Planck-Institut für Ornithologie, Vogelwarte Radolfzell, Am Obstberg 1, 78315 Radolfzell, Germany.	EBP partner
Greece	https://app.bto.org/birdtrack2/main/data-home.jsp	Hellenic Ornithological Society	http://www.ornithologiki.gr/	Danae Portolou (dportolou@ornithologiki.gr): Themistokleous str 80, Athens 10681, Greece.	No	Yes	Yes	Filios Akriotis: Hellenic Bird Ringing Centre, PO Box 4265, GR-10210 Athens, Greece.	EBP partner
Hungary	http://map.mme.hu/	Magyar Madártani és Természetvédelmi Egyesület	http://www.mme.hu/	Károly Nagy (nagy.karoly.mme@gmail.com): P. O. Box 286, H-4401 Nyiregyháza, Hungary.	Yes	Yes	Yes	EBP partner	EBP partner
Ireland	http://blx1.bto.org/birdtrack/	BirdWatch Ireland	https://www.birdwatchireland.ie/	Brian Caffrey (bcaffrey@birdwatchireland.ie): Unit 20, Block D, Bullford Business Campus, Kilcoole, Greystones, Co. Wicklow, A63 RW83, Ireland.	No	Yes	Yes	Dave Leech (dave.leech@bto.org): BTO, The Nunnery, Thetford, Norfolk IP24 2PU, UK.	EBP partner

EU Member State	Portal	EBP Partner	EBP Partner website	EBP Partner contact	EURING scheme	PECBMS scheme	BirdLife partner	EURING scheme contact	PECBMS (EBCC) scheme contact
Italy	https://www.ornitho.it	Lega italiana protezione uccelli (LIPU)	http://www.lipu.it/	Claudio Celada (claudio.celada@lipu.it): Via Udine, 43100 Parma, Italy.	No	Yes	Yes	Fernando Spina (fernando.spina@isprambiente.it): Italian Ringing Centre, Istituto Superiore per la Protezione e la Ricerca Ambientale, Via Ca' Fornacetta 9, I-40064 Ozzano Emilia (BO), Italy.	EBP partner (LIPU, CISO)
		Centro Italiano Studi Ornitologici (CISO)	http://ciso-coi.it/	Giuseppe Bogliani (giuseppe.bogliani@unipv.it): Dipartimento SAF, Università degli Studi di Palermo, Viale delle Scienze, Edificio 4 – Ingresso H, 90128 Palermo, Italy.	No	Yes	No		
		EuroBirdNet Italia	https://www.ebnitalia.it	Luciano Ruggieri (ruggiel@libero.it)	No	No	No		
Latvia	http://dabasdati.lv/	Latvian Fund for Nature	http://www.ldf.lv/	Ilze Priedniece (ilze.priedniece@lu.lv): Vilandes iela 3 – 7, Riga, LV-1010, Latvia.	No	Yes	No	Edmunds Račinskis (ring@latnet.lv): Bird Ringing Centre, Institute of Biology, Miera Str 3, LV-2169 Salaspils, Latvia.	EBP partner
		Latvian Ornithological Society (LOB)	http://www.lob.lv/	Andris Dekants (adekants@gmail.com): Vilandes iela 3 – 7, Riga, LV-1010, Latvia.	No	Yes	Yes		
Lithuania	http://ornitologija.lt/orni/web/	Lithuanian Ornithological Society (LOD)	http://birdlife.lt/	Marius Karlonas (marius.karlonas@birdlife.lt): Naugarduko g. 47-3, LT-03208 Vilnius, Lithuania.	No	Yes	Yes	Ricardas Patapavicius (likcentras@gmail.com): Lithuanian Bird Ringing Centre, Zoological Museum, Laisves aleja 106, LT-44253 Kaunas, Lithuania.	EBP partner
Luxembourg	https://ornitho.lu	natur&ëmwelt	http://naturemwelt.lu/	Patric Lorgé (patlor@naturemwelt.lu): 5 Route de Luxembourg, 1899 Kockelscheuer, Luxemburg.	No	Yes	Yes	Didier Vangeluwe (dvangeluwe@naturalsciences.be): Royal Belgian Institute of Natural Sciences, Vautierstreet 29, B-1000 Brussels, Belgium.	EBP partner
Netherlands	http://trektellen.nl	Dutch Centre for Field Ornithology (Sovon)	http://www.sovon.nl	Ruud Foppen (Ruud.Foppen@sovon.nl): PO Box 6521, 6503 GA Nijmegen, Netherlands.	No	Yes	No	Henk van der Jeugd (h.vanderjeugd@nioo.knaw.nl): Vogeltrekstation, P.O. Box 50, 6700 AB, Wageningen, The Netherlands.	EBP partner
	http://avimap.nl/								
	https://waarneming.nl								
Malta	https://app.bto.org/birdtrack2/main/data-home.jsp			Edward Bonavia					
Poland	https://ornitho.pl	Polish Society for the Protection of Birds (OTOP)	http://www.otop.org.pl/	Tomasz Chodkiewicz (tomasz.chodkiewicz@otop.org.pl): ul. Odrowaza 24, 05-270 Marki, Poland.	No	Yes	Yes	Tomasz Mokwa (tomok@miiz.waw.pl): Ornithological Station, Museum and Institute of Zoology Polish Academy of Sciences, Nadwislanska 108, 80-680 Gdánsk 40, Poland.	EBP partner
Portugal	http://ebird.org/portugal	Portuguese Society for the Study of Birds (SPEA)	http://www.spea.pt/pt/	Pedro Rodrigues (pedro.rodrigues@spea.pt): Avenida João Crisóstomo, 18, 4º Dto, 1000-179 Lisboa, Portugal.	No	Yes	Yes	Vitor Encarnaçao (vitor.encarnacao@icnf.pt): Central Nacional de Anilhagem, Instituto da Conservação da Natureza, Av. Combatentes Grande Guerra 1, 2890-015 Alcochete, Portugal.	EBP partner (SPEA)
		Laboratório de Ornitologia (LABOR)	http://www.labor.uevora.pt/	Carlos Godinho (capg@uevora.pt): ICAAM, Universidade de Évora, 7002-554 Portugal.	No	No	No		
Romania	http://www.openbirdmaps.ro/	Milvus Group	http://www.milvus.ro/	Istvan Kovacs (istvan.kovacs@milvus.ro):	No	Yes	No	Mircea Gogu-Bogdan (rom_ornit_centre@yahoo.com): Centrala Ornitologica Romana,,Institute for Plant Protection,,Bld. Ion Ionescu dela Brad nr. 8,,Sector I – 71592, Bucharest,,Romania.	EBP partner
	http://pasaridinromania.sor.ro/ornitodata	Societatea Ornitologica Romana	http://www.sor.ro/	Cristi Domsa (cristiandomsa@gmail.com): 400370 Cluj, OP 7, CP 18, Romania.	No	Yes	Yes		

EU Member State	Portal	EBP Partner	EBP Partner website	EBP Partner contact	EURING scheme	PECBMS scheme	BirdLife partner	EURING scheme contact	PECBMS (EBCC) scheme contact
Slovakia	http://aves.vtaky.sk	Slovenská ornitologická spoločnosť/BirdLife Slovensko	http://www.vtaky.sk/	Jozef Ridzoň (ridzon@vtaky.sk): Zelinárska 4, 821 08 Bratislava, Slovakia.	Yes	Yes	Yes	EBP partner	EBP partner
Slovenia	http://atlas.ptice.si	BirdLife Slovenia (DOPPS)	http://ptice.si/	Tomaž Mihelič (tomaz.mihelic@dopps.si): Trzaska cesta 2, SI-1000 Ljubljana, Slovenia.	No	Yes	Yes	Al Vrezec (avrezec@pms-lj.si): Bird Ringing Centre, Slovene Museum of Natural History, Presernova 20, PO Box 290, SLO-1001 Ljubljana. Slovenija.	EBP partner
Spain	https://ebird.org/spain https://app.bto.org/birdtrack2/main/data-home.jsp	Sociedad Española de Ornitologia (SEO/BirdLife)	http://www.seo.org/	Blas Molina (bmolina@seo.org): Melquiades Biencinto 34, 28053 Madrid, Spain.	Yes	Yes	Yes	EBP partner (SEO/BirdLife, Aranzadi)	EBP partner (SEO/BirdLife, ICO)
	https://www.ornitho.cat	Catalan Ornithological Institute (ICO)	http://www.ornitologia.org/	Gabriel Gargallo (anella@ornitologia.org): Natural History Museum of Barcelona, Plaça Leonardo da Vinci 4-5, 08019 Barcelona, Spain.	No	Yes	No		
	https://www.ornitho.eus	Aranzadi Zientzia Elkartea	http://www.aranzadi.eus/	Juan Arizaga (jarizaga@aranzadi-zientziak.org): Zorroagagaina, 11, 20014 San Sebastián, Spain.	Yes	No	No		
Sweden	https://artportalen.se/	Swedish Species Information Centre (SLU)	http://www.slu.se/artdatabanken/	Johan Nilsson (Johan.Nilsson@slu.se): Box 7007, 75007 Uppsala, Sweden.	No	No	No	Thord Fransson (thord.fransson@nrm.se): Bird Ringing Centre, Swedish Museum of Natural History, Box 50 007, SE-104 05 Stockholm, Sweden.	Åke Lindström (ake.lindstrom@biol.lu.se): Dept. of Biology, University of Lund, Ecology Building, S-22362 Lund, Sweden.
United Kingdom	http://blx1.bto.org/birdtrack/	British Trust for Ornithology	https://www.bto.org/	Andy Musgrove (Andy.Musgrove@bto.org): BTO, The Nunnery, Thetford, Norfolk IP24 2PU, UK.	Yes	Yes	No	EBP partner	EBP partner

5. Outputs that can be delivered from the data collected by the national online portals (EBP partners), their limitations and possible solutions

The raw data held by the national portals are the most useful for analyses of migration timing in each individual country. These analyses are best developed using phenological graphs in which occurrence or abundance of a focal species is plotted against date either for a single year or for several years combined. Identifying key turning points in such graphs it will usually be possible to obtain reasonably clear measures of the start and end of migration periods. However, it has to be stressed that the capacity to determine the start and end of the migration periods using phenological graphs varies from one species to another or from one area to another due to differences in the seasonal variation of the presence of non-migratory birds. Moreover, such factors as the variation in recording intensity and detection probability also have to be taken very much into account. Though less widely available, the use of breeding evidence data collected by the online portals can also be very informative, particularly for some migratory species and areas where the start of the breeding season of the resident populations can take place prior to the return movements of the migratory ones.

5.1. Brief introduction to the advantages of using the raw data contained in the local online portals

The raw data gathered through online bird recording are held by the national portals. These are the best data to use for analyses of migration timing based on the data from individual countries. Where they have the capacity and expertise to do so it may often be best to ask the relevant portals to undertake any analyses that are required. Otherwise portals will usually have a data request procedure. Online tools for visualising data from individual portals are described in section 3 and portal contacts are given in section 4.

Portals are able to provide data on any species, so analyses of Annex II species are not restricted to the 28 species included in the EBP viewer. Data are available on a daily timescale which is strongly recommended for analytical purposes as outlined further below. They can also be summarised by decades, weeks or any other time units as required. Wherever possible we recommend that analyses of occurrence should be based on complete lists. Where these are not available national portals should make it possible to compute a variety of coverage metrics (e.g. 10 km squares or sites visited on a particular day, observers recording on a particular day at a particular location) based on the full dataset of observations for all species.

Access to the raw data makes it possible to apply a wide range of analyses tailored to the particular questions and data set. It also facilitates more detailed investigation of any unexpected findings. Where national portals do not have their own analysts they will usually be able to facilitate contacts with researchers who have relevant expertise.

5.2. Introduction to the use of phenological graphs/tables, particularly those based on reporting rates, to determine migration periods

Analyses of phenological graphs currently provide the best method for measuring the start and end of migration seasons from bird listing data or casual observations of the type gathered by national portals and collated via EuroBirdPortal. Phenological graphs show measures of occurrence or abundance of a focal species plotted against date either for a single year or for several years combined. By identifying key turning points in such graphs it will usually be possible to obtain reasonably clear measures of the start and end of migration periods. Variation in relative frequency of occurrence between time periods is not always well quantified due to variation in recording intensity and detection probability (details below) but nevertheless the starts and ends of the main migration periods can be quite easily determined in most cases. Understanding what is meant by the migration period is important here since the emphasis of the Key Concepts document is on populations and not individuals. There will often be small numbers of individuals that do not follow the main migration schedule very precisely, perhaps arriving late or departing early. If such individuals are included migration seasons may be greatly extended. In general understanding such movements is likely to require studies of marked birds (section 7) and there will be many species and populations for which appropriately detailed data do not exist. Therefore, analysts should first carefully inspect plots of the raw data to exclude outlier and extreme cases and then establish when the key turning points that identify the start and end of the migration periods take place.

Furthermore, analyses based on phenological graphs can never detect migration in situations where migration is taking place but arrivals approximately balance departures, resulting in no detectable change in occurrence or abundance. Similarly migration is unlikely to be detected where most individuals are not migrating but there is a small throughput of passage individuals. Under these circumstances migration can only be detected through studies of marked individuals (section 7).

The capacity to determine the start and end of the migration periods using phenological graphs varies from one species to another or from one area to another due to differences in the seasonal variation of the presence of non-migratory birds. Five main patterns are commonly observed:

a) The species is mostly a summer visitor in the given region/country.

In these cases the starting decade of the pre-nuptial migration is very obvious due to the absence or scarcity of wintering birds in the area (Figure 5.1). However, to determine the end of this migration period is more difficult since the termination of the migration occurs when the frequency of breeding birds is also high.

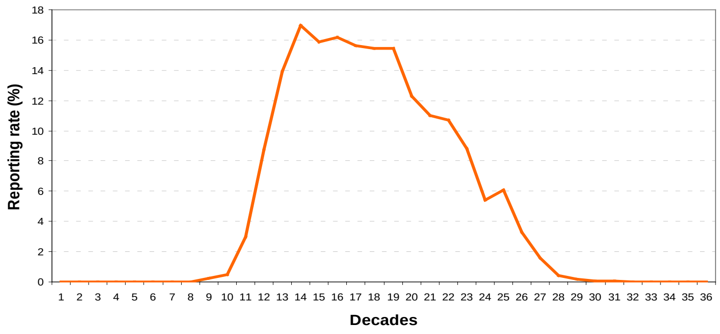


Figure 5.1. Seasonal variation in the reporting rate of the European Turtle-dove (proportion of complete lists containing the species) in Catalonia (NE Spain). Data from ornitho.cat.

b) Cases where the species only or mostly occurs during migration in the given region/country.

In these cases the start and end decade of the pre-nuptial migration period is quite obvious since the species is absent or scarce both in winter and during the breeding season (Figure 5.2). Anyway, even in these cases, local expert advice and/or additional data checking/analyses (see below) can be necessary to make an informed decision regarding the exact decade in which migration is considered to start and end.

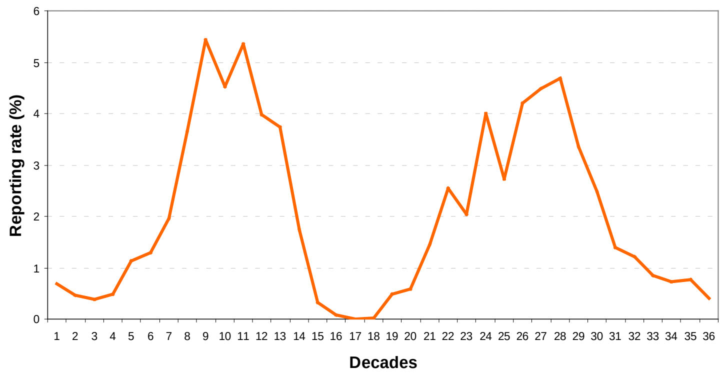


Figure 5.2. Seasonal variation in the reporting rate of the Ruff (proportion of complete lists containing the species) in Catalonia (NE Spain). Data from ornitho.cat. Note how the increase in the reporting rate during the pre-nuptial migration (roughly decades 5 to 15) is quite obvious due to the scarcity of Ruffs in the region outside the migration periods.

c) Cases where the species is present in winter or year-round but much more common/abundant during migration.

In these cases, the autumn and spring migration peaks are quite noticeable but, usually, additional information and data sources are required to determine the decade in which migration starts and ends (Figure 5.3).

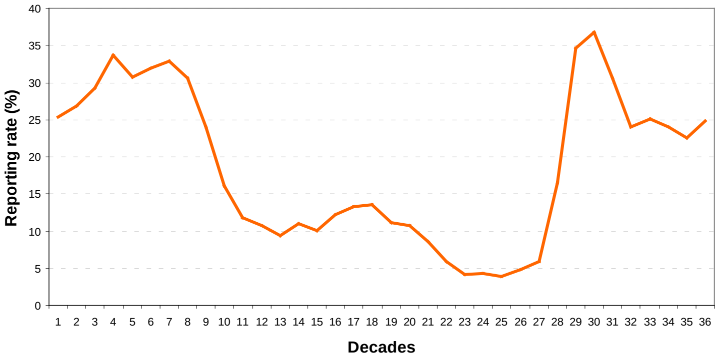


Figure 5.3. Seasonal variation in the reporting rate of the Song Thrush (proportion of complete lists containing the species) in Catalonia (NE Spain). Data from ornitho.cat. In this area, the species is more common in winter than during the breeding season, therefore, the final part of the pre-nuptial migration period is more marked (note the step descent in the reporting rate between decades 7/8 and 11/12). The start is much less clear, however. Although the reporting rate seems to start to increase from the more usual wintering plateau values by decade 2, without additional information (e.g. ringing data) it is not easy to know when the real pre-nuptial migratory movements start.

d) Cases where the species is quite common year-round.

In cases where migration does occur but the species is quite equally common all year-round the migration passage periods often are not readily discernible (Figure 5.4). In such cases, other data sources should be used to help identify the migration periods (see section 7).

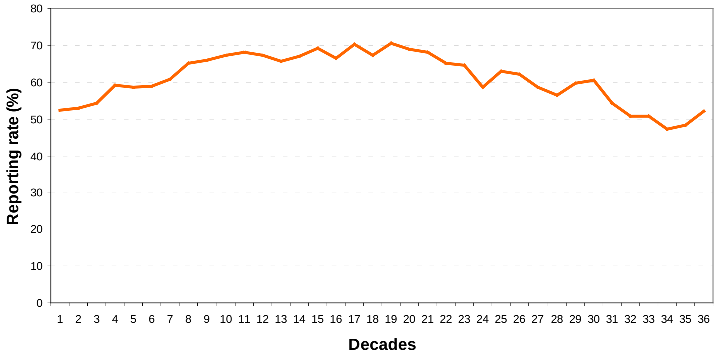


Figure 5.4. Seasonal variation in the reporting rate of the Common Woodpigeon (proportion of complete lists containing the species) in Catalonia (NE Spain). Data from ornitho.cat. Note the lack of any hint of clear migration influxes. Variation in the reporting rate across the year is mostly due to differences in detectability (e.g. increasing singing activity during spring/summer).

e) Cases where the species is mostly a winter visitor.

In these cases the opposite of the species which are summer visitors occurs (see above). Now it is the end of the pre-nuptial migration period that is easily discernible due to the lack or scarcity of breeding birds (Figure 5.5). However, the abundance of wintering birds makes it more difficult the determination of the exact start of the pre-nuptial migration period.

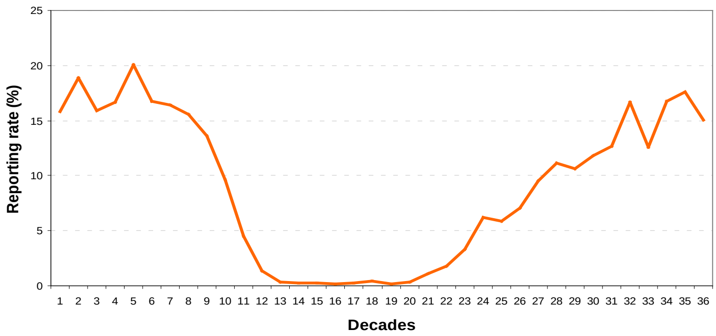


Figure 5.5. Seasonal variation in the reporting rate of the Common Teal (proportion of complete lists containing the species) in Catalonia (NE Spain). Data from ornitho.cat. The final part of the pre-nuptial migration period is quite clearly visible (note the step decrease in reporting rate from decades 8 to 12), however, the start of the migration period is more difficult to determine.

5.3. How to prepare phenological graphs/tables using raw online portals data, and how to use these analyses to assign migration periods to decades (modus operandi for experts willing to prepare phenological graphs)

The starting point for analysis should be to obtain daily data on the occurrence measure to be used from the country portal or EuroBirdPortal as appropriate. Wherever possible we recommend that this should be the proportion of complete lists on which the focal species was recorded. If that is not possible then an alternative measure that makes some allowance for recording effort should be selected. Measures such as the proportion of 10 x 10 km squares or 30 x 30 km squares with bird records on a given day from which the species was recorded should be suitable. Similar approaches could be applied to counts but we do not discuss this further here because in most cases adequate coverage of sufficiently systematic counts will not be available.

For a simple exploratory analysis next calculate the proportion of lists or sampling units containing the focal species for each of the 36 decades for each year. Also tabulate the sample sizes (lists in each decade) and check that they are adequate. Then plot separate graphs for each year and compare the patterns. If they are reasonably similar then producing a graph from the combined data from all years and reading off the approximate turning points is likely to be the best approach. If the phenological graphs vary substantially between years it may be best to report a range of values for the start of migration based on an analysis for each year. Where there is a single year that is markedly different from the rest consider reporting one set of figures for the majority of years and another for the exceptional one.

For a more rigorous analysis (recommended) start by plotting graphs of the selected daily measure of occurrence against date for each year for which data are available. This graph will almost always show substantial fluctuations between days but by fitting a smooth curve through the data a robust measure of the underlying pattern should be revealed. The best way to do this is to use a spline because this non-parametric approach avoids forcing the curve to follow any particular shape. The degree of smoothing is determined by the number of degrees of freedom which we recommend setting to 8 (Newson et al., 2016). If a plot of the daily data and the smoothed curve suggests that there are important features that are not being picked up then the number of degrees of freedom may be increased slightly. However note that having too many degrees of freedom is likely to incorporate unwanted sampling artefacts.

Next, check that the annual graphs show similar patterns which will normally be the case. In these circumstances, data for each day can be pooled across years and a new graph for all years produced. As illustrated in section 5.1 the turning points marking the start and end of the migration period can normally be identified by visual inspection. There is a more objective protocol for identifying turning points that was original developed for analyses of population trends (Fewster et al., 2000; Siriwardena et al., 1998) and has subsequently been extended to the analysis of phenological curves (Newson et al., 2016). This technique should be applied if there is doubt about the identification of turning points but it will require more specialist expertise than the other analyses recommended here.

5.4. Determining the start and end decades for the migration period

For application of the EU key concept approach the start and end decades of the migration period need to be determined. Therefore it might be thought that a good approach would be to calculate the proportion of lists or squares for each of these ten day periods and then use this information to identify the migration period. We do not recommend such an approach because the key turning points are best identified from a smoothed curve based on daily data which will give the most accurate assessment of turning points. The following procedure is therefore recommended, based on the general approach outlined above.

1. Calculate daily measures of occurrence from the raw data
2. Fit a smoothing spline to the daily occurrence measures, based on 8 degrees of freedom
3. Identify turning points indicating the start and end of spring migration from the smoothing spline. These should be measured to the nearest day
4. Assign the turning points measured from the smoothing spline to decades.

This approach will give the most accurate assessment, with the final results still assigned to decades as required by the key concepts approach.

If it is not possible to apply this approach for some reason then in straightforward cases the start and end of migration may be determined from plots of frequency of occurrence against decade as illustrated in section 5.2. However care must be taken to separate sampling errors from the main underlying biological patterns and to avoid putting undue weight on periods with sparse data. Thus if this approach is applied there are likely to be more cases where the onset and end of migration cannot be determined very precisely.

5.5. The relevance of the data on breeding evidence

Breeding evidence codes offer a simple means of recording breeding activity. They have mainly been developed and used for data gathering associated with breeding bird atlases. They allow the recording of breeding evidence that is relatively weak (e.g. presence of singing males) through to firm evidence such as the presence of nests containing eggs or nestlings. Most portals facilitate the collection of such data (section

3.2) but they are often only recorded by proportion of the observers or in relation to some specific projects (e.g. Atlas projects). For atlases, observers normally aim to prove breeding in each spatial unit (usually a 10 x 10 or 2 x 2 km square) and once that has been achieved further data may not be recorded. Thus only some of these datasets are suitable for studying breeding phenology. However, since many Atlas projects record data using the existing online portals the data gathered by some of them is quite extensive.

Moreover, in a few countries more systematic recording of breeding codes is undertaken, and here they may provide particularly useful measures of the start and end of the breeding season, based on analytical approaches similar to those used for occurrence data. For example using data from Wallonia, Belgium, it was possible to identify start and end dates for the breeding seasons of a range of species for which successful breeding could be impacted by hedgerow management (Laudelout and Paquet, 2017). On the other hand, portals such as Ornitho.cat and Faune-France.org are able to provide outputs based on breeding codes that are very useful for determining breeding seasons (Figures 3.2 and 5.6). The collation and presentation of such data at a European scale still requires further developments in data gathering and analysis but the new EBP data standard, which already includes breeding evidence information, is a good first step forward in the good direction.

The breeding evidence information collected by the online portals can be particularly useful to determine the end of the period of reproduction and, thus, the opening of the hunting season (though if only nestling activity information is available, the period of dependence of the young will have to be added). Moreover, since in many areas a mixture of different populations with different temporal patterns of migration and reproduction overlap, it should be noted that in some cases the first breeding evidences of some resident bird populations can occur earlier than the start of the departure of the migratory populations. Therefore, in some migratory species and areas, the start of the reproduction period rather than the start of the spring migration period could be a better determinant of the closing of the hunting season.

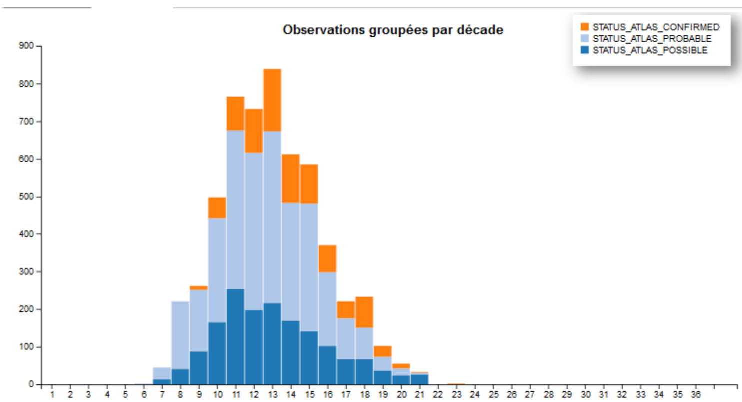


Figure 5.6. Evidence for the duration of the breeding season of Lapwings in France based on atlas breeding codes. Here these are summarised into three standard categories of possible, probable and confirmed breeding and grouped by decade (Faune-France.org).

6. What kind of problems could occur and how to solve them?

Several problems may arise when attempting to determine migration seasons from online portal data. Phenological patterns may be confounded with changes in recording effort or variations in detection probability. Moreover, regions or countries with poor coverage and small sample sizes may give imprecise results. Phenological variation between years also should be checked and taken into account. Finally, some countries or regions may be used by multiple populations each of which may have its own migration and breeding phenology.

The following problems may arise when attempting to determine migration seasons from EBP or national portal complete lists or casual observations. In each case it is important that analysts and data users should be aware of the issues and consider their implications for the conclusions reached from any specific analysis.

6.1. Phenological patterns may be confounded with changes in recording effort

Where all or a high proportion of records comprise casual observations seasonal, variation in frequency of occurrence may be confounded with changes in recording effort. The use of presence only data, that is data limited to casual observations, potentially introduces serious bias into biodiversity datasets. Casual observations may be defined as those where no systematic recording protocol is followed and observers just note observations that they consider to be of interest. Changes in numbers of observations may reflect changes in observer activity rather than true changes in occurrence. For example there is often a spring peak in birdwatching activity as observers are keen to record the first arrivals of summer visitors (Baillie et al 2006, Figure 6.1). Furthermore some observers may record a species when they see it in particular circumstances while other observers may not record the species in exactly the same circumstances. Where data are of this type it is important that this should be made clear and that results should be interpreted with considerable caution.

It is generally possible to convert such data into some form of list structure such as the proportion of active observers or visited spatial units (e.g. 10 km squares) from which the species was recorded in a given time period (day,week or decade). The development of such approaches is an active research area, particularly focussed on the large number of non-avian taxa for which large scale surveys are difficult or impossible (Isaac et al. 2014). It is important that results from such analyses should be cross checked with other data sources wherever possible.

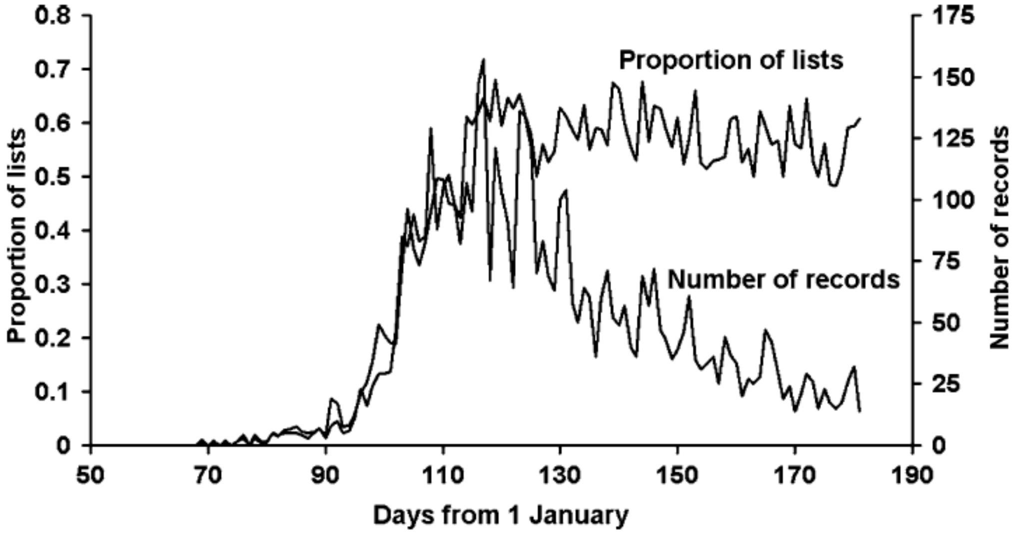


Figure 6.1. Daily numbers of Swallows reported to an on-line recording scheme during the summer of 2003 and the proportion of lists containing Swallows. Fewer records are recorded later in the season due to declining observer interest after the return period but this bias is well corrected by a measure base on the number of lists containing Swallows. From Baillie *et al*. 2006.

6.2. Standard phenology graphs represent some combination of variation in occurrence and detection probabilities

Even where data are in the form of complete lists, or can be coerced into a similar format, occurrence and detection probability are confounded. An obvious example is that migratory songbirds sing very actively when they arrive on the breeding grounds. However as the summer progresses the proportion of complete lists recording such species declines, not through any reduction in abundance but simple because males are more engaged in other aspects of breeding and hence are less conspicuous (Newson et al., 2016, Figure 6.2). This drop off in detection is not seen in species such as Barn Swallows that are mainly detected by sight. Dispersal of waterfowl or waders across the breeding grounds could results in similar effects in some areas. On arrival many birds may be concentrated on water bodies where they are easily observed and that are well covered by observers. As the breeding season progresses and birds spread out onto breeding territories they may become less easy to detect.

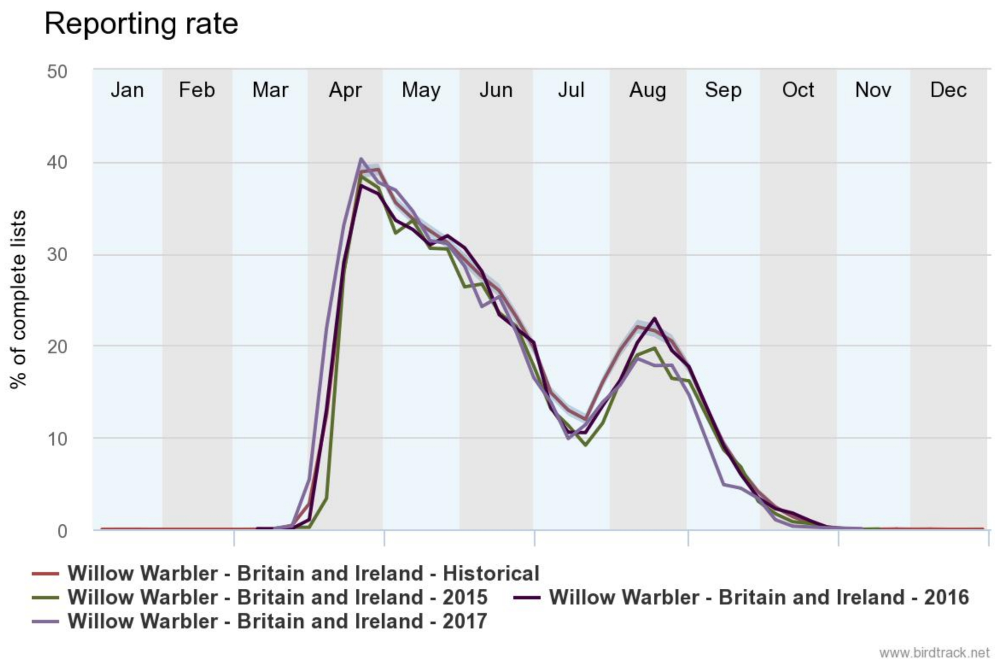


Figure 6.2. Seasonal variation in the proportion of complete lists containing Willow Warblers. Data are for Britain and Ireland from BirdTrack. The timing of spring migration is clear but the decline in recording frequency after the initial arrival peak is clearly due to a change in detectability not a change in occurrence.

A number of complex models that aim to separate seasonal variation in detection and occurrence probabilities have been developed (Roth *et al*. 2014; Strebel *et al*. 2014) and further developments remain an active research area. However such models are very “data hungry” and are time consuming to apply. We do not believe that their application would be feasible for a high proportion of the species of interest here within the resources that are likely to be available, even where sufficient complete lists exist.

At present the most important point is that those interpreting phenology graphs should be aware that they represent some unquantified combination of occurrence and detection probabilities. Often the starts and ends of the main migration periods will still be reasonably obvious but this limitation must be taken into account and results interpreted with appropriate caution.

6.3. For regions or countries with limited observer activity small sample sizes may give imprecise results

The most important point here is to examine the sample sizes, ideally in terms of complete lists per day or per week. Precision will be influenced by both the number of lists and the frequency of occurrence of the focal species. In general graphs of proportion of lists or records against date will show substantial fluctuations where data are imprecise. If frequency of occurrence is calculated on a daily basis phenological graphs may show substantial variation between days even for relatively common species (Figure 6.1). We therefore recommend examining phenological graphs with occurrence measures calculated on a weekly basis. If these show substantial variation between weeks then the data should be treated with appropriate caution.

For a more formal assessment of precision it is straightforward to calculate approximate confidence intervals for frequency of occurrence measures based on the normal approximation to the binomial distribution as documented in standard statistical texts. This approximation will not work well with very small sample sizes or when expected proportions are very high or very low. However in general it offers a useful assessment of likely precision that can be computed very easily. The confidence limits estimated using this method may underestimate the width of the confidence interval where assumptions such as the independence of lists are violated. Those more experienced at statistical analysis may prefer to implement a bootstrap approach.

Nevertheless simple confidence intervals show clearly that measures of frequency of occurrence may not always be very precise, particularly where sample sizes are small. Predicted precision of frequency of occurrence measures based on different numbers of lists and proportions of lists containing the focal species is presented in Table 6.1. This shows, for example, that if we have a sample of 200 lists and a reporting rate for our focal species of 0.25 we are approximately 95% certain that the true value lies between 19% and 31%. Similarly for a sample of 500 lists and a reporting rate of 0.75 we are 95% certain that the true value lies between 71% and 79%. From these simple calculations it is immediately apparent that difference of only a few percentage points are unlikely to be statistically or biologically meaningful. It also further illustrates the benefits of fitting a smoothed phenology curve rather that attempting to estimate turning points from measures based on relatively short time periods (weeks, decades) and limited sample sizes.

Example graphs of real data on frequency of occurrence in complete lists with confidence intervals calculated using the normal approximation to the binomial distribution are presented in Figure 6.3. In both years a similar pattern of occurrence was recorded, which would be likely to give similar assessments of the start and end of the spring migration period. However the individual points show moderate confidence intervals, showing that even for this fairly good data set comparisons of occurrence frequencies between individual decades require careful interpretation.

Where data are imprecise the problems may be mitigated by using results from surrounding areas or by combining inferences from different types of data (e.g. observations, nest recording, ring recoveries).

Number of lists	Reporting rate	Expected	Standard Error	Lower 95% Confidence Limit	Upper 95% Confidence Limit
50	0.05	3	0.031	-0.01	0.11
100	0.05	5	0.022	0.01	0.09
200	0.05	10	0.015	0.02	0.08
500	0.05	25	0.01	0.03	0.07
750	0.05	38	0.008	0.03	0.07
1000	0.05	50	0.007	0.04	0.06
50	0.1	5	0.042	0.02	0.18
100	0.1	10	0.03	0.04	0.16
200	0.1	20	0.021	0.06	0.14
500	0.1	50	0.013	0.07	0.13
750	0.1	75	0.011	0.08	0.12
1000	0.1	100	0.009	0.08	0.12
50	0.25	13	0.061	0.13	0.37
100	0.25	25	0.043	0.17	0.33
200	0.25	50	0.031	0.19	0.31
500	0.25	125	0.019	0.21	0.29
750	0.25	188	0.016	0.22	0.28
1000	0.25	250	0.014	0.22	0.28
50	0.5	25	0.071	0.36	0.64
100	0.5	50	0.05	0.4	0.6
200	0.5	100	0.035	0.43	0.57
500	0.5	250	0.022	0.46	0.54
750	0.5	375	0.018	0.46	0.54
1000	0.5	500	0.016	0.47	0.53
50	0.75	38	0.061	0.63	0.87
100	0.75	75	0.043	0.67	0.83
200	0.75	150	0.031	0.69	0.81
500	0.75	375	0.019	0.71	0.79
750	0.75	563	0.016	0.72	0.78
1000	0.75	750	0.014	0.72	0.78

Table 6.1. Approximate precision of reporting rate measures based on different sample sizes. Precision measures are based on the normal approximation to the binomial distribution and should therefore be regarded as approximate.

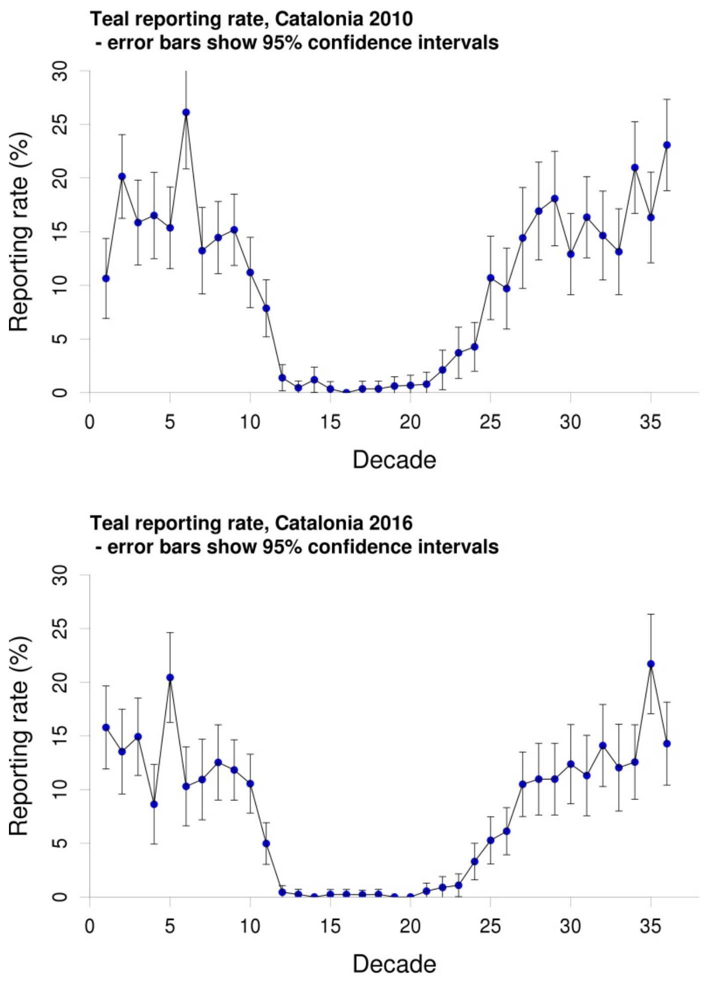


Figure 6.3. Seasonal variation in occurrence frequency of Common Teal from complete lists recorded in Catalonia (NE Spain) in 2010 and 2016 using ornitho.cat.

6.4. Phenological variation between years should be checked and taken into account

It is well established that phenology varies between years in relation to weather, food supplies and other environmental factors. Such variation should be checked where possible, for example by comparing phenology graphs from different years and averaging the results where necessary. For example, review of annual phenology graphs derived from EBP for Common Teal across eight countries/regions of Europe revealed that between year differences were small and that taking average values across these years was therefore appropriate (Figure 6.4).

The most important point here is to start with the expectation that there will be some variation in migration timing between years and that normally data should be analysed for each year separately. Having estimated the start and ends of the migration periods in each year compare them and consider whether any major fluctuations are likely to have arisen from well documented environmental conditions such as late springs. Note that arrival times may be influenced by conditions in the wintering, passage and destination areas. If the observed pattern shows fluctuations of no more than a few weeks and any major fluctuations are explicable by documented environmental factors then it should be reasonable to average the results, and to report this average together with the observed range of annual values. If a single year gives results that are very different from the others without any obvious explanation, and the rest show a consistent pattern then that year should probably be reported separately from the rest. When dealing with this type of ecological variation it is always important to report the results in a clear and transparent manner so that policy makers are aware how they have been derived and can apply the results appropriately.

In many cases it will be possible to make a reasonable interpretation of phenological graphs using the approach outlined here without undertaking a formal statistical analyses. If phenology graphs for most individual years show similar patterns within the expected range of variation based on approximate binomial confidence limits then it will usually be reasonable to combine the results. For example inspection of Figure 6.3 immediately shows the likely width of binomial confidence limits for individual decades based on Common Teal data from one region. Given that level of variation it seems unlikely that the graphs for different years shown for Common Teal in Figure 6.4 show substantial real variation between years. A first step towards checking this would be to add binomial confidence intervals to those graphs. A more robust approach to this problem is possible and would likely involve computing bootstrapped confidence limits for the phenological graphs for each year, based on resampling locations or observers with replacement. Such a bootstrap approach could also produce formal confidence intervals for the turning points that indicate the start and end of the migration period. Turning points would be recalculated for each bootstrap replicate and percentiles of these estimates then provide the required confidence interval.

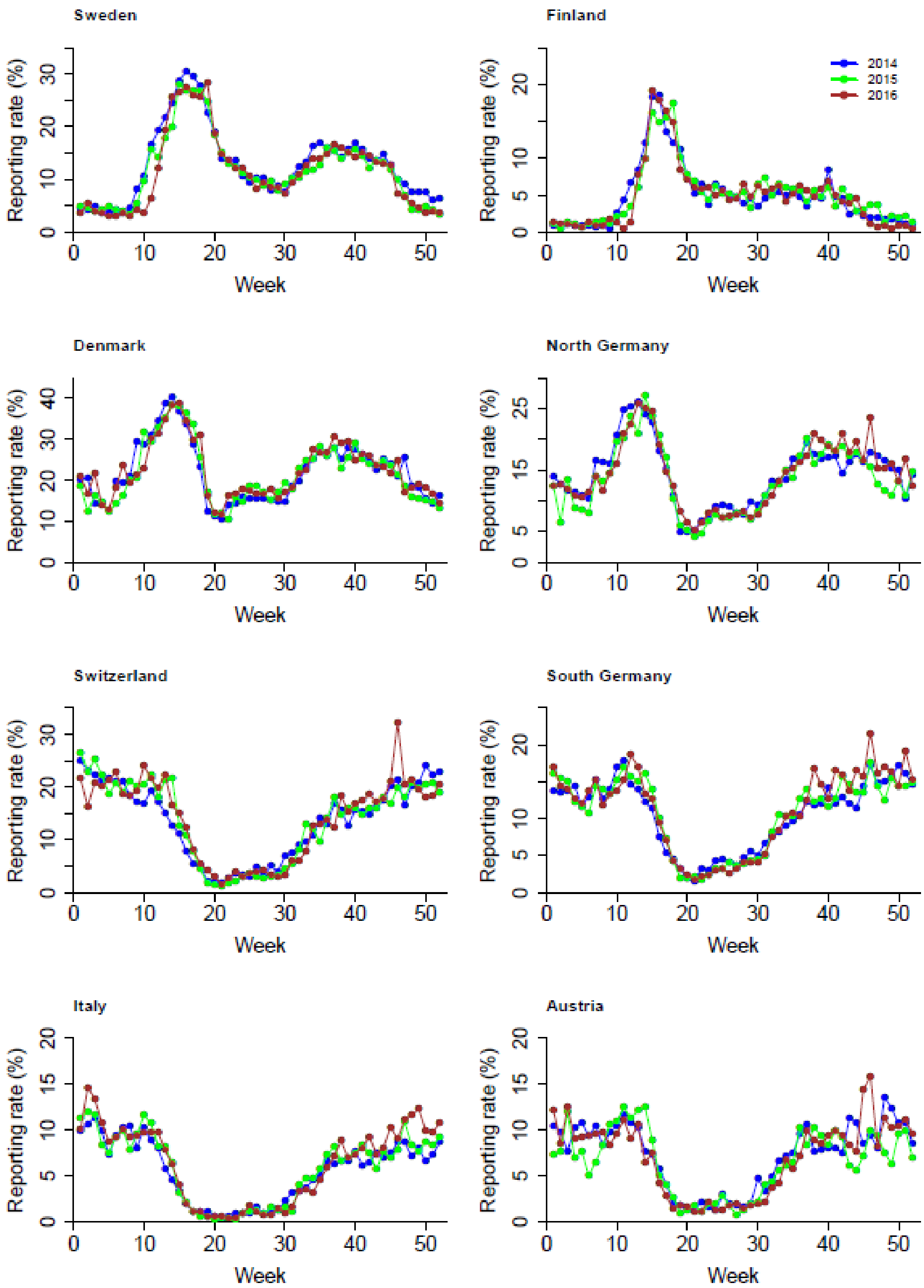


Figure 6.4. Phenological graphs for Common Teal from eight countries/regions of Europe showing differences between the three years 2014-2016. Reporting rate was calculated on a weekly basis and show very similar patterns between years (see text).

6.5. Particular countries or regions may be used by multiple populations each of which may have its own migration and breeding phenology

Normally variation between the migration timing of different populations that use the same area can only be accounted for using studies of marked birds (see section 7 below). Always assess which populations are likely to be present in a particular region at a particular time of year by reference to Migration Atlases and other sources, also reporting on any substantial uncertainty over the populations involved. Where multiple populations are present in the same country or region at the same time and where the populations are relatively similar in size then overlapping distributions of migration times should be expected and start and end dates for the different populations should be estimated if possible. From the point of view of the Key Concepts approach the most important date to estimate will be the start of migratory activity of the population that migrates first. Take into account also that in some migratory species and areas, the start of the reproduction period rather than the start of the spring migration period could better determine the closing of the hunting season (see section 5.5).

7. How EURING or other complementary data can complement EBP partner's data

There are important data sources that can be used to complement the information provided by the online portals. Data on marked birds from either conventional ring recoveries, resightings of colour-marked individuals or tracking are particularly relevant since can provide definitive evidence of migration because individuals are known to have moved within a given time period. Such information provides an ideal complement to measures of overall population shifts based on occurrences and counts. On the other hand, when available, the best information on the period of reproduction can be provided by nest recording schemes and other, more specialized, complementary data sources on breeding behaviour.

7.1. Using data from marked birds to determine migration seasons

Data on marked birds from either conventional ring recoveries, resightings of colour-marked individuals or tracking can provide definitive evidence of migration because individuals are known to have moved within a given time period. Such information provides an ideal complement to measures of overall population shifts based on occurrences and counts. This is particularly helpful in situations where some individuals start migrating but the extent of movements is insufficient to show readily observable population shifts. Where two or more populations are present in the same area they may show different migration patterns and timing which are only likely to be revealed through studies of marked birds.

Many data sets on marked birds are now very extensive and they provide the central basis of both pure and applied migration research. However, studies must nearly always focus on particular study populations or catching locations, so do not offer the relatively comprehensive coverage of species and geographical areas that can be provided by occurrence data from countries with high observer densities. The different types of mark-reencounter data are affected by different features and biases. Some of the most important features are noted below but addressing such issues comprehensively is beyond the scope of this relatively short advisory document. We recommend that policy makers should seek advice and information from specialists in migration research and particularly from organizations running bird Ringing Schemes.

A key first step towards understanding movement and migration patterns and timing of a given species within any country is to understand which populations are involved and their broad migration routes. It is extremely common to have birds from different populations that have different migration routes and strategies present in the same country at the same time and understanding this is crucial for the correct interpretation of occurrence data. This basic information will normally be available from published migration Atlases, supplemented by information from scientific papers and general ornithological handbooks.

Migration Atlases based on ring recoveries have now been published for some 15 European countries. A list of these publications is kept up-to-date on the EURING website.

Refereed scientific publications are very diverse but most relevant ones are likely to be located using an advanced Google Scholar search, for example with species and country as key words (https://scholar.google.co.uk/).

The Migration Mapping Tool was published in 2007 as a result of a study of bird movements in relation to the potential transmission of Avian Influenza, funded by the European Commission. This on-line tool presents dynamic migration maps and analyses of movements based on ring recoveries for 22 species, 18 of which are listed under Annex II of the EU Birds Directive. These 18 species are:

Mute Swan, Greater White-fronted Goose, Greylag Goose, Eurasian Wigeon, Gadwall, Common Teal, Mallard, Northern Pintail, Garganey, Northern Shoveler, Red-crested Pochard, Common Pochard, Tufted Duck. Common Coot, Northern Lapwing, Ruff, Black-tailed Godwit, Black-headed Gull.

The Migration Mapping tool summarizes movements in relation to 37 countries in and around Europe and 14 focal regions:

- Belgium and the Netherlands.
- Finland and the Baltic States.
- France and the Channel Islands.
- Germany and Denmark.
- Great Britain and Ireland.
- Greece, Albania and Macedonia.
- Hungary and the Balkan States.
- Iceland and Faeroes.
- Italy, Switzerland and Austria.
- Norway and Sweden.
- Poland, Czech Republic and Slovakia.
- Romania and others.
- Russia and Belarus.
- Spain and Portugal.

It is therefore well suited to identifying which populations move through particular areas and their broad timing of movements. However temporal resolution is only to the nearest month so it is not suitable for determining the exact timing of migration periods. However any estimates of migration periods derived from other data sources that are not consistent with the maps presented should be critically questioned.

Each country has one or occasionally more Ringing Schemes that co-ordinate bird ringing and hold the resulting data. These national Ringing Schemes are generally the best initial contact points for information and data based on bird ringing within individual member states. The activities of these schemes are co-ordinated at a European level by the European Union for Bird Ringing (EURING). Most of the resulting ring recovery data that provide data on bird movements are held in the EURING databank (EDB). The work of the EDB and of the research areas to which it contributes is the subject of a recent review paper (du Feu et al. 2016). The on-line EDB index provides listings of the data held in the EDB.

In addition to standard ring recoveries based on numbered metal rings found by members of the public, hunters and other bird ringers there are many data based on resightings of colour marked birds made by specific research teams and by birdwatchers. Some of these resighting data are included in national ring recovery datasets but many are not. Comprehensive data are generally held by individual research groups who will normally be known to national ringing centres. Thus these ringing centres will normally be the best initial point of contact (see contact details here). Findings from many of these studies are available in the scientific literature. It will not normally be practical to investigate all such data but they may be worth exploring in relation to specific questions that cannot otherwise be resolved. Many of the resighting data on geese and swans are held by www.geese.org while contact points and other information on particular schemes and species can be obtained via the European Colour-ring birding website.

In recent years there has been an explosion in the number of tracking studies using a range of electronic tracking devices fitted to individual birds from simple radio transmitters to satellite tags. These studies provide very detailed data on individual movements but often cover only a small number of individuals. This is a very dynamic area of research resulting in several hundred new papers every year with consequent rapid improvements in knowledge. Particularly in recent years such studies have often made an important contribution to migration atlases and other overview publications. Detailed interpretation of the results often requires specialist advice because they depend on a range of rapidly changing technologies that all have their own strengths and limitations. Many such datasets are stored in Movebank which provides a data repository and many tools for researchers. This is the best starting point for investigating what data may be available and establishing contacts with relevant research groups. However coverage is not comprehensive.

Over the next three years the Convention on Migratory Species (CMS) will oversee the development of the first component of a Global Animal Migration Atlas. The Eurasian African Bird Migration Atlas is being developed and compiled by EURING, working in close collaboration with Movebank. The project will include a specific module to address the migration seasons of Annex II species. Over this period substantially improved information on movement patterns and timing based on studies of marked birds will therefore become available for these species. The project is only just starting so it will be some time before substantive results are available. Further information on the project is available on the EURING website (https://www.euring.org/migraton-atlas).

Radars studies, particularly those using large networks of radars, can be another good source of information on overall bird movements (Nilsson et al. 2018). Radar information has been becoming more accessible thanks to initiatives such as "ENRAM" (European Network for the Radar surveillance of Animal Movement), which has been working with the European Meteorological Services Network (EUMETNET) to make the data from the European weather radar network available to biologists. However, unlike the methods based on marked birds, radar studies do not provide information on species-specific movements that can be readily used in the context of the Key Concepts Document (KCD). Most radars covering large areas only allow images of migrating birds to be assigned to very broad groups at best. Even with more precise but localised tracking radars metrics such as wing beat frequencies that might aid species identification show substantial overlaps between species (Bruderer *et al* 2010). Nevertheless, the large scale information on migration intensity and migratory directions that can be derived from radar studies may help, in the future, to better interpret the data on species-specific bird movements provided by tracking individual birds, bird ringing or online bird recording portals. However at the present time this should be regarded as an area providing opportunities for further research rather than something that is likely to provide rapid answers to applied questions about individual species.

7.2. Using data from nest recording and bird ringing to determine the onset of breeding

Some online bird portals collect considerable breeding evidence data (see section 5.5), however, in several cases the best or more detailed information on the period of reproduction is provided by nest recording schemes and other, more specialized, complementary data sources.

Country-specific information of the onset of breeding should ideally be available from nest recording schemes and from published scientific research on individual species. Such information may also be derived from the dates on which chicks or nestlings are ringed by taking account of the age of the chicks and hence of the time that is likely to have elapsed between nest initiation and ringing. Such measures will inevitably be less precise than those derived from focussed nest recording. The availability of large scale nest recording data is limited to a small number of countries (below) while estimates derived from chick ringing dates require careful interpretation. Hence these sources of information are best regarded as being supplementary to those described above.

The onset of breeding may ideally be defined by the occupation of breeding territories or the initiation of nest building. However this type of information is not generally collected systematically through large scale monitoring schemes. Atlas and observational studies often collect information on nest building and this has already been used in relation to other applied problems such as the timing of hedgerow management (Laudelout and Paquet, 2017). If it is desired to measure breeding initiation from the start of territory occupation or nest building then the best approach will generally be to obtain estimates of these periods from published studies and to combine them with large scale data on the initiation of laying.

Information on the initiation of laying can potentially be obtained from first egg dates gathered by large-scale nest recording schemes (Crick, Baillie, & Leech, 2003, Franks et al., 2018). However only six countries within the European Union currently operate large scale nest record schemes:

- Britain and Ireland – The BTO Nest Record Scheme is the largest nest record scheme in Europe and currently gathers over 45,000 nest histories each year. The total card collection now exceeds 1.8 million. Further details are available here.

- Estonia has had an active nest record scheme since 1959. Further details are available here.

- Finland operates a nest record scheme for which details are available here.

- The Netherlands has an active nest record scheme and a collection of over 900,000 nest record cards, most of which relate to nests found since 2000. Details are available here.

- Poland has a nest record scheme that has operated since 1978 and is run by Professor Tomasz Wesolowski which has a collection of around 100,000 nest histories. Details are available here.

A few other countries have had nest record schemes in the past but they are no longer active. Only some nest records data are computerized so there would be large variation in the time and resources required to produce relevant analyses.

Detailed information on nesting seasons is also available from many individual published scientific studies. These can potentially be located using standard tools for searching the scientific literature but the results will usually need to be interpreted on a study-specific basis. Such papers may not contain simple measures of the timing of breeding or the raw data required to derive them. Thus where substantial sets of nest recording or chick ringing data exist in computerized form they are likely to be the best source of large-scale information on the onset of breeding and should certainly be used wherever possible. Targeted computerization of data and development of more systematic recording should be encouraged.

8. Selected bibliography

Baillie, S.R., Balmer, D.E., Downie, I.S., Wright, K.H.M., 2006. Migration Watch: an Internet survey to monitor spring migration in Britain and Ireland. *J. Ornithol.* **147**, 254–259. doi:10.1007/s10336-006-0062-8

Bruderer, B., Peter, D., Boldt, A. and Liechti, F., 2010. Wing-beat characteristics of birds recorded with tracking radar and cine camera. Ibis, 152, 272-291.

Crick, H.Q.P., Baillie, S.R., Leech, D.I., 2003. The UK Nest Record Scheme: its value for science and conservation. *Bird Study* **50**, 254–270. doi:10.1080/00063650309461318

du Feu, C.R., Clark, J.A., Schaub, M., Fiedler, W., Baillie, S.R., 2016. The EURING databank – a critical tool for continental scale studies of marked birds. *Ringing Migr.* **31**, 1–18. doi:10.1080/03078698.2016.1195205

Fewster, R., Buckland, S., Siriwardena, G., Baillie, S., Wilson, J., 2000. Analysis of population trends for farmland birds using generalized additive models. *Ecology* **81**, 1970–1984.

Fink, D., Hochachka, W.M., Zuckerberg, B., Winkler, D.W., Shaby, B., Munson, M.A., Hooker, G., Riedewald, M., Sheldon, D., Kelling, S., 2010. Spatiotemporal exploratory models for broad-scale survey data. *Ecol. Appl.* **20**, 2131–2147. doi:10.1890/09-1340.1

Franks, S.E., Pearce-Higgins, J.W., Atkinson, S., Bell, J.R., Botham, M.S., Brereton, T.M., Harrington, R., Leech, D.I., 2018. The sensitivity of breeding songbirds to changes in seasonal timing is linked to population change but cannot be directly attributed to the effects of trophic asynchrony on productivity. *Glob. Chang. Biol.* **24**, 957–971. doi:10.1111/gcb.13960

Isaac, N.J.B., van Strien, A.J., August, T. a, de Zeeuw, M.P., Roy, D.B., 2014. Statistics for citizen science: extracting signals of change from noisy ecological data. *Methods Ecol. Evol.* **5**, 1052–1060. doi:10.1111/2041-210X.12254

La Sorte, F.A., Fink, D., Johnston, A., 2018. Seasonal associations with novel climates for North American migratory bird populations. *Ecol. Lett.* **21**, 845–856. doi:10.1111/ele.12951

Laudelout, A., Paquet, J.-Y., 2017. Uand tailler les haies ? Le Benefice pour les oiseaux nicheurs d'une extension de la periode d'interdiction de taille des haies eb milieu agricole. *Aves* **54**, 49–58.

Newson, S.E., Moran, N.J., Musgrove, A.J., Pearce-Higgins, J.W., Gillings, S., Atkinson, P.W., Miler, R., Grantham, M.J., Baillie, S.R., 2016. Long-term change in spring and autumn migration phenology of common migrant breeding birds in Britain: results from large-scale citizen science bird recording schemes. *Ibis* **158**, 481–495. doi:10.1111/ibi.12367

Nilsson, C., Dokter, A. M., Verlinden, L., Shamoun-Baranes, J., Schmid, B., Desmet, P., Bauer, S., Chapman, J., Alves, J. A., Stepanian, P. M., Sapir, N., Wainwright, C., Boos, M., Górska, A., Menz, M. H., Rodrigues, P., Leijnse, H., Zehtindjiev, P., Brabant, R., Haase, G., Weisshaupt, N., Ciach, M., Liechti, F., 2018. Revealing patterns of nocturnal migration using the European weather radar network. Ecography. doi:10.1111/ecog.04003

Roth, T., Strebel, N., Amrhein, V., 2014. Estimating unbiased phenological trends by adapting site-occupancy models. *Ecology* **95**, 2144–2154. doi:10.1890/13-1830.1

Siriwardena, G.M., Baillie, S.R., Buckland, S.T., Fewster, R.M., Marchant, J.H., Wilson, J.D., 1998. Trends in the abundance of farmland birds: A quantitative

comparison of smoothed Common Birds Census indices. *J. Appl. Ecol.* **35**, 24–43. doi:10.1046/j.1365-2664.1998.00275.x
Strebel, N., Kéry, M., Schaub, M., Schmid, H., 2014. Studying phenology by flexible modelling of seasonal detectability peaks. *Methods Ecol. Evol.* **5**, 483–490. doi:10.1111/2041-210X.12175