Wild birds, *Aves*

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Brief description of the species/group of species: basic ecology and its relevance from an epidemiological perspective

Birds are good bio-indicators of an ecosystem's health and integrity. This is because it is easier to gather information about diversity and population density for birds than for other taxa, and because birds are sensitive to ambient changes (Moser et al. 1995).Moreover, birds are hosts for several flaviviruses and influenza viruses of relevance for human and animal health and for enterobacteria including pathogenic strains of the genera Campylobacter, Escherichia and Salmonella. Therefore, from an epidemiological perspective, birds are also important for three main reasons: (1) their short and long distance movements (including migrations), which may increase their infection risks, and enable them to transfer pathogens between sites more easily than other vertebrates; (2) their close links to human and domestic animal housings, which facilitate pathogen transmission between humanized and natural environments (e.g. sparrows, starlings, corvids and gulls); (3) and because some species such as gallinaceous birds, pigeons and waterfowl include game species which might be captive-bred and can be consumed.

Recommended method(s) for most accurate population estimation

Given the huge diversity of European bird species, there is no single gold standard method to estimate bird population density. Information on the main techniques applied for representative species or groups can be found below.

Mini-review of methods applied in Europe

General reviews

Local and international organizations (e.g. Birdlife, EBCC) publish global population data and trends for most of the European bird species, frequently updating the findings (e.g. Hagemeijer and Blair 1997; Birdlife International 2004; SEO/Birdlife 2012).

However, if small scale population studies are required, several methods are available depending on the bird species considered, life cycle and habitat. The most appropriate survey method employed will depend of the purpose of the study, the size and number of study areas, the duration of the monitoring and the available budget. There are a huge number of publications about bird survey and monitoring methods (e.g. Bibby et al. 2000, Voříšek et al. 2008), describing and advising on bird census methods for use in different contexts. In this document we give a brief description of the bird survey methods applicable to epidemiological studies. The population of study in a particular area may be resident or migratory, breeding or wintering. Breeding birds are assessed as breeding pairs, and wintering birds as individuals; reflecting differences in methodology between summer and winter. In addition, the size of the migratory bird populations varies through the year, as a result of seasonal reproduction, mortality and movements; and distributions change not only seasonally, but also in the longer term, as for example in association with climate change (Gale et al., 2010). Complete counts can be made of waterfowl, colonial nesting birds and highly conspicuous species in open habitats. Transects or point counts, often based on bird vocalisations identification, are a frequent alternative for estimating the abundance of forest birds and cryptic species(reviewed by Gregory et al. 2004).

Direct methods (i.e. based on the direct observation of animals)

Complete counts:

Examples of complete counts in ornithology include waterfowl censusing, migration counts, territory mapping

and area searches undertaken by a line of people. Waterfowl can be counted while resting on open water. This method is used, for instance, when monitoring numbers of wintering ducks and other waterbirds in Europe (International Waterbird Census:

http://www.wetlands.org/Whatwedo/Savingwaterbirds/Monitoringwaterbirdpopulations/tabid/773/Default.aspx). The method consists of spotting and counting individual birds, species by species, in a coordinated manner with one or more experienced observers. Absolute population estimates should, however, be interpreted with care since there are species-related differences in detectability (Pehlak et al. 2006).

Certain sites, such as geographic straits and prominent capes, allow counting wild birds during spring or autumn migration. Observers record total numbers (or numbers per time) of each identifiable species passing over set viewpoints. These counts do not give an accurate estimate of a wintering or breeding population but over long periods of years, such counts give a good indication of long-term population trends. For instance, in Western Europe, estimates of trends in raptor population sizes have been made counting migrating individuals in the southern tip of the Scandinavian Peninsula (Falsterbo) or at the Gibraltar strait, (Kjellén and Roos 2000).

A special case of complete counts is territory mapping. This is done in the breeding season (spring) and consists in mapping the territorial pairs present, generally based on direct sight or sound records (or sound recordings and responses to taped sounds) of singing or otherwise displaying males. If done with a proper stratification by habitat and over a sufficient area, this method allows estimating breeding bird densities (Gillings and Fuller 1998). Alternatively, birds flushed while fields were beaten by a line of people has been used successfully to count galliformes (e.g. Bro et al. 2004).

Line transects:

Line transects are often used in ornithology, and can produce either raw abundance estimates (kilometric abundance index) or data suitable for the application of the Distance Sampling procedure (Buckland 2006, Thomas et al. 2010). Together with point counts, they are the most appropriate survey methods in many situations (Gregory et al. 2004).They are highly adaptable methods and can be used in terrestrial, freshwater, and marine ecosystems. They can be used to survey individual species, or groups of species, and have been successfully applied to forest and steppe-land species (Lee et al. 2014,Timmer et al. 2014). Distance Sampling allows complex modelling to estimate detection probabilities of animals not easily observed in the wild (Borchers et al. 2002). Moreover, it allows incorporating covariates, which provide additional information about detectability and hence improve the fit of models as well as the precision of estimates (Marques and Buckland 2003).

Point counts:

Point counts are essentially an evolution of the line transect method to adapt to the peculiarities of bird detection. Birds, particularly woodland birds and cryptic species, are often more easily detected by their vocalisation than by direct observation. The point count technique requires the observer to quantify the birds detected during a set period from a series of locations across the study area, considering observation time, habitat and sometimes distance data. Locations can be chosen at random or regular intervals. These data are later treated with specific statistics tools, similarly to line transect data (Buckland 2006).

Indirect methods (i.e. based in the detection of presence signs, but not animals)

Indirect methods are not as frequent in birds as they are in some more cryptic mammals. However, the detection of feathers, pellets, characteristic droppings and other signs has occasionally been used as a proxy for bird abundance (Evans et al. 2007).

Hunting bags (i.e. indices based on data derived from hunting activities)

In hunted populations, harvest data can be transformed into a relative abundance index, which might constitute a reliable indicator of bird population trends except if releases of farm-bred birds are significant. Hunting statistics can provide time trends on population abundance, provided the hunting effort is maintained. It is however difficult to compare hunting bag data between regions of different hunting traditions and regulations.

Others (i.e. include other relevant methods – direct or indirect – applied or susceptible to be applied on the target species)

Searching for nests is mainly used for raptors and other species that build large conspicuous nests on trees or cliffs. Nests can be found when they are not occupied, and visited during the following breeding seasons to check for occupancy. As these nests are often used repeatedly in different breeding seasons data on occupancy gives an estimate of both, abundance and density. Statistical modelling is another way to estimate bird population abundance in a given area. Modelling allows relating data on the species (presence/absence, abundance, performance, etc.) with environmental variables in order to obtain an output that is related tothe habitat suitability for the species. Model predictions should be validated with independent data as indicators of population abundance since there are several factors modulating that relation (Acevedo et al. 2007).

For species that can be readily caught, capture-recapture methods are viable, particularly at smaller spatial scales and for highly visible bird species (visual recapture). However, this method is rarely used for epidemiology or monitoring purposes.

Ornithological databases obtained from ringing birds form a key resource for assessing the risks of introducing and spreading specific diseases (Martínez et al. 2009), as such databases often contain information on the paths taken by migratory birds including stop-over locations. In recent years, many birds have been tagged and tracked on their migrations from satellites or using data loggers, a method that gives precise information on the migration routes of individuals, and the time spent in different areas. Many efforts have been made to obtain information about wild bird abundance and distribution indifferent countries and by different institutions, including the European EURING Data Bank (http://www.euring.org/edb/index.html).

APHAEA protocol (for harmonization at large scale)

Given the diversity of European bird species no single gold standard protocol applicable to all species/families can be recommended. Depending on the scale, existing global/local population data should be consulted in order to obtain background/historic data and information on methods employed. For most, especially the conspicuous bird species, any method providing actual density or numbers rather than abundance indexes should be employed based upon the most recent literature.

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Tables

Table 1. Peculiarities of the species that modulate the methods to be used.

Characteristic	Observations
Distribution	Omnipresent, and distributions well mapped. Information by species can be found in the EBCC Atlas of European Breeding Birds inhttp://s1.sovon.nl/ebcc/eoa/
Population trends	Bird population trends obviously depend on species, with most opportunistic synanthropic species increasing in time, and several specialists decreasing. Detailed population trends and indices of 163 common European bird species for the time period 1980 - 2011 that have been produced by the Pan-European Common Bird Monitoring Scheme (PECBMS) in 2013 are accessible in http://www.ebcc.info/index.php?ID=509It has been observed that 38% of these species are suffering a moderate to steep decline in numbers, whereas 29% areincreasing
Density range	n.a.
Main habitat	Every terrestrial, freshwater and marine habitat
Introduction-Releases	Wild bird translocations occur occasionally for reasons of conservation. Gamebird releases, by contrast, take place annually, involving millions of birds per year. The main captive-bred bird species are ring-necked pheasant (*Phasianus colchicus*), partridges of the genus *Alectoris*, quails and mallards (*Anas platyrhynchos*).
Activity rhythms	Most birds are diurnal, often with activity peaks in the morning and evening. A few groups are nocturnal, including owls and nightjars.
Detectability	Good compared to most other animals and more readily identified to species. depending on the species and season.
Gregarism	In general, waterfowl, shorebirds and some passerines are highly gregarious, especially outside the breeding season, while on migration or at wintering sites. Seabirds and others are also gregarious at their nesting colonies.
Migration	Many bird species are migrants, meaning that they move long distances during the course of a year, and their presence and abundance in particular regionsvary withthe season. For instance, most insectivorous birds will be absent from northern Europe in winter, while waterfowl concentrations will be higher in winter in Mediterranean countries

Table 2. Classification of the different methods (all cited in this species' review) based on desirable characteristics for monitoring populations from an epidemiological perspective (1-very low, 5-very high).

Method	**Complete counts**	**Line transects**	**Point counts**	**Indirect methods**	**Hunting bags**	**Nest counts**
Abundance/density	A/D	A/D	A/D	A	A	A/D
Temporal /**S**patial trends	T/S	T	T	T	T	T/S
Info on population structure (**Y**/**N**)	Y	Y	N	N	Y	N
Precision	5	4	4	3	3	3
Seasonal independence	1	2	2	4	1	
Visibility independence	1	3	4	4	4	
Effort effectiveness	3	3	3	2	2	
Budget effectiveness	3	3	3	4	3	
Ease of learning	3	3	2	1	1	
Applicable at large scales	3	3	3	3	3	
Useful at very low density	3	2	2	4	2	
Useful at very high density	5	5	5	4	5	