Bird Migration Routes and Risk for Pathogen Dispersion into Western Mediterranean Wetlands

Elsa Jourdain,*† Michel Gauthier-Clerc,* Dominique J. Bicout,† and Philippe Sabatier†

Wild birds share with humans the capacity for moving fast over large distances. During migratory movements, birds carry pathogens that can be transmitted between species at breeding, wintering, and stopover places where numerous birds of various species are concentrated. We consider the area of the Camargue (southern France) as an example to highlight how ad hoc information already available on birds' movements, abundance, and diversity can help assess the introduction and transmission risk for birdborne diseases in the western Mediterranean wetlands. Avian influenza and West Nile viruses are used as examples because birds are central to the epidemiology of these viruses.

Birds are the only terrestrial vertebrates that share with humans the peculiarity of traveling in a few hours across national and intercontinental borders. The record for distance covered in a single year belongs to the arctic tern (*Sterna paradisaea*), which travels ≈50,000 km between Antarctica and northern Scandinavia. As a whole, billions of birds travel between continents twice a year in only a few weeks (*1*). During these yearly migrations, birds have the potential of dispersing microorganisms that can be dangerous for public as well as animal health (*2*,*3*). For instance, birds are believed to be responsible for the wide geographic distribution of various pathogens, including viruses (e.g., West Nile, Sindbis, influenza A, Newcastle), bacteria (e.g., borrelia, mycobacteria, salmonellae), and protozoa (e.g., cryptosporidia). Insight into the ecology of bird populations is necessary to understand the epidemiology of bird-associated diseases. Furthermore, data about avian movements might be used to improve disease surveillance schemes or to adapt preventive measures. However, solid bridges between ecology and human medicine are still lacking.

We explored the bird sector, in an attempt to provide general ideas on bird abundance, migration, geographic origin, and interspecies mingling. We focused on the Camargue area, an alluvial lowland covering some 140,000 ha in the Rhône Delta. As other Mediterranean wetlands (Figure 1), the Camargue is a major rallying point for Palearctic birds that are migrating between the great continental masses of Eurasia and Africa. This area is the current focus of intense sampling to study 2 pathogens closely associated with wild birds: avian influenza (AI) virus and West Nile virus (WNV). These 2 viruses have very different transmission cycles and ecology: AI viruses have a waterborne transmission, and ducks are their main natural reservoirs (*4*–*8*); WNV has a vectorborne transmission, and passerines are believed to play a major role in the

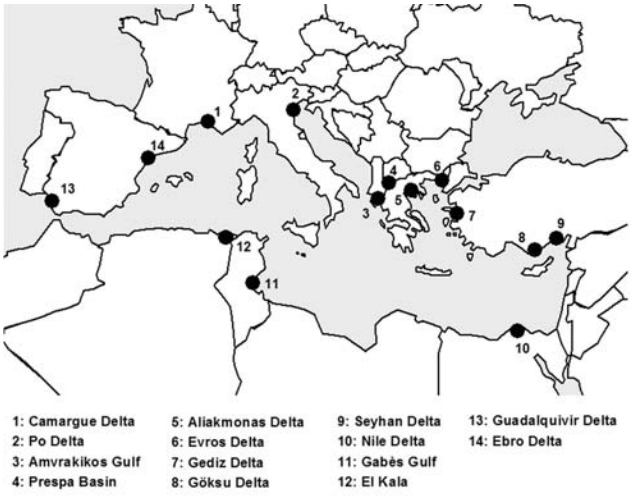

Figure 1. Map of the main Mediterranean wetlands (sites 1, 2, 11, 12, 13, and 14 are considered western Mediterranean wetlands).

*Station Biologique de la Tour du Valat, Arles, France; and †Ecole Nationale Vétérinaire de Lyon – Institut National de la Recherche Agronomique, Marcy l'Etoile, France

amplification cycle (*9*–*11*). However, both viruses are known to be carried by reservoir birds during migration and have been associated with emerging disease transmission risk for humans and domestic animals (*2*,*5*,*7*,*11*,*12*). For both of them, the avifauna abundance, diversity, and departure origin may be of key importance in terms of disease transmission. We use these 2 viruses as examples in our discussion of the risk for dispersion of bird-carried pathogens into Mediterranean wetlands.

We address the following questions: 1) What are the main geographic origins of birds observed in western Mediterranean wetlands? 2) How abundant and diverse in species are they during the year cycle? 3) When are interspecies contacts between birds from different origins most likely to occur? To address these issues, we used crude empiric indexes, which are known to have biases yet prove valuable within the scope of our objectives. Readers interested in modern ecologic methods used to study wildlife diseases in natural populations may refer to general publications on host-parasite systems (*13*–*15*).

Methods

Bird Origins from Individual Ringing

Migration research is constantly changing, and new methods are always emerging. Historically, information about the movements of individual birds was first acquired through ringing studies. Bird ringing (also known as bird banding) consists of catching birds and attaching a small individually numbered metal or plastic ring to their legs or wings. Ring-recovery data are obtained when ringed birds are resighted, recaptured, hunted, or found dead. In Europe, large-scale ringing projects have been conducted, mostly between the 1950s and 1980s, and they represent a wealth of information that has not yet been fully exploited.

Data recovered from birds ringed from 1950 to 1975 at the Station Biologique de la Tour du Valat in the Camargue were collected from annual reports. Seven species of waterbirds were chosen to illustrate various migratory patterns. We selected 4 species of the Anatidae family, known to have different geographic origins, including 3 dabbling ducks, i.e., ducks that search for their food primarily in surface water (mallard, *Anas platyrhynchos*, n recovered = 434; green-winged teal, *A. crecca*, n = 3,903; garganey, *A. querquedula*, n = 181) and 1 diving duck, i.e., a species that mostly searches for its food under water (tufted duck, *Aythya fuligula*, n = 313). We also took the example of the common coot (*Fulica atra*, n = 99), a diving bird of the Rallidae family that frequently shares ponds with ducks. The common snipe (*Gallinago gallinago*, n = 54) is an example among waders, i.e., shorebirds that feed in muddy swamps and coastlines. Finally, the purple heron (*Ardea purpurea*, n = 39) is an ardeid species that lives in reed beds and marshes. All these species are large or hunted, which explains the high number of rings recovered. We only considered data recovered from birds ringed in the Camargue area and later reported outside France.

Migratory Bird Abundance and Diversity

Since the 1950s, a large amount of data have been collected at the Station Biologique de la Tour du Valat thanks to bird counts, netting records, and field ornithologists' observations (see supplemental, online Technical Appendix Table l, indicating the methods used for each bird genus; available from www.cdc.gov/EID/content/13/3/365-appT1.htm). This information was used to create a database with a row for each of the 289 avian species regularly observed in the Camargue (*16*). Strictly pelagic birds were not taken into account as they do not have any contact with terrestrial vertebrate species. Quantitative data were completed on the number of birds (abundance) and number of bird species (diversity) observed monthly in the Camargue. Three categories of migrating birds were considered, depending on the area from which they come: incoming birds from sub-Saharan Africa in spring and those arriving in autumn either from continental Europe or from Scandinavian and the Siberian tundra and taiga. Analyses were performed for all species and separately for species of the Anatidae family (ducks, swans, geese) and waders (shorebirds of the families Scolopacidae and Charadriidae), which are essentially associated with wetlands or coastlines.

Interspecies Bird Cohabitation

Regular bird counts provide information on bird populations for the studied area and therefore give an idea of potential contacts between species that share similar biotopes. Since September 1964, the Camargue duck and coot populations have been estimated every winter (*17*). The count was made monthly by the same observer from a plane flying at an altitude of 200 feet. One hundred brackish lakes and marshes used by waterbirds as resting places were counted. The arrival of the plane made dabbling ducks fly off, which is necessary for detecting them and identifying their species. To count diving ducks, it was necessary to turn the group of birds around by using the plane. Results of the winter 2004–05 counts were used as examples.

Results

Bird Origins from Individual Ringing

Ringing recoveries provide a valuable insight into the origins and dispersion areas of bird species. Figure 2 illustrates that western Mediterranean wetlands provide habitat for birds from a wide geographic range: all European

countries but also other areas in the Mediterranean Basin, central and northern Asia, and sub-Saharan Africa. Ringed common coots and common snipes were mostly reported from continental Europe and Mediterranean areas, whereas mallards and common teals were also found in more northern places, including the former Soviet Union and Scandinavia. The pattern was slightly different for tufted ducks, for which >40% of recoveries were located in areas of taiga and tundra. Garganeys were recaptured in very distant places far north (Siberia, Finland), far east (Kazakhstan, Altai), and far south (Senegal, Mali) of the Camargue. In contrast to the previously described species, purple heron rings were recovered only from areas located south, including 4 countries in the Guinea Gulf in Africa (Benin, Côte d'Ivoire, Ghana, and Sierra Leone). As a whole, we discerned 3 broad areas from which Mediterranean waterbirds come and potentially disperse pathogens: continental Europe, northern Siberia and Scandinavia, and sub-Saharan Africa.

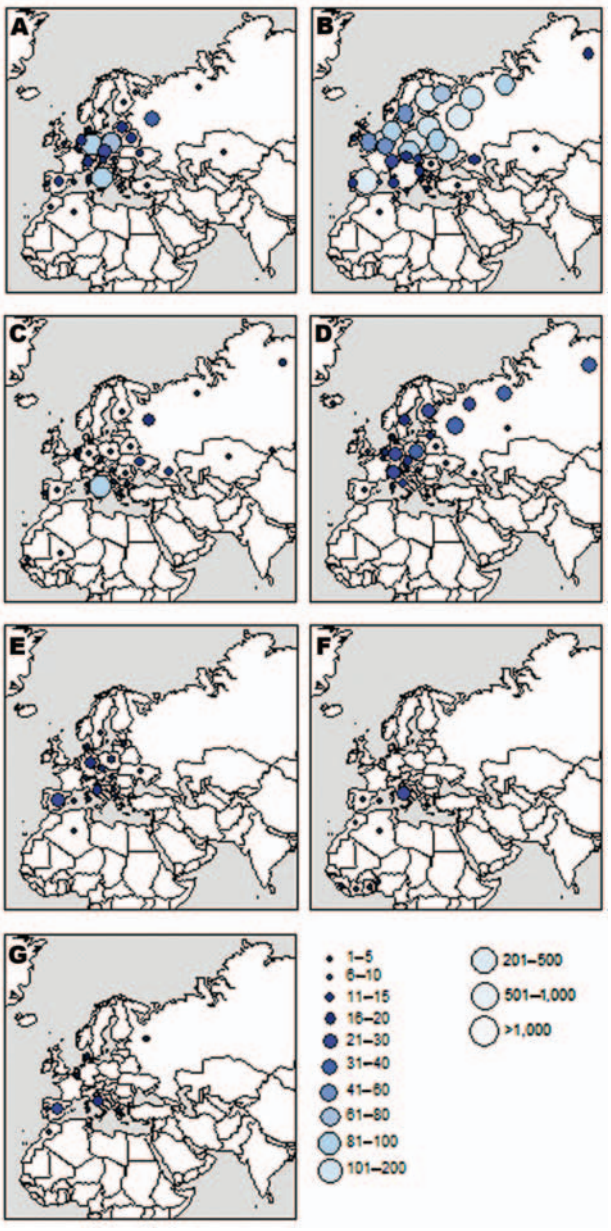

Figure 2. Countries and regions of the former USSR where birds ringed in the Camargue were recaptured for 7 species (n = number of ring recoveries and m = number of marked individual birds): A) mallard (*Anas platyrhynchos*), n = 434, m = 13,176; B) green-winged teal (*A. crecca*), n = 3,903, m = 58,347; C) garganey (*A. querquedula*), n = 181, m = 2,436; D) tufted duck (*Aythya fuligula*), n = 313, m = 3,845; E) common coot (*Fulica atra*), n = 99, m = 7,866; F) purple heron (*Ardea purpurea*), n = 39, m = 5,017; G) common snipe (*Gallinago gallinago*), n = 54, m = 2,445. These maps provide an insight into the potential origins and dispersion areas of birdborne pathogens.

Migratory Bird Abundance and Diversity

Monthly abundance (number of individual birds) and diversity (number of species) in the Camargue are presented respectively in Figures 3 and 4 for birds originating from the 3 major areas of provenance described above. These figures show how many birds are in the Camargue, just as monthly photographs of bird populations do. A corresponding table indicates monthly abundance of each species (online Technical Appendix Table 2, available from www.cdc.gov/EID/content/13/3/365-appT2.htm.).

Birds Coming from sub-Saharan Africa

As many as 111 bird species might disperse pathogens from sub-Saharan Africa into the Camargue. Broadly speaking, birds coming from sub-Saharan Africa become rapidly and simultaneously abundant and diverse in spring, are still numerous in summer, and decrease in winter. The pattern is different if one considers solely ducks, as only 3 duck species fly south to tropical Africa, namely, the northern pintail (*Anas acuta*), the garganey, and the northern shoveler (*Anas clypeata*). Conversely, numbers and species diversity are high for waders, which are mainly passage visitors, especially in spring and late summer.

Birds Coming from Northern Areas of Tundra and Taiga

A total of 53 species might introduce pathogens from northern areas into the Camargue. Abundance is highest in April and October–November with a higher peak in autumn, notably because of juvenile birds. Species diversity is high during winter and low from May to July. The opposite pattern was observed for sub-Saharan species. This pattern is even clearer for birds of the Anatidae family: They are abundant from October to January and in very small numbers from March to September. In contrast to ducks, waders are mainly transient visitors, and only a few individual birds spend the winter in the Camargue. Their number is greatest in spring and autumn.

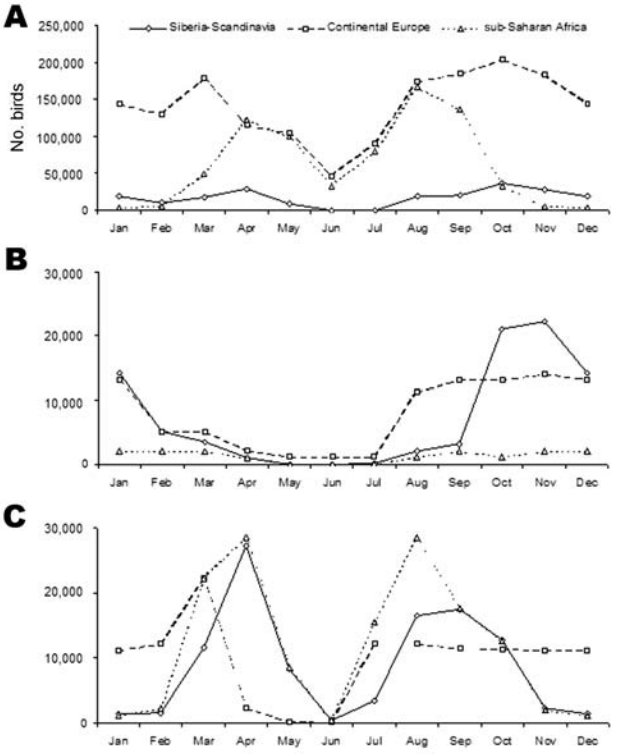

Figure 3. Monthly abundance in the Camargue of birds coming from Siberia/Scandinavia, continental Europe, and sub-Saharan Africa for A) all species, B) species of the Anatidae family, and C) waders, respectively. Peaks in bird abundance are expected to be associated with a higher probability of dispersing birdborne pathogens into the Camargue.

Birds Coming from Continental Europe

Up to 135 species could be involved in pathogen dispersion from continental Europe. Their abundance is highest from February to April and later from September to November. Species diversity remains high year-round with peaks in spring and autumn due to migrating passage visitors. The pattern observed for Anatidae species is the same as the 1 we described for Arctic species: birds are abundant in autumn and winter and in very small numbers in spring and early summer. However, the number of duck species remains stable year-round. Indeed, in species such as the mallard or the red-crested pochard (*Netta rufina*), some birds are sedentary whereas others are migratory. Waders show a constant level of species diversity because migration staggers over several months, but numbers are highly variable throughout the year.

Interspecies Bird Cohabitation

The results of the winter 2004–05 waterfowl counts are presented in Figure 5 for the species mentioned in Methods. Other species are also present, such as the northern pintail or the common shelduck (*Tadorna tadorna*). Garganeys are present in small numbers in September and February–March, but from an airplane they cannot be distinguished from common teals. These counts show that numerous species, with various migratory patterns, congregate on the same wetlands during the long winter period and therefore easily transmit waterborne pathogens such as AI virus. Most wintering birds are still present in March, when the first African migratory birds have already returned to breed in the Camargue or make a stop for refueling before flying further north. For instance, as many as 11,550 black-tailed godwits (*Limosa limosa*) were counted in the Camargue in March 2005.

Moreover, the movement and abundance of birds vary greatly from 1 year to another because of movements influenced by weather conditions. For example, the duck population in the Camargue was estimated at ≈60,000 ducks in March 2005 compared with only ≈40,000 the previous year, when climatic conditions in Europe were warmer.

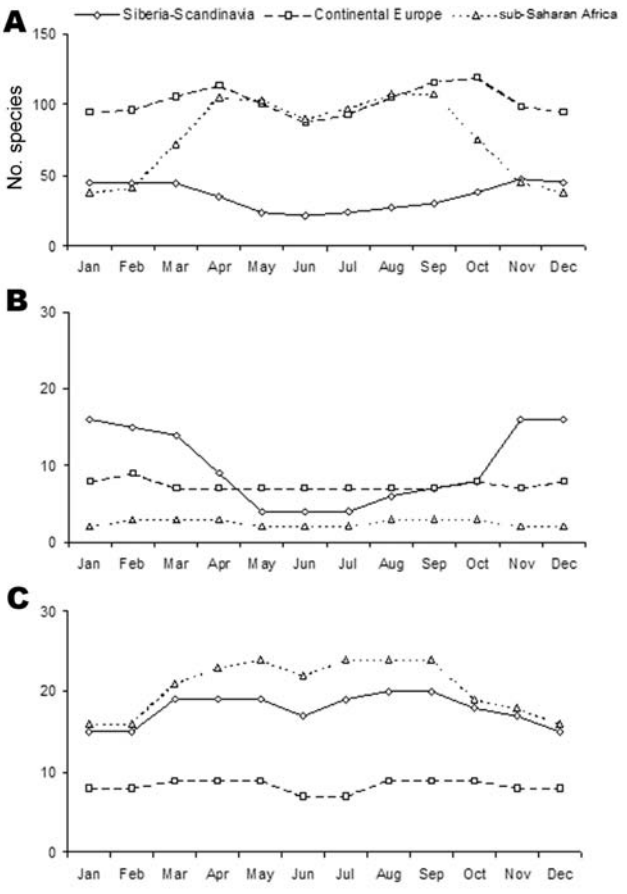

Figure 4. Monthly diversity in the Camargue of birds coming from Siberia/Scandinavia, continental Europe, and sub-Saharan Africa for A) all species, B) species of the Anatidae family, and C) waders, respectively. Peaks in bird species diversity are expected to be associated with a higher diversity of birdborne pathogens.

Discussion

Maps of ring-recovery data and graphs of monthly variations in bird abundance and diversity show that western Mediterranean wetlands such as the Camargue are a hub for birds from all origins (Central Asia, Siberia, northern and Eastern Europe, western Africa, and the Mediterranean basin) and that numerous birds of various species are seasonally aggregated in similar habitats. Under the hypothesis that risk for dispersion of pathogens into the Camargue is correlated with the number of birds and bird species encountered in a given area, these indices are helpful to determine periods at higher risk for introduction and emergence of birdborne diseases. We recall that these empiric estimates are skewed, which is briefly discussed with the perspectives below.

Periods of Higher Risk for Pathogen Introduction

Birds Coming from sub-Saharan Africa

The risk for introduction of African pathogens in Mediterranean wetlands would be highest from March to July, which corresponds with spring migration and breeding for birds. Conversely, in autumn, birds return to Africa and are more likely to introduce pathogens originating from the north than from the south (Table). Of the 111 species that come every year to the Camargue from different countries of sub-Saharan Africa, most are insectivorous passerines that spend winter in Africa and breed in Europe; among aquatic birds, waders are the most numerous.

Up to now, no evidence exists that birds migrating from sub-Saharan regions play a major part in the epidemiology of AI viruses. However, under the assumption that this area became an important epicenter for AI viruses, ducks would likely have the highest probability of introducing AI viruses in Mediterranean wetlands, even if they are less numerous than waders. Indeed, recent studies in Europe showed that overall AI virus prevalence in waders is really low compared with that in dabbling ducks (*7*). WNV, which is transmitted by arthropod vectors, could potentially be introduced by any species of bird that comes from disease-endemic areas in Africa, is exposed to mosquito or tick bites (*18*), and sustains high viremia levels. Insectivorous passerines are the most numerous and thus may be particularly suspected. WNV dispersion by birds migrating from sub-Saharan Africa might explain why an outbreak occurred in 2000 in the Camargue, even though the virus had not been observed there since the 1960s (*19*).

Birds Coming from Northern Areas of Tundra and Taiga

Pathogens may be introduced into Mediterranean wetlands by birds coming from northern areas of Scandinavia and Siberia. The risk would be higher from September to December when Arctic bird abundance reaches its peak (Table). In spring, the northern birds observed in the Camargue have recently spent a long time in southern lands so that their associated probability of introducing pathogens originating from Scandinavia or Siberia is rather low. Waterbirds and granivorous passerines, which do not need to fly further south to find food supplies throughout the cold season, could introduce pathogenic microorganisms that could be transmitted later between wintering birds when densities are high. Waders, which migrate from Siberia and stop in the Mediterranean wetlands in autumn before crossing the Mediterranean Sea, could contaminate other bird species before pursuing their flight. As a whole, 53 species seen in the Camargue come from Arctic areas, which is half the number of species that come from sub-Saharan Africa or continental Europe. As a result, the probability of pathogens being introduced from Arctic areas should be lower than from birds of these 2 other areas. Another scenario can nevertheless be considered: if birds coming from northern areas disseminate a pathogen all along their migration route, then this pathogen would also infect continental European species and the probability of its being introduced into the Mediterranean wetlands would depend on the arrival of both Arctic and continental birds.

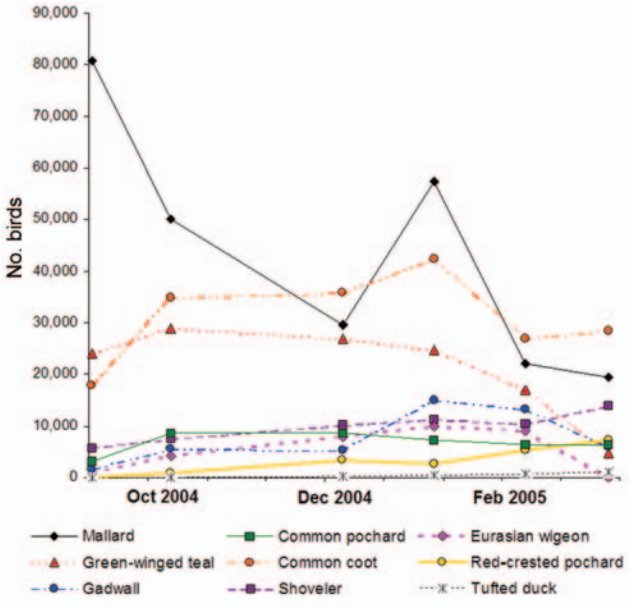

Figure 5. Cumulative number of the most abundant waterfowl species recorded in the Camargue during winter 2004–05: mallard (*Anas platyrhynchos*), northern shoveler (*A. clypeata*), green-winged teal (*A. crecca*), Eurasian wigeon (*A. penelope*), gadwall (*A. strepera*), red-crested pochard (*Netta rufina*), common pochard (*Aythya ferina*), tufted duck (*Aythya fuligula*), and common coot (*Fulica atra*). This figure shows that numerous birds and bird species are congregated in the same wetlands during winter and can therefore easily transmit pathogens to each other.

Table. Periods of major risk for pathogen introduction in the Camargue from sub-Saharan Africa, Siberia-Scandinavia, or continental Europe for all species, Anatidae species, and waders*

Origin	Species	Spring	Summer	Autumn	Winter
Sub-Saharan Africa	All	++	+	(±)	(–)
	Waterfowl	+/–	–	(±)	(–)
	Waders	++	+	(+)	(–)
Siberia-Scandinavia	All	(±)	(–)	++	+
	Waterfowl	(–)	(–)	++	++
	Waders	(+)	(±)	++	±
Continental Europe	All	(±)	(–)	++	+
	Waterfowl	(–)	(–)	++	++
	Waders	(+)	(–)	++	+

*The risk is supposed to increase both with the number of species and the number of individual birds present in the Camargue (++, very high; +, high; ±, medium; –, low). In addition, the timing of migration matters since the introduction of pathogens from Africa (Eurasia) during the autumn (spring) migration is less likely because birds do not come directly from these areas. The corresponding risks are therefore in parentheses.

AI viruses are likely to be introduced in autumn by ducks that breed in northern Europe and Siberia, especially since numbers are high because of the presence of juveniles. Furthermore, surveillance studies of wild ducks showed that the prevalence of AI viruses is primarily high in juveniles (*5*,*7*,*20*). Conversely, WNV activity has never been reported in Scandinavia and Siberia, probably because the transmission cycle cannot be maintained in these northern biotopes.

Birds Coming from Continental Europe

Autumn and winter are the 2 seasons during which the transmission of bird pathogens originating from continental Europe would be most likely (Table). Indeed, in spring, the introduction of pathogens from continental Europe is less probable because birds have been absent from this area for 5 or 6 months. As previously seen, up to 135 species have the potential to introduce pathogenic agents in the Camargue. Granivorous passerines, birds of prey, and waterfowl are among the species that come in large numbers to take advantage of the Mediterranean wetlands' temperate climate during winter. Aquatic birds, which need unfrozen ponds to feed, show variations in their movements, depending on climatic conditions. For instance, if a cold spell occurs in eastern or northern Europe, the number of green-winged teals in the Camargue increases (*17*). These weather-associated movements might at certain times prove essential in pathogen dispersion within European and Mediterranean wetlands.

Surveys of wild waterbirds in Europe have shown that AI viruses are frequently found (*21–24*), which means that waterbirds arriving from continental Europe might often be carriers of AI viruses. Similarly, because WNV activity was recently reported in Romania (*25*) and the Czech Republic (*26*), wild birds migrating in autumn from these countries to the Mediterranean basin could introduce WNV, either because of a high viremia level or because they carry infected ectoparasites. If the virus managed to overwinter in a reservoir host or a vector, it could then be responsible for an outbreak the next summer, when mosquito vectors are abundant (*27*).

Risk for Bird-to-Bird Transmission of Pathogens

Several factors affect the risk for bird-to-bird transmission: bird abundance or density, bird diversity, species receptivity and sensitivity to pathogens, interspecies interactions, and environmental conditions (*14*). For water-transmitted pathogens such as AI viruses, risk for transmission may be associated with the number of ducks congregated in the same pond, particularly in autumn and winter (Figure 5). This crowding of wintering species, in addition to the permanent presence of a transient population of birds using wetlands to stop off during migration, could allow AI viruses to circulate and be maintained because of rapid dissemination on shared water. For vector-transmitted pathogens such as WNV, transmission possibilities depend both on the bird reservoir density and on the dispersion abilities and activity periods of the arthropod vectors.

The risk for interspecies transmission of disease is particularly problematic when wild and domestic species are involved. Ducks are aquatic birds that are most likely to come in contact with free-range poultry, especially because the presence of congeners can induce migrating wild ducks to make a stopover. Captive-bred mallards, used for hunting purposes and voluntarily put in the wild to attract other ducks, are particularly likely to share pathogens with their migratory congeners and facilitate the transmission of diseases to other domestic species. The risk is different for domestic chickens or turkeys, which are more likely to have contact with granivorous birds. Conversely, waders are rarely in direct contact with human-raised species.

Bird-carried pathogens are above all susceptible to being spread worldwide because of human activities such as legal or illegal trade of wild and domestic birds or bird products (*28*). The mechanism for the introduction of WNV into America in 1999 is not known with certainty,

but a plausible scenario is the importation of an infected bird (*29*,*30*). Similarly, the highly pathogenic AI strain H5N1 was isolated in Belgium from crested hawk-eagles (*Spizaetus nipalensis*) smuggled by air travel (*31*). In Asia, transmission of H5N1 influenza virus has mainly been the result of human activity such as live-poultry markets and the international trade of birds, bird products, or contaminated equipment (*32*–*35*).

Methodologic Concerns and Perspectives

The ornithologic data we have presented are merely crude estimates. Ring-recovery data, for instance, are subject to strong biases related to where and when the ringing was conducted but also to high variability in the probability of reporting marked animals among areas (*36*). Similarly, our estimates of bird abundance and diversity are basic indices associated with the number of birds heard, seen, or caught in the Camargue (see online Technical Appendix Table 1). These estimates do not take into account 2 important sources of error: detection error, related to the fact that the probability of detecting a bird is <1, and survey error, associated with spatial and temporal variability (*37*). Since our motivations were merely to show that information already available on birds may lead to better understanding of animal and human health issues associated with birdborne pathogens, these biases do not invalidate our objectives.

The results obtained were helpful to identify key groups of species likely to introduce pathogens from a given area at a given time of year. We voluntarily chose to focus on birds and leave pathogens aside, but studies of diseases in natural bird populations are obviously critically needed. Ecology, the science of interactions between living organisms and their physical environment, has been extended to include microorganisms. Understanding the relationships between organisms (such as hosts, pathogens, predators, competitors) and their environment is the aim of disease ecology. As studying the dynamics of systems with many hosts and pathogenic agents is complex, efforts should primarily focus on a few specific bird-pathogen models.

Mathematical modeling may help to predict specific bird-pathogen interactions and to identify key parameters that need to be better estimated through additional research. Long-term records enable establishment of databases, which would illustrate bird-pathogen relationships in natural conditions. These data would focus on hosts, their migration, population age, behavior, and so forth. Host-pathogen interactions should be described by using data such as antibody prevalence in different age classes, frequency of virus isolation, and characterization of the strains involved. Complementary laboratory and field experiments within a controlled environment might also provide relevant information. All these investigations should gradually make it possible to gather valuable baseline data to test specific hypotheses and gain new insights in bird-pathogen relationships in Mediterranean wetlands.

Acknowledgments

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Dr Jourdain is researching the role of wild birds in the epidemiology of emerging infectious diseases such as WNV infection and AI. She works in the Epidemiology Unit of the College of Veterinary Medicine (Lyon, France) and at the Station Biologique de la Tour du Valat, a private foundation specialized in bird ecology and located in the Camargue, France. She is particularly interested in wildlife diseases and zoonoses.

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Address for correspondence: Elsa Jourdain, Unité EPSP-TIMC, UMR 55-25, Ecole Nationale Vétérinaire de Lyon–Institut National de Recherche Agronomique, 1, Avenue Bourgelat F-69280 Marcy l'Etoile, France; email: e.jourdain@vet-lyon.fr

Technical Appendix Table 1. Census methods used since 1970s for each bird genus in the Camargue*

Family	Genus	A	B	C	D	E	F	G	H	I	J	K	L	M	N
GAVIIDAE	*Gavia*	x	x	x	x							x			
PODICIPEDIDAE	*Tachybaptus, Podiceps*	x	x	x	x							x			
PROCELLARIIDAE	*Calonectris, Puffinus*														
HYDROBATIDAE	*Hydrobates*														
SULIDAE	*Morus*														
PHALACROCORACIDAE	*Phalacrocorax*	x	x	x	x	x									
ARDEIDAE	*Botaurus*	x	x	x								x			x
	Ixobrychus	x	x	x								x			x
	Ardeola, Nycticorax, Egretta, Ardea, Bubulcus	x	x	x	x	x		x	x						x
CICONIIDAE	*Ciconia*	x	x	x	x										
THRESKIORNITHIDAE	*Plegadis, Threskiornis*	x	x	x	x	x		x							
	Plataela	x	x	x	x		x	x	x						
PHŒNICOPTERIDAE	*Phoenicopterus*	x	x	x	x		x	x							
ANATIDAE	*Cygnus*	x	x	x	x		x		x						
	Anser, Aythya	x	x	x	x		x								
	Tadorna, Anas	x	x	x	x		x					x			
	Netta	x	x	x	x		x								x
	Somateria, Clangula, Melanitta, Bucephala, Mergus	x	x	x											
ACCIPITRIDAE	*Pernis, Milvus, Neophron*	x	x	x	x					x		x			
	Circaetus, Circus, Accipiter, Buteo	x	x	x	x					x		x			
	Aquila, Hieraaetus	x	x	x	x					x					
PANDIONIDAE	*Pandion*	x	x	x	x					x					
FALCONIDAE	*Falco*	x	x	x	x					x		x			
PHASIANIDAE	*Alectoris, Coturnix, Phasianus*	x	x	x	x							x			
RALLIDAE	*Rallus, Gallinula*	x	x	x	x							x			
	Crex, Porzana	x	x	x	x										
	Fulica	x	x	x	x		x					x			
GRUIDAE	*Grus*	x	x	x	x		x								
HAEMATOPODIDAE	*Haematopus*	x	x	x	x										
RECURVIROSTRIDAE	*Himantopus, Recurvirostra*	x	x	x	x										
BURHINIDAE	*Burhinus*	x										x			
GLAREOLIDAE	*Glareola*	x	x	x	x										x
CHARADRIIDAE	*Charadrius, Pluvialis, Vanellus, Xenus*	x	x	x	x										
SCOLOPACIDAE	*Limosa, Numenius*	x	x	x	x		x								

Family	Genus	A	B	C	D	E	F	G	H	I	J	K	L	M	N
	Scolopax	x											x		
	Gallinago, Lymnocryptes	x	x	x	x								x		
	Calidris, Limicola, Tringa, Actitis, Philomachus, Phalaropus, Phalaropus, Arenaria	x	x	x	x										
STERCORARIIDAE	*Catharacta, Stercorarius*	x	x	x	x										
LARIDAE	*Larus, Sterna, Gelochelidon, Chlidonias*	x	x	x	x	x		x							x
ALCIDAE	*Alca, Fratercula*														
PTEROCLIDIDAE	*Pterocles*	x													
COLUMBIDAE	*Streptopelia, Columba*	x										x			
CUCULIDAE	*Cuculus, Clamator*	x										x			
STRIGIDAE	*Tyto, Otus, Asio, Bubo, Strix, Athene*	x										x			
CAPRIMULGIDAE	*Caprimulgus*	x										x			
APODIDAE	*Apus*	x													
ALCEDINIDAE	*Alcedo*	x													
MEROPIDAE	*Merops*	x													x
CORACIIDAE	*Coracias*	x										x			
UPUPIDAE	*Upupa*	x										x			
PICIDAE	*Jynx*	x										x			
	Picus, dendrocops	x										x			x
ALAUDIDAE	*Galerida, Lullula, Alauda, Calandrella, Melanocorypha*	x								x	x	x	x	x	
HIRUNDINIDAE	*Riparia, Hirundo, Delichon*	x								x	x	x	x	x	x
MOTACILLIDAE	*Anthus, Motacilla*	x								x	x	x	x	x	
CINCLIDAE	*Cinclus*	x								x	x	x	x	x	
TROGLODYTIDAE	*Troglodytes*	x								x	x	x	x	x	
PRUNELLIDAE	*Prunella*	x								x	x	x	x	x	
TURDIDAE	*Oenanthe, Saxicola, Phoenicurus*	x								x	x	x	x	x	
	Erithacus, Turdus, Monticola	x								x	x	x	x	x	
	Luscinia	x								x	x	x	x	x	x
SYLVIIDAE	*Acrocephalus*	x								x	x	x	x	x	x
	Locustella, Cisticola	x								x	x	x	x	x	
	Regulus, Phylloscopus, Hippolais, Sylvia, Cettia	x								x	x	x	x	x	
MUSCICAPIDAE	*Ficedula, Muscicapa*	x								x	x	x	x	x	
TIMALIIDAE	*Panurus*	x								x	x	x	x	x	
AEGITHALIDAE	*Aegithalos*	x								x	x	x	x	x	
PARIDAE	*Parus*	x								x	x	x	x	x	
SITTIDAE	*Sitta*	x								x	x	x	x	x	

Family	Genus	A	B	C	D	E	F	G	H	I	J	K	L	M	N
TICHODROMADIDAE	*Tichodroma*	x								x	x	x	x	x	
CERTHIIDAE	*Certhia*	x								x	x	x	x	x	
REMIZIDAE	*Remiz*	x								x	x	x	x	x	
ORIOLIDAE	*Oriolus*	x								x	x	x	x	x	
LANIIDAE	*Lanius*	x								x	x	x	x	x	
CORVIDAE	*Corvus, Pica*	x								x	x	x	x	x	x
	Garrulus	x								x	x	x	x	x	
STURNIDAE	*Sturnus*	x								x	x	x	x	x	
PASSERIDAE	*Montifringilla, Petronia, Passer*	x								x	x	x	x	x	
FRINGILLIDAE	*Carduelis, Serinus, Fringilla,*	x								x	x	x	x	x	
EMBERIZIDAE	*Miliari, Plectrophenax, Emberiza*	x								x	x	x	x	x	
	Coccothraustes, Pyrrhula, Loxia	x								x	x	x	x	x	

*A: network of birdwatchers in the Camargue; B: monthly census on protected areas; C: Wetlands International census of waterbirds in mid January by plane and on ground; D: weekly census on Tour du Valat Estate (2,500 ha); E: count on roosting places during winter by a network of ornithologists; F: count on winter roosting places by plane monthly from September to March by a network of ornithologists; G: localization of colonies by plane and count on ground by Tour du Valat ornithologists in spring; H: counts of nests by plane; I: estimation of the number of breeding birds on Tour du Valat Estate every five years; J: weekly census by J. Blondel during three years based on visual contacts and songs on a transect; K: extrapolation according to habitat surfaces during the reproduction period; L: extrapolation according to habitat surfaces during migration and wintering; M: capture with mist nets during migration in the 1960s, 1970s, and since 2004; N: specific studies (detailed references provided on request).

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Id	Family	English Name	Latin Name	Areas from where birds come				
				Siberia Scandinavia	Continental Europe	Sub-Saharan Africa	J	F
1	GAVIIDAE	Red-throated Diver (Red-throated loon)	*Gavia stellata*	1			1	1
2	GAVIIDAE	Black-throated Diver (Arctic loon)	*Gavia arctica*	1			1	1
3	GAVIIDAE	Great Northern Diver (Common loon)	*Gavia immer*	1			1	1
4	PODICIPEDIDAE	Little Grebe	*Tachybaptus ruficollis*		1		1	1
5	PODICIPEDIDAE	Great crested Grebe	*Podiceps cristatus*		1		1	1
6	PODICIPEDIDAE	Red-necked Grebe	*Podiceps grisegena*	1			1	1
7	PODICIPEDIDAE	Slavonian Grebe	*Podiceps auritus*	1			1	1
8	PODICIPEDIDAE	Black-necked Grebe	*Podiceps nigricollis*		1		1	1
9	PROCELLARIIDAE	Cory's Shearwater	*Calonectris diomedea*				0	0
10	PROCELLARIIDAE	Yelkouan Shearwater	*Puffinus yelkouan*				1	1
11	HYDROBATIDAE	Storm Petrel	*Hydrobates pelagicus*				1	1
12	SULIDAE	Gannet	*Morus bassanus*				1	1
13	PHALACROCORACIDAE	Cormorant	*Phalacrocorax carbo*		1		1	1
14	ARDEIDAE	Bittern	*Botaurus stellaris*		1		1	1
15	ARDEIDAE	Little Bittern	*Ixobrychus minutus*		1	1	0	0
16	ARDEIDAE	Night Heron	*Nycticorax nycticorax*			1	1	1
17	ARDEIDAE	Squacco heron	*Ardeola ralloides*			1	0	0
18	ARDEIDAE	Cattle Egret	*Bubulcus ibis*				1	1
19	ARDEIDAE	Little Egret	*Egretta garzetta*				1	1
20	ARDEIDAE	Great White Egret	*Egretta alba*		1		1	1
21	ARDEIDAE	Grey Heron	*Ardea cinerea*				1	1
22	ARDEIDAE	Purple Heron	*Ardea purpurea*			1	0	0
23	CICONIIDAE	Black Stork	*Ciconia nigra*		1	1	1	1
24	CICONIIDAE	White Stork	*Ciconia ciconia*		1	1	1	1
25	THRESKIORNITHIDAE	Glossy Ibis	*Plegadis falcinellus*				1	1
26	THRESKIORNITHIDAE	Sacred Ibis	*Threskiornis aethiopicus*				1	1
27	THRESKIORNITHIDAE	Spoonbill	*Platalea leucorodia*		1		1	1
28	PHŒNICOPTERIDAE	Greater Flamingo	*Phoenicopterus ruber*			1	1	1
29	ANATIDAE	Mute Swan	*Cygnus olor*				1	1
30	ANATIDAE	Bewick's Swan	*Cygnus columbianus*	1			1	1
31	ANATIDAE	Bean Goose	*Anser fabalis*	1			1	1
32	ANATIDAE	Greylag Goose	*Anser anser*		1		1	1

33	ANATIDAE	Common Shelduck	*Tadorna tadorna*		1		1	1
34	ANATIDAE	Eurasian Wigeon	*Anas penelope*	1			1	1
35	ANATIDAE	Gadwall	*Anas strepera*		1		1	1
36	ANATIDAE	Common Teal (Green-winged Teal)	*Anas crecca*	1			1	1
37	ANATIDAE	Mallard	*Anas platyrhynchos*		1		1	1
38	ANATIDAE	Pintail (Northern Pintail)	*Anas acuta*	1		1	1	1
39	ANATIDAE	Garganey	*Anas querquedula*	1	1	1	0	1
40	ANATIDAE	Shoveler (Northern Shoveler)	*Anas clypeata*		1	1	1	1
41	ANATIDAE	Red-Crested Pochard	*Netta rufina*		1		1	1
42	ANATIDAE	Common Pochard	*Aythya ferina*	1			1	1
43	ANATIDAE	Ferruginous Duck	*Aythya nyroca*		1		1	1
44	ANATIDAE	Tufted Duck	*Aythya fuligula*	1			1	1
45	ANATIDAE	Scaup	*Aythya marila*	1			1	1
46	ANATIDAE	Eider	*Somateria mollissima*	1			1	1
47	ANATIDAE	Long-tailed Duck	*Clangula hyemalis*	1			1	1
48	ANATIDAE	Common Scoter	*Melanitta nigra*	1			1	1
49	ANATIDAE	Velvet Scoter	*Melanitta fusca*	1			1	1
50	ANATIDAE	Goldeneye	*Bucephala clangula*	1			1	1
51	ANATIDAE	Smew	*Mergus albellus*	1			1	0
52	ANATIDAE	Red-breasted Merganser	*Mergus serrator*	1			1	1
53	ANATIDAE	Goosander	*Mergus merganser*		1		1	1
54	ANATIDAE	White-fronted Goose	*Anser albifrons*	1			1	0
55	ACCIPITRIDAE	Honey Buzzard	*Pernis apivorus*		1	1	0	0
56	ACCIPITRIDAE	Black Kite	*Milvus migrans*		1	1	1	1
57	ACCIPITRIDAE	Red Kite	*Milvus milvus*		1		1	1
58	ACCIPITRIDAE	Egyptian Vulture	*Neophron percnopterus*			1	0	0
59	ACCIPITRIDAE	Short-toed Eagle	*Circaetus gallicus*			1	0	0
60	ACCIPITRIDAE	Marsh Harrier	*Circus aeruginosus*		1		1	1
61	ACCIPITRIDAE	Hen Harrier	*Circus cyaneus*		1		1	1
62	ACCIPITRIDAE	Montagu's Harrier	*Circus pygargus*		1	1	0	0
63	ACCIPITRIDAE	Goshawk	*Accipiter gentilis*		1		1	1
64	ACCIPITRIDAE	Sparrow Hawk	*Accipiter nisus*		1		1	1
65	ACCIPITRIDAE	Common Buzzard	*Buteo buteo*		1		1	1
66	ACCIPITRIDAE	Long-legged Buzzard	*Buteo rufinus*		1		1	1
67	ACCIPITRIDAE	Spotted Eagle	*Aquila clanga*		1		1	1
68	ACCIPITRIDAE	Booted Eagle	*Hieraaetus pennatus*		1	1	1	1

69	ACCIPITRIDAE	Bonelli's Eagle	*Hieraaetus fasciatus*				1	1
70	PANDIONIDAE	Osprey	*Pandion haliaetus*		1	1	1	1
71	FALCONIDAE	Lesser Kestrel	*Falco naumanni*			1	0	0
72	FALCONIDAE	Common Kestrel	*Falco tinnunculus*				1	1
73	FALCONIDAE	Red-footed Falcon	*Falco vespertinus*		1	1	0	0
74	FALCONIDAE	Merlin	*Falco columbarius*	1			1	1
75	FALCONIDAE	Hobby	*Falco subbuteo*		1	1	0	0
76	FALCONIDAE	Eleonora's Falcon	*Falco eleonorae*			1	0	0
77	FALCONIDAE	Peregrine Falcon	*Falco peregrinus*		1		1	1
78	PHASIANIDAE	Red-legged Partridge	*Alectoris rufa*				1	1
79	PHASIANIDAE	Quail	*Coturnix coturnix*		1	1	0	0
80	PHASIANIDAE	Common Pheasant	*Phasianus colchicus*				1	1
81	RALLIDAE	Water Rail	*Rallus aquaticus*		1		1	1
82	RALLIDAE	Corncrake	*Crex crex*		1	1	0	0
83	RALLIDAE	Spotted Crake	*Porzana porzana*		1	1	1	1
84	RALLIDAE	Little Crake	*Porzana parva*		1	1	0	0
85	RALLIDAE	Moorhen	*Gallinula chloropus*				1	1
86	RALLIDAE	Common Coot	*Fulica atra*		1		1	1
87	GRUIDAE	Common Crane	*Grus grus*	1			1	1
88	OTIDIDAE	Little Bustard	*Tetrax tetrax*				1	1
89	HAEMATOPODIDAE	Oystercatcher	*Haematopus ostralegus*				1	1
90	RECURVIROSTRIDAE	Black-winged Stilt	*Himantopus himantopus*			1	1	1
91	RECURVIROSTRIDAE	Avocet (Pied Avocet)	*Recurvirostra avosetta*				1	1
92	BURHINIDAE	Stone Curlew	*Burhinus oedicnemus*				1	1
93	GLAREOLIDAE	Pratincole	*Glareola pratincola*			1	0	0
94	CHARADRIIDAE	Little ringed Plover	*Charadrius dubius*		1	1	1	1
95	CHARADRIIDAE	Great ringed Plover	*Charadrius hiaticula*	1		1	1	1
96	CHARADRIIDAE	Kentish Plover	*Charadrius alexandrinus*				1	1
97	CHARADRIIDAE	Dotterel	*Charadrius morinellus*		1		0	0
98	CHARADRIIDAE	Golden Plover	*Pluvialis apricaria*	1			1	1
99	CHARADRIIDAE	Grey Plover	*Pluvialis squatarola*	1			1	1
100	CHARADRIIDAE	Lapwing	*Vanellus vanellus*		1		1	1
101	SCOLOPACIDAE	Black-tailed Godwit	*Limosa limosa*		1	1	1	1
102	SCOLOPACIDAE	Bar-tailed Godwit	*Limosa lapponica*	1		1	0	0
103	SCOLOPACIDAE	Terek Sandpiper	*Xenus cinereus*	1		1	0	0
104	SCOLOPACIDAE	Woodcock	*Scolopax rusticola*		1		1	1

105	SCOLOPACIDAE	Curlew Sandpiper	*Calidris ferruginea*	1		1	0	0
106	SCOLOPACIDAE	Temminck's Stint	*Calidris temminckii*	1		1	1	1
107	SCOLOPACIDAE	Broad-billed Sandpiper	*Limicola falcinellus*	1		1	0	0
108	SCOLOPACIDAE	Knot	*Calidris canutus*	1		1	1	1
109	SCOLOPACIDAE	Little Stint	*Calidris minuta*	1		1	1	1
110	SCOLOPACIDAE	Sanderling	*Calidris alba*	1		1	1	1
111	SCOLOPACIDAE	Dunlin	*Calidris alpina*	1		1	1	1
112	SCOLOPACIDAE	Snipe	*Gallinago gallinago*		1		1	1
113	SCOLOPACIDAE	Jack Snipe	*Lymnocryptes minimus*	1			1	1
114	SCOLOPACIDAE	Greenshank	*Tringa nebularia*	1		1	1	1
115	SCOLOPACIDAE	Spotted Redshank	*Tringa erythropus*	1		1	1	1
116	SCOLOPACIDAE	Green Sandpiper	*Tringa ochropus*	1		1	1	1
117	SCOLOPACIDAE	Common Redshank	*Tringa totanus*		1		1	1
118	SCOLOPACIDAE	Common Sandpiper	*Actitis hypoleucos*		1	1	1	1
119	SCOLOPACIDAE	Marsh Sandpiper	*Tringa stagnatilis*		1	1	0	0
120	SCOLOPACIDAE	Wood Sandpiper	*Tringa glareola*	1		1	0	0
121	SCOLOPACIDAE	Ruff	*Philomachus pugnax*	1		1	1	1
122	SCOLOPACIDAE	Curlew	*Numenius arquata*		1		1	1
123	SCOLOPACIDAE	Whimbrel	*Numenius phaeopus*	1		1	1	1
124	SCOLOPACIDAE	Red-necked Phalarope	*Phalaropus lobatus*	1		1	0	0
125	SCOLOPACIDAE	Turnstone	*Arenaria interpres*	1		1	1	1
126	STERCORARIIDAE	Great Skua	*Catharacta skua*				1	1
127	STERCORARIIDAE	Pomatorhine Skua	*Stercorarius pomarinus*				0	0
128	STERCORARIIDAE	Arctic Skua	*Stercorarius parasiticus*				1	1
129	LARIDAE	Hering Gull	*Larus argentatus*		1		1	1
130	LARIDAE	Lesser Black-backed Gull	*Larus fuscus*		1		1	1
131	LARIDAE	Common Gull	*Larus canus*		1		1	1
132	LARIDAE	Audoin's Gull	*Larus audouinii*				0	0
133	LARIDAE	Yellow-legged Herring Gull	*Larus cachinnans*				1	1
134	LARIDAE	Slender-billed Gull	*Larus genei*			1	1	1
135	LARIDAE	Mediterranean Gull	*Larus melanocephalus*			1	1	1
136	LARIDAE	Little Gull	*Larus minutus*		1	1	1	1
137	LARIDAE	Black-headed Gull	*Larus ridibundus*		1		1	1
138	STERNIDAE	Common Tern	*Sterna hirundo*			1	1	1
139	STERNIDAE	Little Tern	*Sterna albifrons*			1	0	0
140	STERNIDAE	Gull-billed Tern	*Gelochelidon nilotica*			1	0	0

141	STERNIDAE	Sandwich Tern	*Sterna sandvicensis*				1	1
142	STERNIDAE	Caspian Tern	*Sterna caspia*		1	1	0	0
143	STERNIDAE	Black Tern	*Chlidonias niger*		1	1	1	1
144	STERNIDAE	Whiskered Tern	*Chlidonias hybridus*		1	1	1	1
145	STERNIDAE	White-winged Black Tern	*Chlidonias leucopterus*		1	1	0	0
146	ALCIDAE	Razorbill	*Alca torda*				1	1
147	ALCIDAE	Puffin	*Fratercula arctica*				1	1
148	PTEROCLIDIDAE	Pin-tailed Sandgrouse	*Pterocles alchata*				1	1
149	COLUMBIDAE	Collared Dove	*Streptopelia decaocto*				1	1
150	COLUMBIDAE	Turtle Dove	*Streptopelia turtur*		1	1	0	0
151	COLUMBIDAE	Wood Pigeon	*Columba palumbus*		1		1	1
152	COLUMBIDAE	Stock Dove	*Columba oenas*		1		1	1
153	COLUMBIDAE	Rock Dove (Feral Pigeon)	*Columba livia*				1	1
154	CUCULIDAE	Common Cuckoo	*Cuculus canorus*		1	1	0	0
155	CUCULIDAE	Great Spotted Cuckoo	*Clamator glandarius*			1	0	0
156	TYTONIDAE	Barn Owl	*Tyto alba*				1	1
157	STRIGIDAE	Scops Owl	*Otus scops*			1	0	0
158	STRIGIDAE	Long-eared Owl	*Asio otus*		1		1	1
159	STRIGIDAE	Short-eared Owl	*Asio flammeus*		1		1	1
160	STRIGIDAE	Eagle Owl	*Bubo bubo*				1	1
161	STRIGIDAE	Tawny Owl	*Strix aluco*				1	1
162	STRIGIDAE	Little Owl	*Athene noctua*				1	1
163	CAPRIMULGIDAE	Nightjar	*Caprimulgus europaeus*			1	0	0
164	APODIDAE	Common Swift	*Apus apus*		1	1	0	0
165	APODIDAE	Pallid Swift	*Apus pallidus*			1	0	0
166	APODIDAE	Alpine Swift	*Apus melba*			1	0	0
167	ALCEDINIDAE	European Kingfisher	*Alcedo atthis*		1		1	1
168	MEROPIDAE	European Bee-eater	*Merops apiaster*			1	0	0
169	CORACIIDAE	European Roller	*Coracias garrulus*			1	0	0
170	UPUPIDAE	Hoopoe	*Upupa epops*			1	0	1
171	PICIDAE	Wryneck	*Jynx torquilla*		1	1	1	1
172	PICIDAE	Green Woodpecker	*Picus viridis*				1	1
173	PICIDAE	Lesser Spotted Woodpecker	*Dendrocopos minor*				1	1
174	PICIDAE	Greater Spotted Woodpecker	*Dendrocopos major*				1	1
175	ALAUDIDAE	Crested Lark	*Galerida cristata*				1	1
176	ALAUDIDAE	Wood Lark	*Lullula arborea*		1		1	1

177	ALAUDIDAE	Skylark	*Alauda arvensis*		1		1	1
178	ALAUDIDAE	Short-toed Lark	*Calandrella brachydactyla*				0	0
179	ALAUDIDAE	Calandra Lark	*Melanocorypha calandra*				1	1
180	HIRUNDINIDAE	Sand Martin	*Riparia riparia*		1	1	0	0
181	HIRUNDINIDAE	Crag Martin	*Hirundo rupestris*				1	1
182	HIRUNDINIDAE	Barn Swallow	*Hirundo rustica*		1	1	1	1
183	HIRUNDINIDAE	Red-rumped Swallow	*Hirundo daurica*			1	0	0
184	HIRUNDINIDAE	House Martin	*Delichon urbica*		1	1	0	1
185	MOTACILLIDAE	Water Pipit	*Anthus spinoletta*		1		1	1
186	MOTACILLIDAE	Tawny Pipit	*Anthus campestris*			1	0	0
187	MOTACILLIDAE	Meadow Pipit	*Anthus pratensis*		1		1	1
188	MOTACILLIDAE	Tree Pipit	*Anthus trivialis*		1	1	0	0
189	MOTACILLIDAE	Red-throated Pipit	*Anthus cervinus*	1		1	0	0
190	MOTACILLIDAE	Yellow Wagtail (Blue-headed Wagtail)	*Motacilla flava*		1	1	1	1
191	MOTACILLIDAE	White Wagtail (Pied Wagtail)	*Motacilla alba*		1		1	1
192	MOTACILLIDAE	Grey Wagtail	*Motacilla cinerea*		1		1	1
193	CINCLIDAE	Dipper	*Cinclus cinclus*				0	0
194	TROGLODYTIDAE	Wren	*Troglodytes troglodytes*		1		1	1
195	PRUNELLIDAE	Dunnock (Hedge Sparrow)	*Prunella modularis*		1		1	1
196	PRUNELLIDAE	Alpine Accentor	*Prunella collaris*		1		1	1
197	TURDIDAE	Black-eared Wheatear	*Oenanthe hispanica*			1	0	0
198	TURDIDAE	Wheatear (Northern Wheatear)	*Oenanthe oenanthe*		1	1	0	0
199	TURDIDAE	Stonechat	*Saxicola torquata*		1		1	1
200	TURDIDAE	Whinchat	*Saxicola rubetra*		1	1	0	0
201	TURDIDAE	Black Redstart	*Phoenicurus ochruros*		1	1	1	1
202	TURDIDAE	Common Redstart	*Phoenicurus phoenicurus*		1	1	0	0
203	TURDIDAE	Eurasian Robin	*Erithacus rubecula*		1		1	1
204	TURDIDAE	Common Nightingale	*Luscinia megarhynchos*		1	1	0	0
205	TURDIDAE	European Blackbird	*Turdus merula*		1		1	1
206	TURDIDAE	Rock Trush	*Monticola saxatilis*			1	0	0
207	TURDIDAE	Blue Rock Trush	*Monticola solitarius*				1	1
208	TURDIDAE	Ring Ouzel	*Turdus torquatus*				0	1
209	TURDIDAE	Song Trush	*Turdus philomelos*		1		1	1
210	TURDIDAE	Redwing	*Turdus iliacus*	1			1	1
211	TURDIDAE	Fieldfare	*Turdus pilaris*		1		1	1
212	TURDIDAE	Mistle Trush	*Turdus viscivorus*		1		1	1

213	TURDIDAE	Bluethroat	*Luscinia svecica*				1	1
214	SYLVIIDAE	Marsh Warbler	*Acrocephalus palustris*		1	1	0	0
215	SYLVIIDAE	Great Reed Warbler	*Acrocephalus arundinaceus*		1	1	0	0
216	SYLVIIDAE	Reed Warbler	*Acrocephalus scirpaceus*		1	1	0	0
217	SYLVIIDAE	Firecrest	*Regulus ignicapillus*		1		1	1
218	SYLVIIDAE	Goldcrest	*Regulus regulus*		1		1	1
219	SYLVIIDAE	Chiffchaff	*Phylloscopus collybita*		1		1	1
220	SYLVIIDAE	Wood Warbler	*Phylloscopus sibilatrix*		1	1	0	0
221	SYLVIIDAE	Willow Warbler	*Phylloscopus trochilus*		1	1	0	0
222	SYLVIIDAE	Bonelli's Warbler	*Phylloscopus bonelli*		1	1	0	0
223	SYLVIIDAE	Sedge Warbler	*Acrocephalus schoenobaenus*		1	1	0	0
224	SYLVIIDAE	Aquatic Warbler	*Acrocephalus paludicola*		1	1	0	0
225	SYLVIIDAE	Moustached Warbler	*Acrocephalus melanopogon*				1	1
226	SYLVIIDAE	Grasshopper Warbler	*Locustella naevia*		1	1	0	0
227	SYLVIIDAE	Savi's Warbler	*Locustella luscinioides*			1	0	0
228	SYLVIIDAE	Melodious Warbler	*Hippolais polyglotta*			1	0	0
229	SYLVIIDAE	Icterine Warbler	*Hippolais icterina*		1	1	0	0
230	SYLVIIDAE	Dartford Warbler	*Sylvia undata*				1	1
231	SYLVIIDAE	Subalpine Warbler	*Sylvia cantillans*			1	1	1
232	SYLVIIDAE	Orphean Warbler	*Sylvia hortensis*			1	0	0
233	SYLVIIDAE	Sardinian Warbler	*Sylvia melanocephala*				1	1
234	SYLVIIDAE	Whitethroat	*Sylvia communis*		1	1	0	0
235	SYLVIIDAE	Garden Warbler	*Sylvia borin*		1	1	0	0
236	SYLVIIDAE	Lesser Whitethroat	*Sylvia curruca*		1	1	0	0
237	SYLVIIDAE	Blackcap	*Sylvia atricapilla*		1		1	1
238	SYLVIIDAE	Spectacled Warbler	*Sylvia conspicillata*				1	1
239	SYLVIIDAE	Fan-tailed Warbler	*Cisticola juncidis*				1	1
240	SYLVIIDAE	Cetti's Warbler	*Cettia cetti*				1	1
241	MUSCICAPIDAE	Pied Flycatcher	*Ficedula hypoleuca*		1	1	0	0
242	MUSCICAPIDAE	Spotted Flycatcher	*Muscicapa striata*		1	1	0	0
243	TIMALIIDAE	Bearded Tit	*Panurus biarmicus*				1	1
244	AEGITHALIDAE	Long-tailed Tit	*Aegithalos caudatus*				1	1
245	PARIDAE	Coal Tit	*Parus ater*		1		1	1
246	PARIDAE	Great Tit	*Parus major*				1	1
247	PARIDAE	Blue Tit	*Parus caeruleus*				1	1
248	SITTIDAE	Nuthatch	*Sitta europaea*				1	1

249	TICHODROMADIDAE	Wall Creeper	*Tichodroma muraria*		1		1	1
250	CERTHIIDAE	Short-toed Treecreeper	*Certhia brachydactyla*				1	1
251	REMIZIDAE	Penduline Tit	*Remiz pendulinus*		1		1	1
252	ORIOLIDAE	Golden Oriole	*Oriolus oriolus*			1	0	0
253	LANIIDAE	Red-backed Shrike	*Lanius collurio*		1	1	0	0
254	LANIIDAE	Lesser Grey Shrike	*Lanius minor*			1	0	0
255	LANIIDAE	Great Gray Shrike	*Lanius excubitor*		1	1	1	1
256	LANIIDAE	Mediterranean Great Gray Shrike	*Lanius meridionalis*				1	1
257	LANIIDAE	Woodchat Shrike	*Lanius senator*		1	1	0	0
258	CORVIDAE	Common Magpie	*Pica pica*				1	1
259	CORVIDAE	Raven	*Corvus corax*				1	1
260	CORVIDAE	Eurasian Jay	*Garrulus glandarius*				1	1
261	CORVIDAE	Carrion Crow	*Corvus corone*		1		1	1
262	CORVIDAE	Rook	*Corvus frugilegus*		1		1	1
263	CORVIDAE	Jackdaw	*Corvus monedula*				1	1
264	STURNIDAE	Spotless Starling	*Sturnus unicolor*				1	1
265	STURNIDAE	Common Starling	*Sturnus vulgaris*		1		1	1
266	PASSERIDAE	Snow Finch	*Montifringilla nivalis*		1		1	1
267	PASSERIDAE	Rock Sparrow	*Petronia petronia*				0	0
268	PASSERIDAE	Tree Sparrow	*Passer montanus*				1	1
269	PASSERIDAE	House Sparrow	*Passer domesticus*				1	1
270	FRINGILLIDAE	Greenfinch	*Carduelis chloris*		1		1	1
271	FRINGILLIDAE	Citril Finch	*Serinus citrinella*		1		1	1
272	FRINGILLIDAE	Siskin	*Carduelis spinus*	1			1	1
273	FRINGILLIDAE	Redpoll	*Carduelis flammea*	1			1	1
274	FRINGILLIDAE	European Serin	*Serinus serinus*		1		1	1
275	FRINGILLIDAE	Brambling	*Fringilla montifringilla*	1			1	1
276	FRINGILLIDAE	Chaffinch	*Fringilla coelebs*		1		1	1
277	FRINGILLIDAE	Linnet	*Carduelis cannabina*		1		1	1
278	FRINGILLIDAE	Hawfinch	*Coccothraustes coccothraustes*		1		1	1
279	FRINGILLIDAE	Goldfinch	*Carduelis carduelis*		1		1	1
280	FRINGILLIDAE	Bullfinch	*Pyrrhula pyrrhula*		1		1	0
281	FRINGILLIDAE	Crossbill	*Loxia curvirostra*	1			1	1
282	EMBERIZIDAE	Cirl Bunting	*Emberiza cirlus*		1		1	1
283	EMBERIZIDAE	Corn Bunting	*Miliaria calandra*		1		1	1
284	EMBERIZIDAE	Ortolan Bunting	*Emberiza hortulana*			1	0	0

285	EMBERIZIDAE	Yellowhammer	*Emberiza citrinella*		1		1	1
286	EMBERIZIDAE	Rock Bunting	*Emberiza cia*				1	1
287	EMBERIZIDAE	Reed Bunting	*Emberiza schoeniclus*		1		1	1
288	EMBERIZIDAE	Snow Bunting	*Plectrophenax nivalis*	1			1	1
289	EMBERIZIDAE	Pine Bunting	*Emberiza leucocephalos*	1			1	1

Bird diversity										Bird abundance											
M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
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1	0	0	0	0	0	0	1	1	1	10	10	10	0	0	0	0	0	0	10	10	10
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1	1	1	1	1	1	1	1	1	1	10000	10000	10000	1000	1000	1000	1000	1000	1000	10000	10000	10000
0	0	0	0	0	0	0	1	1	1	10	0	0	0	0	0	0	0	0	10	10	10
0	0	0	0	1	1	1	1	1	1	10	10	0	0	0	0	10	10	10	10	10	10
1	1	1	1	1	1	1	1	1	1	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
1	1	1	1	1	1	1	1	1	1	10000	10000	10000	1000	1000	1000	1000	1000	1000	10000	10000	10000
0	1	1	1	1	1	1	0	0	0	0	0	0	1000	1000	1	1	100	1000	0	0	0

1	0	0	0	0	0	0	0	1	1	1000	1000	1000	0	0	0	0	0	0	0	1000	1000
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1	1	1	1	1	1	1	1	1	1	10000	10000	1000	1000	1000	1000	1000	1000	1000	1000	10000	10000
0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	1	1
0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	1	1