



Original Research Article

Wild birds as potential vectors for pathogen dissemination on migration routes in the Danube Delta Wetlands

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ABSTRACT

Wild birds have the capacity to move fast over very large distances. During migration, they could become dissemination vectors of different pathogens that might be transmitted intra- and interspecies especially during the prevernal-vernal periods - characteristic of the spring migration, and during the fall-prehivernal periods – characteristic of the fall migration, when the numerical abundance and specific diversity are at their peak. At the same time the horizontal dissemination including the pathogens transmission may reach a high level during the post vernal-estival and serotinal periods corresponding to the periods of breeding and juvenile individuals erratic flights. The last but not the least important are the resting and feeding areas of the passage bird species where bird populations show high and very high quantitative and qualitative levels and where the mutual pathogenic intra- and interspecies contamination may be very intense. The purpose of this article is to analyze the role of wild birds during their migration in the transmission and dissemination of several emerging zoonoses.

Keywords

Danube River, wild birds, migration

Introduction

Romania is geographically situated at the crossroads of the most important migration routes of the Central and Eastern Europe and due to its landscape richness and variety it is a place of major importance for the evolution and stability of the sedentary and migratory bird populations

migration areas, the Eastern one including the East-Elbic, Pontic and Sarmatic routes is the most important migration area of Eastern Europe, since it collects wild birds from the largest migration area built up of the remote Siberian Taiga, Central and Eastern Europe and Africa, an itinerary

generically called the Eur-Asian-African route.

Danube Delta wetlands

The Danube is one of the most important rivers in Romania and flows into the Black Sea through three branches: Chilia, Sulina and Sfîntul Gheorghe, which form the Danube Delta. The Danube Delta is recognised as one of Europe's premier wetlands and the Danube Delta Special Protection Area (SPA) (Birdlife). It is considered to be a paradise for birds, being visited by over 330 species of wild migratory birds in every season (Ionita et al., 2010). Birds are the only vertebrates which have the capacity of flying across large intercontinental areas in very short periods of time to exploit seasonal opportunities for breeding habitats and food supplies (Georgopoulou et al., 2008). Most of the wetland bird populations that nestle in Central Asia are migratory and fly along the migration routes in a dispersed manner.

The nestling bird populations of the Central Asia migrate mainly to south-west towards the South of Europe (a migration direction from the Black Sea to the Mediterranean) or towards Eastern Africa (a migration itinerary from the West of Asia to the East of Africa) or towards the South of Asia (the Central Asia migration route). There are also bird species migrating to the West of Europe. Like many other eastern wetland areas of the eastern Mediterranean basin, the forest area of the banks and the Sacalin Island located in the south of the Sfântu Gheorghe armmouth (Paunescu 2012) is an important starting point for the transition of Palearctic birds migrating between the three large continents: Asia, Europe and Africa.

Due to their migration across national and intercontinental borders these birds can become long-range vectors for several pathogenic microorganisms (Grenfell et al., 1995). A high percentage of pathogens are more often isolated in migratory birds compared with other animal species (Rappole et al., 2003, Peterson et al., 2003, Tsiodras et al., 2008) and the potential for transport and dissemination of these pathogens by wild birds is of increasing public health concern (Rappole et al., 2003, Qiu 2005, Tsiodras et al., 2008).

In general, millions of birds are flying between continents twice a year in only a few weeks (Berthold 1993). During migratory movement wild birds have the potential to carry pathogens that might be dangerous for the human population but also for various plant and animal species (Reed et al., 2003; Hubalek 2004). These pathogens can also be transmitted between species at breeding, wintering, and stopover places where numerous birds of various species are concentrated (Jourdain et al., 2007).

Migratory birds – biological carriers

Wild birds are susceptible to spread pathogenic agents and the migration may increase an individual's exposure to pathogens (Klaassen et al., 2012). These pathogens can be contacted directly along their own migration routes (Reed et al., 2003, Hubálek 2004, Foti et al., 2011) or by the occasional interference with other bird populations that follow a different migration route, mostly in the stopover and feeding areas (Klaassen et al., 2012). This constitutes a potential risk of the migratory birds spreading pathogenic species to very remote areas from the initial site of contagion and particularly to Europe.

Understanding bird movements and the interactions between populations is essential in estimating the potential to disseminate pathogenic microbes. Collecting and processing samples from these migratory routes is necessary for assessment of bird-related pathogens' dynamics.

Migratory birds - reservoirs of bacteria

Billions of birds travel between continents twice a year in only a few weeks (Berthold, 1993). During these migrations, birds have the potential to distribute widely pathogenic microorganisms (Reed et al., 2003, Hubalek 2004). These bird species are important to public health because they can be reservoirs for different types of pathogenic microorganisms (Reed et al., 2003, Schettler et al., 2003, Ahmed et al., 2011, Pardal et al., 2012).

Migratory wild birds belonging to the *Motacilla alba* species (pied wagtail) in India, *Streptopelia turtur* species (turtle dove) in Israel, *Ardeola ralloides* species (squacco heron) in Azerbaidjan, *Gallinago gallinago* species (snipe) in Tadjikistan, *Acrocephalus scirpaceus* species (reed warbler), *Vanellus vanellus* species (lap wing) and *Sturnus vulgaris* species (starling) in Slovakia and Estonia, *Tadorna ferruginea* (ruddy shelduck), *Phalacrocorax carbo* (cormorant) are involved in carrying, transmitting and disseminating of certain pathogenic microorganisms (viruses, bacteria, protozoa, fungi) (Hubálek 2004, Sehgal 2010).

Between these microorganisms *Salmonella spp.*, thermotolerant *Campylobacter jejuni* and *Campylobacter coli* (Dipineto et al.,

2008, Dipineto et al., 2009) glycopeptide resistant *Enterococcus* were found in songbirds, gulls, waterfowl, partridges. Similarly, *Mycobacterium avium*, *Mycobacterium genevense*, *Chlamydia psittaci* were identified in psittacine birds, pigeons, poultry, *Pseudomonas spp.* was present on avian plumage (Bisson et al., 2007), while *Helicobacter* and *Staphylococcus* were isolated from redshank (*Tringa totanus*), black-winged stilt (*Himantopus himantopus*), black-tailed godwit (*Limosa limosa*). Furthermore, other bacteria pathogenic for both humans and animals such as *Clostridium*, *Mycobacterium*, *Rhodococcus*, *Legionella* and *Corynebacterium* were present in black-winged stilts (Santos et al., 2012), faecal *Escherichia coli*, *Brachyspira hyodysenteriae* was carried by cormorants, mallards, gulls (Tausova et al., 2012, Klimaszyk 2012). Microbes of *Pasteurella* genus (*Pasteurella multocida*) were cultivated from (Pedersen et al., 2003) eiders, while blue tit (*Cyanistes caeruleus*) and great tit (*Parus major*) hosted *Pseudomonas aeruginosa*, *Pseudomonas fluorescens*, *Pseudomonas putida*, *Staphylococcus hyicus*, *Enterobacter cloacae*, keratinolytic bacteria *Pseudomonas stutzeri*, *Bacillus subtilis* (Goodenough et al., 2010), *Vibrio cholerae*, *Borrelia burgdorferi* (Hubálek 2004, Sehgal 2010).

Migratory birds - reservoirs of viruses

Migratory birds can also play significant roles in the ecology and circulation of some arboviruses (Eastern and Western equine encephalomyelitis and Sindbis alphaviruses, West Nile and St. Louis encephalitis flaviviruses), Newcastle disease virus, duck plague herpes-virus (Hubálek 2004), avian influenza viruses

(garganey - *Anas querquedula*) (Okazaki et al., 2000, Munster et al., 2005, Gaidet et al., 2008, Klaassen et al., 2012), avian pox virus (short-toed larks - *Calandrella brachydactyla*, Berthelot's pipits - *Anthus berthelotii*) (Smits et al., 2005). The most studied viruses are West Nile virus (WNV) and avian influenza virus (AI). Wild birds are central to the transmission cycle of WNV (Reed et al., 2003) and the wild birds' mortality has been used as an indicator of the extent of WNV, and it continues to provide an early warning system for the emergence of the virus in new locations (USGS). These two viruses have quite different transmission and ecology cycles. The AI virus has a close water-related transmission, through anatides (ducks) as the AI main natural reservoir (Easterday et al., 1997; Alexander, 2000; Krauss et al., 2004, Tracey et al., 2004, Olsen et al., 2006, Delogu et al., 2012, Kajihara et al., 2013), and causes severe respiratory disease outbreaks in a wide variety of animals, including humans, pigs, horses, sea mammals and wild and domestic birds (Horimoto et al., 2001, Reed et al., 2003). Avian influenza virus is considered an infectious agent of major importance for the world, but especially for Romania, because of the geographical particularities the Danube Delta, the phenomenon of bird migration, and natural reservoirs involved in disease transmission (Valeanu et al., 2011). Numerous studies indicated that AI virus is commonly found in European waterfowl (Hannoun and Devaux, 1980, Sussi et al., 1994, Fouchier et al., 2003, De Marco et al., 2003). Therefore waterfowl arriving from Continental Europe often serve as carriers for AI virus. It is well-known that WNV is a mosquito-borne virus and can result in fatal encephalitis in humans, horses, and domestic and wild birds (Reed et al., 2003,

Lawrie et al., 2004, McMullen et al., 2013 Crowder et al., 2013). The presence of WNV was reported in Romania (Campbell et al., 2001, ECDC and WHO, 2010) and Czech Republic (Hubalek et al., 1999). Migration of wild birds from the Mediterranean basin countries may introduce WNV, either due to an increased level of infection or because they were carrying ectoparasites. If the virus manages to survive the winter in a reservoir host or vector, it could then be responsible for the outbreak during the following summer, if mosquito vectors are abundant (Hurlbut 1956, Jourdain et al., 2007). *Passeriformes* are supposed to play a major role in the amplification cycles (Hurlbut 1956).

The risk of disseminating these diseases to humans and other mammals is highly associated with migrating birds, which are known as either reservoirs or amplifying hosts for AI and WN viruses. Furthermore, for both viruses the abundance of avian fauna, diversity of the species, dynamics and the geographic origin may be factors of great importance in the dissemination of pathogens (Reed et al., 2003, Krauss et al., 2004, Olsen et al., 2006, Rappole et al., 2000).

Migratory birds - reservoirs of pathogenic fungi and protozoa

Fungal pathogens are found in birds and can survive for at least 12 days without multiplying, remaining viable after excretion (Georgopoulou et al., 2008). This group includes *Candida albicans*, *Candida tropicalis*, *Aspergillus fumigatus* (Hubálek 2004, Sehgal 2010), *Cladosporium cladosporioides*, *Cladosporium tropicum*, *Microsporium gallinae*, *Aspergillus flavus*, *Aspergillus nidulans*, *Microsporium gypseum*,

Microsporium ripariae, *Microsporium persicolor*, *Trichophyton mentagrophytes* (Hubálek 1994, Hubálek 2000, Goodenough et al., 2010).

Of the protozoa, *Cryptosporidium baileyi* (Hubálek 2004), *Babesia microti* (Alekseev, et al., 2003, Hubálek 2004) *Plasmodium relictum*, *Plasmodium circumflexum*, *Plasmodium vaughani*, *Plasmodium trochilus* (Bensch et al., 2003, Hubálek 2004) were proven to be carried/transferred by wild birds.

Danube Delta wetlands, especially the forest plantation on the Saraturile sand banks and the Sahalin Island, next to the Sfantu Gheorghe village in Eastern Romania may qualify as reference areas for studies related to wild birds as vectors for different pathogens.

Knowledge in the bird populations' ecology and ethology is necessary for understanding the epidemiology of bird-associated diseases. Moreover, the data regarding the bird populations' dynamics may be used for upgrading disease monitoring schemes and for adopting suitable prevention measures. Yet, the connections between ecology, ethology and the dynamic character of avian fauna and human health care are still poorly studied.

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Transparency declarations

The authors of this paper declare they have no conflicts of interest.

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