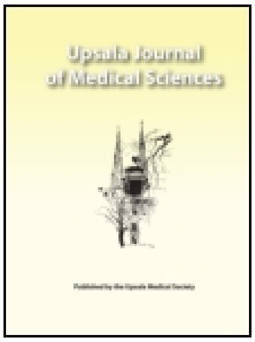

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REVIEW ARTICLE

Antibiotic resistance in wild birds

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Abstract

Wild birds have been postulated as sentinels, reservoirs, and potential spreaders of antibiotic resistance. Antibiotic-resistant bacteria have been isolated from a multitude of wild bird species. Several studies strongly indicate transmission of resistant bacteria from human rest products to wild birds. There is evidence suggesting that wild birds can spread resistant bacteria through migration and that resistant bacteria can be transmitted from birds to humans and vice versa. Through further studies of the spatial and temporal distribution of resistant bacteria in wild birds, we can better assess their role and thereby help to mitigate the increasing global problem of antibiotic resistance.

Key words: *Antibiotic resistant bacteria, avian, bird migration, environment, ESBL, human–animal interface, transmission*

Wild birds are important with regard to antibiotic resistance in several different ways: 1) As sentinels, mirroring human activity and its impact on the environment because of the diverse ecological niches of birds and as they easily pick up human and environmental bacteria. 2) As a reservoir and melting pot of antibiotic-resistant bacteria and resistance genes. 3) As potential spreaders of antibiotic resistance through the ability to migrate long distances in short periods of time. 4) As a possible source of antibiotic-resistant bacteria colonizing and/or infecting human beings.

Isolation of antibiotic-resistant bacteria from wild birds

The first antibiotic-resistant bacteria noted in wildlife were in fact from wild birds—strains of *Escherichia coli* resistant to multiple antibiotics, e.g. chloramphenicol—were isolated in pigeons around 1975 (1). Not until 10 years later were the famous studies with baboons in South Africa performed, where the degree of antibiotic resistance carriage among baboons was correlated with the degree of human interactivity (2).

Many bird species have been found to carry antibiotic-resistant bacteria. Resistant *E. coli* have been isolated from ducks and geese (3-6), cormorants (7,8), birds of prey (9,10), gulls (6,8,11-15), doves (1,16), and passerines (17-22).

Extended spectrum β-lactamase (ESBL)-producing *E. coli* were first isolated from wild birds in 2006 (23). In recent years, many reports have followed, mostly from Europe (10,12,15,24-29). ESBL-producing *E. coli* have now been isolated from wild birds from all continents of the world except Australia and Antarctica.

Wild birds as sentinels for antibiotic resistance

Many factors contribute to the prevalence of antibiotic resistance among wild birds in a certain geographic location. Probably, several characteristics of an area are more important than its actual location in the world. Natural preservation state, livestock and human densities, and the remoteness of an area have been postulated as important factors (30).

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Furthermore, levels of resistance seem to correlate with the degree of association to human activities (30,31). Contaminated habitats where antibiotic-resistant bacteria have been frequently isolated include intensively managed livestock farms, landfills, and waste-water treatment facilities (9,13,32). Gulls have been found to carry the same strains of *E. coli* as can be isolated from landfills and waste-water treatment plants, which demonstrates the possibility of transmission between sewage and birds (33). Another example of the association between waste/sewage and birds is red-billed choughs (*Pyrrhocorax pyrrhocorax*) that feed on soil invertebrates and thus can pick up antibiotic-resistant bacteria from contaminated manure used as fertilizer. In areas where the spreading of manure is extensively used in agriculture, resistance to multiple antibiotics can be found in bacteria from choughs. The resistance profiles of the bacteria resemble those found in pig slurry and sewage sludge from the same area (9). Transmission routes from livestock to birds can be exemplified by the use of *muladares* in Spain—places where carcasses are left for consumption by scavengers. In this way, both antibiotics and antibiotic-resistant bacteria resulting from an intense livestock industry can be spread to birds and environment (9). Aquatic associated species seem, however, especially prone to pick up antibiotic resistance including ESBL-producing strains (34).

Wild birds as spreaders of antibiotic resistance

Given that birds can migrate long distances in short periods of time and the abundance of reports of carriage of antibiotic-resistant bacteria discussed above, there is a possibility that wild birds can act as spreaders of antibiotic resistance. For humans, the spread of antibiotic-resistant bacteria through travel has been demonstrated (35). There are also examples where wild bird migration has been linked to the spread of pathogens, such as the dissemination of West Nile Virus in the US (36). A study on chickens has demonstrated carriage of ESBL-producing bacteria for several weeks and that ESBL-producing bacteria can be rapidly transmitted between individuals (37). Although this study was performed in a domesticated bird, it is reasonable to believe that also wild birds can carry antibiotic-resistant bacteria long enough during migration with the potential of intercontinental spread of resistance.

A recent study in Chile has shown a prevalence of ESBL-producing *E. coli* among Franklin's gulls (*Leucophaeus pipixcan*) that is more than twice as high as in humans in the same area. Humans and gulls share sequence types indicating transmission, but interestingly gulls also share sequence types with human clinical samples from central Canada, a nesting place for those gulls suggesting that migration could be a mechanism of dissemination (29). Similarly, the isolation of antibiotic-resistant *Salmonella* strains from black-headed gulls (*Chroicocephalus ridibundus*) just arriving in southern Sweden from non-breeding areas in West and Southwest Europe suggests spread through migration (38). Antibiotic-resistant strains including ESBL-producing *E. coli* have also been isolated from birds from remote and/or preservation areas (39-43). This could be interpreted as possible footprint of human activity, but at least in some cases it seems more plausible with spread through bird migration (39,42). Spread of antibiotic-resistant bacteria to remote areas that are reached mainly by migrating birds could also influence bacterial communities in these fragile ecosystems, as antimicrobial substances are part of the cross-talk of bacteria (30).

Conclusions

There is ample evidence to suggest that wild birds can carry antibiotic-resistant bacteria and that transmission can occur from human rest products. There are indications of spread of antibiotic resistance through migration of wild birds and of transmission between humans and wild birds and vice versa. As previously suggested, thorough spatial and temporal studies of antimicrobial drug resistance in different natural habitats of wild birds are warranted (39,44). This research can help us to better understand the dissemination of antibiotic resistance in the environment, to understand and potentially be able to decrease spread through bird migration, and to assess the risk of spread of resistance from wild birds to humans.

Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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