Role of Wild Birds in Spreading Potential Zoonotic Diseases in Poultry

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ABSTRACT

There are many pathogens which are of zoonotic concern. Among these major pathogens are directly or indirectly transmitting zoonotic disease. Wild birds are major source of transmission of these diseases including viral as well as bacterial pathogens. Wild birds not only harbor these diseases but also spread these pathogens where it travels to various other species like poultry and ultimately to human. This indicates that there is not incubation risk of those pathogens but also flight risk that result in carrying pathogen load to their migration site or premises where other species are also cultivating or living. These infectious diseases can be worsen when comes in contact with different serotypes of those infectious pathogens resulting in not only severity of disease but also make prevention difficult. There is a need to limit the migration of wild birds to prevent the major loss in poultry as well as human being.

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1. INTRODUCTION

Avian species in the wild exhibit a wide range of diversity, including several ecological niches. Pakistan has a diverse range of wildlife, including 188 species of mammals, 666 migratory and resident species of birds, 174 species of reptiles, 16 species of amphibians, 525 species of fish, 16 species of amphibians and 20,000 species of insects and vertebrates as mentioned in the workshop of the center of disease control and prevention. Wild birds can transmit pathogens directly and indirectly through vectors and numerous diseases are transmitted from wild birds as they travel long distances. They have a tendency to travel long distances and travel in flocks (Vogt 2023). Birds are less susceptible to zoonotic diseases than mammals as they have developed the immune systems. But they are natural hosts, reservoirs, and amplifying hosts for different zoonotic agents (Contreras et al. 2016).

Direct transmission of zoonotic diseases is possible when other species come in contact with their body excretions. Direct transmission of zoonotic diseases from wild birds is least possible because of taxonomical differences (Bengis et al. 2004). Indirect transmission is possible when other species come in contact with the contaminated surfaces. Examples include pet habitats, aquarium tank water, chicken coops, plants, barns and soil, as well as pet food and water dishes. Tick or insect bites can aid in vector-borne diseases. Foodborne diseases are a major prevalent transmission factor. Wild birds transmit diseases to domestic and commercial poultry, leading to public health concerns. Undercooked meat and eggs will lead to the transmission of zoonotic pathogens. Contaminated water is also a source of pathogen entry (Brown and O’Brien 2011).

Public health concerns about emerging diseases are 60%, and out of these 60%, 70% of these diseases originated from wildlife as reported in “Asia Pacific strategy for emerging diseases: 2010”. There are many emerging zoonotic diseases and newly emerged diseases are associated with animal-origin foods (Rahman et al. 2020). Interspecies transmission is an essential factor in the transmission of zoonotic diseases. There are various diseases of public health concerns reported in interspecies transmission. One of them is avian influenza. After interspecies transmission from wild birds to chicken and then human H5 and H7, avian influenza viruses can become highly pathogenic. These viruses have been transmitted directly to humans from birds in Eurasia and Africa (H5N1), the Netherlands (H7N7) and Canada (H7N3) (Uzma et al. 2009). When we talk about viral zoonotic diseases from wild birds to poultry and ultimately to humans, we must consider the Newcastle disease virus (NDV) that transmit from waterfowl. It is also reported that F genes in NDV isolated from wild waterfowl are similar to NDV of poultry (Goraichuk et al. 2023).

Poultry birds getting infected from premises, or direct contact with wild birds can lead to transmission of multi-drug-resistant bacteria that not only transmit pathogens in humans but also create multi-drug resistance. One of the examples is Salmonella and *E. coli* (karim et al. 2020). Wild birds (wild fauna and migratory birds) harbor an emerging pathogen of Enterobacteriaceae, which is closely linked to *E. coli* based on DNA hybridization and is multi-drug resistant (Shah et al. 2022). Wild birds not only transmit Salmonella and *E. Coli* to poultry and humans but are also responsible for transmitting Campylobacter. *C. jejune* is the most prevalent species found in wild birds (Ahmed et al. 2022). It is important to highlight the potential zoonotic diseases from wild birds so that regular surveillance can be done in practice for early detection and control of emerging infectious diseases. These proactive measures help to prevent the spread of diseases and protect human health (Shah et al. 2022). Surveillance over a broad geographical area is possible with hypothesis-driven methods through standardized and local surveys. In surveillance, it is always important to share samples taken and geographical areas from where and when samples are collected (Hoye et al. 2010).

This chapter will cover all emerging and reemerging zoonotic diseases transferring from wild birds to other species of birds like poultry and also infect humans. These pathogens are of serious public health concern because they cannot only affect immune system but also lead to other symptomatic signs.

2. VIRAL DISEASES TRANSMITTED FROM WILD BIRDS

2.1. NEWCASTLE DISEASE

Newcastle disease virus belongs to *Avulavirius* genus. Data was isolated from various wild birds and free-ranging birds and tested for NDV. It is found that almost 17 species of different habitat is found top shed vaccine derived NDV. Lasota and Hitchner B1 are the most commonly found strains. The synanthropic and ubiquitous nature of wild pigeons highlights their potential role in shedding of low virulent NDV in environment (Ayala et al. 2016).

In NDV, there are six genes forming the code of 6 proteins. In this structure of virus fusion protein plays an important role. Fusion protein is basically non-functional, and host protease breaks down this protein into F1 and F2, which is responsible for the induction of pathogenicity (Zanetti et al. 2005). NDV can be transmitted directly from excretion or indirectly by consuming infected poultry products.

3. WILD BIRDS TO OTHER SPECIES

3.1. WILD BIRD-BIRD TRANSMISSION

NDV Pigeon variant virus and virulent enteric NDV transmit from bird to bird or commercial poultry by ingesting feces from infected birds. Birds that take virus from this route usually have respiratory tract involvement.

4. WILD BIRD TO HUMAN TRANSMISSION

Poultry faces numerous economic losses after getting infected by wild birds (Rehan et al., 2019). Humans having direct contact with poultry, i.e., poultry practitioners, may harbor infection. Other route of infection is consuming infected meat and eggs (Abdisa and Tagesu 2017).

5. CLINICAL SIGNS

5.1. POULTRY

Clinical signs in poultry vary according to strains of the virus. It may cause 100% mortality if the strain is virulent, and birds end up with prostration and death. In neurotropic NDV form, neurogenic lesions are followed by respiratory tract involvement. The mesogenic form of ND only causes mortality in young birds and causes respiratory problems associated with a drop in production. The lentogenic form of ND causes few signs only in young birds. These signs include airsacculiutis and colisepticemia. This form of ND is also prevalent after vaccine exposure. In ND, the gross lesions observed are hemorrhages in the proventriculus and ulcers in the intestine as shown in Fig. 1.

6. HUMAN

a) Usually have eye infection including unilateral and bilateral reddening, excessive lachrymation, edema of eyelid, conjunctivitis, and subconjunctival hemorrhages. Transient infection is there, and it doesn't affect the cornea.
b) There may be chill, fever, headache, and can have conjunctivitis or without conjunctivitis.

Fig. 1: Proventricular hemorrhages and ulcers in the intestine of NDV-infected poultry bird

7. AVIAN INFLUENZA

Avian influenza is highly pathogenic and causes major economic loss in poultry. This virus is a pandemic and global threat worldwide as high pathogenic avian influenza (HPAI) not only infects poultry but is also reported as a zoonotic virus and is present in the human population. It is also reported that wild birds and migratory birds, especially waterfowl, is reported as a natural reservoir of this virus. Waterfowl not only carry this pathogen but also transfer it along the path of their migration, leading to antigenic shift and drift in this virus, which results in the emergence of new strains in avian influenza and can be more lethal (Reed et al., 2003)

H5N1, highly pathogenic avian influenza is reported in poultry that is transmitted from wild waterfowl. There are two subtypes of avian influenza depending upon two surface proteins of this virus, one is haemagglutinin (HA) and other is neuraminidase (NA). There are 16 HA and 9 NA proteins identified in birds. These subtypes are also reported in humans and adopt shifting and drifting mechanism to sustain in human population and other species (Abubakar et al. 2023).

Since 2003, HPAI (H5N1) has been reported as enzootic and cause a serious outbreak in poultry and disease in human. Anseriformes, the order of waterfowl in wild birds, are reported as a natural reservoir of low pathogenic avian influenza (LPAI). In a recent study, it is also reported that H5N1 is also present in waterfowl. This led to a conclusion that waterfowl, a natural reservoir of LPAI can get antigen shifting and drifting, which leads to its conversion into HPAI and causes great economic loss and is of serious public health concern (Kim et al. 2012). It is reported that HPAI H5 is only found in the surrounding wild birds where poultry outbreak occurs. Outbreak of H5N1 is also season-dependent. It mostly occurs in winter. Samples collected from juvenile birds are negative for HPAI. H5N1 in mild migratory or adult birds is common due to their migration from one premise to another (Siengsanan et al. 2009).

Influenza A virus causes high mortality (100%) in poultry. HPAI includes H5 and H7 viruses are basically transmitted primarily by direct contact with wild birds and, secondly human involvement either by migration of birds or infected feces. In overall outbreak, this virus caused hundreds of mortalities in poultry and posed a significant public health concern (Alexander 2007). Low pathogenic avian influenza (LPAI) can be converted into high pathogenic avian influenza (HPAI). To report effective surveillance in wild birds, it is important to practice postmortems, lab practice, and improve diagnostic capabilities (Gourlay et al. 2014).

8. CLINICAL SIGNS

8.1. WILD BIRDS

In wild birds, it usually remains asymptomatic. They can only carry the disease virus, harbor it, and transfer it to domestic poultry birds via feces and their secretions in the vicinity of domestic poultry (Abubakar et al. 2023).

8.2. POULTRY

Classical signs involve cyanosis and edema of the head, vesicle and ulceration on combs, edema of feet, petechiation in abdominal fat and various mucosal and serosal surfaces, and necrosis or hemorrhages in the mucosa of proventriculus and gizzard. All AI viruses are categorized as either low or high pathogenic AI. HPAI produces severe signs and symptoms as compared to LPAI. It also produces high mortality and severe systemic infection. This virus is excreted in large amount in the respiratory tract and to a lesser contact in the intestinal tract. Death is always associated with high replicating titers in the host (Swayne and Pantin-Jackwood 2006).

9. HUMAN

Flu-like illness and weak immune response was reported in human infected with HPAI. Reassortment of H1N1 occurred, and this strain is a new emerging zoonotic pathogen. This virus is reported to have a 60% case fatality rate with H5N1 associated and sporadic in nature, and human-to-human transmission is occasionally limited (Van Kerkhove et al. 2011).

10. BACTERIAL DISEASES

10.1. SALMONELLOSIS

Salmonellosis is also an emerging zoonotic disease that is transmitted from wild birds. *Salmonella enterica* subtype typhimurium is commonly associated with wild birds. Viruses can be direct (from contact with their excretions) or indirectly (from an infected environment or surfaces) transmitted from wild birds. Humans get infections by eating contaminated poultry products (Tizard 2004).

In an agriculture farm near affected calves with salmonellosis, samples were collected to check the prevalence of these bacteria in the environment. Samples from municipal waste and in different birds fecal samples were positive for salmonellosis. This result indicates that not only household poultry feeding on infected fecal samples are at risk of infection, but humans can also get infected from the infected environment (Cizek et al. 1994).

In a study, it is reported that salmonella infection is transmitted from wild birds to Humans. Migratory birds are not natural carriers of salmonella bacteria. Therefore, the incidence of the occurrence of salmonella in wild birds is relatively low (Hernandez et al. 2003). There are different pathways in which wildlife can transmit salmonella to humans.

a) Direct contact with humans.
b) Via contact with transmitting vectors or domestic animals.
c) Via consumption of contaminated food products like eggs and meat (Hilbert et al. 2012).

The leading cause of food-borne zoonosis is nontyphoidal salmonella. Antimicrobial resistance of salmonella in food and wildlife is checked by taking samples from both of them and find that none of wildlife samples showed resistance against any antimicrobial. Still, in food samples, there was a resistance of one antimicrobial. Hence, antimicrobial resistance is an issue faced in foodborne pathogens (Aung et al. 2019).

As salmonella is prevalent in feed sources, different strategies must be adopted to control salmonella in feed and cease its replication. Salmonella killing may involve thermal processing and chemical treatment. Contamination of feed is prevented by dust, contaminated vehicles, rodent infestation, and management of the flow of equipments and humans. Thermal treatment prevents the replication of bacteria but does not completely remove it. Chemical treatment, like the addition of organic acids or formaldehyde, may reduce the pathogen load (Jones 2011).

In a recent study, it is investigated that samples of salmonella isolated from wild birds (waterfowl and raptors are found 1.87% multi drug resistance. But their number is quite low that's why it is not major concern but continuous survillence is necessary to prevent antimicrobial resistant *S. typhimurium* in human (Fu et al. 2022).

11. WILD BIRDS

Salmonella typhimurium causes huge mortality in wild birds, as reported in 2000. *S. typhimurium* causes a huge loss in the winter and spring season in wild birds. Birds usually have acute septicemia with multifocal necrosis of the liver and spleen. It is an emerging disease and also reported in wild sparrows as this bird has a close association with humans, which may lead to serious public health concerns (Alley et al. 2002).

12. POULTRY

In poultry, there are two host-adapted serovars: *Salmonella pullorum* (Fowl Typhoid) and *Salmonella gallinarum* (Tariq et al. 2022). White pasted vent due to white diarrhea is a common problem in fowl typhoid. Further gross lesion involves hepatomegaly and bronzed color discoloration of the liver, as shown in Fig. 2.

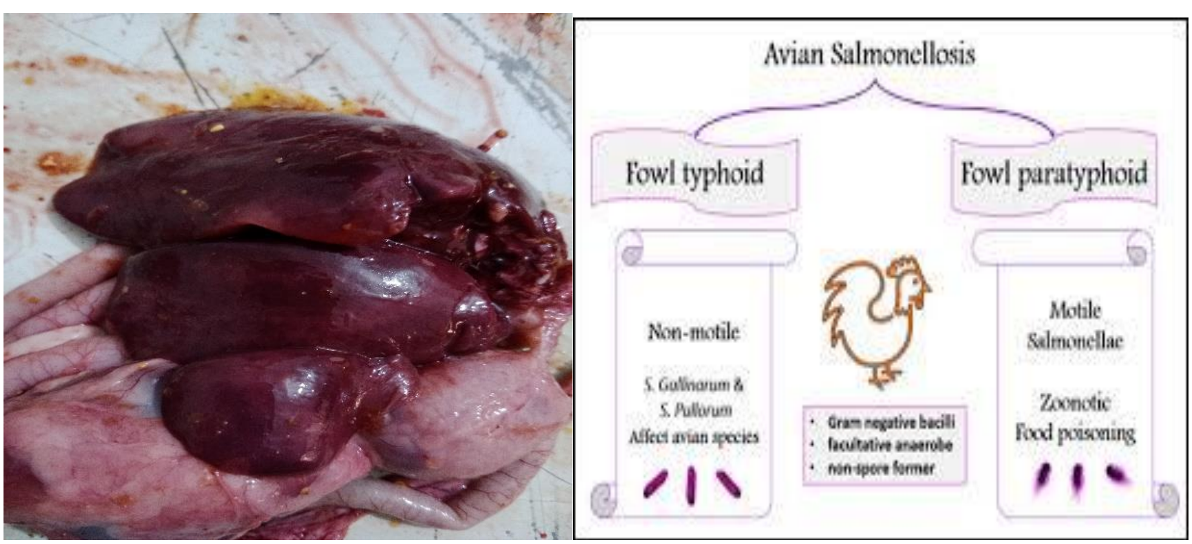

Fig. 2: Fowl typhoid infected poultry bird having bronzed color discoloration.

13. HUMAN

Salmonella in human cause lethargy and anorexia. 57% of infected animals suffered from vomiting, and 31% had diarrhea, as reported in a recent study on transmission of *Salmonella typhimurium* from wild birds (Tauni and Osterlund 2000).

14. *E. coli*

E. coli is a common bacterium found in the gut of animals. It can cause pathogenicity and is now an emerging zoonotic disease. Antimicrobial resistance against these bacteria is a serious public health concern. Samples from wildlife are collected and confirmed for *E. coli*. After this, antimicrobial resistance was checked and samples were found resistant to each class of antimicrobial from 3.8 to 73.1%. These resistant bacteria were further detected for antimicrobial resistant (AMR) genes and found that bla_{TEM-1B} and qnrS1 could be the resistant genes found commonly in the environment (Ong et al. 2020).
Wild birds and cattle harbor antimicrobial-resistant *E. coli* and have the potential for interspecies transmission. Samples were collected from wild birds pooled and cattle. These samples were tested against *E. coli* and the prevalent serotype was O9H4, O9H9, and O9H30. Many enterobacteriaceae produce third-generation cephalosporins (3GC) hydrolyzing enzymes (Extended spectrum *b* lactamases-ES*B*L), which makes them resistant to 3GC (Fashae et al. 2021).
The emergence of AMR in wild birds is due to the dissemination of contaminated environment and exposure to resistant bacteria because wildlife is rarely exposed to direct antimicrobial agents. There were 5.8% AMR strains, and 26.3% were multi-drug resistant found in isolates of wildlife isolates. These isolates harbor three genes $bla_{CTX-M-15}$, $bla_{CTX-M-55}$ and $bla_{CTX-M-65}$ originating from grey herons, carrion crows and common blackbirds. Among these genes, $bla_{CTX-M-55}$ was responsible for recent antimicrobial resistance against fluroquinolone (Zurfluh et al. 2019).
A total of 115 *E. coli* and 138 Enterobacteriaceae were observed antimicrobial resistant. In all enterococcal isolates, *Enterococcus fetalis* is the most prevalent species among this. In the enterococcus strain, high resistance was reported against tetracycline to ciprofloxacin and erythromycin. Low antimicrobial resistance to ampicillin, teicoplanin, and chloramphenicol. These resistance genes were reported to transfer from wild birds to poultry and humans (Santos et al. 2013).
Shiga toxin-producing *E. coli* (STEC) is usually zoonotic and includes O157:H7 strain. STEC with O157 strains is easily detectable. Although non O157 strains are also present these are difficult to detect. The main source of infection is the environment, drinking water, and food contaminated with direct contact or infected feces or contaminated environment. Different strategies are adopted to control the zoonotic STEC, including treatment with probiotics (direct-fed microbial or competitive exclusion), modification of diet, and administration of bacteriophages (Fairbrother and Nadeau 2006).
Wild birds are reservoirs and potential sources of dissemination of antimicrobial-resistant pathogens. These resistant bacteria can be transferred from birds to humans and vice versa (Bonnedahl and Jarhult 2014).

15. WILD BIRDS

None of STEC is reported to cause signs and disease in wild birds (Morabito et al. 2000).

16. POULTRY

In poultry, signs of *E. coli* include fibrinous pericarditis and perihepatitis, as shown in Fig. 3. Acute septicemia and lymphocytic depletion of the thymus and bursa is also observed. *E. coli* results in colibacillosis. Higher prevalence of avian pathogenic *E. coli* causes huge economic loss in poultry (Van der Westhuizen and Bragg 2012).

Fig. 3: Bird suffering from *E. coli* having pericarditis and perihepatitis.

17. HUMAN

Enterotoxigenic *E. coli* can cause complex illness syndrome and basically involve enteric signs due to enteritis (Porter et al. 2016).

18. CAMPYLOBACTER

Campylobacter has been isolated from various species of wild birds and *C. jejuni* is the most prevalent among all. The prevalence of these bacteria in wild birds is variable depending upon bird species, season, geographical location, ecological factor, bird's health status, samples used, and method type. All bacteria reported in poultry or humans can't be of wild bird origin (Ahmed and Gulhan 2022).

Wildlife may be the zoonotic carrier of campylobacter. *C. jejuni* and *C. coli* are not only responsible for enteric syndrome but can also cause extra intestinal disease in human. These two strains were isolated from the long-eared owl and is reported as antimicrobial resistant after testing with different methodologies. These resistant antibiotics are enrofloxacin, ciprofloxacin, sulfamethoxazole and trimethoprim (Casalino et al. 2022).

Campylobacters isolated from wildlife such as waterfowl is isolated and these bacteria are tested to identify the pathogenic genes. There is high variability in testing the pathogenic gene and environmental pathogen. *C. coli* is mostly isolated from environmental samples.

Virulence genes were detected in isolated of wild birds are cadF, flaA and cytolethal distending toxins. It was also reported that in samples of daurian jackdaw, crow, and silver pheasant the virulent gene was cdt gene. Silver pheasant harboring *C. jejuni* has truncated cdt gene clusters. It is also reported that urban and suburban areas having wild birds harbor campylobacteriosis and of serious public health concern not only for poultry but also important for public health concern (Du et al. 2019).

Campylobacter not only involve in gastroenteritis but also trigger Guillain-Barre syndrome which is a poly neuropathic disorder. *C. jejuni* causing this syndrome is reported to have wlaN or cgtB genes. These genes code for an enzyme β-1,3-galactosyltransferase that is required for sialylated lipooligosaccharide. These gene sequencing highlight various new variants that are predominant in wild birds and similar genes were isolated from broiler chicken and human infected with *C. jejuni* (Guirado et al. 2020).

19. WILD BIRDS

Wild birds may serve as a reservoir of campylobacter, but they show no signs. These bacteria reside in the intestinal tract of wild birds (Kwon et al. 2017).

20. POULTRY

Poultry birds may serve as a carrier of this pathogen and show intestinal signs, including gastroenteritis, but are the primary source of pathogen transfer via contaminated carcass or meat (Umar et al. 2016).

21. HUMAN

Poultry birds are the leading cause of campylobacteriosis and gastroenteritis in humans worldwide. Contaminated premises and poultry products are the main routes of transmission by this pathogen (Sahin et al. 2015).

CONCLUSION

Wild birds are natural reservoirs of many zoonotic pathogens. These birds may not directly lead to the potential zoonotic diseases but, transfer these zoonotic pathogens to poultry that comes in contact with human and leads to major public health concern.

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