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Review on the prevalence of potential zoonotic bacterial pathogens in pigeons and their emergence of multi drug resistance.

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ABSTRACT

wildlife has spread over urban areas and become more accustomed to human habitats, some species-like gulls and pigeons-are now commonly thought of as permanent residents in Indian and European metropolitan regions, which has a number of detrimental effects. For example, these birds have already been linked to the spread of disease to people, therefore there may be significant health implications. Humans select domestic species based on a wide range of morphological and behavioral characteristics for purposes such as meat quality, eggs, fur/plumage, companionship, competitions, and task performance. Public health may be greatly impacted by pigeon excrement in public locations, which have been found to be a source of bacterial pathogenic diseases like *Salmonella*, *E. Coli*, and *Campylobacter* in multiple publications. When pigeons are unwell or exhibit no symptoms, they can release harmful *Escherichia coli* into the surrounding air. Hence could contribute to the environmental spread of these infections. Pigeons play a significant role in the transmission of salmonellae. To comprehend the dynamics of resistant bacteria's transmission and prevent the creation of new pathogens, multi-sectoral One Health approaches are necessary to address antimicrobial resistance, which has emerged as one of the most significant global health challenges of the twenty-first century. Antimicrobial resistance has been linked to wild birds as possible sentinels, reservoirs, and vectors. The present review aims to throw the light on the disease transmission and the spread of multidrug resistant microbial pathogens through pigeons.

Keywords : Pigeon, public health, pathogen, multidrug resistance.

INTRODUCTION

Pigeon belongs to the order *Columbiformes* and is a plump, rounded-bodied bird in the family *Columbidae*. There are 289 species in the family *Columbidae* globally, with 30 of them species being found in the Indian subcontinent (Dey *et al*., 2013).). 289 species of pigeons are known to exist among the 8600 bird species that are known to exist. Pigeons have long been used in human civilization as a food source and as cage birds (Dutta *et al*., 2013). Many farmers raise pigeons in their homes, and they are seen to be a staple diet for the wealthy (Ibrahim, 2007).Pigeons are extensively available in Egypt and are valued by many, particularly during hunting and racing festivals.There are three types of pigeons: racing, carrier, and poultry. In addition, certain foreign pigeons, such as Porter, King, and others, are incapable of hatching their eggs, but our native pigeons are able to do so. Thus, for us, this is a good scope. Hence the Pigeons are called as "Birds of all countries" (Sari *et al*., 2008).Humans select domestic species based on a wide range of morphological and behavioral characteristics for purposes such as meat quality, eggs, fur/plumage, companionship, competitions, and task performance (Kruska 1988; Francis 2015).The homing pigeon (*Columba livia*), among the numerous species and varieties that humans have tamed, is arguably one of the most well-known instances of artificial selection for a behavioral characteristic. The ancestor of domestic pigeons, the wild rock dove, uses homing to navigate between nesting and foraging sites 20 km apart (Alleva *et al*., 1975; Baldaccini*et al*., 2000). However, due to decades of intense selection and training by competitive pigeon racers, homing pigeons can navigate home from a novel location over 1,000 km away (Guyonnet 2022; Kligerman 1978).

PIGEON – A FACTOR OF HUMAN HEALTH AND ILLNESS

Pigeons may be quiet carriers of numerous undetected human illnesses. They can potentially spread more than thirty diseases to people and ten more to household animals. It is clear that pigeon droppings are causing environmental contamination. It has previously been investigated how different pathogenic agents can spread from sick pigeons to different types of poultry (Alexander *et al*., 1985). Pigeons have been found to have numerous distinct zoonotic agents that have been detected and identified (Haag-Wackernagel., 2011). Past research shown that *Salmonella spp.* and *Escherichia coli* might potentially be found in both feral and domestic pigeons (Vasconcelos *et al*., 2018; Saim*et al*.,2023&Lacassin*et al*., 1995).

PIGEON MEDIATED ZOONOSIS IN DIFFERENT COUNTRY

Pigeon mediated zoonosis in Korea

In 2009, the South Korean Ministry of Environment designated pigeons as dangerous wild animals in response to public outcry, the fact that the birds spread disease and damaged property with their waste. Numerous studies (Comer *et al*., 2001; Donovan and Shinsek, 2013; Foucault *et al*., 2002; Leibler*et al*., 2016; Ralli *et al*., 2021 and Wolitski*et al*., 2007) have documented the ways in which the homeless population can contribute to public health issues. Additionally, some of the studies have discovered that the homeless play a significant role as vectors for zoonotic diseases (Comer *et al*., 2001; Foucault *et al*., 2002; Leibler*et al*., 2016).

Pigeon mediated zoonosis in Bangladesh

One of the native poultry species in Bangladesh is the pigeon, which is traditionally raised by impoverished farmers to support their livelihoods. Pigeons raised in commercial farms accounted for less than 1% of the poultry in any division (Dolberg.,2008). For many years, domestic pigeons have been raised in Bangladesh for their meat. In Bangladesh's coastal regions, pigeon rearing is done on a local scale, much like chicken rearing (Paul *et al*., 2015).

Pigeon in indian scenario

In an urban setting, they might also become polluted by intimate human contact (Haag-Wackernagel and Moch.,2004, Rosengren *et al*., 2009).Like other major cities across in India, there are various nosocomial zones, public gardens, and squares dispersed across the metropolis.

The evidence presented by Silva *et al*., (2009) indicates that drug-resistant *E. coli* strains have been discovered from pigeon excrement. These findings could be attributed to the misuse of these medications in our society.

In Indian cities, where pigeon populations congregate on public hospital grounds and surrounds, Wilson *et al*., (2024) conjectured that houseflies and wild pigeons may be conspicuous contributors to the spread of staphylococcal infections.

Kamaraj and Vuppu (2024) observed three distinct types of feathers in *Columba livia*. The majority of the down feathers on the body are small, shaftless feathers. The surface of the bird is aerodynamically shaped by contour feathers (Kardong, 2006). The fragile feathers known as filoplumes have a hair-like stalk, or shaft, with fine barbs at the tip. Every year, feather scraps are created, and because they are improperly disposed of in the environment, they can cause a variety of illnesses in both humans and animals.

INFECTION SPREAD BY FERAL PIGEON (*Columba livia)*AND DOMESTIC PIGEONS (*Columba liviaforma domestic)*

Columba livia pigeons are used to fly between islands in the region, and pigeon racing is growing in popularity on the island. It is unknown how many entero pathogens these pigeons have. In Trinidad, enteric pathogens including *Salmonella spp*., *Campylobacter spp*., and *Yersinia spp*. have been isolated from market meat (Adesiyun, 1993), slaughtered pigs (Adesiyun and Krishnan, 1995), and domestic cattle on farms (Adesiyun and Kaminjolo, 1994).

According to Haag and Wackernagel (2011), domestic pigeons, also known as *Columba liviaforma domestica*, are a common sight in urban areas across the globe, with an estimated population of several hundred million. Homing pigeons are considered an epidemiological link to wild birds and may spread infections due to their training and competitive flying. Moreover, racing flights have the potential to travel beyond 1000 km and cross international borders (Jakoby &Ko¨sters, 1983), which increases the risk of diseases spreading across large geographic areas.

DISSEMINATION OF MICROBIAL PATHOGEN THROUGH PIGEONS, PIGEON FAECES AND HUMAN CONTACT

Numerous ecto- and endo parasites can be found living on pigeons (Marques *et al.*, 2007; Sivajothi and Reddy, 2014). Protozoan and helminth parasites are examples of endoparasites (Ghazi *et al*., 2002).

Pigeons contracted the disease by eating or drinking tainted food or water, or by coming into close contact with dust, feathers, or excrement tainted with germs (Ritchie and Dreesen, 1988). According to numerous studies (Ibrahim 2008, Kobayashi *et al*., 2007), it is possible to isolate *Salmonella* from the feces and cloacal swab of infected pigeons in a variety of urban, suburban, and rural locations across the globe. These pigeons serve as carriers of the infection, assisting in its spread through their contaminated feces (Lillehaug *et al*., 2005, Jafari *et al*., 2007). Pigeon

droppings may house a variety of microbes, which could aid in the transmission of infectious diseases in urban settings (Haag-Wackernagel and Moch.,2004, Tanaka *et al*., 2005).
Humans commonly come into contact with feral pigeons since they are found in nearly every major city in the world in huge numbers (Haag-Wackernagel and Moch 2004).They haven't, however, had their potential health risk sufficiently evaluated. When cleaning feral pigeon excrement from buildings or culling them, clinicians are frequently faced with the need to inform people about the risk of catching disease.

BACTERIA PATHOGENS AND DISEASES LINKED TO PIGEONS

Diseases and diseases known as zoonoses are those that move haphazardly from vertebrates to humans. Over 1415 pathogens are known to be harmful to humans, with zoonotic illnesses accounting for over 61% of these infections (Akhter *et al*. 2020, Nupur *et al*., 2023). Zoonotic bacteria linked to companion birds comprise *Chlamydia psittaci*, *Salmonella species*, *Mycobacterium species*, *Campylobacter species*, *Borrelia burgdorferi*, *Pasteurella species*, *Klebsiella species*, *Yersinia species*, *Pseudomonas species*, *Aeromonas species*, *Citrobacter species*, and *Escherichia coli* (Akhter *et al*.,2010; Williams *et al*.,2011; Boseret*et al*. 2013).

S. aureus is the primary cause of **staphylococcal infections** in pigeons (*Columba livia domestica*). According to Sudagidan and Aydin (2012), Gharajalar and Shahbazi (2018), Chrobak-Chmiel *et al*. (2021), Badr *et al*. 2022 and other sources, it is acknowledged as the cause of skin inflammation, wound infections, skin abscesses, conjunctivitis, meningitis, and brain abscesses. Staphylococcal infection is particularly common in young pigeons subjected to increased physical demands during the race season and in birds that had previously or concurrently contracted another pathogen (Zigo *et al*., 2017, Szczuka*et al*.,2023).
Food poisoning is just one aspect of **salmonellosis.** In most cases, the symptom is gastroenteritis. A return of enteric fever or septicemia may occur many weeks later. Septicemias frequently result in death. Although they are less common, persistent infections remain crucial. An abscess or a local infection such as osteomyelitis, pyeleonephritis, meningitis, arthritis, or bronchopneumonia could be the cause. Because the bacteria are left behind wherever pigeons urinate, pigeons play a significant role in the transmission of salmonellae (MÜller 1965).
The intestinal tract microbiome of humans and animals normally contains *Enterococcus spp*. (Scupham *et al* 2008, Quednau, Ahrné, Petersson, & Molin 1998, Baele *et al* 2002, Stępień-Pyśniak*et al* 2016). Owing to the significant discharge of enterococci (105–107 /g per stool) with feces, there is a significant environmental contamination with these germs (Cetinkaya 2000). **Enterococci** are therefore present in a variety of biological niches, such as soil, water, animal feces, fermented foods, and plants (White et al 2022). Enterococcus species have consequently emerged as a potentially dangerous zoonotic pathogen that poses a serious global hazard and can result in serious public health issues (Hammerum 2012, Osman *et al*., 2019).
A **Streptococcosis**outbreak in five tiny breeding pigeon lofts in Poland was reported by Madej.,(1961). *S. gallolyticus* was sometimes discovered in the faeces and stomach of pigeons that were asymptomatic. It has been isolated from a variety of pigeon pathologies. Additionally, it was separated from the crop and a small percentage of healthy pigeons' pharynx (Devriese*et al*., 1990a). Caused by *Streptococcus gallolyticus (S. gallolyticus)*, formerly known as *S. bovis*, streptococcosis is a significant septicemic disease in pigeons (Devriese*et al*., 1990b; De Herdt*et al*., 1994 a and Devriese*et al*., 1999).
Listeria monocytogenes is the cause of **listeriosis**. It modifies the nervous system's cell structure. Skin infections, endocarditis, and conjunctivitis could result from it. In addition, it can result in

abortions, early deliveries, stillbirths, meningitis in infants, and even death. Pigeons are the source of the isolated organism.

The disease *Yersinia pseudotuberculosos* and *Yersinia enterocolitica* cause **yersiniosis** is similar to the plague. In terms of clinical presentation, the illness is identical to appendicitis. In addition to fever and pain in the stomach, these illnesses can induce nausea and headaches. In September 1976, 32 schoolchildren in Oneida County, New York were admitted to the hospital because to the similarities. An unneeded appendectomy was reported to have been performed on 14 patients. It was found that the sick youngsters had *Y. enterocolitica* serotype 8. First discovered in 1916, it was isolated from pigeons. Pigeon excrement, eggs, or ticks may all be vectors of transmission (Hubert 1972).

Pasteurella multicida is the bacteria that cause **parteurellosis**, and it is extremely contagious. Four categories of syndromes can be used to categorize the 157 disease: 1) infection of the lower respiratory tract, such as pneumonia or bronchitis; 2) infection of the upper respiratory tract, such as conjunctivitis or nasal discharge; 3) infection of internal organs, such as appendicitis or urinary tract inflammation; 4) abscessed wound infections. Through their droppings or nasal discharge, pigeons can disperse the bacterium. The organism can survive for three months in a dead pigeon or for up to a month in pigeon dung.

The Gram-negative, obligatorily intracellular coccoid bacteria that make up the *Chlamydiaceae*family are spread via physiologically inert particles known as elementary bodies (Ebs) (Binet and Maurelli, 2007). The most prevalent species that mostly infects parrots as **psittacosis** (ornithosis), pigeons (*Columbiformes*), doves, and mynah birds is *Chlamydi psittaci*. Though common clinical indicators include weight loss, diarrhea, anorexia, polyuria, respiratory signs (dyspnea), conjunctivitis, overheating, aberrant excretions, decreased egg production, and abrupt death, affected birds may not exhibit any symptoms at all (Vanrompay., 2020). *Chlamydi avium*, a recent addition to this family that causes diarrhea and respiratory illnesses in pigeons and psittacines, was discovered (Sachse *et al*., 2014).This bacterium has been found in pigeons in several European investigations (Sachse *et al*., 2014, Burt *et al*., 2018, Mattmann *et al*., 2019), but it is still unknown whether this bacterium may spread to humans. Similar to influenza, pustacosis in humans can cause pneumonia as well as non-respiratory conditions such endocarditis, myocarditis, meningitis, and conjunctivitis (Vanrompay*et al.*, 1995).

Possible factors influencing the Pigeon infections

According to Mohamed and Abdelaziz (2023), pigeons are susceptible to a variety of bacterial, viral, and parasite infections because of inadequate management, unsanitary housing, a lack of vaccines, seasonal fluctuations, heat stress, and humidity. Pigeons are a key source of numerous bacterial, viral, and parasite infections, including NDVs, Salmonella, MG, MS, and AIV. These pathogens can pose a hazard to domestic animals, poultry, humans, and the environment at large (Alexander, 2011; Hemida*et al*., 2019; Islam *et al*., 2020). Subclinical infections in pigeons can cause certain diseases to spread across long distances and for a set amount of time without showing any outward symptoms (Catroxo*et al*., 2011).

ANTIMICROBIAL RESPONSE OF PIGEON SPREAD PATHOGENS

The capacity of a bacteria to withstand antibiotic growth inhibition and death is known as antimicrobial resistance (Brauner *et al*., 2016).Antimicrobial resistance (AMR) bacteria pose a significant concern to public health due to the clinical burden of illnesses they produce (Nolan *etal*., 2023).

The issue of bacterial resistance to antibiotics sparked a conversation regarding the prudent application of antimicrobial medicines in animal health, nutrition, and farming. It is generally accepted that heavy antibiotic use is the primary risk factor for an increase in bacterial resistance. Both people and animals have the same issue (Zigo *etal*., 2017).

E. coli has emerged as the world's most dangerous public health threat due to its resistance to commonly prescribed antibiotics (Subashchandra Bose *et al* 2014). While sensitivity to some antibacterial drugs, such neomycin, enrofloxacin, florfenicol, and ceftriaxone, was encouraging, resistance to some antibacterial drugs, like amoxicillin, lincospectin, tetracycline, and doxycycline, was worrying (Jaafar and Abdullah., 2022).

The misuse and unmonitored application of antibiotics can lead to a drug-induced selection pressure, which in turn can cause the emergence of bacteria resistant to numerous drugs (Mathews *et al*., 2021).

MDR associated pathogen spread

According to Lapierre *et al*. (2020), there is a growing worry regarding the global public health issue of *Salmonella spp*. infections and the evolution of antibiotic resistance (MDR) from both human and poultry sources. Most *Salmonella spp*. virulence-associated plasmids have transfer functions,which means that plasmids are mobile genetic elements that carry resistance genes of one or more antimicrobial agents and facilitate the horizontal transfer of genetic material between related or unrelated species as well as among bacteria (Ammar *et al*., 2015 Eid *et al* 2023). Due of its interrelated transmission and emergence, antimicrobial resistance is one of the biggest dangers to public health worldwide (Martínez *et al*., 2011). Antimicrobial resistance has been linked to wild birds as possible sentinels, reservoirs, and vectors (Bonnedahl and Järhult, 2014). Public health is interested in synanthropic animals like urban pigeons (*Columba livia*) because of their close proximity to people and interactions with livestock and wildlife (Cunha *et al*., 2019). More research is required to determine the factors influencing the dissemination and persistence of resistant genes within these avian communities as well as to investigate their potential effects on ecosystems and public health.

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