

Migratory birds as carrier of zoonotic pathogens Eman, M. Rashad* and Shawky, A. Helmy**

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Review Article

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Abstract

Migratory birds are considered a dangerous biological source of diseases, as they carry pathogens to the places they go. As they migrate long or short distances, they land and rest in different places, bringing down pathogens with them. Some of microbe are carried mechanically on the feathers or in their digestive or respiratory systems, and some of them are biologically transmitted via migratory birds. The intermediate hosts, such as ticks, mosquitoes, and their bacteria and viruses, is either infected with microbes or carries them only without being infected with them. These are several microbes, which causes zoonotic diseases to public health. It is documented that birds that are free-living, especially migratory species, can spread serious harmful microbes. This review aimed to enumerate number of migratory birds act as carrier of different pathogens of animal and public health importance.

Keywords: *Migratory birds , intermediate host, zoonotic disease, virus and bacteria*

Introduction

Despite the lack of definitive evidence about the pathways of transmission, wild birds are thought to be reservoirs of many poultry diseases (Sánchez-Cano *et al.*, 2024). The diseases are spread over large geographic areas by migratory birds. Due to their ability to spread the fatal H5N1 avian influenza (bird flu) virus without becoming ill themselves, migratory birds have recently drawn attention from all around the world during bird flu epidemics. There have been reports of migratory birds dying from H5N1 in Asia. West Nile virus, equine encephalitis virus, and *Borrelia burgdor-*

feri are all spread by migratory birds (Dhama *et al.*, 2008).

Migratory birds have been linked to trillions of infections that are hazardous to poultry or other vertebrates, and they have the ability to disperse microbes over international borders. As biological, mechanical, or vectors of infected hematophagous ecto-parasites (such as ixodid ticks), migratory birds may contribute to the spread of germs. Free-living migratory birds have been linked to numerous types of germs that are harmful to humans and other homeothermic mammals (Hubalek, 2004).

Birds that migrate spread the diseases they carry by flying in short flights, especially at night and during stops (**Reed et al., 2003**). Migration-related stress might increase a bird's vulnerability to infections or speed up its pace of shedding. Due to the high demands of migration, birds that become infected may spread the viruses over shorter distances as opposed to longer ones (**Weber and Stilianakis, 2007**).

There are three ways that migratory birds might spread microbial pathogens: 1) as biological transporters, 2) as mechanical transporters, and 3) as hosts and transporters of ectoparasites that are infected. The prokaryotic and eukaryotic microorganisms (bacteria, fungus, and protozoa) and viruses which pose a threat to warm-blooded vertebrates and found in migrating birds or their ectoparasites are briefly reviewed (**Hubalek, 2004**). As biological carriers, the infection in migratory birds might be asymptomatic (salmonellosis, influenza), chronic (pox), or acute (Newcastle disease, duck viral enteritis, and pasteurellosis). Avian influenza viruses, paramyxovirus, herpes virus, *C. psittaci*, Salmonella, Campylobacter, *Mycobacterium avium*, *P. multocida*, and Clostridium spp. are all spread by the feces and nasal and respiratory exudates of infected migrants. Similarly, they move diseases and ticks from one location to another (**Hubalek, 1994, 2004**).

According to (**Najdenski et al., 2018**), a wide range of migratory birds may be zoonotic pathogen vectors. According to (**Najdenski et al., 2018**), enteric bacteria such Salmonella, Listeria, E. Coli, Yersinia, and Campylobacter are present in birds traveling through Bulgaria. Our findings show that birds using this highly active flyway could spread bacterial pathogens over long distances and potentially infect humans, animals, and other birds with antibiotic-resistant bacteria, even though the carriage of pathogenic strains of *Y. enterocolitica* and *L. monocytogenes* was minimal. Considerable studies have demonstrated the critical role migrating wild birds play in the ecology, movement, and spread of harmful organisms (**Reed et al., 2003**), such as arbovirus, influenza A virus (**Reed et al., 2003**), Herpesvirus, Chla-

mydophila psittaci, Anaplasma phagocytophilum, Mycobacterium avium, Duck plague, Newcastle disease, and Candida spp. (**Hubalek, 2004**), *Borrelia burgdorferi* (**Humair, 2002**), Salmonella species, *Campylobacter jejuni*, *Escherichia coli*, enterotoxigenic and verotoxin-producing bacteria (O157-H7), and blood sucking ectoparasite infections are examples of pathogenic enterobacteria that function as biological and mechanical vectors of pathogens (**Hubalek, 1994; Wallace et al., 1997; Hernandez et al., 2003; Reed et al., 2003**).

1. Viruses isolated from different birds in different places:

VIRUSES	Migratory birds' types	Region	Reference
Togaviridae: Genus Alpha-virus Sindbis virus Afr, Eur, As, Aus Arboviruses	migratory spp. Motacilla alba	India	Shah <i>et al.</i> (1960)
	Streptopelia turtur	Israel	Nir <i>et al.</i> (1967)
	Ardeola ralloides	Azerbaijan	Gaidamovich <i>et al.</i> (1968)
	the common snipe (Gallinago gallinago)	Tajikistan	Gordeeva (1980)
	Reed warbler (Acrocephalus scirpaceus), Sturnus vulgaris and Vanellus vanellus	Slovakia	Ernek <i>et al.</i> (1973, 1977)
	free-living migratory birds	Estonia	Uryvaev <i>et al.</i> (1992)
		Fennoscandia	Huba'lek (1994), (2004)
Eastern and western equine encephalitis viruses	songbirds and Culiseta melanura mosquitoes	America	Hill <i>et al.</i> (2023) Huba'lek (2004)
Venezuelan equine encephalitis virus	young herons and ibis	Central America	Dickerman <i>et al.</i> , (1976)
Mayaro virus (Mosquito borne)	orchard orioles and Red-eyed vireo	Louisiana in the USA	Calisher <i>et al.</i> (1974)
Semliki Forest virus (Mosquito borne)	Motacilla flava	Kazakhstan	Huba'lek (2004)
Flaviviridae: genus Flavivirus Japanese encephalitis viruses.	in colonial ardeids Nycticorax and Egretta spp. herons	Asia	Boyle <i>et al.</i> (1983)
West Nile virus Afr, Eur, As, Am WNV encephalitis arboviruses	migrating Sylvia nisoria An ectoparasite in the eastern Mediterranean.	Cyprus	Watson <i>et al.</i> (1972)
	Tringa ochropus, Larus ridibundus, S. turtur and V. vanellus	Slovakia	Ernek <i>et al.</i> (1977)
	wild birds (Sterna albifrons)	Tajikistan	Gordeeva (1980)
	other migratory species	Europe	Huba'lek (1994)
	cloacal and oral swabs of dead (Corvus brachyrhynchos) and Cynocitta cristata	North America	Komar <i>et al.</i> (2002)
	S. turtur, M. alba, and many migrating young storks (Ciconia ciconia)	the Middle East	Malkinson <i>et al.</i> (2002)
	A large number of wild Migratory birds	North America	Reed <i>et al.</i> (2003) Hubalek (2004)
	Passerine birds, European Robin, Common Whitethroat, Common Redstart, Common House Martin, Lesser Whitethroat, Song Thrush	Sweden	Olofsson <i>et al.</i> (2024).
Usutu virus: USUV: an African mosquito-borne Flavivirus	Passerine birds, Common Whitethroat, Common House Martin	Sweden	Olofsson <i>et al.</i> (2024).
	caused an epornitic among the common blackbird (Turdus merula) in Austria during late summers in 2001–03	only in South Africa	Weissenböck <i>et al.</i> (2002)
St. Louis encephalitis flaviviruses): (SLEV): American mosquito borne Flavivirus	free-living migratory birds	the Caribbean and Amazon basin America	Theiler and Downs (1973). Huba'lek (2004)
Tick borne encephalitis virus (TBE): complex viruses:	by transporting infected ixodid ticks) nymphal Ixodes Ricinus collected on T. merula	Slovakia	Ernek <i>et al.</i> (1968)
	Migratory passerine birds	Russia	Alekseev &Dubinina, (2003)

1. Viruses isolated from different birds in different places:

<i>Omsk hemorrhagic fever (OHF) and Kyasanur Forest disease (KFD):</i>	the tick borne KFD virus might be a variant of OHF virus after transport to the Indian subcontinent by migrating birds' Russian spring-summer virus	India	Work (1958)
		Siberia	Hubalek (2004)
<i>Tyuleniy virus</i>	Ixodes uriae ticks inhabiting nests of seabirds and it is brought via the birds	Nauka, Moskva	(Lvov and Ilichev, 1979).
<i>Meaban virus</i>	Ornithodoros maritimus ticks collected in nests of Larus argentatus; Sterna paradisaea terns	France	(Chastel, 1988).
<i>Bunyaviridae: Genera bunya virus, Nairo virus Simbu group bunyaviruses: (mosquito-borne): Ingwavuma virus</i>	two northward-migratory the spotted flycatcher in Cyprus,	Egypt	Watson et al. (1972)
<i>Thimiri virus</i>	Lesser whitethroat Bird and common white throat		
<i>Tete group bunyaviruses: Bahig virus and Matruh virus</i>	south- migrating Eurasian birds; prevailing hosts were Sylviidae, Finches - Fringillidae, and Turdidae.	Egypt and Cyprus	Watson et al. (1972) Hoogstraal (1976)
<i>Tete group Bahig virus</i>	larval Hyalomma marginatum rufipes ticks parasitizing a northward-migrating Oenanthe oenanthe	Egypt and Italy	Converse et al. (1974)
<i>Bhanja virus: such as (CCHF virus)</i>	migrating birds as carrier of infected immature amblyommine ticks	Czechoslovakia	Hubalek et al. (1982)
<i>Reoviridae: genus Orbivirus Kemerovo virus (tickborne): Mono Lake virus</i>	Phoenicurus phoenicurus that migrate a southward a migrating common redstart of Eurasia.	Egypt	Schmidt and Shope (1971)
<i>Other orbiviruses of the Great Island antigenic complex</i>	I. uriae ticks inhabiting seabird nests from Argas cooleyi (Acari: Argasidae)	Colorado	Calisher et al. (1988)
<i>Orthomyxoviridae Influenza A virus: All of the antigenic subtypes (H1-H14 and N1-N9)</i>	aquatic migrating birds, (ducks, geese, terns, gulls, shearwaters, guillemots, and, less often, passerine species and shorebirds) Aquatic waterfowl are asymptomatic carriers	worldwide	Reed et al. (2003) Fouchier et al. (2003) Hubalek (2004)
<i>HPAI H5N1 virus</i>	bar-headed geese	China	Zhou et al. (2006)
	(Common tern -Sterna hirundo) migrating wader populations	worldwide	Stroud et al. (2004) Dhama et al. (2008)
<i>different (LPAI) viruses (Majority)</i>	migrating ducks, gulls, geese, and other shorebirds,	worldwide	Dhama et al. (2008)

1. Viruses isolated from different birds in different places:

<i>HPAI H5N1virus</i>	free-grazing ducks	Southeast Asia	Gilbert <i>et al.</i> (2008)
	house sparrows and rock pigeons	USA	Brown <i>et al.</i> (2009)
	wildfowl	Asia, Europe and Africa	Gaidet <i>et al.</i> (2010)
	Eurasian tree sparrows	Japan	Yamamoto <i>et al.</i> (2013)
<i>H9N2 AIV</i>	wild terrestrial birds	Pakistan	Iqbal <i>et al.</i> (2013)
<i>Avian influenza a virus</i>	Anseriformes (ducks, geese) Psittaciformes (parrots) Apodiformes (swifts) Cuculiformes (cuckoos)	Delaware Bay, USA	Caron <i>et al.</i> (2017)
<i>HPAI H5N1virus</i>	Feral birds and trading in domestic fowls may bridge transmission to native birds.	Nigeria	Meseko <i>et al.</i> (2018)
<i>AIV H6N1, H6N2, H9N2, and H10N7</i>	wild fauna (Gulls, Dabbling ducks)	Netherlands	Elbers & Gonzales. (2020)
<i>AIV</i>	Synanthropic birds, European starling, Crow, House sparrow and Pigeon	USA	Shriner & Root. (2020)
<i>H1N6, H3N6, H4N6, H4N8, H9N1, H11N9</i>	Wild migrating waterfowl	Sub-Saharan Africa	Kalonda <i>et al.</i> (2020)
<i>HPAI</i>	wild waterfowl	Russia	Blagodatski <i>et al.</i> (2021)
<i>AIV H4N6</i>	European starlings	USA	Ellis <i>et al.</i> (2021)
	a flocking passerine, <i>Sturnus vulgaris</i> (<i>Colinus virginianus</i>)	USA	Root <i>et al.</i> (2022)
<i>AIV</i>	peridomestic wild birds House sparrows	the Emirates	Hirschinger <i>et al.</i> (2021)
<i>HPAI, H5N1 clade 2.3.4.4b Eurasian lineage viruses.</i>	deaths in domestic and wild birds and mammals involving major die-offs in seabird settlements and among endangered species.	Worldwide	Caliendo <i>et al.</i> (2022)
<i>Avian influenza virus</i>	wild waterfowl	USA	McDuie <i>et al.</i> (2022)
<i>HPAI</i>	Magpies, Blackbirds, Cattle Egrets, Pheasants, Eurasian Collared Doves and Wood Pigeons	Italy	Martelli <i>et al.</i> (2023)
<i>H5N1 HPAI clade 2.3.4.4b</i>	wild and domestic birds	USA	Youk <i>et al.</i> (2023)
<i>HPAI H5N1virus</i>	wild birds	China	Xie <i>et al.</i> (2023)
<i>Paramyxoviridae: Newcastle disease viruses</i>	healthy wild birds	Argentina	Zanetti <i>et al.</i> (2005)
	many species of free-living Migratory birds	worldwide	Dhama <i>et al.</i> (2008)
	peridomestic wild birds	the Emirates	Hirschinger <i>et al.</i> (2021)
	wild cattle egrets and house sparrows	Egypt	Abd Elfatah <i>et al.</i> (2021)
<i>Pneumoviridae: avian pneumovirus</i>	choanal swab or nasal turbinate samples of a variety of wild birds like geese, mallards, sparrows, swallows and starlings	India	Dhama <i>et al.</i> (2008)
<i>Picornaviridae: Foot-and-mouth disease V.</i>	mechanical carriers with migrants (<i>S. vulgaris</i> , <i>C. frugilegus</i> , <i>Larus</i> spp.) domestic poultry and free-living birds	continental Europe to the British Isles	Huba'lek (2004)
<i>Adenoviridae: Egg drop syndrome virus:</i>	migratory ducks, coots, and grebes, by migratory anseriform species'	Europe, Israel, and USA.	Huba'lek (2004)
<i>Herpesviridae duck plague herpes- virus</i>	wild anseriforms (ducks, geese, swans) carried by healthy migratory waterfowl (<i>Branta canadensis</i> , <i>Anas</i> spp.)	North America and Europe	Wobeser (1997) Dhama <i>et al.</i> (2017)
	wild birds		Ziedler and Hlinak, (1992)
<i>Poxviridae: genus Avipox-virus Avian pox</i>	fully 10 species of Avipoxvirus have been described in about 232 avian species Many of them affect migratory avian species	worldwide	Bolte <i>et al.</i> (1999)

2. Bacteria isolated from different birds in different places:

Bacteria	Migratory birds' types	Disease, Region	Reference
(1) <i>Rickettsiaceae</i> 1- <i>Rickettsia sibirica</i>	<i>Haemaphysalis concinna</i> ticks) a common rodent tick species (present on birds in the Far East	North- Asian tick typhus, tick-borne spotted typhus	Somov & Soldatov (1964)
<i>Rickettsia</i> species 2- <i>R. aeschlimannii</i> , 3- <i>R. helvetica</i> , and 4- <i>R. massiliae</i>	<i>Alcedo atthis</i> , <i>Athene noctua</i> , <i>Asio flammeus</i> <i>Buteo buteo</i> , <i>Bubo bubo</i>	Portugal	Santos-Silva, <i>et al.</i> (2006).
(2) <i>Coxiellaceae</i> <i>Coxiella burnetii</i>	<i>Hirundo rustica</i> , <i>P. phoenicurus</i> and <i>Motacilla alba</i>	Q-fever in Czech- land	Syru ^o c ^{ek} and Ras ^{ka} , (1956). Hubalek (2004)
	Acrocephalidae, Alcedinidae, Ardeidae Anatidae, Fringillidae, , Passeridae, Turdidae: Sylviidae, Paridae, Phylloscopidae, Motacillidae ... and other families	Bulgaria	Najdenski <i>et al.</i> , (2018)
(3) <i>Anaplasmataceae</i> 1- <i>Ehrlichia muris</i>	Migratory passerine birds	Russia	Alekseev & Dubinina, (2003)
2- <i>Anaplasma phagocytophilum</i> : <i>Holarctic</i>	Immature Ixodes scapularis or I. ricinus vector ticks associated with migratory passerine birds	Russia	Alekseev <i>et al.</i> (2001) Alekseev & Dubinina, (2003)
		Sweden	Bjoersdorf <i>et al.</i> (2001)
		North America	Daniels <i>et al.</i> (2002)
	Migratory birds	wide distribution	Hubalek (2004)
(4) <i>Chlamydiaceae Chlamydophila psittaci</i> :	terns, waterfowl, pigeons, shorebirds, Anseriformes, passerines, alks, gulls etc	ornithosis	Kaleta and Taday (2003) Dhama <i>et al.</i> (2008)
(5) <i>Mycoplasmataceae</i> 1- <i>Mycoplasma gallisepticum</i> :	Birds, passerines (Carpodacus mexicanus, Carduelis tristis)	mycoplasmal conjunctivitis USA	Hartup <i>et al.</i> (2001)
2- <i>Nonetheless, M. gallisepticum</i>	a short-distance migrant, (<i>Uria aalge</i>), three-toed gulls, silver gulls and black-headed gulls	German	Petermann <i>et al.</i> , (1989)
3- <i>Mycoplasma synoviae</i>	a dead black-legged kittiwake	Brittany, France	Kempf <i>et al.</i> (2000)
4- <i>Mycoplasma cloacale</i>	migratory tufted duck, The Eurasian skylark, and <i>Sturnus vulgaris</i>)	Great Britain & France	Bradbury <i>et al.</i> (1987)
(6) <i>Spirochaetaceae</i> <i>Borrelia burgdorferi sensu lato</i> genomic species (<i>B. burgdorferi sensu stricto</i> , <i>B. garinii</i> , <i>B. valaisiana</i> , but not <i>B. afzelii</i>):	Migratory birds transmit the infection to Ixodes ticks.	tickborne Lyme disease	Hubalek (2004) Reed <i>et al.</i> (2003)
	The Atlantic puffin blood	spirochetemia and reactivate infection in red- wing	Gylfe <i>et al.</i> (1999)
<i>Borrelia burgdorferi s.s.</i>	Acrocephalidae, Alcedinidae, Ardeidae Anatidae, Fringillidae, , Passeridae, Turdidae: ...and other families	Bulgaria	Najdenski <i>et al.</i> , (2018)
	Migratory passerine birds	Russia	Alekseev & Dubinina, (2003)

2. Bacteria isolated from different birds in different places:

<i>(V)Campylobacteraceae Campylobacter jejuni:</i>	aquatic and terrestrial wild birds V. vanellus, Milvus milvus, Eurasian coot, common moorhen, and Corvus frugilegus	intestinal campylobacteriosis	Sacks et al. (1986)
			Glunder (1989) in Germany
			Hubalek (2004)
	European starling and house sparrows	USA	Craven et al. (2000)
	European starlings	Ohio, USA.	Sanad et al. (2013)
	Wild Birds six species backed sparrows and Rock pigeon.	Malaysia	Elnohi et al. (2013)
	Sandhill cranes	Southcentral Alaska	Kwan et al. (2014)
	resident wild birds (crows and pigeons)	Tokachi area, Japan.	Shyaka et al. (2015)
	Western Jackdaws and Game Birds	Finland.	Kovanen et al. (2019)
	Wild Birds seven species. crows (Corvus sp.), daurian jackdaw (Corvus dauurica), silver pheasant (Lophura nycthemera), mallard (Anas platyrhynchos), mandarin duck (Aix galericulata), black swan (Cygnus atratus) and rock pigeon (Columba livia).	Beijing, China.	Du et al. (2019)
	Migratory seagulls various species of wild birds	worldwide	Ahmed & Gulhan (2022)
<i>Campylobacter jejuni strains</i>	Mandarin duck, mallard, Indian spot-billed duck, dunlin, common teal, Eurasian wigeon, Greater white-fronted goose, Black-tailed gull, Eurasian tree sparrow, azure-winged magpie, White-checked starling and greater sand plover	South Korea.	Wei et al. (2019)
<i>Campylobacter jejuni, C. lari, and C. coli</i>	Shorebirds, Passerines, and Turdus spp.	southern Sweden	Waldenstrom et al. (2002)
	Haematopus ostralegus, Pica pica	Northern England.	Hughes1 et al. (2009)
	wild and domesticated Mallard ducks (Anas platyrhynchos).	UK	Colles et al. (2011)
	Urban. and Rural. Black-Headed Gulls	north-central Poland	Indykiewicz et al. (2021)

2. Bacteria isolated from different birds in different places:

Campylobacter spp. <i>C. jejuni</i> and <i>C. coli</i>	Black headed gulls, Herring gulls and Common gulls	northern Germany.	Glünder <i>et al.</i> (1991)
	different migratory birds. Passeriformes	Campania region, Italy	Sensale <i>et al.</i> (2006)
	three Long-eared Owls (<i>Asio otus</i>) omnivorous species	Italy	Casalino <i>et al.</i> (2022)
	(Black-headed gulls and Great tits Parus major)	Poland	Andrzejewska <i>et al.</i> (2022)
	(Northern shoveler, Common pochard, Common teal, Northern pintail, Eared Grebe, Great Crested Grebe and Garganey)	Egypt	Tawakol <i>et al.</i> (2023)
Campylobacter 16S	Acrocephalidae, Alcedinidae, Ardeidae Anatidae, Fringillidae, , Passeridae, Turdidae: ...and other families	Bulgaria	Najdenski <i>et al.</i> (2018)
<i>Campylobacter fetus subsp. jejuni</i>	Hooded Crow, gulls, puffin, common tern, common gull, black-headed gull, herring gull, the Ural owl, goldeneye, and reed bunting	Norway	Kapperud & Rosef (1983)
Campylobacter spp.	wild birds Charadriidae, Ardeidae, Turdidae, Anatidae	South Korea	Kwon <i>et al.</i> (2017)
(8) <i>Vibrionaceae</i> <i>Vibrio cholerae</i>: <i>V. parahaemolyticus</i> and <i>V. mimicus</i>	faeces samples free-living migratory water birds	cholera outbreaks in China	Fu <i>et al.</i> (2019)
<i>Vibrio cholerae</i>, <i>V. fluvialis</i>, <i>V. alginolyticus</i>, <i>V. mimicus</i>, <i>V. vulnificus</i>, <i>V. parahaemolyticus</i>, <i>V. metschnikovii</i>	Eurasian sparrowhawk, common snipe, wood sandpiper, black-crowned night heron, squacco heron, Eurasian teal, common greenshank, red-backed shrike, icterine warbler, red-footed falcon, garden warbler, common whitethroat, common kingfisher, Eurasian blackcap, barred warbler.	Danube Delta Romania	Pall <i>et al.</i> (2021)
halophilic <i>Vibrio</i> spp.	fresh feces of six types of aquatic birds (gulls, pelicans, Canada geese, swans, egrets, cormorants)	Connecticut and Florida.	Buck (1990)
<i>Vibrio parahaemolyticus</i> Strains	Aquatic Bird Feces. Chroicocephalus brunnicephalus	Thailand	Muangnapoh <i>et al.</i> (2022)
	Feces of Mallard, Heron and Charadriiformes.	China	Zheng <i>et al.</i> (2023)
<i>Vibrio</i> Species	Wild Birds (Gulls), (Pelicans), (Ducks), (Shorebirds) and Domestic Birds. (Crows and Pigeons)	World wide	Ayala and Ogbunugafor, (2023)
<i>Aeromonas</i> sp. and <i>Vibrio</i> sp.	alive and debilitated wrecked marine birds	southeastern Brazil	Cardoso <i>et al.</i> (2018)
<i>Vibrio cholerae</i> and <i>Vibrio metschnikovii</i> Strains	Larus ridibundus, Pluvialis squatarola, Tadorna ferruginea, Anas poecilorhyncha, and Aix galericulata,	at Dali Nouer Lake in Chifeng, China.	Zheng <i>et al.</i> (2021)
(9) <i>Enterobacteriaceae</i> <i>Escherichia coli</i>: Enteropathogenic strains, as vero cytotoxin-producing O157:H7 strain,	migrants as grey heron Bird, Canada goose, tundra swan, common murre, and common wood pigeon	Colibacillosis	Huba'lek (1994)
	gulls	UK	Wallace <i>et al.</i> (1997)
Enterobacteriaceae	in European Wild Bird Species (Raptors, Waterbirds, Passerines)	Italy	Giacopello <i>et al.</i> (2016)

2. Bacteria isolated from different birds in different places:

Enterobacterales Strains	Raptors, Waterbirds Passerines	Italy	Russo <i>et al.</i> (2022)
<i>Shiga toxin-producing E. coli</i>	Migratory ducks and quails, Northern shoveler, Pintail, Common Teal, Mallard, Common Coot, Quail	Egypt	Seleem <i>et al.</i> (2021)
<i>E. coli</i>	Crow, Black Bittern, Myna, Sparrow Hawk, Yellow Bittern, Black-naped oriole, Brahminy Kite, Crested Goshawk, Grey Heron, Hooded Pitta, Pied Fantail, Scops Owl	Singapore	Ong <i>et al.</i> (2020)
<i>diarrheagenic E. coli</i>	Wild birds and urban pigeons	Brazil	Borges <i>et al.</i> (2017)
<i>Escherichia coli</i> 16S	Acrocephalidae, Alcedinidae, Ardeidae Anatidae, Fringillidae, , Passeridae, Turdidae: ...and other families	Bulgaria	Najdenski <i>et al.</i> (2018)
<i>E. coli</i> virulence genes	wild bird Faeces)Seagulls, waterfowl ,feral pigeons and <i>Athene noctua</i>	Italy	Bertelloni <i>et al.</i> (2019)
<i>Enteropathogenic E. coli</i> and <i>Shiga-toxin producing E. coli</i> (EPEC and STEC)	Captive wild birds (Psittaciformes) ,)Strigiformes) and (Columbiformes).	Brazil	Sanches <i>et al.</i> (2017)
<i>Verocytotoxin-producing E. coli</i> (VTEC/STEC)	(<i>Sturnus vulgaris</i>) (<i>Hirundo rustica</i>), (<i>Passer montanus</i>), (<i>Passer domesticus</i>) and (<i>Turdus merula</i>)	Denmark	Nielsen <i>et al.</i> (2004)
Shiga toxin- producing and enteropathogenic <i>E. coli</i>	Geese, Duck, Lesser kestrel and Myna	Iran	Koochakzadeh <i>et al.</i> (2015)
<i>E. coli</i> virulence genes eae, stx1 and stx2	(<i>Strigiformes</i> (owls). And (<i>Passeriformes</i>)	Great Britain.	Hughes 2 <i>et al.</i> (2009)
eaeA-positive <i>E. coli</i> and <i>E. albertii</i> strains	healthy wild waterfowl.	Korea	Oh <i>et al.</i> (2011)
verocytotoxin-producing <i>E. coli</i> O157.	fecal samples of one of (blackbirds, house sparrows, green-finches, and chaffinches).	Scotland	Foster <i>et al.</i> (2006)
<i>Escherichia coli</i>	(<i>Asio otus</i> , <i>Buteo rufinus</i> , <i>Pelecanus onocrotalus</i> , <i>Falco tinnunculus</i> , <i>Ciconia ciconia</i> , <i>Scolopax rusticola</i> , <i>Buteo buteo</i> , <i>Anas platyrhynchos</i> , <i>Crex crex</i> , <i>Tyto alba</i> , <i>Pelecanus onocrotalus</i> , <i>Athene noctua</i> , <i>Ardea cinerea</i> , <i>Accipiter gentilis</i> , <i>Pernis apivorus</i> , <i>Garrulus glandarius</i> , <i>Tadorna ferruginea</i> , <i>Apus apus</i> , <i>Phoenicopiterus roseus</i> , <i>Larus michahellis</i> , <i>Columba livia</i> and <i>Phalacrocorax carbo</i>).	Turkey	Yapicier <i>et al.</i> (2022)
<i>Escherichia coli</i> and <i>E. vulneris</i>	Isabelline Shrike, Barn Swallow, Tawny Pipit, Willow Warbler, Sand Martin, Isabelline Shrike	Saudi Arabia	Shobrak & Abo-Amer, (2015)

2. Bacteria isolated from different birds in different places:

<i>Escherichia coli</i> Strains	Common teal, Tufted duck	Bangladesh	Hasan et al. (2012)
	Eurasian sparrow hawk, Eurasian golden oriole, White-tailed eagle, Mute swan, Mallard, Eurasian tawny owl, little bittern, Common buzzard, Lesser spotted woodpecker, little owl, European green woodpecker, Bohemian wax-wing, Eurasian tawny owl, Short-eared owl, Great spotted woodpecker, Western capercaillie and grey heron.	Poland	Nowaczek et al. (2021)
Multi-Drug-Resistant Pathogenic <i>E. coli</i>	Wading birds	China	Yuan et al. (2021)
Pathogenic <i>E. coli</i> <i>eaeA</i> gene.	the Eurasian Tree Sparrow and the white-Vented Myna	Malay villages, Malaysia	Mohamed et al. (2022)
(10) <i>Salmonella typhimurium</i> , <i>S. Indiana</i> and <i>S. djugu</i> .	Common Gull, three different species of gulls.	Norway	kapperud & Rosef (1983)
<i>S. Typhimurium</i>	Black headed gulls, Herring gulls and Common gulls	northern Germany	Glünder et al. (1991)
<i>Salmonella</i> spp.	European starling and house sparrows	USA	Craven et al. (2000)
<i>Salmonella enterica: Salmonella Schleissheim</i>	<i>Mistle Thrush</i>	Sweden	Hernandez et al., (2003)
<i>S. Typhimurium</i> ,	Raptors, Vultures, Crows, Gulls, Colonial waterbirds, Finches, Cowbirds and House sparrows.	USA	Tizard, (2004)
different serotypes of <i>Salmonella enterica Salmonella Typhimurium</i> DT40, DT56, DT41, DT195, DT2, DT99	greenfinches, house sparrows, chaffinches, goldfinches, feral pigeons and different species of gulls.	Great Britain	Pennycott et al. (2006)
<i>S. Typhimurium</i> , Enteritidis, Derby, Panama) of <i>S. enterica</i>	migrating birds (largely gulls, but also ducks, terns, and some passerines)	Review	Dhama et al. (2008)
<i>S. Typhimurium</i>	Accipitridae, Ardeidae, Columbidae, Corvidae, Cuculidae, Falconidae, Fringillidae, Laridae, Passeridae, Picidae, Scolopacidae, Strigidae, Sturnidae, Tetraonidae, Turdidae and Tytonidae	north-western Italy	Botti et al. (2013)
<i>Salmonella</i> spp	Acrocephalidae, Alcedinidae, Ardeidae Anatidae, Fringillidae, , Passeridae, Turdidae: ...and other families	Bulgaria	Najdenski et al. (2018)
<i>Salmonella</i> serovars: Typhimurium, Potengi, Enteritidis, and Kentucky.	crows and waterfowls	Egypt	Fadel & Ahmed, (2019)
<i>Salmonella enterica</i> subsp. <i>Enterica</i> serovar Bispebjerg and the common serotype <i>Salmonella enterica</i> subsp. <i>enterica</i> serovar Kentucky	<i>Asio otus</i> (long-eared owl) and <i>Buteo buteo</i> (common buzzard).	Turkey	Yapicier et al. (2022)
<i>S. Typhimurium</i>	Wild Songbirds.	USA	(CDC). (2023)

2. Bacteria isolated from different birds in different places:

(11) <i>Yersinia</i> spp. <i>Yersinia enterocolitica</i>	Common grackle and Great horned owl	New York state	Shayegani <i>et al.</i> (1986)
	migratory birds, ducks, swallows and <i>Sturnus cineraceus</i>	Japan	Kaneuchi <i>et al.</i> (1989)
	Acrocephalidae, Alcedinidae, Ardeidae Anatidae, Fringillidae, , Passeridae, Turdidae: ...and other families	Bulgaria	Najdenski <i>et al.</i> (2018)
<i>Yersinia enterocolitica</i>, <i>Yersinia frederiksenii</i> <i>Yersinia intermedia</i> <i>Yersinia kristensenii</i>	wild-living birds; Blue magpie, Pheasant, Gray starling, Tree sparrow, Bulbul, Crow, Eastern turtledove and Chinese bamboo pheasant)	Japan	Kato <i>et al.</i> (1985)
five <i>Yersinia</i> strains: <i>Y. kristensenii</i>, <i>Y. intermedia</i>, and "<i>Yersinia X2</i>"	cloacal samples of gulls and Sternidae	Norway	Kapperud & Rosef (1983)
<i>Yersinia pseudotuberculosis</i>:	Eastern spot-billed duck and Wigeon	Japan	Fukushima & Gomyoda, (1991)
	Migrating Motacilla alba, Black-faced Bunting, Indian spot-billed duck, A. penelope, L. ridibundus, and Larus crassirostris, seabirds and shorebirds	Review	Huba'lek (2004)
<i>Yersinia pseudotuberculosis</i> and <i>Y. enterocolitica</i>	<i>S. vulgaris</i> in France; Thrushes and Barnacle goose	Sweden	Niskanen <i>et al.</i> (2003)
Pasteurellaceae: Pasteurella multocida:	wild waterfowl ducks) long-term carriers(	avian cholera Review	Wobeser (1997) Dhama <i>et al.</i> (2008)
<i>Riemerella anatipestifer</i>:	a short-distance migrant, Uria aalge, R. tridactyla, silver gulls and black-headed gulls	German	Petermann <i>et al.</i> (1989)
	normal <i>Branta canadensis</i>	Canada	Wobeser (1997)
	Black-headed gull , Free-living wild ducks, Guillemots, Budgerigar , Herring gull	German	Hinz <i>et al.</i> (1998)
<i>Francisella tularensis</i>:	migrating bird species, via infected, attached ixodid ticks Acrocephalidae, Alcedinidae, Ardeidae Anatidae, Fringillidae, , Passeridae, Turdidae: ...and other families	Bulgaria	Huba'lek (1994)
			Najdenski <i>et al.</i> (2018)
(12) Gram-positive cocci <i>Staphylococcus aureus</i>	excreta of seagulls (the glaucous-winged gull (<i>Larus glaucescens</i>)).		Wood & S Trust, (1972)
	migrating bird species	Ludhiana (Punjab), India.	Sambyal & Baxi (1980)
	free-living birds. Corvids Birds of prey, Water birds and Pheasants	Czechoslovakia	Hajek <i>et al.</i> (1991)
	Acrocephalidae, Alcedinidae, Ardeidae Anatidae, Fringillidae, , Passeridae, Turdidae: ...and other families	Bulgaria	Najdenski <i>et al.</i> (2018)
	fecal matter of wild birds	Pakistan	Tareen & Zahra, (2023)

2. Bacteria isolated from different birds in different places:

Enterococcus faecalis: Vancomycin-resistant enterococci	a north-migrating Black-headed gull	Southern Sweden	Sellin et al. (2000)
few other strains	gulls	Sub-Antarctic Bird Island in 1996	
(13) Endospore-forming Clostridium botulinum:	Birds disseminate spores to neighboring or far water reservoirs where they can germinate	avian botulism	Huba'lek (2004)
Clostridium perfringens:	defunct pelicans and naval birds	Florida	Ankerberg, (1984) USA
	waterbirds, shorebirds, raptors, Turdus migratorius	USA	Wobeser (1997)
	European starling and house sparrows	USA	Craven et al. (2000)
	wild crows (Large-billed crow)	Japan	Asaoka et al. (2004)
	wild birds	China.	Cao et al. (2020)
	wild resident birds (Corvus spp, Sturnus cineraceus, Passer montanus)	Ibaraki prefecture. Japan	Seki et al. (2022)
(14) Listeria monocytogenes:	Seagulls, Rooks	Scotland	Fenlon, (1985)
	(Falco columbarius, E. rubecula, S. vulgaris, Anthus trivialis)	review	Huba'lek, (1994)
	in droppings from urban rooks (Corvus frugilegus)	France	Bouttefroy et al. (1997)
	wild birds (unspecified species)	Helsinki region, Finland	Hellström et al. (2008)
	Peridomestic Birds, pigeon and crow.	India	Jagtap et al. (2017)
	Acrocephalidae, Alcedinidae, Ardeidae Anatidae, Fringillidae, , Passeridae, Turdidae: ...and other families	Bulgaria	Najdenski et al. (2018)
	crows and waterfowls	Egypt	Fadel & Ahmed, (2019)
(15) Erysipelothrix rhusiopathiae:	mergansers, ducks, geese, storks, gulls, cranes, etc.	Erysipelas	Huba'lek, (2004)
(16) Mycobacterium avium:	raptors, C. palumbus, or C. frugilegus	Tuberculosis	Huba'lek, (2004)
(17) Brucella species	Acrocephalidae, Alcedinidae, Ardeidae Anatidae, Fringillidae, , Passeridae, Turdidae: ...and other families	Bulgaria	Najdenski et al. (2018)

3. Fungi isolated from different migratory birds in different places:

Fungi	isolated from	Region	Reference
Yeasts and yeast-like fungi <i>Candida albicans</i>	excreta of migratory gulls and Canada geese	Connecticut	Buck, (1983) Buck, (1990) Huba'lek, (2004)
	cormorants, Gulls and Brown Pelican	Florida.	
<i>Candida tropicalis</i> :yeast species	in the digestive tracts and excreta of migratory gulls and terns.	Portugal	Kawakita & van Uden, (1965)
Hyphomycetes <i>Aspergillus fumigatus</i>	throat swabs of migratory water birds: 7% of Anserbrachyrhynchus, 7% of B. canadensis, and 13% of L. argentatus in the throats of wild geese and gulls.		Beer, (1963)
<i>Aspergillus fumigatus</i>	the feathers of 11% of wild birds	Britain	Huba'lek, (1994).
	the feathers of 17% of wild birds	Czechland,	
<i>Aspergillus flavus</i> , <i>Aspergillus nidulans</i> , <i>Microsporum gypseum</i> , <i>M. ripariae</i> , <i>M. persicolor</i> and <i>Trichophyton mentagrophytes</i>	feathers of migratory birds (mechanical carriers) e.g., spores of fungi can survive for at least 12 days when inoculated on feathers of migratory swallows.	Mexico	Huba'lek, (1994). Warner and French, (1970)

4. Protozoa isolated from different migratory birds in different

PROTOZOA Name	Transmission	Disease /region	Reference
Piroplasmida <i>Babesia microti</i> : tick-borne pathogens	Migratory passerine birds via attached, infective nymphal and larval Ixodes ticks (Acarina: Ixodidae).	human babesiosis Russia	Alekseev & Dubinina, (2003)
Haemosporina Leucocytozoon simondi	blackflies (Simuliidae) ducklings and goslings.	Leucocytozoonosis	Huba'lek, (2004)
Haemoproteus spp.	hematophagous ceratopogonid or hippoboscids biting flies. hematozoans willow warblers.	Haemoproteosis Scandinavia	Bensch & Akesson, (2003)
	Anatidae	Haemoproteosis North America	Huba'lek, (2004)
<i>Plasmodium relictum, P. circumflexum and P. vaughani</i>	migratory spp. including passerines, pigeons, anatids, and raptors	mosquito borne avian malaria,	Huba'lek, (2004)
<i>Plasmodium trochilus</i>	common in migratory birds	Scandinavia	Bensch & Akesson (2003)
Eimeriina <i>Toxoplasma gondii</i>	many migratory ducks, L. ridibundus, raptors, S. vulgaris, C. frugilegus, and C. monedula	Moscow	Huba'lek, (2004) Lvov and Ilichev, (1979)
<i>Eimeria, Isospora:</i> <i>e.g. E. boschadis, E. somateriae, and E. truncate</i>	migratory waterfowl, raptors or seabirds	renal coccidia of wild ducks and geese	Huba'lek, (2004)
<i>E. aythiae, E. bucephalae, and E. anseris</i>	diving ducks and geese	severe intestinal coccidiosis	
Sarcocystis, Frenkelia:	in adult avian intermediate hosts	Sarcosporidiosis	Huba'lek, (2004)
S. rileyi	Migratory ducks, herons, columbids, corvids, gulls, and swallows	Sarcocystosis North America	
<i>Frenkelia microti</i>	Migrating Buteo buteo	Europe	Huba'lek, (1994)
	Buteo jamaicensis	North America.	
<i>Cryptosporidium baileyi:</i>	feces of migratory gulls	Avian Cryptosporidiosis	Huba'lek, (2004)
Infectious cryptosporidial oocysts Cryptosporidium parvum oocysts	in feces of migratory B. canadensis in Maryland and in the feces of migratory Canada geese.	USA	Graczyk et al. (1998)
Kinetoplastida Trypanosoma everetti	migrating passerine spp.	Trypanosomiasis Britain	Huba'lek, (2004)
<i>Trypanosoma avium</i> and related avian trypanosomes	hippoboscids flies, black-flies, or biting midges	mild disease in young birds	Huba'lek, (1994)

Conclusion

Interest in migratory birds is a global concern now. Pathogens or isolated microbes from migratory birds seem to be more than we expected. Our review confirmed the presence of many spp. of migratory wild birds captured from different locations in the world which are positive for a broad spectrum of potentially pathogens indicating a great risk to public health. That wild birds may be a latent source for further microbial pollution of various habitats, including nesting places, and thus transfer it to offspring in different region. Further studies are important to assess and determinants the role of wild birds as a reservoir of different spp., including viruses, bacteria, fungi and protozoa.

In most parts of the world, we had found isolates from migratory birds of different species and types. so, oversight these birds to find out what microbes they carry is an immediate demand, and confronting migratory birds is one of our most important upcoming attentions. To ensure the safety of both human and avian sector against pathogens associated with migratory birds, more effective prevention and control measures must be done. This is done by monitoring diseases and knowing the extent of their spread, especially in coastal cities that are exposed to bird migration, developing fortifications to keep pace with new viral strains and genetic changes that may occur in birds, and following the rules of security and biosafety on our farms and in home breeding.

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