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Migratory birds as carrier of zoonotic pathogens

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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 burgdorferi* 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, Chlamydophila psittaci, Anaplasma phagocytophilum, Mycobacterium avium, Duck plague, Newcastle disease, and Candida spp. **(Hubalek, 2004),** *Borrelia burgdorferi* **(Humair, 2002**), Salmonella species, *Campylobacter jejuni, Escherichia coli,* enterotoxic 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 *et al.* (1960)**
	Streptopelia turtur	Israel	**Nir *et al.* (1967)**
	Ardeola ralloides	Azerbaijan	**Gaidamovich *et al.* (1968)**
	the common snipe (Gallinago gallinago)	Tajikistan	**Gordeeva (1980)**
	Reed warbler (Acrocephalus scirpaceus), Sturnus vulgaris and Vanellus vanellus	Slovakia	**Ernek *et al.* (1973, 1977)**
	free-living migratory birds	Estonia	**Uryvaev *et al.* (1992)**
		Fen-noscandia	**Huba´lek (1994), (2004)**
Eastern and western equine encephalitis viruses	songbirds and Culiseta melanura mosquitoes	America	**Hill *et al.* (2023)** **Huba´lek (2004)**
Venezuelan equine encephalitis virus	young herons and ibis	Central America	**Dickerman *et al.*, (1976)**
Mayaro virus (Mosquito borne)	orchard orioles and Red-eyed vireo	Louisiana in the USA	**Calisher *et al.* (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 *et al.* (1983)**
West Nile virus **Afr, Eur, As, Am** ***WNV encephalitis*** **arboviruses**	migrating Sylvia nisoria An ectoparasite in the eastern Mediterranean.	Cyprus	**Watson *et al.* (1972)**
	Tringa ochropus, Larus ridibundus, S. turtur and V. vanellus	Slovakia	**Ernek *et al.* (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 *et al.* (2002)**
	S. turtur, M. alba, and many migrating young storks (Ciconia ciconia)	the Middle East	**Malkinson *et al*. (2002)**
	A large number of wild Migratory birds	North America	**Reed *et al.* (2003)** **Hubalek (2004)**
	Passerine birds, European Robin, Common Whitethroat, Common Redstart, Common House Martin, Lesser Whitethroat, Song Thrush	Sweden	**Olofsson *et al.* (2024).**
***Usutu virus*: USUV: an African mosquito- borne Flavivirus**	Passerine birds, Common Whitethroat, Common House Martin	Sweden	**Olofsson *et al.* (2024).**
	caused an epornitic among the common blackbird (Turdus merula) in Austria during late summers in 2001–03	only in South Africa	**Weissenbo¨ck *et al.* (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 *et al.* (1968)**
	Migratory passerine birds	Russia	**Alekseev &Dubinina, (2003)**

1. Viruses isolated from different birds in different places:

***Omsk hemorrhagic fever (OHF) and Kyasanur Forest disease (KFD)*:**	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)**
Tyuleniy virus	Ixodes uriae ticks inhabiting nests of seabirds and it is brought via the birds	Nauka, Moskva	**(Lvov and Ilichev, 1979).**
Meaban virus	Ornithodoros maritimus ticks collected in nests of Larus argentatus; Sterna paradisaea terns	France	**(Chastel, 1988).**
Bunyaviridae: Genera bunya virus, Nairo virus Simbu group bunyavirus-es:* (mosquito- borne): *Ingwavuma virus	two northward-migratory the spotted flycatcher in Cyprus,	Egypt	**Watson *et al.* (1972)**
Thimiri virus	Lesser whitethroat Bird and common white throat		
Tete group bunyaviruses: Bahig virus and Matruh virus	south- migrating Eurasian birds; prevailing hosts were Sylviidae, Finches - Fringillidae, and Turdidae.	Egypt and Cy-prus	**Watson *et al.* (1972) Hoogstraal (1976)**
Tete group Bahig virus	larval Hyalomma marginatum rufipes ticks parasitiz-ing a northward-migrating Oenanthe oenanthe	Egypt and Italy	**Converse *et al.* (1974)**
Bhanja virus:* such as *(CCHF virus)	migrating birds as carrier of infected immature am-blyommine ticks	Czechoslovakia	**Huba´lek *et al.* (1982)**
Reoviridae*: *genus Orbivirus Kemerovo virus (tickborne): Mono Lake virus	Phoenicurus phoenicurus that migrate a southward a migrating common redstart of Eurasia.	Egypt	**Schmidt and Shope (1971)**
Other orbiviruses of the Great Island antigenic complex	I. uriae ticks inhabiting seabird nests from Argas cooleyi (Acari: Argasidae)	Colorado	**Calisher *et al.* (1988)**
Orthomyxovirida Influenza A virus: All of the antigenic subtypes (H1 –H14 and N1–N9)	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)**
HPAI H5N1virus	bar-headed geese	China	**Zhou *et al.* (2006)**
	(Common tern -Sterna hirundo) migrating wader populations	worldwide	**Stroud *et al.* (2004) Dhama *et al.* (2008)**
different (LPAI) viruses (Majority)	migrating ducks, gulls, geese, and other shorebirds,	worldwide	**Dhama et al. (2008)**

1. Viruses isolated from different birds in different places:

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

2. Bacteria isolated from different birds in different places:

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

2. Bacteria isolated from different birds in different places:

(ˇ)Campylobacteraceae Campylobacter jejuni:	aquatic and terrestrial wild birds V. vanellus, Milvus milvus, Eurasian coot, common moorhen, and Corvus frugilegus	intestinal campylobacteriosis	**Sacks et al. (1986)**
			Glu¨nder (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)**
Campylobacter jejuni strains	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-cheeked starling and greater sand plover	South Korea.	**Wei *et al.* (2019)**
Campylobacter jejuni, C. lari, and C. coli	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. *C. jejuni and C. coli*	Black headed gulls, Herring gulls and Common gulls	northern Germany.	**Glünder *et al.* (1991)**
	different migratory birds. Passeriformes	Campania region, Italy	**Sensale *et al.* (2006)**
	three Long-eared Owls (*Asio otus*) omnivorous species	Italy	**Casalino *et al.* (2022)**
	(Black-headed gulls and Great tits Parus major)	Poland	**Andrzejewska *et al.* (2022)**
	(Northern shoveler, Common pochard, Common teal, Northern pintail, Eared Grebe, Great Crested Grebe and Garganey)	Egypt	**Tawakol *et al.* (2023)**
Campylobacter *16S*	Acrocephalidae, Alcedinidae, Ardeidae Anatidae, Fringillidae, , Passeridae, Turdidae: …and other families	Bulgaria	**Najdenski *et al.* (2018)**
Campylobacter fetus subsp. jejuni	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 *et al.* (2017)**
(8) Vibrionaceae Vibrio cholerae: V. parahaemolyticus and V. mimicus	faeces samples free-living migratory water birds	cholera outbreaks in China	**Fu *et al.* (2019)**
Vibrio cholerae, V. fluvialis, V. alginolyticus, V. mimicus, V.vulnificus, V. parahaemolyticus, V. metschnikovii	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 *et al.* (2021)**
halophilic Vibrio spp.	fresh feces of six types of aquatic birds (gulls, pelicans, Canada geese, swans, egrets, cormorants)	Connecticut and Florida.	**Buck (1990)**
Vibrio parahaemolyticus Strains	Aquatic Bird Feces. Chroicocephalus brunnicephalus	Thailand	**Muangnapoh *et al.* (2022)**
	Feces of Mallard, Heron and Charadriiformes.	China	**Zheng *et al.* (2023)**
Vibrio Species	Wild Birds (Gulls), (Pelicans), (Ducks), (Shorebirds) and Domestic Birds. (Crows and Pigeons)	World wide	**Ayala and Ogbunugafor, (2023)**
Aeromonas sp. and Vibrio sp.	alive and debilitated wrecked marine birds	southeastern Brazil	**Cardoso *et al.* (2018)**
Vibrio cholerae and Vibrio metschnikovii Strains	Larus ridibundus, Pluvialis squatarola, Tadorna ferrgina, Anas poecilorhyncha, and Aix galericulata,	at Dali Nouer Lake in Chifeng, China.	**Zheng *et al.* (2021)**
(9) *E*nterobacteriaceae *Escherichia coli:* 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 *et al.* (1997)**
Enterobacteriaceae	in European Wild Bird Species (Raptors, Waterbirds, Passerines*)*	Italy	**Giacopello *et al.* (2016)**

2. Bacteria isolated from different birds in different places:

Enterobacterales Strains	Raptors, Waterbirds Passerines	Italy	**Russo *et al.* (2022)**
Shiga toxin-producing E. coli	Migratory ducks and quails, Northern shoveler, Pintail, Common Teal, Mallard, Common Coot, Quail	Egypt	**Seleem *et al.* (2021)**
E. coli	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 *et al.* (2020)**
diarrheagenic E. coli	Wild birds and urban pigeons	Brazil	**Borges *et al.* (2017)**
Escherichia coli 16S	Acrocephalidae, Alcedinidae, Ardeidae Anatidae, Fringillidae, , Passeridae, Turdidae: …and other families	Bulgaria	**Najdenski *et al.* (2018)**
E. coli virulence genes	wild bird Faeces)Seagulls, waterfowl ,feral pigeons and *Athene noctua*	Italy	**Bertelloni *et al.* (2019)**
Enteropathogenic E. coli and Shiga-toxin producing E. coli (EPEC and STEC)	Captive wild birds (Psittaciformes) ،)Strigiformes) and (Columbiformes).	Brazil	**Sanches *et al.* (2017)**
Verocytotoxin-producing E. coli (VTEC/STEC)	(*Sturnus vulgaris)* (*Hirundo rustica*), (*Passer montanus*), (*Passer domesticus*) and (*Turdus merula*)	Denmark	**Nielsen *et al.* (2004)**
Shiga toxin- producing and enteropathogenic E. coli	*Geese*, *Duck*, *Lesser kestrel* and *Myna*	Iran	**Koochakzadeh *et al.* (2015)**
***E. coli* virulence genes eae, stx1 and stx2**	(*Strigiformes (owls). And* (*Passeriformes*)	Great Britain.	**Hughes 2 *et al.* (2009)**
eaeA-positive E. coli and E. albertii strains	healthy wild waterfowl.	Korea	**Oh *et al.* (2011)**
verocytotoxin-producing E. coli O157.	fecal samples of one of (blackbirds, house sparrows, greenfinches, and chaffinches).	Scotland	**Foster *et al.* (2006)**
Escherichia coli	(*Asio otus, Buteo rufinus, Pelecanus onocrotalus, Falco tinnunculus, Ciconia ciconia, Scolopax rusticola, Buteo buteo, Anas platyrhynchos, Crex crex, Tyto alba, Pelecanus onocrotalus, Athene noctua, Ardea cinerea, Accipiter gentilis, Pernis apivorus, Garrulus glandarius, Tadorna ferruginea, Apus apus, Phoenicopterus roseus, Larus michahellis, Columba livia and Phalacrocorax carbo*).	Turkey	**Yapicier *et al.* (2022)**
Escherichia coli and E. vulneris	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:

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

2. Bacteria isolated from different birds in different places:

(11) Yersinia spp. ***Yersinia enterocolitica***	Common grackle and Great horned owl	New York state	**Shayegani *et al.* (1986)**
	migratory birds, ducks, swallows and *Sturnus cineraceus*	Japan	**Kaneuchi *et al.* (1989)**
	Acrocephalidae, Alcedinidae, Ardeidae Anatidae, Fringillidae, , Passeridae, Turdidae: …and other families	Bulgaria	**Najdenski *et al.* (2018)**
Yersinia enterocolitica*, *Yersinia frederiksenii* *Yersinia intermedia* *Yersinia kristensenii	wild-living birds; Blue magpie, Pheasant, Gray starling, Tree sparrow, Bulbul, Crow, Eastern turtledove and Chinese bamboo pheasant)	Japan	**Kato *et al.* (1985)**
five Yersinia strains: Y. *kristensenii, Y. intermedia, and "Yersinia X2"*	cloacal samples of gulls and Sternidae	Norway	**Kapperud & Rosef (1983)**
***Yersinia pseudotuberculosis*:**	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)**
Yersinia pseudotuberculosis and Y. enterocolitica	*S. vulgaris* in France; Thrushes and Barnacle goose	Sweden	**Niskanen *et al.* (2003)**
Pasteurellaceae: Pasteurella multocida:	wild waterfowl ducks) long-term carriers(	avian cholera Review	**Wobeser (1997) Dhama *et al.* (2008)**
***Riemerella anatipestifer*:**	a short-distance migrant, Uria aalge, R. tridactyla, silver gulls and black-headed gulls	German	**Petermann *et al.* (1989)**
	normal *Branta canadensis*	Canada	**Wobeser (1997)**
	Black-headed gull , Free-living wild ducks, Guillemots, Budgerigar , Herring gull	German	**Hinz *et al.* (1998)**
Francisella tularensis:	migrating bird species, via infected, attached ixodid ticks Acrocephalidae, Alcedinidae, Ardeidae Anatidae, Fringillidae, , Passeridae, Turdidae: …and other families	Bulgaria	**Huba´ lek (1994)**
			Najdenski *et al.* (2018)
(12) Gram-positive cocci *Staphylococcus aureus*	excreta of seagulls (the glaucous-winged gull (Larus glaucescens).		**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 *et al.* (1991)**
	Acrocephalidae, Alcedinidae, Ardeidae Anatidae, Fringillidae, , Passeridae, Turdidae: …and other families	Bulgaria	**Najdenski *et al.* (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, Sturnuscineraceus, Passermontanus)	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 *Candida albicans*	excreta of migratory gulls and Canada geese	Connecticut	**Buck, (1983) Buck, (1990) Huba´lek,(2004)**
	cormorants, Gulls and Brown Pelican	Florida.	
***Candida tropicalis* :**yeast species	in the digestive tracts and excreta of migratory gulls and terns.	Portugal	**Kawakita & van Uden, (1965)**
Hyphomycetes *Aspergillus fumigatus*	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)**
Aspergillus fumigatus	the feathers of 11% of wild birds	Britain	**Huba´lek, (1994).**
	the feathers of 17% of wild birds	Czechland,	
Aspergillus flavus, Aspergillus nidulans, Microsporum gypseum, M. ripariae, M. persicolor and Trichophyton mentagrophytes	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 ***Babesia microti*:** 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 hippoboscid biting flies. hematozoans willow warblers.	Haemoproteosis Scandinavia	**Bensch & Akesson, (2003)**
	Anatidae	Haemoproteosis North America	**Huba´lek, (2004)**
Plasmodium relictum, P. circumflexum and P. vaughani	migratory spp. including passerines, pigeons, anatids, and raptors	mosquito borne avian malaria,	**Huba´lek, (2004)**
Plasmodium trochilus	common in migratory birds	Scandinavia	**Bensch &Akesson (2003)**
Eimeriina ***Toxoplasma gondii***	many migratory ducks, L. ridibundus, raptors, S. vulgaris, C. frugilegus, and C. monedula	Moscow	**Huba´lek, (2004) Lvov and Ilichev, (1979)**
Eimeria, Isospora: e.g. E. boschadis, E. somateriae, and E. truncate	migratory waterfowl, raptors or seabirds	renal coccidia of wild ducks and geese	**Huba´lek, (2004)**
E. aythyae, E. bucephalae, and E. anseris	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	
Frenkelia microti	Migrating Buteo buteo	Europe	**Huba´lek, (1994)**
	Buteo jamaicensis	North America.	
Cryptosporidium baileyi:	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)**
***Trypanosoma avium* and related avian trypanosomes**	hippoboscid 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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