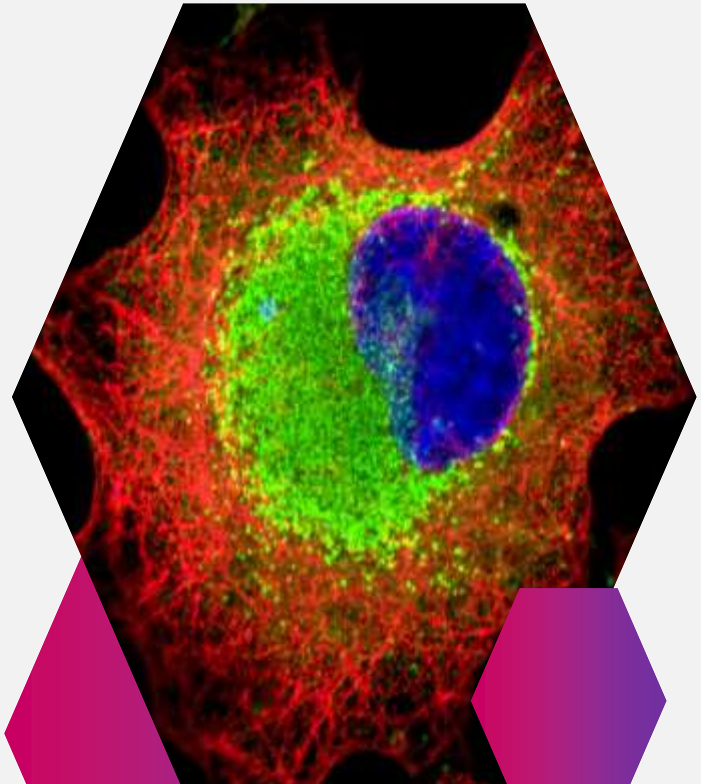


Global development of HPAI during the last two years.

Prof Ian Brown
ian.brown@pirbright.ac.uk

IABS
22nd October 2024

Pirbright receives strategic funding from BBSRC UKRI

Key developments in HPAI epidemiology since Oct 22

- Exceptional global spread; panzootic most continents affected
- High infection pressure
  - Increased spread to domestic birds
  - High environmental contamination
  - Exposure to greater range of species of wild bird
- Mammalian infections: spillover to scavengers, some M2M transmission
- Dairy cattle infection in USA: sustained transmission non respiratory, back spill to domestic birds
- H5 HPAI virus evolving with high fitness traits
- Antigenically clade 2.3.4.4b moderately stable

Global impact of HPAI

Table 1. Impact of a widening of bird-bird flu

(% change in GDP, relative to the baseline)

	Bird-bird [a]
World total	**-0.1**
High income countries	-0.1
Low & Middle-income countries	-0.4
East Asia and Pacific	-0.4
Europe & Central Asia	-0.4
Latin America &the Caribbean	-0.7
Middle East & North Africa	-0.4
South Asia	-0.4
Sub Saharan Africa	-0.3

Source: World Bank.

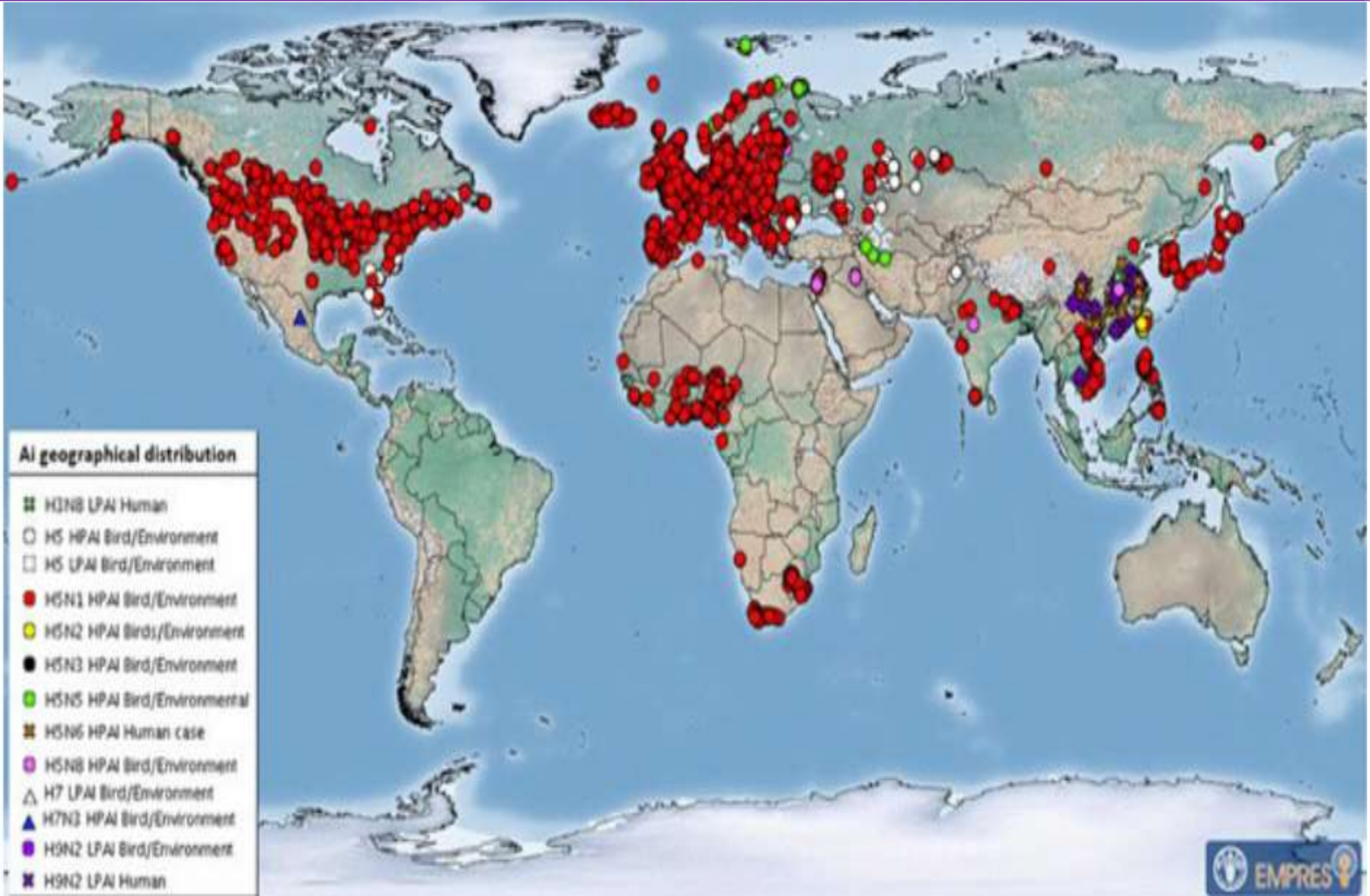
[a] Assumes that 12 percent of domestic birds in each region die from the disease or are killed in efforts to prevent its spread.

57 million birds died/culled in last year

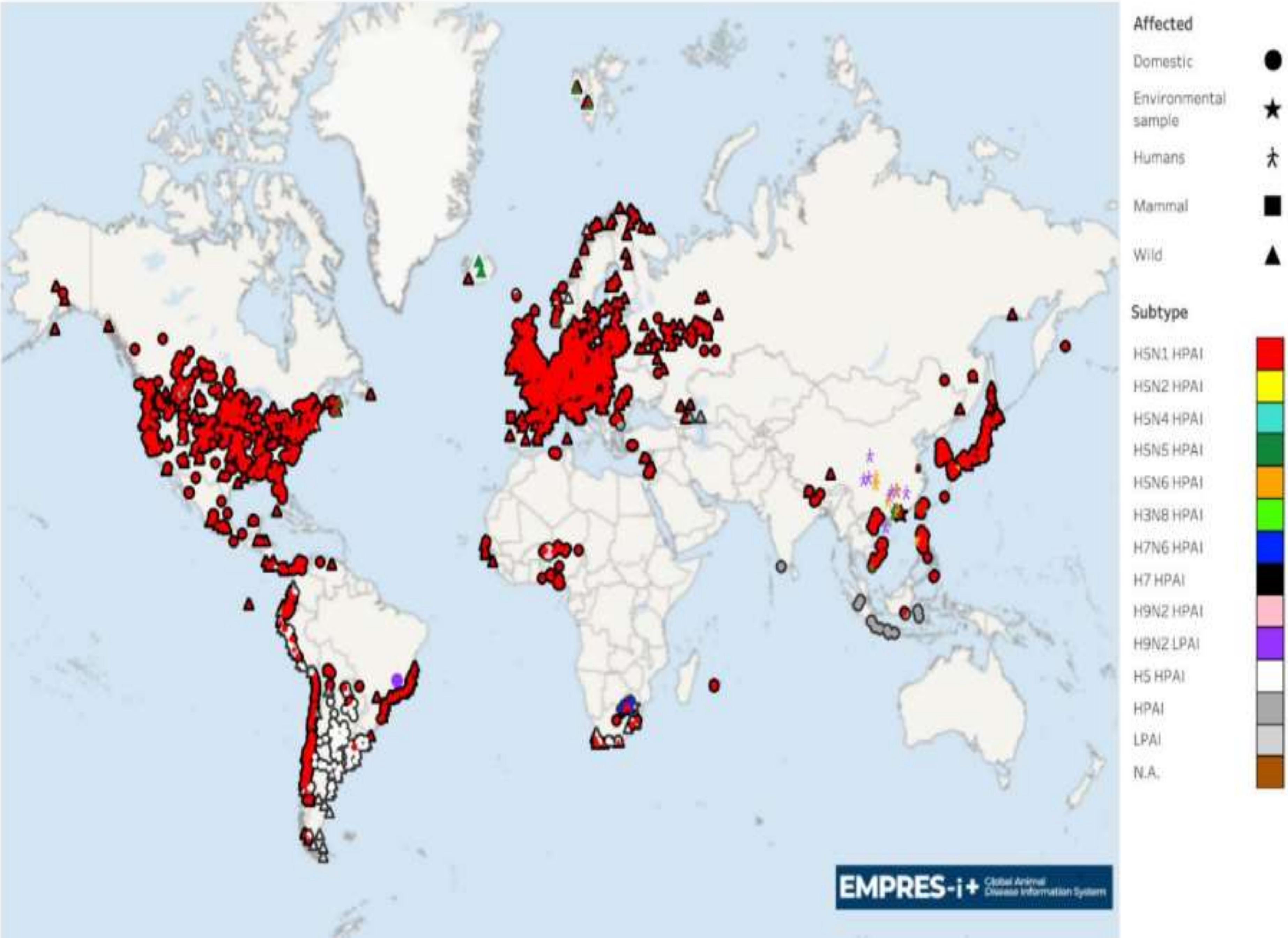
$4bn/pa?

3.4% (range 2.6-4.4%) global economy

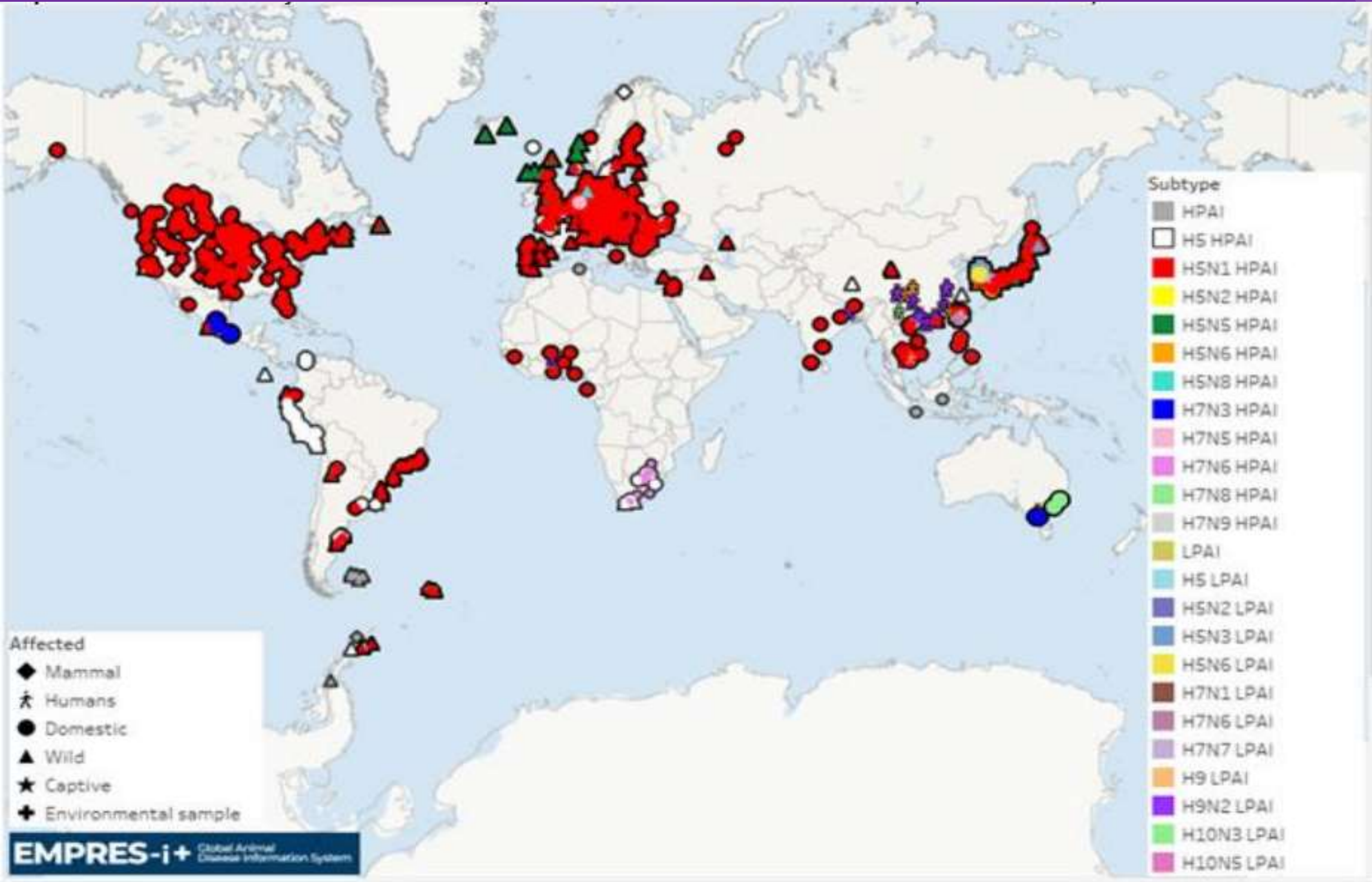
Global distribution of Avian Influenza
1st October 2021- 30th September 2022



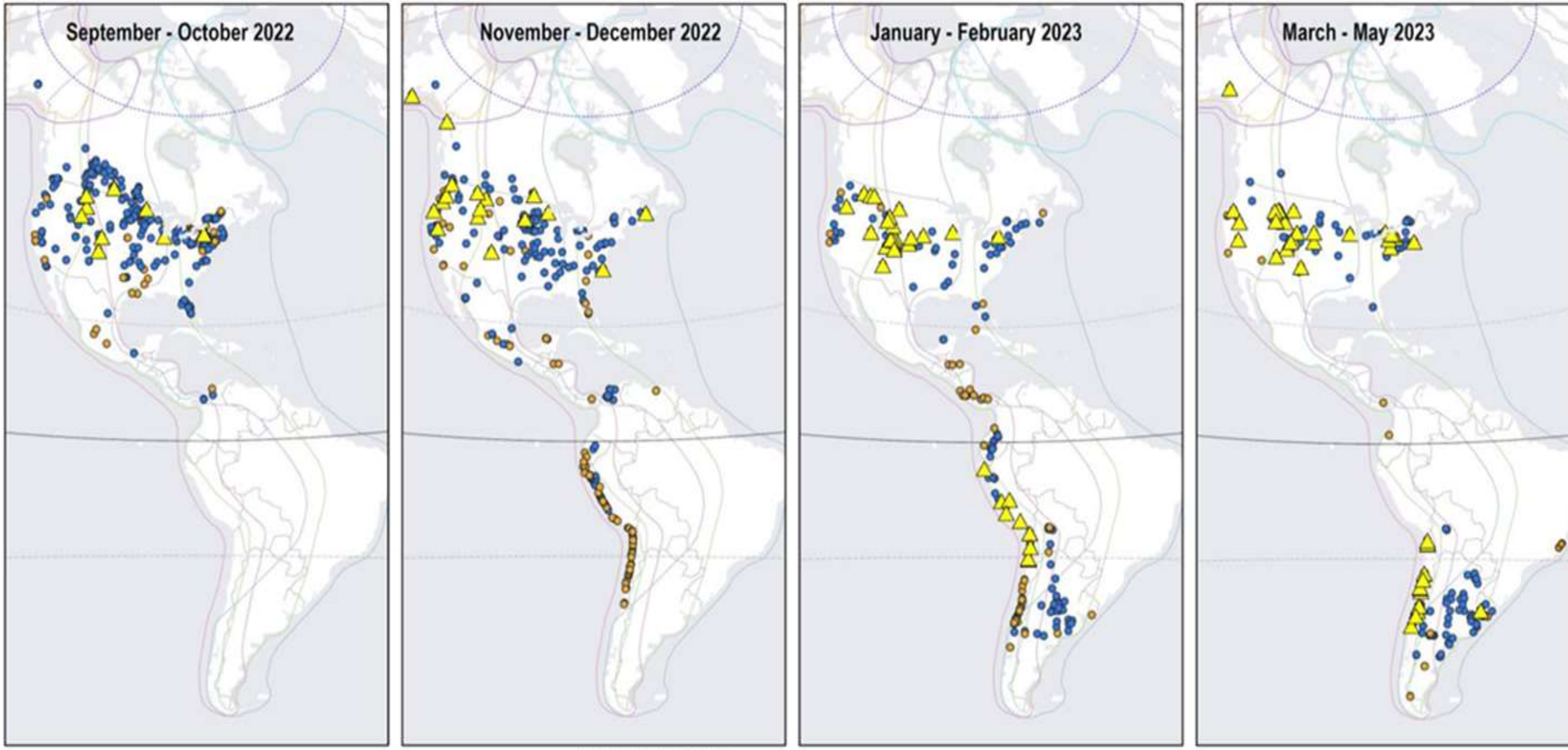
Confirmed Avian influenza events worldwide from 1 October 2022 to 30 September 2023



Global distribution of Avian Influenza
1st October 2023- 26th September 2024



Introduction into Central and Latin America



Avian Influenza Outbreak
Type of animal

- Poultry or domestic birds
- Wild birds
- Mammals

Major flyways

- Mississippi
- Pacific
- West Atlantic
- East Atlantic

N

0 1,500 3,000 6,000 km

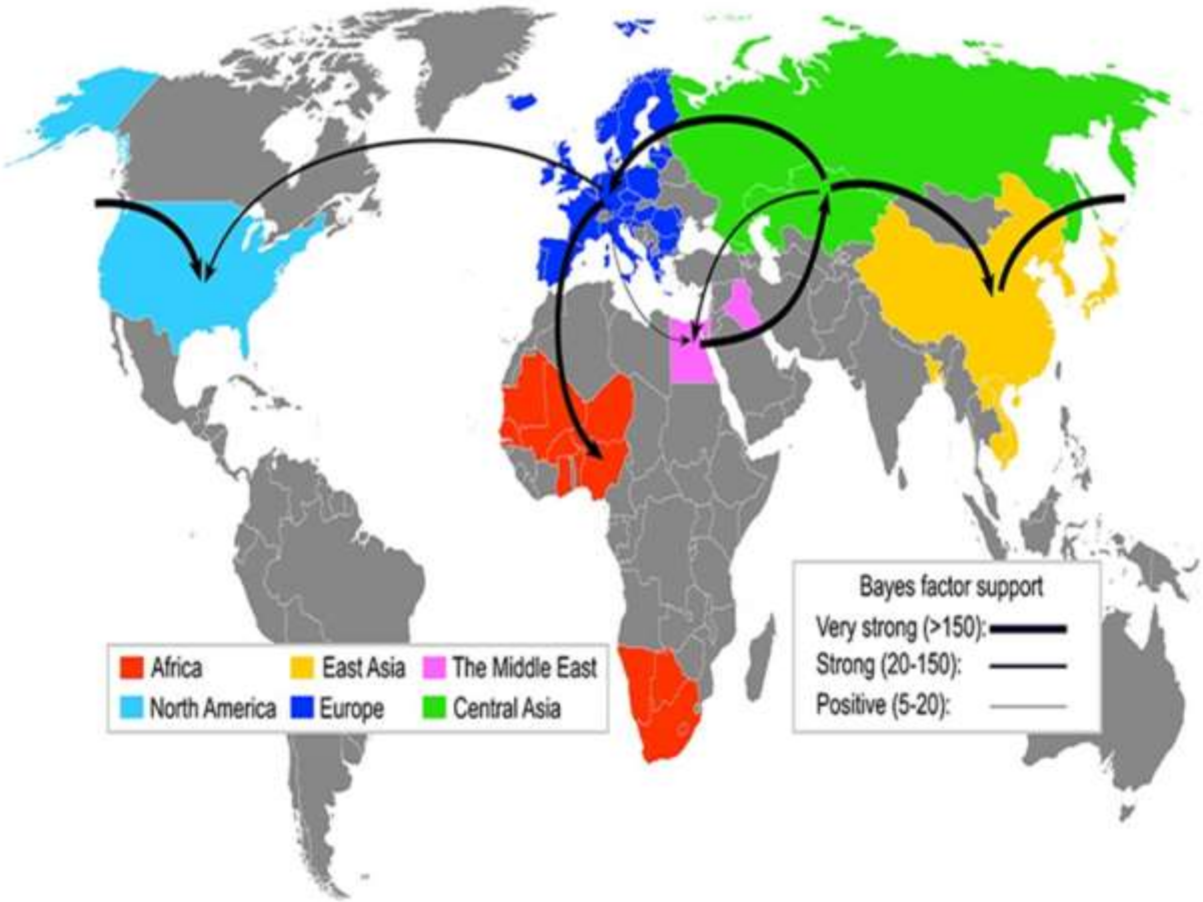
PAHO

Pan American Health Organization | World Health Organization Americas

The designations employed and the presentation of the material in these maps do not imply the expression of any opinion whatsoever on the part of the Secretariat of the Pan American Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted and dashed lines on maps represent approximate border lines for which there may not yet be full agreement.
Map production: PAHO Health Emergencies Department/ Health Emergency Information and Risk Assessment Unit. GIS Team.

Sources
- Data: World Organization for Animal Health (WOAH) (2023). Retrieved on 12 May 2023. Data extracted by Pan American Health Organization. Reproduced with permission. WOAH bears no responsibility for the integrity or accuracy of the data contained herein, but not limited to, any deletion, manipulation, or reformatting of data that may have occurred beyond its control
- Cartography: WHO Detailed ADM0 Boundaries; Conservation of Artic Flora and Fauna - Data Service (SHP) Major flyways of Artic Birds Shapefile Accessed February 2023.

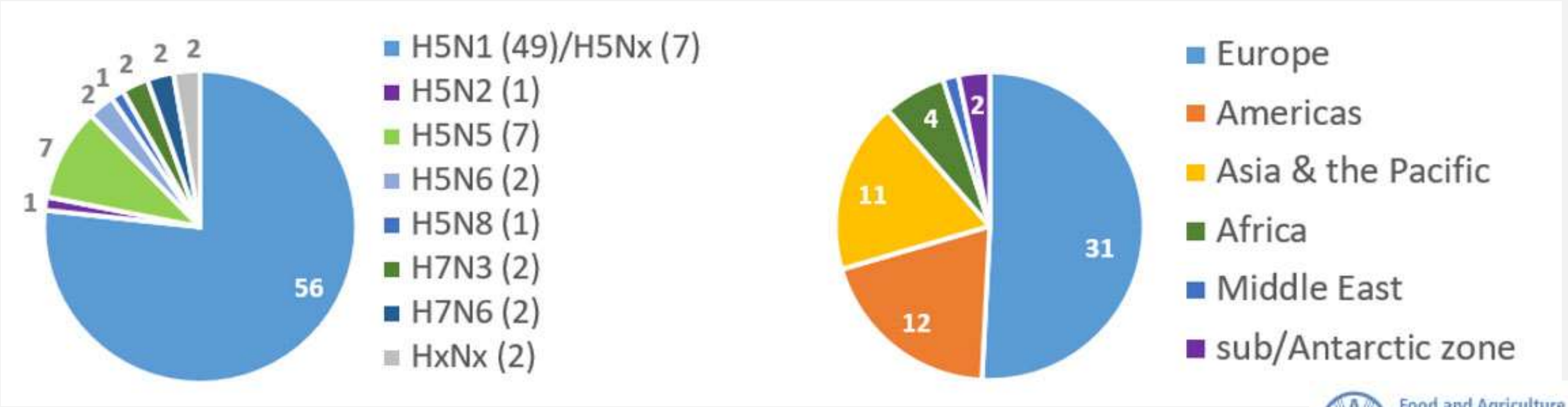
Global migration rates among the geographic regions of clade 2.3.4.4b (2020-2022)



Fusaro et al High pathogenic avian influenza A(H5) viruses of clade 2.3.4.4b in Europe—Why trends of virus evolution are more difficult to predict, Virus Evolution, Volume 10, Issue 1, 2024, veae027, https://doi.org/10.1093/ve/veae027

Global Avian Influenza Viruses situation

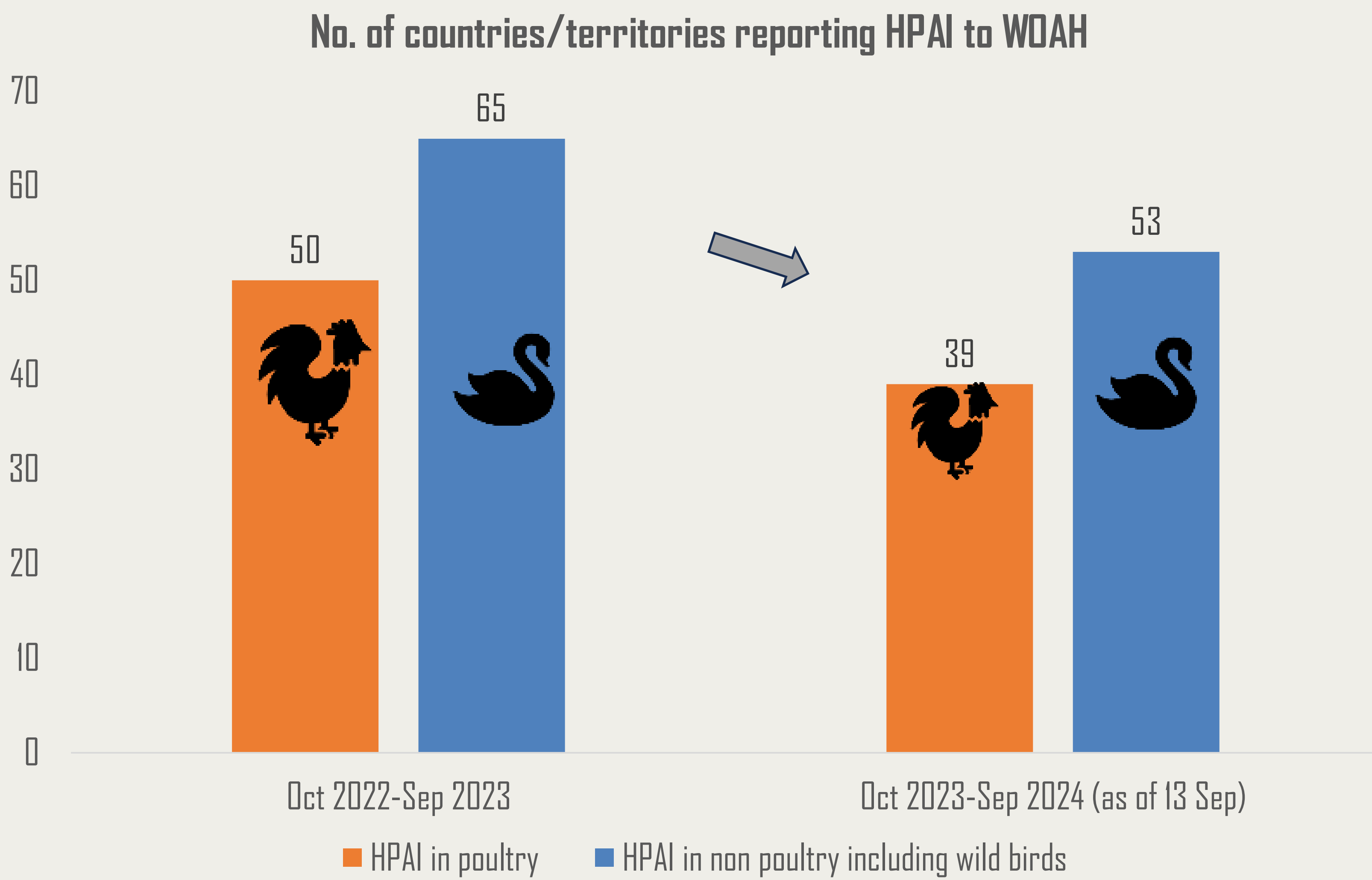
Countries reporting HPAI since 01 October 2023 by subtype (left) and by region (right) as of 22 May 2024



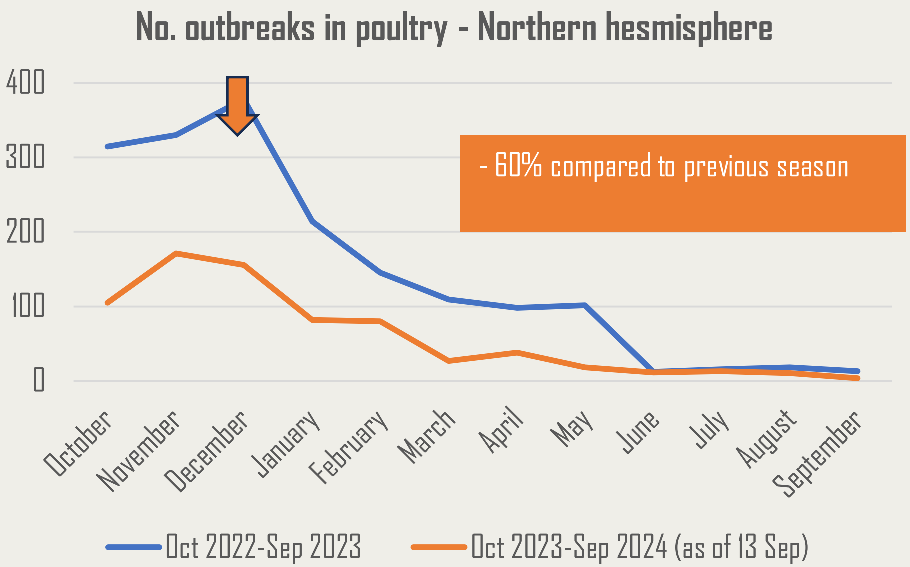
Source, FAO https://www.fao.org/animal-health/situation-updates/global-aiv-with-zoonotic-potential

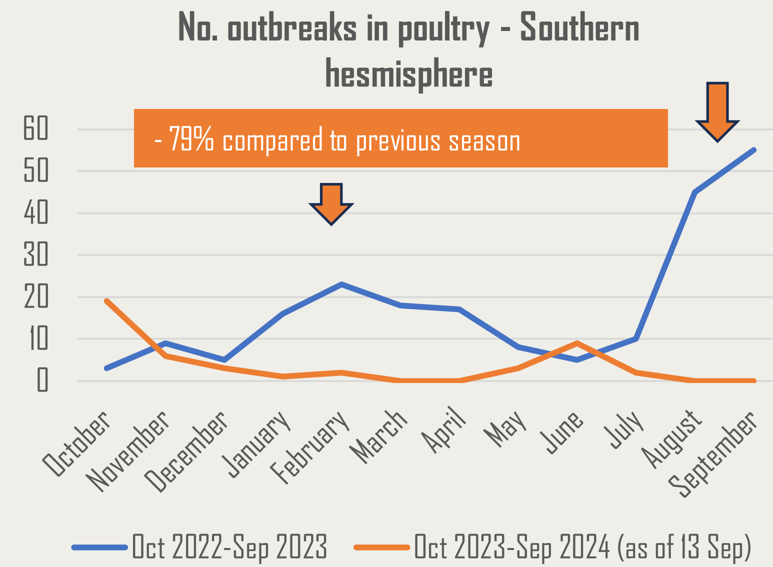
Food and Agriculture Organization of the United Nations

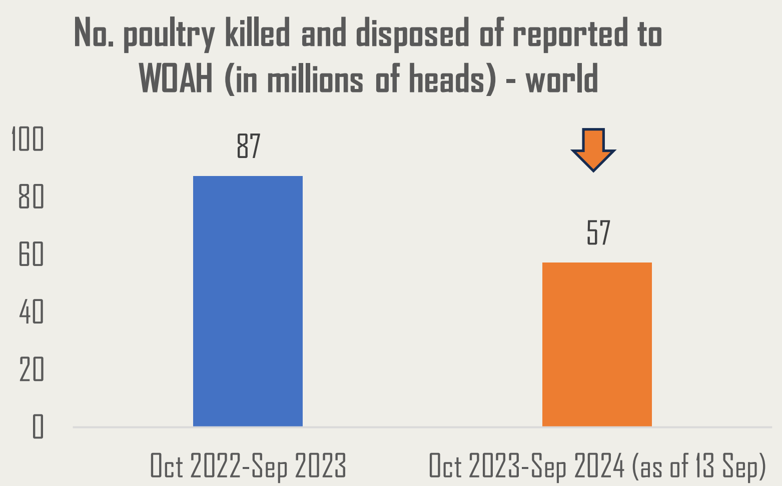
Declining HPAI trend between Oct 2022- Sep 2023 vs Oct 2023 – Sep 2024 Underlying factors?



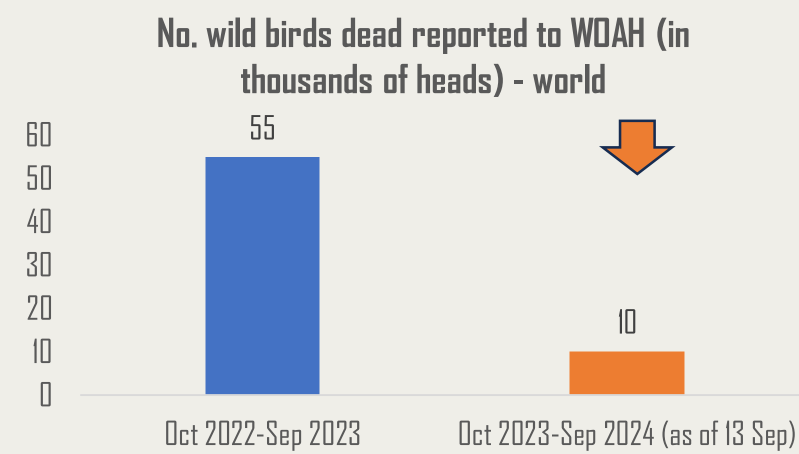
Reducing trend of disease burden in last 2 years







- 34% compared to previous season

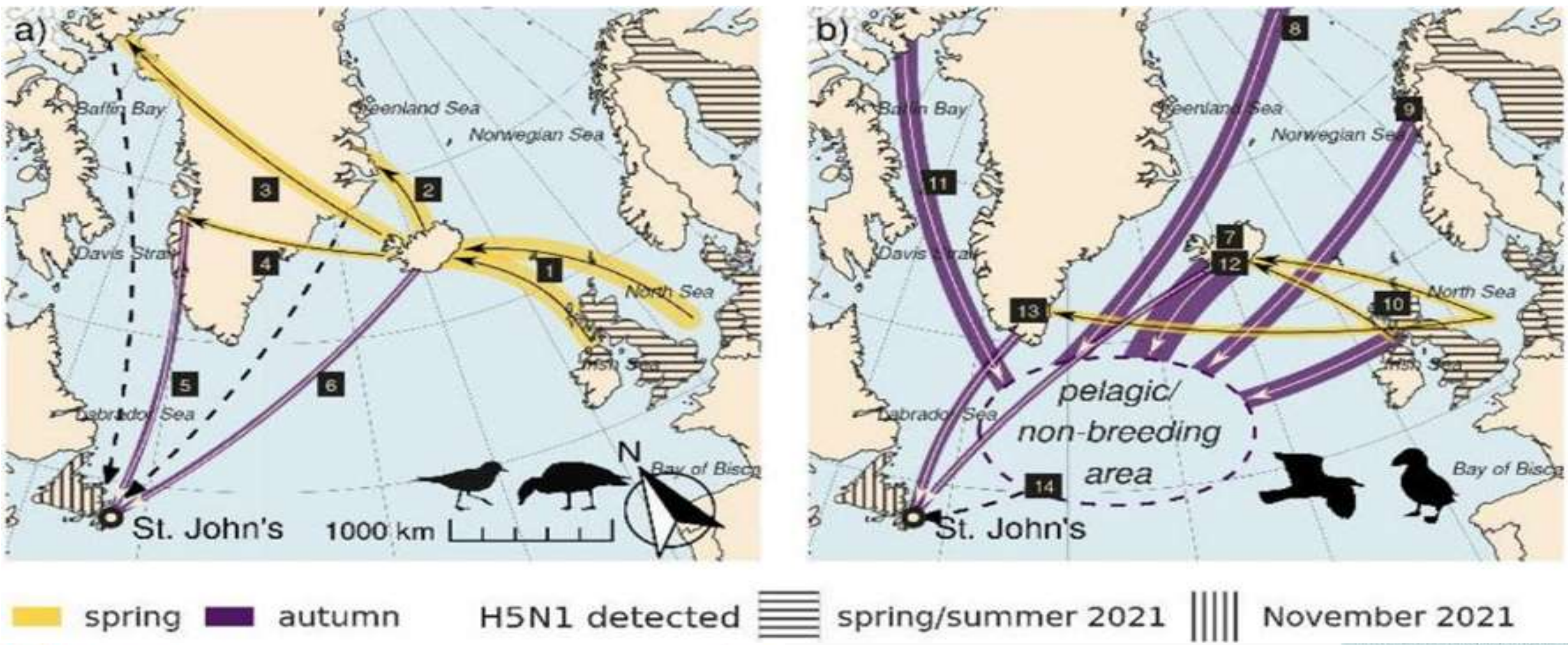


- 82% compared to previous season

(caution : many dead birds go undetected & unreported)

Transatlantic transmission

Putative transmission pathways between Europe and Newfoundland via migratory waterfowls/shorebirds



viruses

MDPI

Communication

Recurring Trans-Atlantic Incursion of Clade 2.3.4.4b H5N1 Viruses by Long Distance Migratory Birds from Northern Europe to Canada in 2022/2023

Tamiru N. Alkie [1,4], Alexander M. P. Byrne [2,4], Megan E. B. Jones [3,4], Benjamin C. Mollett [2], Laura Bourque [3], Oliver Lung [1], Joe James [2,3], Carmencita Yason [4], Ashley C. Banyard [2,5], Daniel Sullivan [1], Anthony V. Signore [1], Andrew S. Lang [6], Meghan Baker [7], Beverly Dawe [7], Ian H. Brown [2,5,*] and Yohannes Berhane [1,8,9,*]

www.nature.com/scientificreports

scientific reports

OPEN

Transatlantic spread of highly pathogenic avian influenza H5N1 by wild birds from Europe to North America in 2021

V. Caliendo, N. S. Lewis, A. Pohlmann, S. R. Baillie, A. C. Banyard, M. Beer, I. H. Brown, R. A. M. Fouchier, R. D. E. Hansen, T. K. Lameris, A. S. Lang, S. Laurendeau, O. Lung, G. Robertson, H. van der Jeugd, T. N. Alkie, K. Thorup, M. L. van Toor, J. Waldenström, C. Yason, T. Kuiken & Y. Berhane

Expansion in wild bird host range:susceptibility?

Primary hosts: Often highly susceptible

- Many long distance migratory species may be tolerant to infection with HPAIV in the absence of disease

Secondary hosts: Differential susceptibility

Expansion in wild bird host range:susceptibility

Tertiary: Medium-Low Susceptibility




Occasionally seen to succumb to infection.

Quaternary: Resistant?

Dalmatian pelican


European shag

Wild bird species affected: >300 species/25+orders

Wild bird orders affected by Gs/Gd H5Nx HPAI		
	Since 2021	
Accipitriformes (n=51)	Galliformes (n=19)	Psittaciformes (n=25)
Anseriformes (n=94)	Gaviiformes (n=3)	Rheiformes (n=1)
Caprimulgiformes (n=1)	Gruiformes (n=16)	Sphenisciformes (n=4)
Casuariiformes (n=1)	Passeriformes (n=49)	Strigiformes (n=18)
Cathartiformes (n=2)	Pelecaniformes (n=31)	Struthioniformes (n=1)
Charadriiformes (n=111)	Phoenicopteriformes (n=4)	Suliformes (n=25)
Ciconiiformes (n=6)	Piciformes (n=3)	Trogoniformes (n=1)
Columbiformes (n=7)	Podicipediformes (n=8)	
Falconiformes (n=13)	Procellariiformes (n=14)	

Wild bird species affected by Gs/Gd H5Nx HPAI Since 2021		
Anseriformes (n=40)	Galliformes (n=8)	Phoenicopteriformes (n=2)
Amazonetta brasiliensis (Brazilian Teal)*	Alectoris rufa (Red legged partridge)	Phoenicopterus chilensis (Chilean flamingo)*
Anas cyanoptera (Cinnamon Teal)	Bonasa umbellus (Ruffed grouse)	Phoenicopterus ruber (American Flamingo)*
Anas discors (Blue-winged Teal)	Callipepla californica (California Quail)	Gruiformes (n=7)
Anas flavirostris (Andean Teal)	Centrocercus urophasianus (Greater sage-grouse)	Anthropoides virgo (Demoiselle Crane)
Anas formosa (Baikal Teal)*	Coturnix coturnix (Common Quail)*	Balearica regulorum (Crowned crane)
Anas fulvigula (Mottled Duck)	Cracidae (incognita)*	Fulica americana (American coot)
Anas rhynchotis (Australasian Shoveler)	Lagopus lagopus (Willow Grouse)	Fulica armillata (Red-gartered Coot)
Anas rubripes (American Black Duck)	Perdix perdix (Grey Partridge)*	Grus canadensis (Sandhill Crane)
Anser cygnoides (Swan Goose)*	Charadriiformes (n=78)	Grus leucogeranus (Siberian crane)*
Anser rossii (Ross's Goose)	Alca torda (Razorbill)	Rallus aquaticus (Water Rail)
Aythya affinis (Lesser Scaup)	Alle alle (Little auk)	Psittaciformes (n=10)
Aythya americana (Redhead Duck)	Arenaria interpres (Ruddy Turnstone)	Amazona farinosa (Southern mealy amazon)*
Aythya baeri (Baer's pochard)*	Arenaria melanocephala (Black turnstone)	Amazona ochrocephala (Yellow-crowned Parrot)*
Aythya valisineria (Canvasback)	Calidris alba (Sanderling)	Amazona oratrix (Yellow-headed amazon)*
Branta ruficollis (Red breasted goose)	Calidris alpina (Dunlin)	Ara militaris (Military macaw)*
Branta sandvicensis (Nene)*	Calidris fuscicollis (White-rumped Sandpiper)	Brotogeris versicolurus (White-winged Parakeet)*
Bucephala albeola (Bufflehead)	Calidris maritima (Purple sandpiper)	Cyanoliseus patagonus (Burrowing Parrot)
Bucephala islandica (Barrow's goldeneye)*	Calidris pusilla (Semipalmated sandpiper)	Enicognathus ferrugineus (Austral Parakeet)
Chloephaga melanoptera (Andean Goose)	Cepphus grylle (Black Guillemot)	Enicognathus leptorhynchus (Slender-billed Parakeet)
Chloephaga picta (Upland Goose)	Charadrius hiaticula (Common ringed plover)	Loriculus spp. (Hanging Parrot)*
Cygnus bewickii (Tundra swan)	Charadrius mongolus (Lesser Sand Plover)	Pycnonotus zeylanicus (Straw-headed bulbul)*
Cygnus buccinator (Trumpeter Swan)	Charadrius nivosus (Snowy plover)	Falconiformes (n=8)
Cygnus melancoryphus (Black-necked swan)	Chlidonias hybrida (Whiskered Tern)	Caracara cheriway (Northern Crested Caracara)
Dendrocygna bicolor (Fulvous whistling Duck)	Chroicocephalus maculipennis (Brown-hooded gull)	Caracara plancus (Southern Caracara)
Dendrocygna viduata (White-faced Whistling-Duck)	Chroicocephalus ridibundus (Black-headed Gull)	Falco biarmicus (Lanner Falcon)
Lophodytes cucullatus (Hooded Merganser)	Fratercula arctica (Atlantic Puffin)	Falco columbarius (Merlin)
Mareca falcata (Falcated Duck)	Gallinago gallinago (Common Snipe)	Falco mexicanus (Prairie falcon)
Marmaronetta angustirostris (Marbled Teal)	Gallinago stenura (Pin-tailed Snipe)	Falco sparverius (American Kestrel)
Melanitta fusca (Velvet Scoter)	Gelochelidon nilotica (Common Gull-billed Tern)	Falco vespertinus (Red-footed Falcon)
Melanitta nigra (Common Scoter)	Haematopus ater (Blackish Oystercatcher)	Milvago chimango (Chimango Caracara)
Melanitta perspicillata (Surf Scoter)	Haematopus ostralegus (Eurasian oystercatcher)	Accipitriformes (n=30)
Mergellus albellus (Smew)*	Haematopus palliatus (American oystercatcher)	Accipiter brachyurus (New Britain Sparrowhawk)
Mergus serrator (Red-breasted merganser)	Hydroprogne caspia (Caspian Tern)	Accipiter gularis (Japanese Sparrowhawk)
Mergus squamatus (Scaly-sided merganser)*	Ichthyaetus melanocephalus (Mediterranean Gull)	Accipiter striatus (Sharp-shinned Hawk)
Oxyura jamaicensis (Ruddy Duck)	Larosterna inca (Inca tern)	Aquila audax (Wedge-tailed Eagle)
Spatula cyanoptera (Cinnamon Teal)	Larus atricilla (Laughing Gull)	Aquila chrysaetos (Golden Eagle)
Spatula puna (Puna Teal)*	Larus audouinii (Audouin's Gull)	Aquila fasciata (Bonelli's eagle)
Spatula querquedula (Garganey)	Larus belcheri (Belcher's Gull)	Aquila rapax (Tawny Eagle)*
Tachyeres pteneres (Magellanic Steamerduck)	Larus brachyrhynchus (Short-billed Gull)	Buteo lagopus (Rough-legged Hawk)
Tadorna ferruginea (Ruddy Shelduck)	Larus brunnicephalus (Brown-headed Gull)	Buteo lineatus (Red-shouldered Hawk)
Gaviiformes (n=3)	Larus cachinnans (Caspian Gull)	Buteo magnirostris (Roadside Hawk)
Gavia immer (Common Loon)	Larus californicus (California Gull)	Buteo platypterus (Broad-winged Hawk)
Gavia pacifica (Pacific Loon)	Larus crassirostris (Black-tailed Gull)	Buteo polyosoma (Red-backed Hawk)*
Gavia stellata (Red-throated Loon)	Larus delawarensis (Ring-billed Gull)	Buteo regalis (Ferruginous Hawk)
Sphenisciformes (n=3)	Larus dominicanus (Kelp Gull)	Buteo swainsoni (Swainson's Hawk)
Eudyptes chrysocome (Southern Rockhopper Penguin)	Larus genei (Slender-billed Gull)	Buteogallus urubitinga (Great Black Hawk)
Spheniscus humboldti (Humboldt Penguin)	Larus glaucescens (Glaucous-winged Gull)	Cathartes aura (Turkey Vulture)
Spheniscus magellanicus (Magellanic Penguin)	Larus glaucoides (Iceland Gull)	Circus assimilis (Spotted Harrier)
Ciconiiformes (n=3)	Larus hyperboreus (Glaucous Gull)	Circus cyaneus (Hen Harrier)
Ciconia boyciana (Oriental Stork)	Larus michahellis (Yellow-legged Gull)	Circus pygargus (Montagu's Harrier)
Ciconia nigra (Black Stork)	Larus novaehollandiae (Silver Gull)	Coragyps atratus (Black Vulture)
Mycteria americana (American Wood Stork)	Larus occidentalis (Western Gull)	Geranoaetus melanoleucus (Black-chested buzzard-eagle)
Procellariiformes (n=13)	Larus philadelphia (Bonaparte's Gull)	Gypaetus barbatus (Bearded vulture)
Ardenna gravis (Great Shearwater)	Larus pipixcan (Franklin's Gull)	Gyps africanus (White-backed vulture)*
Ardenna grisea (Sooty Shearwater)	Larus schistisagus (Slaty-backed Gull)	Haliaeetus pelagicus (Steller's Sea Eagle)
Ardenna tenuirostris (Short-tailed Shearwater)	Larus scopulinus (Silver Gull)	Haliaeetus vocifer (African Fish Eagle)
Fulmarus glacialis (Northern Fulmar)	Larus smithsonianus (Arctic Herring Gull)	Milvus migrans (Black Kite)
Fulmarus glacialoides (Southern Fulmar)	Larus thayeri (Thayer's gull)	Milvus milvus (Red Kite)
Macronectes giganteus (Southern Giant Petrel)	Leucophaeus modestus (Grey gull)	Pandion haliaetus (Osprey)
Macronectes halli (Northern Giant Petrel)	Numenius phaeopus (Whimbrel)	Parabuteo unicinctus (Harris's Hawk)
Pachyptila desolata (Antarctic Prion)	Phalaropus lobatus (Red-necked phalarope)	Sagittarius serpentarius (Secretary Bird)
Phoebastria irrorata (Waved Albatross)	Pluvialis dominica (American Golden Plover)	Strigiformes (n=6)
Procellaria aequinoctialis (White-chinned Petrel)	Pluvialis squatarola (Grey Plover/Black-bellied Plover)	Aegolius acadicus (Northern Saw-whet Owl)
Pterodroma macroptera (Great-winged Petrel)	Rissa tridactyla (Black-legged Kittiwake)	Megascops asio (Eastern Screech Owl)
Puffinus puffinus (Manx Shearwater)	Rynchops niger (Black skimmer)	Megascops choliba (Tropical Screech-owl)
Thalassarche melanophris (Black-browed Albatross)	Scolopax rusticola (Eurasian Woodcock)	Megascops kennicottii (Western Screech-Owl)
Suliformes (n=18)	Stercorarius antarcticus (Brown skua)	Strix nebulosa (Great grey owl)
Fregata magnificens (Magnificent Frigatebird)	Stercorarius chilensis (Chilean Skua)	Strix varia (Barred owl)
Fregata minor (Great Frigatebird)	Stercorarius parasiticus (Arctic Skua)	Caprimulgiformes (n=1)
Leucocarbo atriceps (Imperial Shag)	Stercorarius skua (Great Skua)	Caprimulgus fossii (Mozambique Nightjar)
Morus capensis (Cape Gannet)	Sterna dougallii (Roseate Tern)	Columbiformes (n=2)
Nannopterum brasilianum (Neotropic Cormorant)	Sterna forsteri (Forster's Tern)	Columbina inca (Inca Dove)
Phalacrocorax auritus (Double-crested Cormorant)	Sterna hirundinacea (South American Tern)	Streptopelia turtur (European Turtle-dove)
Phalacrocorax bougainvillii (Guanay Cormorant)	Sterna paradisaea (Arctic Tern)	Piciformes (n=3)
Phalacrocorax brasilianus (Neotropical Cormorant)	Sternula albifrons (Little Tern)	Dendrocopos major (Great spotted woodpecker)
Phalacrocorax gaimardi (Red-legged Cormorant)	Thalasseus acuflavidus (Cabot's Tern)	Pteroglossus castanotis (Chestnut-eared aracari)*
Phalacrocorax lucidus (White-breasted Cormorant)	Thalasseus elegans (Elegant Tern)	Ramphastos cuvieri (white-throated toucan)*
Phalacrocorax magellanicus (Rock Shag)	Thalasseus maximus (Royal Tern)	Trogoniformes (n=1)
Phalacrocorax neglectus (Bank Cormorant)	Tringa flavipes (Lesser Yellowlegs)	Harpactes erythrocephalus (Red-headed Trogon)
Phalacrocorax punctatus (Spotted Shag)	Tringa melanoleuca (Greater Yellowlegs)	Passeriformes (n=22)
Sula leucogaster (Brown Booby)	Tringa semipalmata (Willet)	Agelaius phoeniceus (Red-winged Blackbird)
Sula nebouxii (Blue-footed Booby)	Tringa totanus (Common Redshank)	Carduelis carduelis (European goldfinch)
Sula sula (Red-footed Booby)	Uria aalge (Common Murre)	Carduelis chloris (European Greenfinch)
Sula variegata (Peruvian Booby)	Uria lomvia (Thick-billed Murre)	Corvus brachyrhynchos (American Crow)
Urile penicillatus (Brandt's Cormorant)	Vanellus chilensis (Southern Lapwing)	Corvus caurinus (Northwestern Crow)
Pelecaniformes (n=13)	Vanellus vanellus (Northern Lapwing)	Corvus corone (Carrion Crow)
Ajaia ajaja (Roseate Spoonbill)	Xema sabini (Sabine's Gull)	Corvus monedula (Western Jackdaw)
Ardea herodias (Great Blue Heron)	Podicipediformes (n=8)	Corvus ossifragus (Fish Crow)
Bostrychia hagedash (Hadeda Ibis)	Aechmophorus occidentalis (Western Grebe)	Cyanocitta cristata (Blue Jay)
Egretta caerulea (Little Blue Heron)	Podiceps auritus (Horned Grebe)	Cyanocorax chrysops (Plush-crested Jay)
Egretta intermedia (Intermediate Egret)	Podiceps grisegena (Red-necked Grebe)	Garrulus glandarius (Eurasian Jay)
Egretta thula (Snowy Egret)	Podiceps major (Great Grebe)	Junco hyemalis (Dark-eyed Junco)
Eudocimus ruber (Scarlet Ibis)*	Podilymbus podiceps (Pied-billed Grebe)	Passer montanus (Eurasian Tree Sparrow)
Geronticus eremita (Northern Bald Ibis)	Spilornis cheela (Crested Serpent Eagle)	Phylloscopus trochilus (Willow warbler)
Pelecanus erythrorhynchos (American White Pelican)	Spizaetus nipalensis (Mountain hawk-eagle)	Pica hudsonia (Black-billed Magpie)
Pelecanus occidentalis (Brown Pelican)	Vultur gryphus (Andean condor)*	Pygochelidon cyanoleuca (Blue-and-white Swallow)
Pelecanus rufescens (Pink-backed Pelican)	Cathartiformes (n=2)	Pyrrhula pyrrhula (Eurasian Bullfinch)
Pelecanus thagus (Peruvian Pelican)	Gymnogyps californianus (California Condor)	Quiscalus mexicanus (Great-tailed grackle)
Plegadis chihi (White-faced Ibis)*	Sarcoramphus papa (King Vulture)	Quiscalus quiscula (Common Grackle)
		Tachycineta bicolor (Tree Swallow)
		Turdus iliacus (Redwing)
		Turdus migratorius (American Robin)

Impacts on biodiversity







SCIENTIFIC TASK FORCE ON AVIAN INFLUENZA AND WILD BIRDS

STATEMENT - JULY 2023

https://openknowledge.fao.org/server/api/core/bitstreams/9b880198-02d2-4eda-a860-d1a56299bc31/content

Mortality in worlds largest breeding colony of Northern Gannets

Species affected – Wild birds – mortality events

- Africa – Long distance migratory birds and resident birds: e.g. Pelicans, Terns, African penguins

Figure 8. As this outbreak of HPAI in pelicans in Senegal shows, there are challenges in carcass removal but this can be undertaken safely if appropriate PPE is worn and carcasses are disposed of appropriately. Planning for such operations should be built into emergency response plans and developed in 'peacetime'. Image credits: FAO

Photo: CMS FAO Co-convened Scientific Task Force on Avian Influenza and Wild Birds (2023). Scientific Task Force on Avian Influenza and Wild Birds statement on H5N1 high pathogenicity avian influenza in wild birds – Unprecedented conservation impacts and urgent needs. Available at: https://www.cms.int/en/workinggroup/scientific-task-force-avian-influenza-and-wild-birds

Species affected – Wild birds – mortality events

- Asia: Crane species and Spoonbill

Increased infectivity in effective bridging species?

Charadriiformes: diverse order live near water

Sub group Laridae (gulls, terns, noddies, skimmers, kittiwakes);ubiquitous

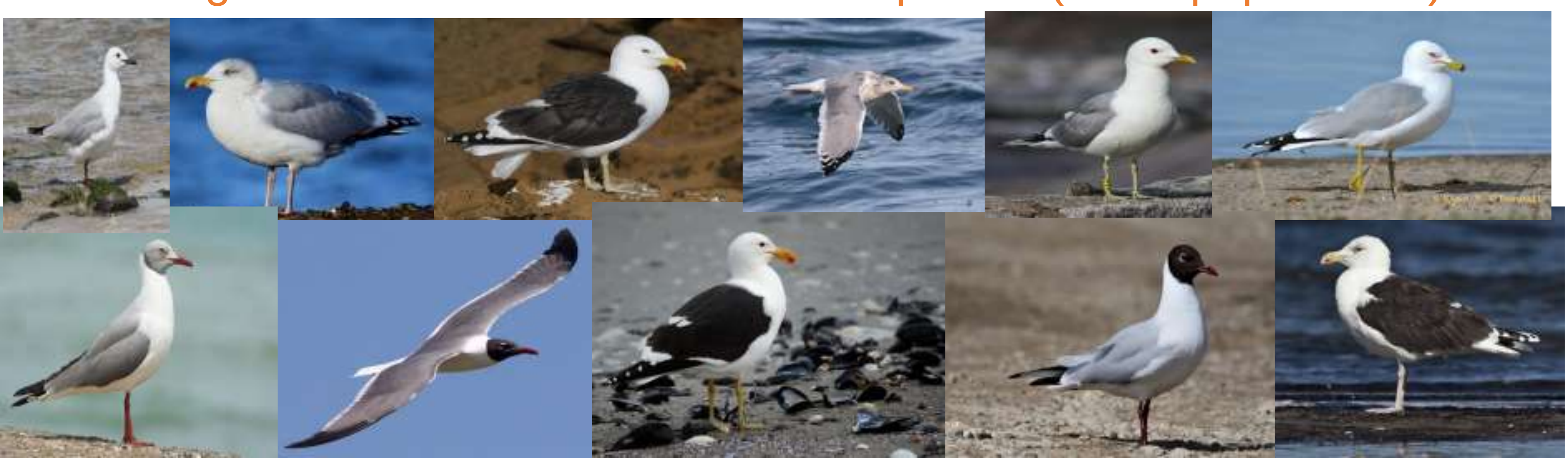
100 species from 22 genera many of which have become infected with H5N1

Genetic changes in virus

High susceptibility and virus shedding

Behavioural; move between habitats (land, sea, remote land masses)

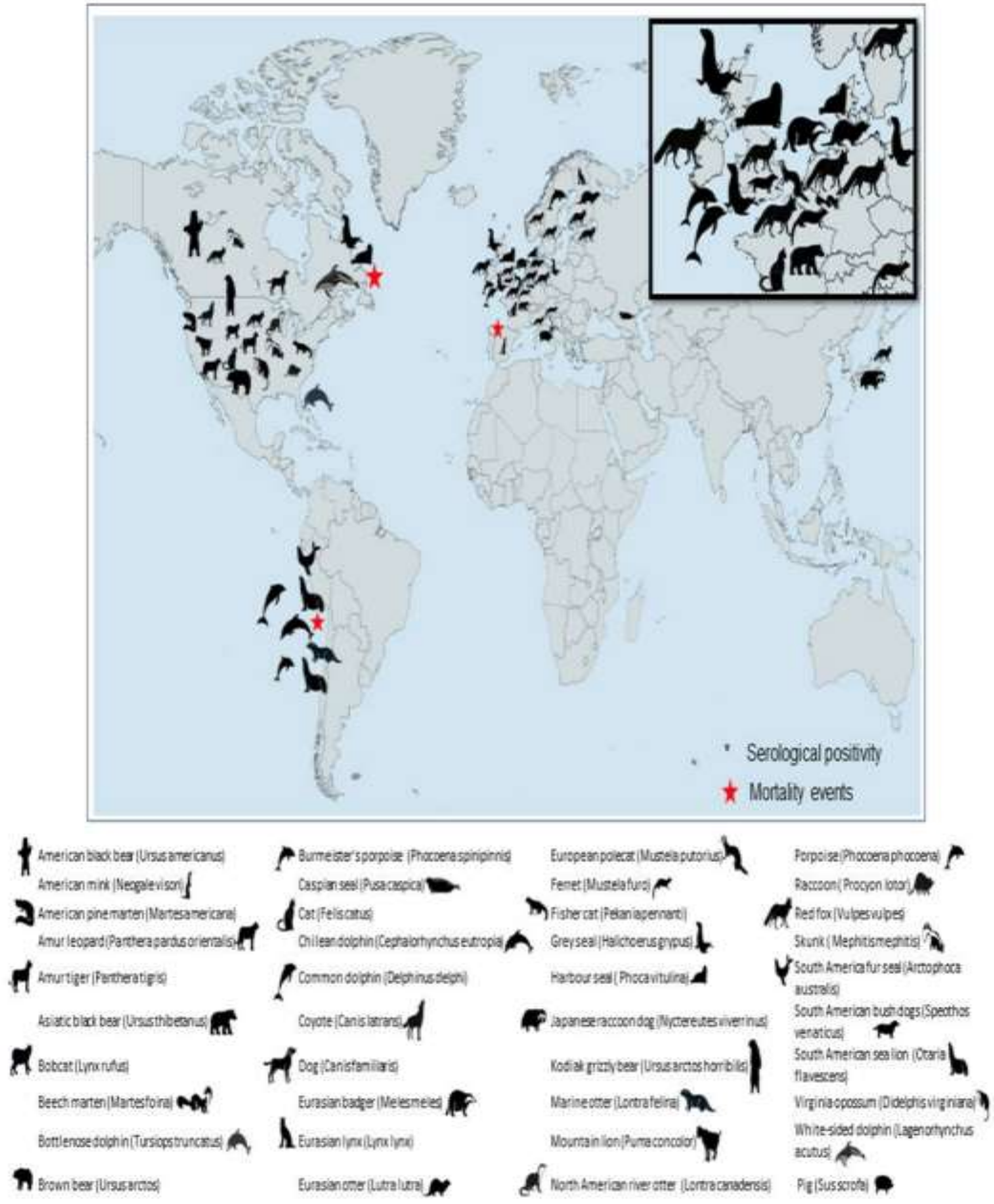
Increasing environmental contamination/exposure (naïve populations)



Spread to mammals

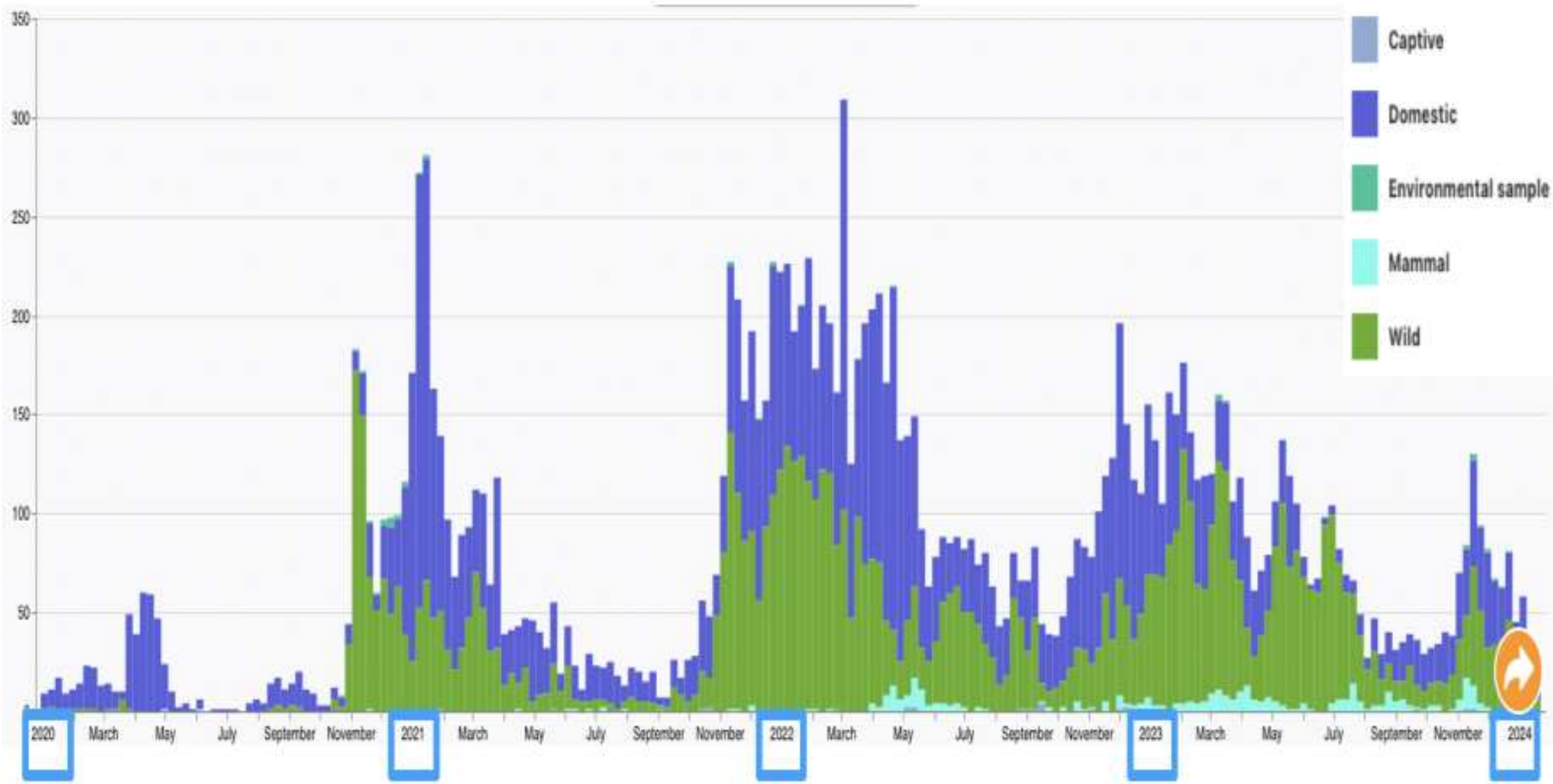
- Captive bred animals: mink, foxes
- Wild Scavengers; ie foxes, seals, stoat, otter
- Domestic ; cats

Avian influenza overview March - April 2023



H5 detections: Expanded host range

Timeline of number of outbreaks of HPAI from 2020 to present



HPAI in mammals - impact on biodiversity

Mass mortality events (biodiversity)

More than **51,000** mammals died in South America (Oct-22 Nov-23)

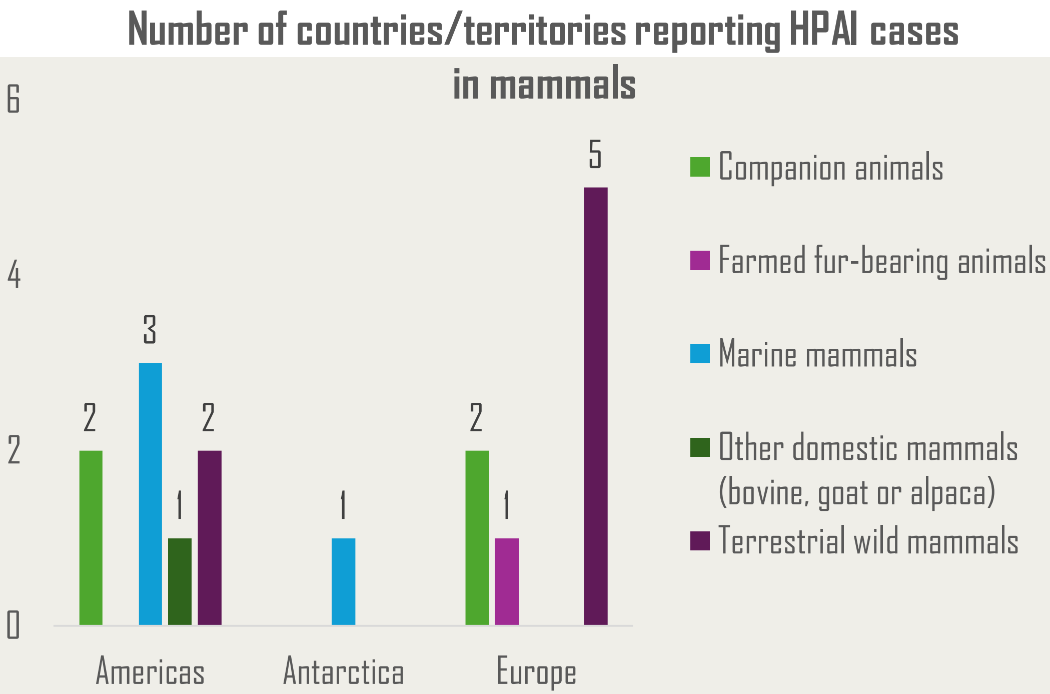
More than 10,000 dead South American sea lions in Peru

offlu
WOAH FAO
network of expertise on animal influenza

21 December, 2023

Continued expansion of high pathogenicity avian influenza H5 in wildlife in South America and incursion into the Antarctic region

Reporting by mammal category October 2023 – September 2024

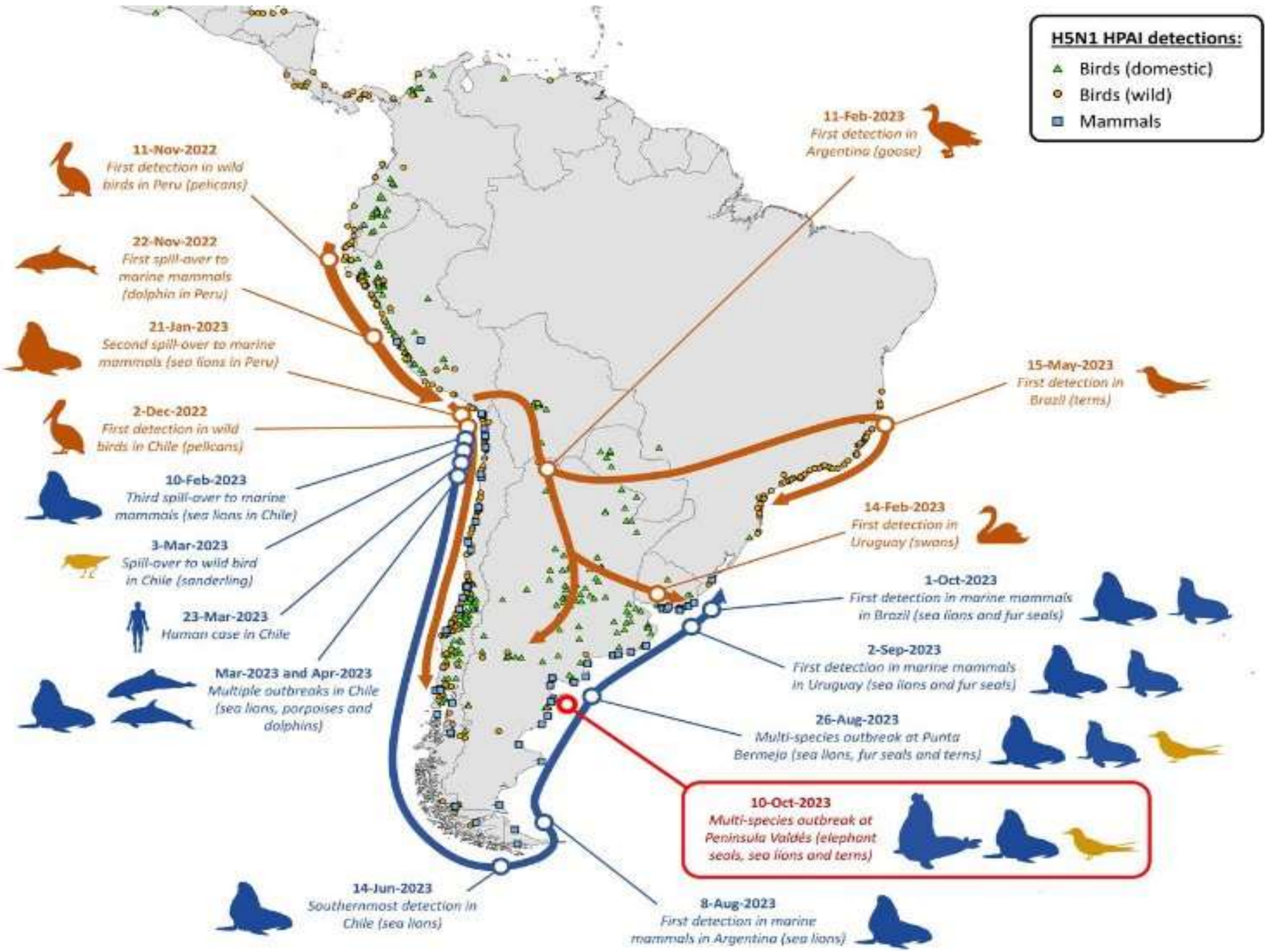


12 countries/territories

Argentina, Brazil, Canada, Finland, Germany, Hungary, Norway, United Kingdom, United States of America, South Georgia, Sweden, Uruguay

- **Companion animals** : cats and dogs
- **Farmed fur-bearing mammals** : 4 species *(American mink, Arctic fox, raccoon dog, sable)*
- **Marine mammals** : 4 species *(Antarctic fur seal, South American fur seal, South American sea lion, Southern elephant seal)*
- **Other domestic mammals** : 3 species *(alpaca, bovine, goat)*
- **Terrestrial wild mammals:** 13 species (e.g. raccoon, red fox, Eurasian otter)

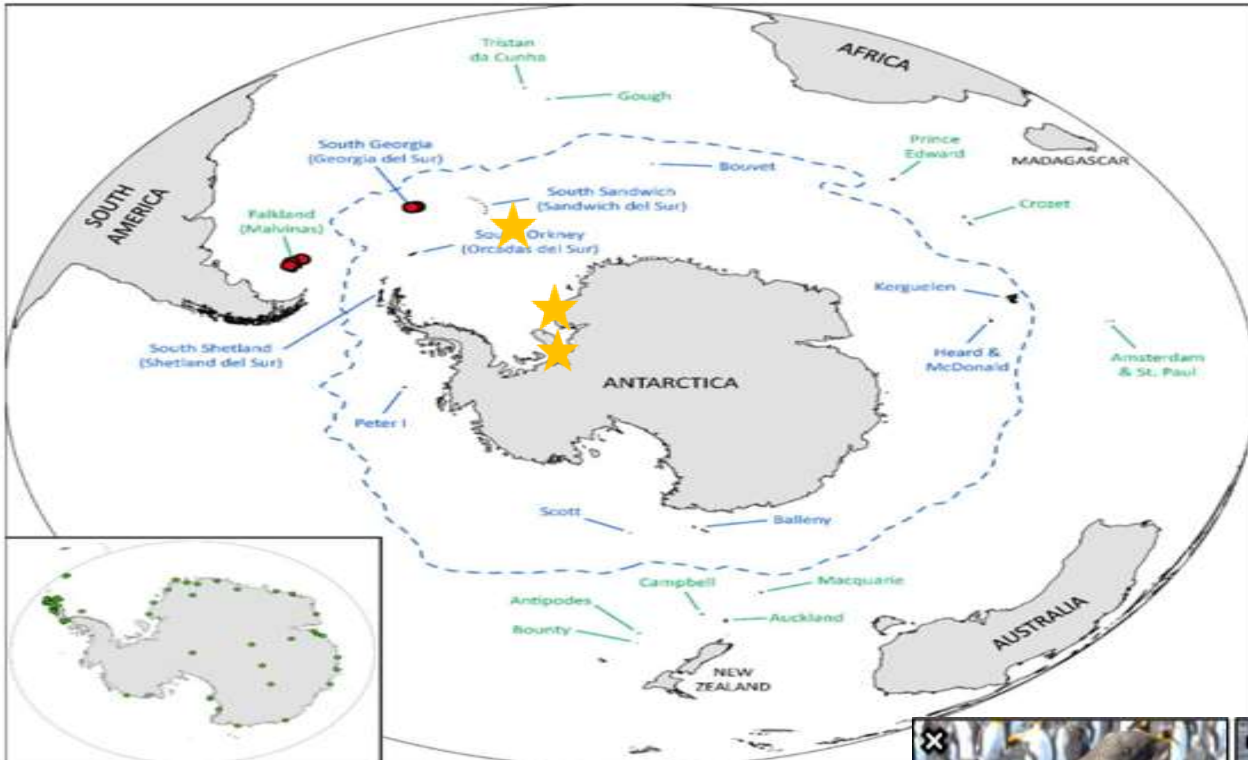
Semi-aquatic mammals in South America
Mammal to mammal transmission



Uhart et al, bioRxiv, 2024

Spread to Antarctica

OFFLU ad-hoc group on HPAI H5 in wildlife of South America and Antarctica (2023) Continued expansion of high pathogenicity avian influenza H5 in wildlife in South America and incursion into the Antarctic region.



Separate introductions into South Georgia, South Sandwich Islands and Falkland islands; spread to shelf

nature communications

Article

Detection and spread of high pathogenicity avian influenza virus H5N1 in the Antarctic Region

Received: 23 November 2023
Accepted: 8 August 2024
Published online: 03 September 2024

Ashley C. Banyard[1,2], Ashley Bennison[3], Alexander M. P. Byrne[1,4], Scott M. Reid[1], Joshua G. Lynton-Jenkins[1,7], Benjamin Mollett[1], Dilhani De Silva[1], Jacob Peers-Dent[1], Kim Finlayson[4], Rosamund Hall[4], Freya Blockley[4], Marcia Blyth[3], Marco Falchieri[1], Zoe Fowler[6], Elaine M. Fitzcharles[3], Ian H. Brown[1,2] & Joe James[1,6]

Highly Pathogenic Avian Influenza A (H5N1) Suspected in penguins and shags on the Antarctic Peninsula and West Antarctic Coast

Fabiola León, Céline Le Bohec, Eduardo J. Pizarro, Loïcka Baille, Robin Cristofari, Aymeric Houstin, Daniel P. Zitterbart, Gonzalo Barriga, Elie Poulin, Juliana A. Vianna

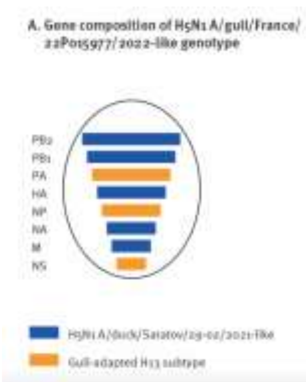
doi: https://doi.org/10.1101/2024.03.16.585360

This article is a preprint and has not been certified by peer review [what does this mean?].

Abstract | Full Text | Info/History | Metrics | Preview PDF

Outbreaks in captive bred mammals

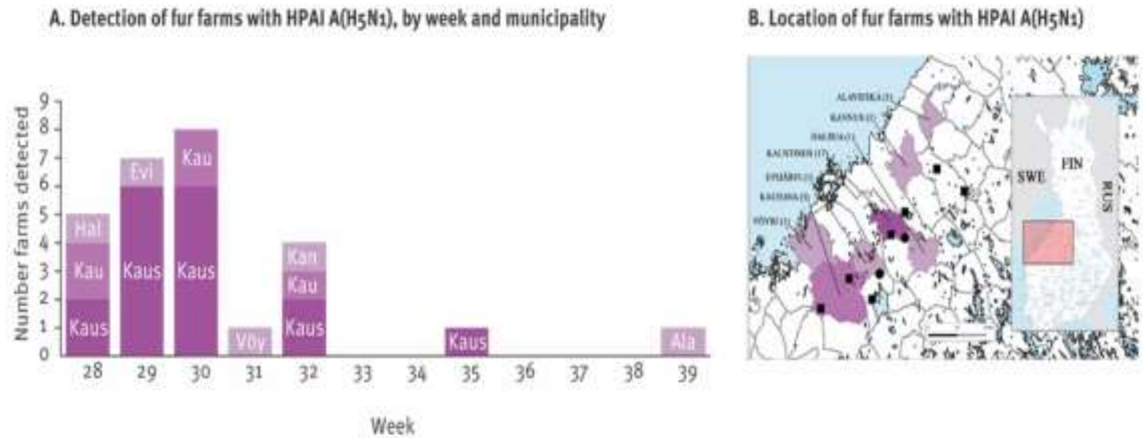
Spain ; Oct 22 outbreak in mink farm (52k)



Limited adaptive changes in the virus (T271A) in the PB2 gene

Montserrat et al (https://doi.org/10.2807/1560-7917.ES.2023.28.3.2300001)

H5N1 HPAI in fur farms in Finland July-Oct 2023



- Initial point introductions from wild birds
- Secondary spread between fur farms
- Up to 7 genetic changes associated with mammalian adaptation but not all viruses

- Depopulation and other control measures
- Prophylactic vaccination of fur farms workers now offered


Eurosurveillance

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Outbreaks

Open Access

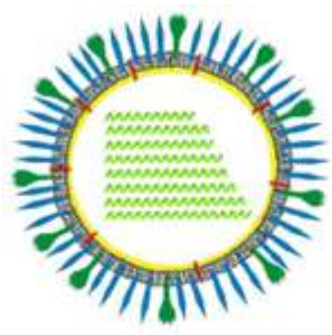
Highly pathogenic avian influenza A(H5N1) virus infections on fur farms connected to mass mortalities of black-headed gulls, Finland, July to October 2023

Companion animals: H5 HPAI

- H5N1 HPAI infections in cats have been widely reported
- Variable clinical manifestations, including respiratory and neurological signs, often fatal outcomes.
- Infection via exposure to infected birds, other animals, contaminated feed or in the milking parlour!
- Captivity die offs ie Large cats in zoos

- Dogs susceptible
- Very infrequent reports

The virus driving the impact!



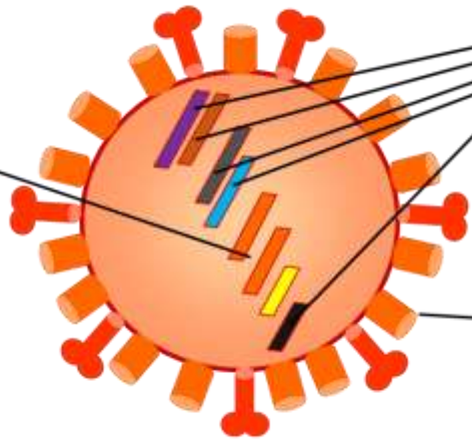
The 2021-24 H5N1 HPAI is the most infectious and dangerous of strains to date

Multiple evolved traits

Virological explanations for the unprecedented 2021-present H5N1 epidemic

1. Acquisition of N1 NA conferred fitness in ducks and wild birds

but possibly not fitness in chickens due to long stalk



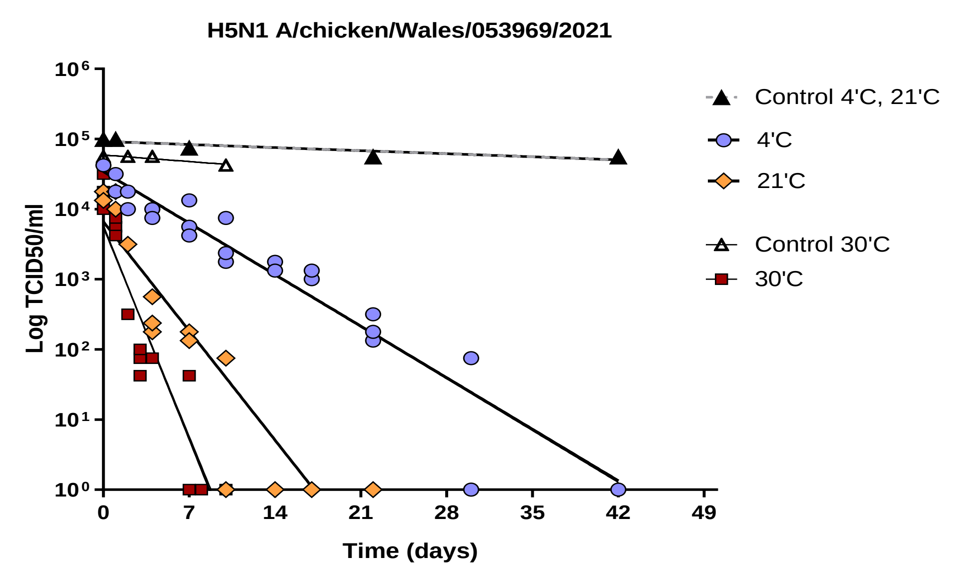
2. Increased fitness in wild birds enabled multiple reassortment events to acquire optimized internal gene constellation

3. Mutations in H5 HA restored thermostability but it remains specific for α2,3 sialic acid

Contemporary H5N1 viruses have enhanced fitness to infect, transmit and persist in birds, but remain un-adapted to humans.

Animal & Plant Health Agency

H5N1 HPAI viruses have enhanced survival kinetics in the environment

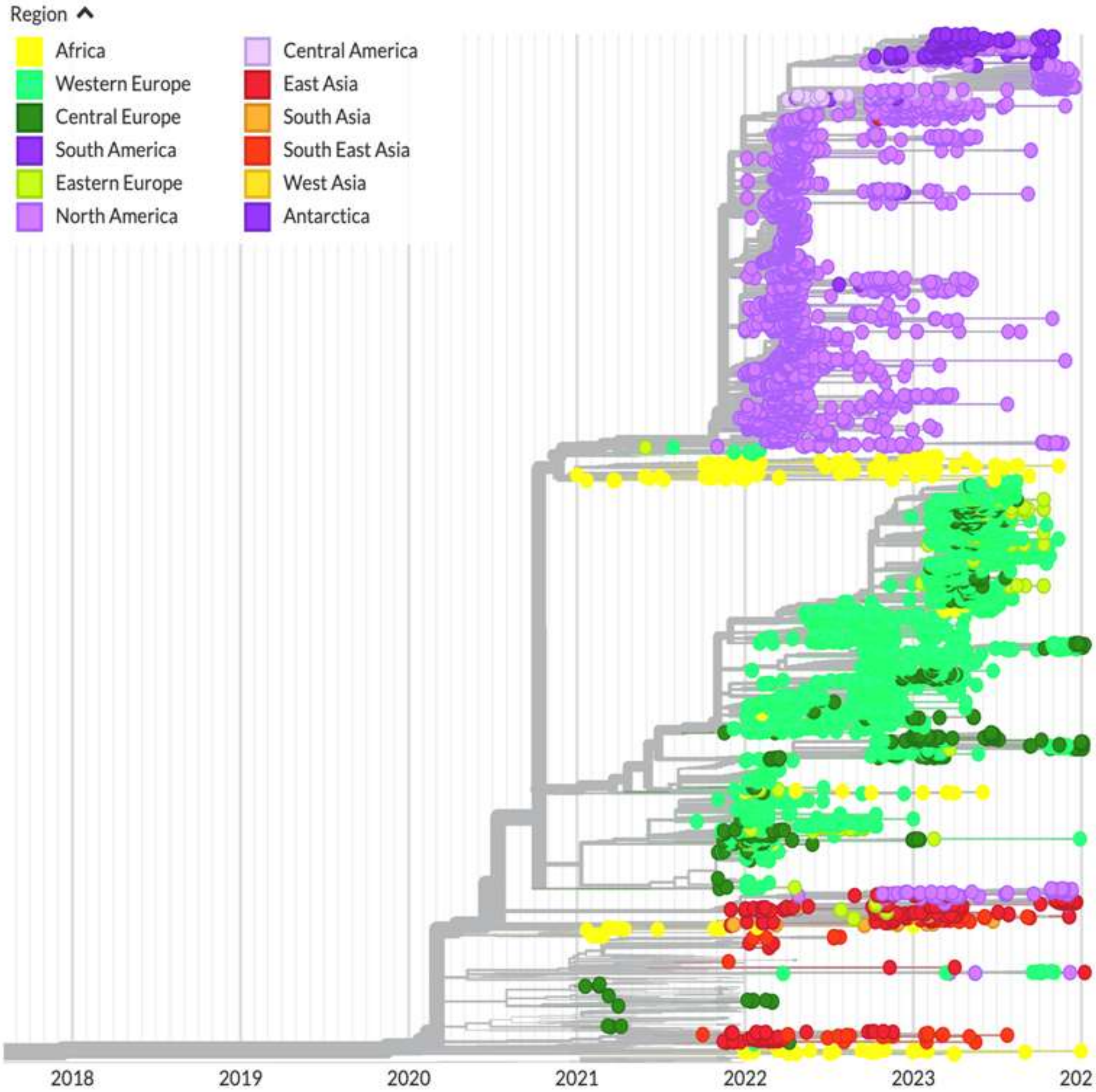


- D_t is time taken in days for a 90% reduction in viral infectivity, (a 1 log_{10} decrease) at temperature t.
- Survival of H5N1-2021 at 4˚C is 43.2 days dose adjusted

- **H5N1-2021 at 4˚C** **D_4 of 9.5 days** (R^2 0.93, to 6 weeks) X=0 at 43.2 days
- **H5N1-2021 at 20˚C** **D_{20} of 4.5 days** (R^2 0.87, to 3 weeks) X=0 at 17.2 days
- **H5N1-2021 at 30˚C** **D_{30} of 2.3 days** (R^2 0.88, to 2 weeks) X=0 at 8.7 days

Warren et al (2024) Assessment of Survival Kinetics for Emergent Highly Pathogenic Clade 2.3.4.4 H5Nx Avian Influenza Viruses. Viruses 2024, 16, 889. https://doi.org/10.3390/v16060889

Genetic analysis of Gs/Gd A(H5) sequences



Monitoring viral spread: Collaboration with multi-national laboratories and institutions

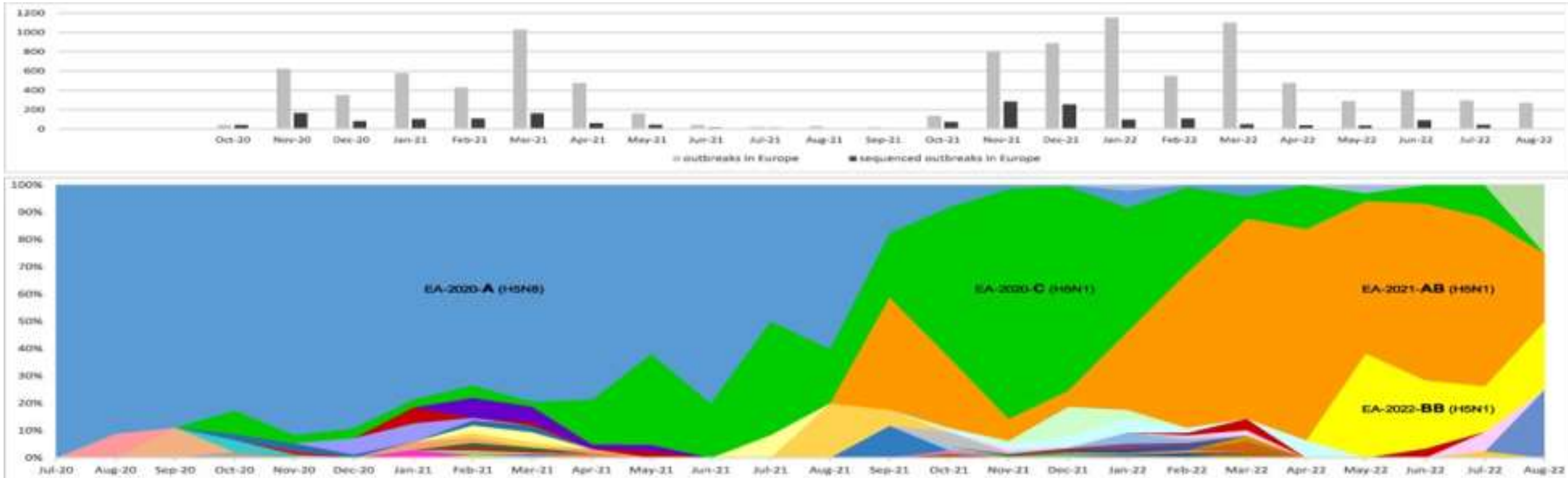
Introductions into continents through long range migratory birds

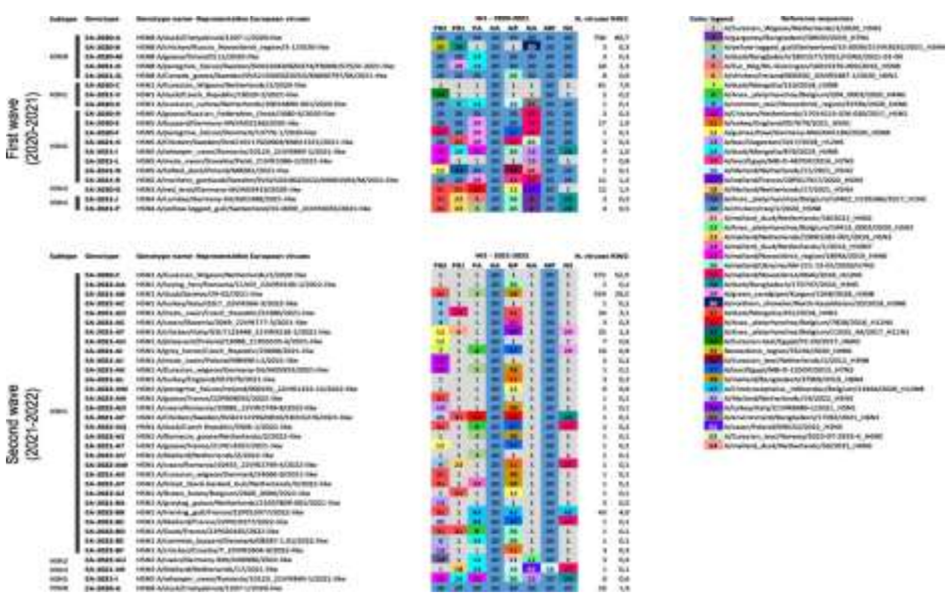
Maintenance and secondary spread of the virus in poultry populations and resident wild birds

Occasional spillover into mammals

Occasional spillover into humans

Extensive genetic heterogeneity: large genotype diversity in Europe






JOURNAL ARTICLE

High pathogenic avian influenza A(H5) viruses of clade 2.3.4.4b in Europe—Why trends of virus evolution are more difficult to predict

Alice Fusaro, Bianca Zecchin, Edoardo Giussani, Elisa Palumbo, Montserrat Agüero-García, Claudia Bachofen, Ádám Bálint, Fereshteh Banihashem, Ashley C Banyard, Nancy Beerens ... Show more

Author Notes

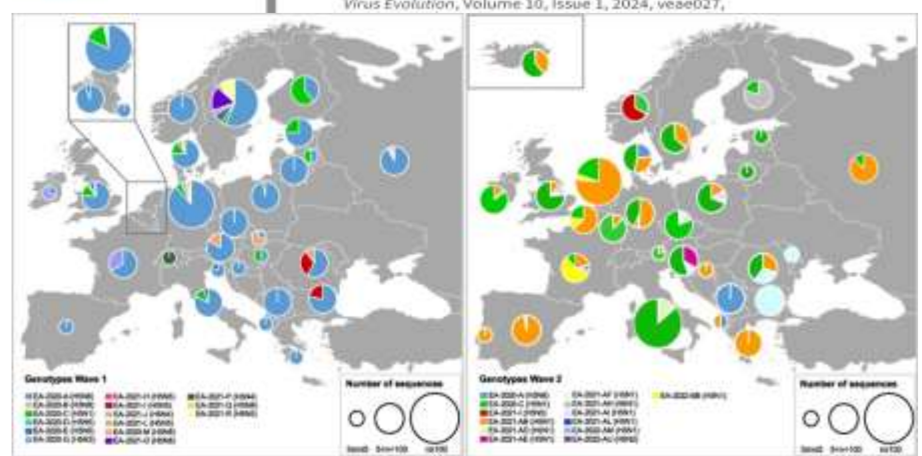
Virus Evolution, Volume 10, Issue 1, 2024, veae027,

VIRUS EVOLUTION

Volume 10, Issue 1

2024

(In Progress)



Further genetic heterogeneity in the America's

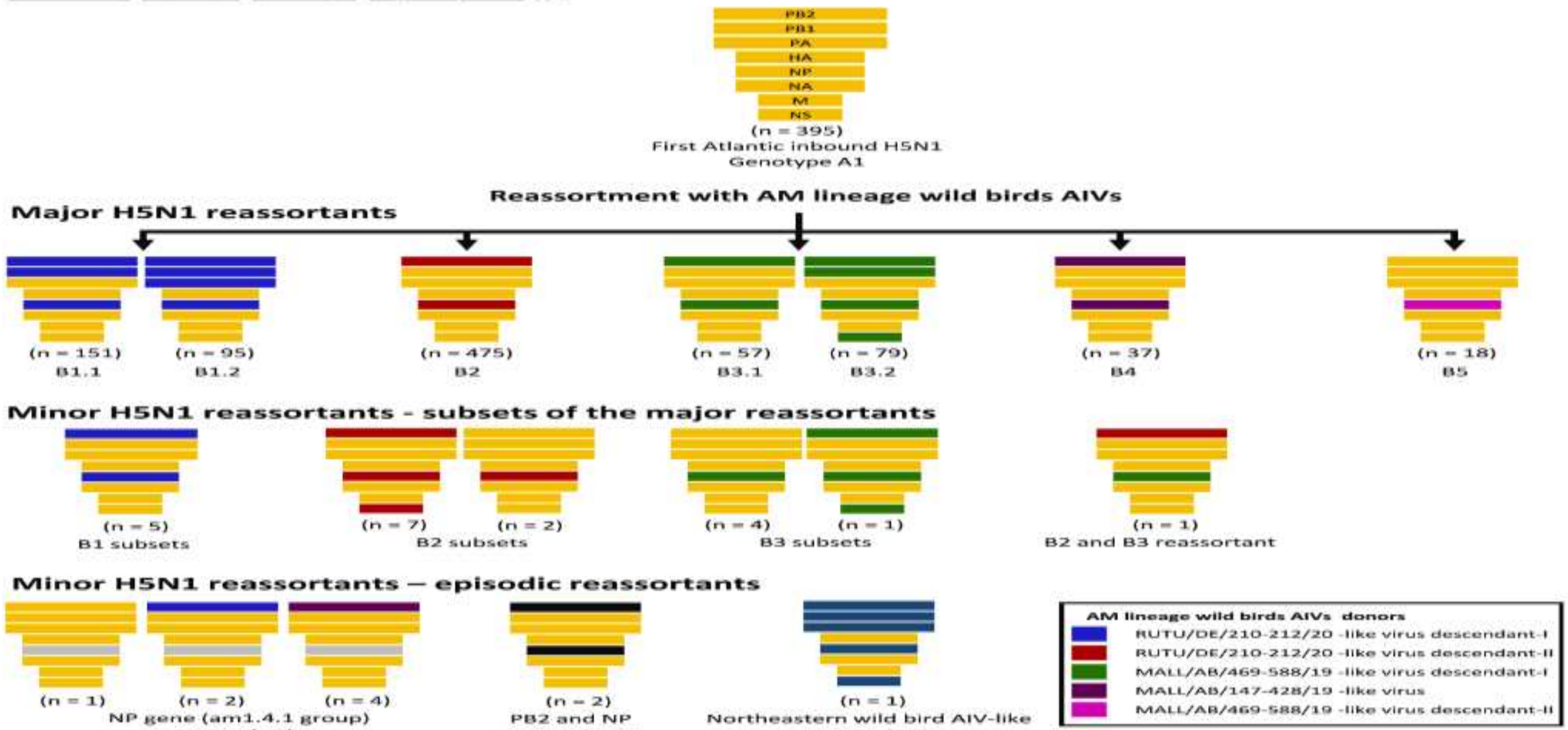
ELSEVIER

Virology

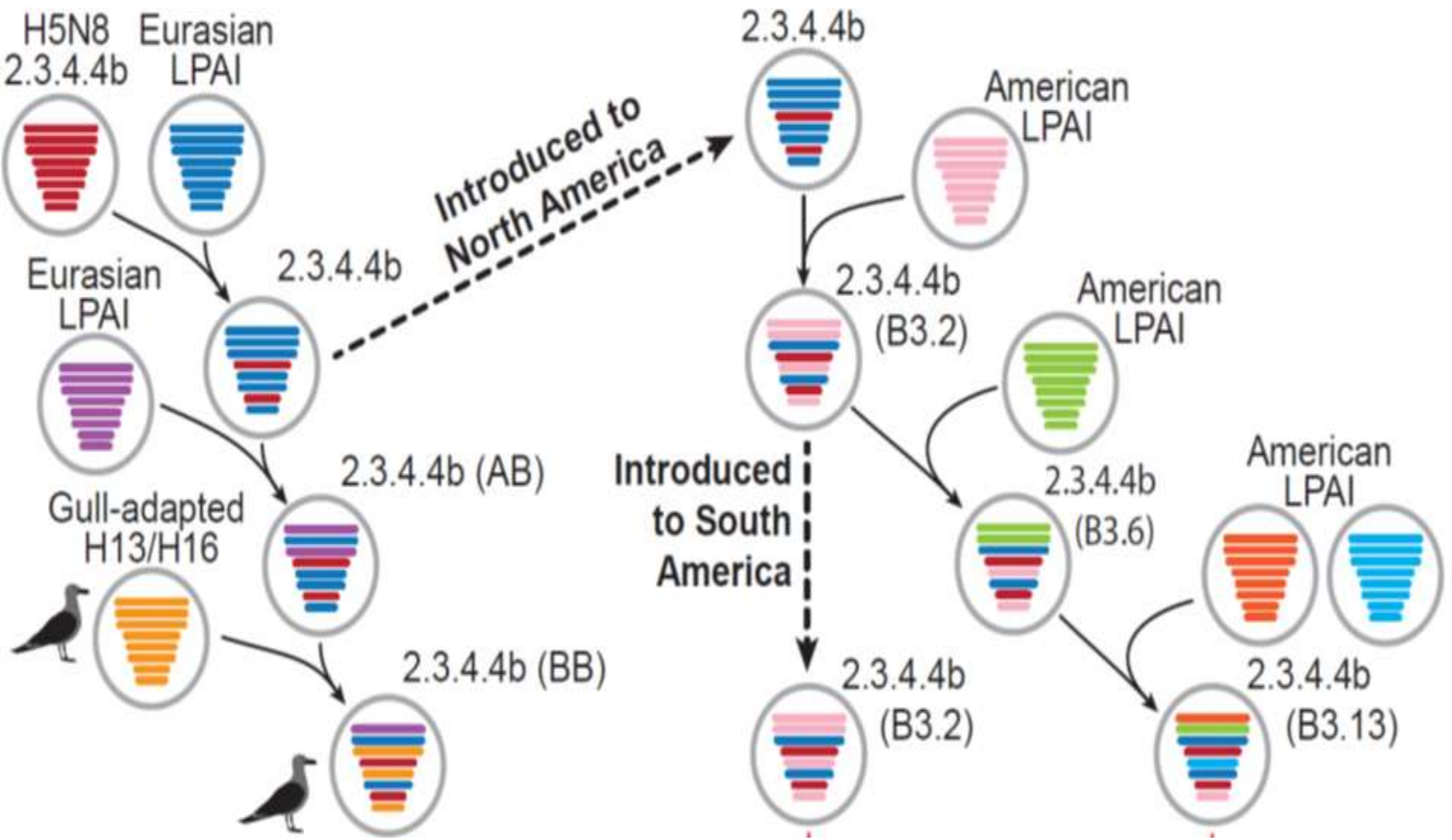
Volume 587, October 2023, 109860

H5N1 highly pathogenic avian influenza clade 2.3.4.4b in wild and domestic birds: Introductions into the United States and reassortments, December 2021–April 2022

Sungsu Youk [a,f], Mia Kim Torchetti [b], Kristina Lantz [b], Julianna B. Lenoch [c], Mary Lea Killian [b], Christina Leyson [a], Sarah N. Bevins [c], Krista Dilione [c], Hon S. Ip [d], David E. Stallknecht [e], Rebecca L. Poulson [e], David L. Suarez [a], David E. Swayne [a], Mary J. Pantin-Jackwood [a]



Iterative reassortment drove the emergence and propagation of the H5N1 panzootic



Peacock et al, 2024 (Figure credit Martha Nelson and David VanInsberghe)

Future changes in the H5 viruses

Immune pressure in an exposed recovered population will shape virus selection

Immune escape variants of the virus which carry a 'fitness' for host population can persist and spread

In time will carry a selection advantage of previous epizootic strains

The contribution of prior immunity to all influenza A viruses is not understood

Why are wild birds spreading less virus?

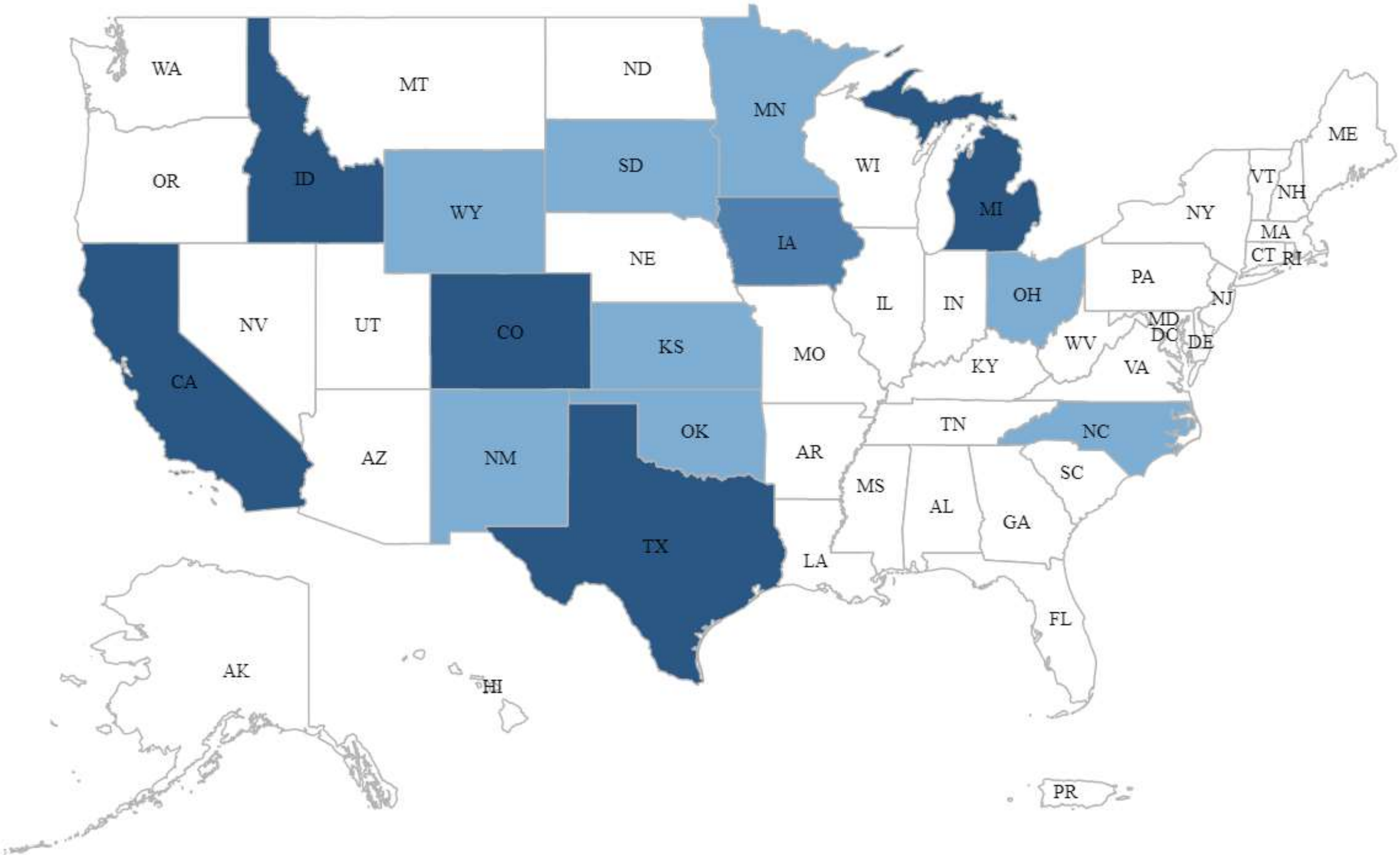
- Immunity is building in the population ie 3-4 years
- Immune birds less susceptible and shed less virus
- Less virus being shed into the environment
- Less virus to find its way through farm defences
- If the virus devises a way to escape wild bird immunity

= NEW EPIDEMIC STRAIN

- Continued close monitoring required in naïve and vaccinated populations to assess any changes in virus; relevance for vaccine strain selection

Spread of H5N1 HPAI to dairy cattle

H5N1 HPAI dairy cattle outbreak 10th March 2024 to present
Cases 300/14 states



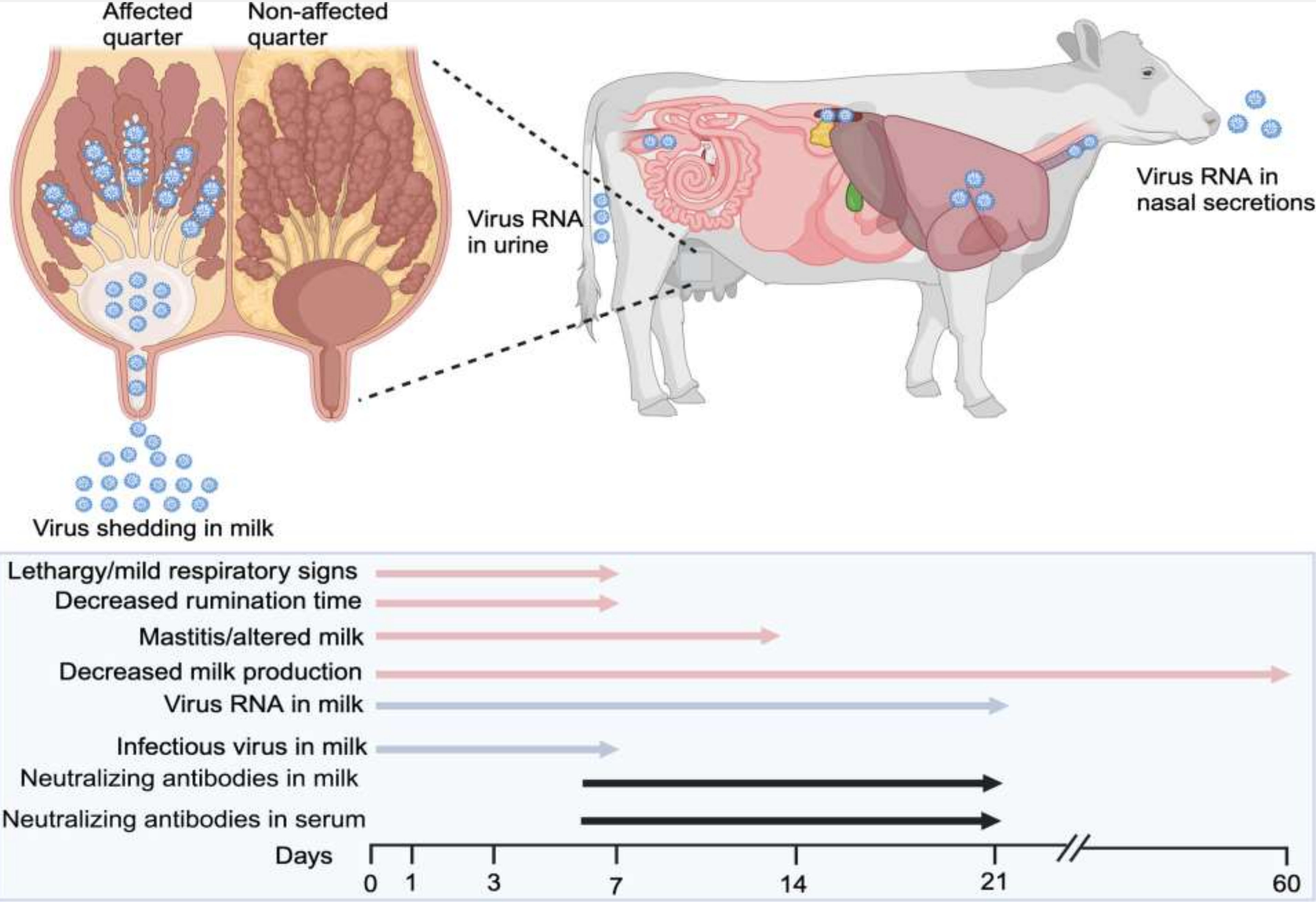
Dairy cattle; infection and epidemiology

- Single spill over of H5N1 HPAI (B3.13 genotype)
- Initial signs are drop in feed intake and milk output
- Mastitis
- Symptoms range from asymptomatic to lethal
- Viral load in milk can be very high
- Almost exclusively lactating cows
- More in older animals

- Replication largely in mammary gland
- Respiratory infection at best transient

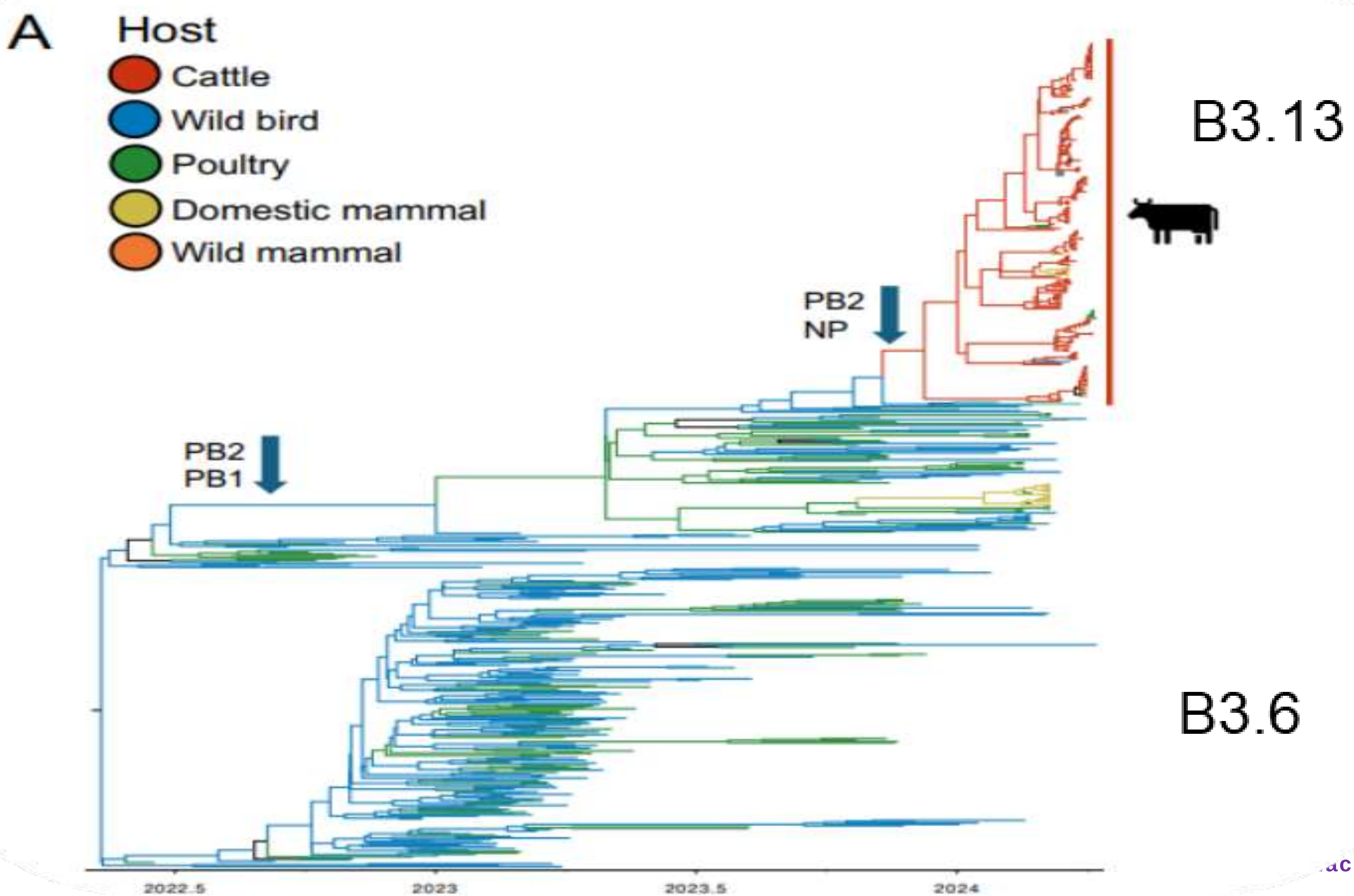
- Spread pathways mechanical ie via fomite, or movement of infected animals but high uncertainties

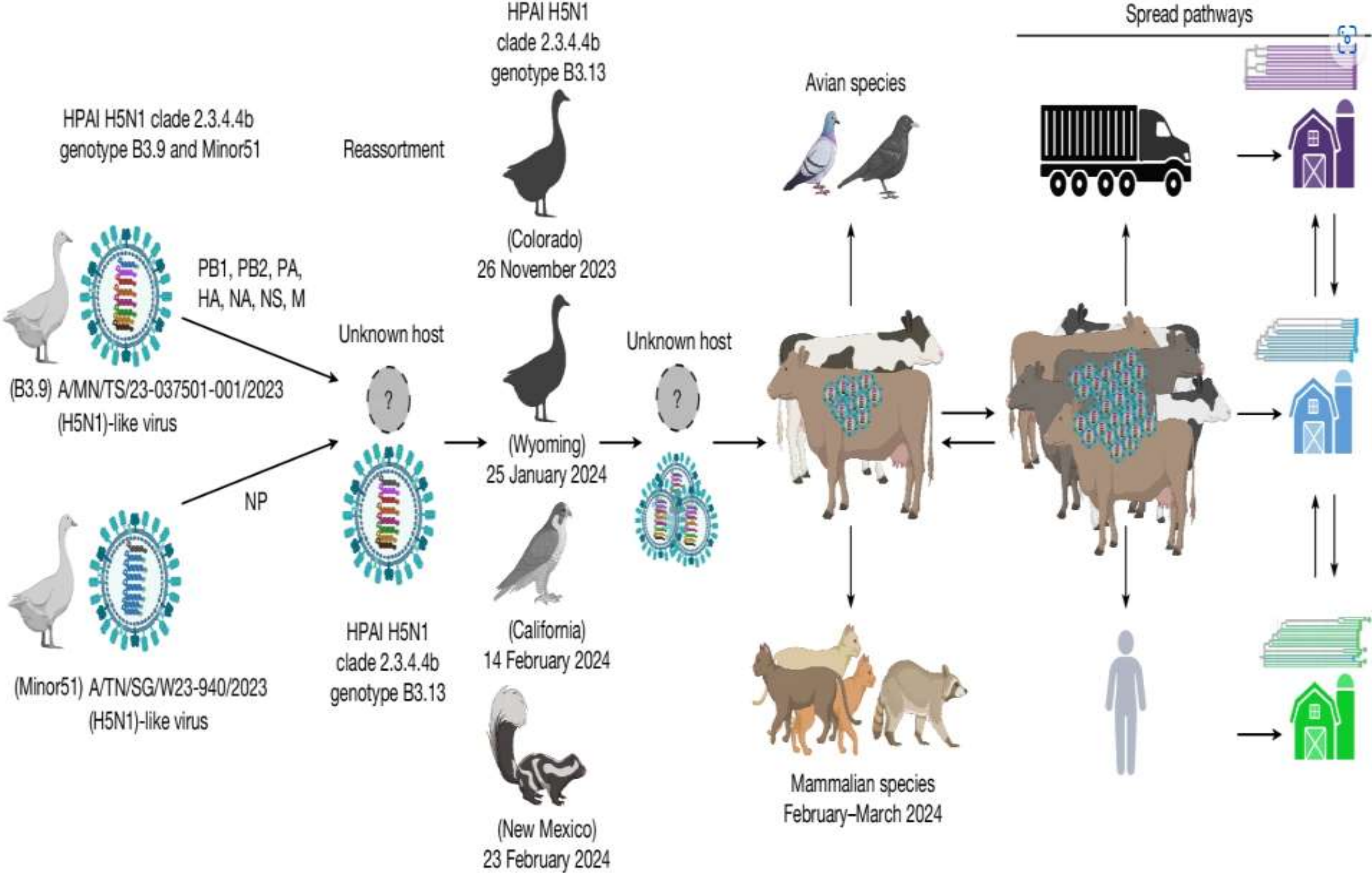
Salman et al https://doi.org/10.3168/jdsc.2024-0638.



Genetic characteristics of H5N1 in dairy cattle

Nguyen et al bioRxiv https://doi.org/10.1101/2024.05.01.591751; t





Caserta, L.C., Frye, E.A., Butt, S.L. et al. Spillover of highly pathogenic avian influenza H5N1 virus to dairy cattle. Nature (2024). https://doi.org/10.1038/s41586-024-07849-4

Dairy cattle epidemic; implications for poultry?

- Dairy farms often close proximity to poultry
- Poorer biosecurity practices
- Shared personnel/household contacts between sectors
- Cattle virus whilst replicating in mammary gland phenotypically avian
- Fully infectious for domestic birds
  - Human cases; mild
- No evidence to date for spill over into wild birds of diary cattle B3.13 virus
- Infection confined to USA

- Reduction of threat from cattle via vaccination?
- Field Studies with Nonviable, Non-replicating Veterinary Vaccines Targeting Highly Pathogenic Avian Influenza in Livestock https://www.aphis.usda.gov/news/program-update/cvb-notice-24-13-field-studies-nonviable-non-replicating-veterinary-vaccines

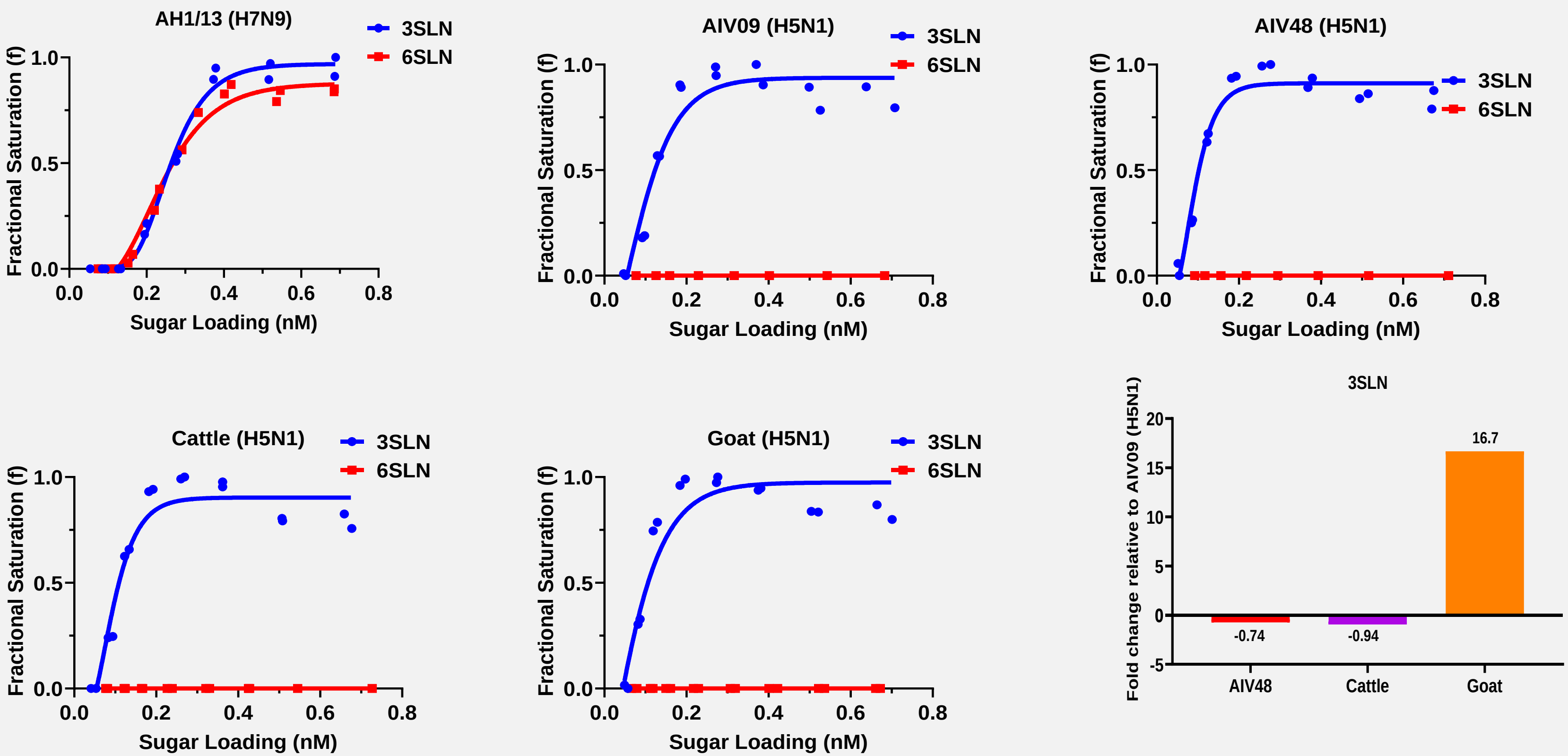
Human case summary associated with dairy cattle epidemic (16/10/24)

State	Cattle	Poultry	Unknown	State Total
California	6	0	0	6
Colorado	1	9	0	10
Michigan	2	0	0	2
Missouri	0	0	1	1
Texas	1	0	0	1
Source Total	**10**	**9**	**1**	**20**

Pasteurisation kills live virus in the milk

https://www.cdc.gov/bird-flu/situation-summary/index.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fbird-flu%2Fphp%2Favian-flu-summary%2Findex.html

Do the cattle and goat H5N1 viruses pose risk to humans?



Cattle and goat H5N1 viruses retain affinity for avian-like receptor analogue 3SLN.

Do the cattle and goat H5N1 viruses pose risk to humans?

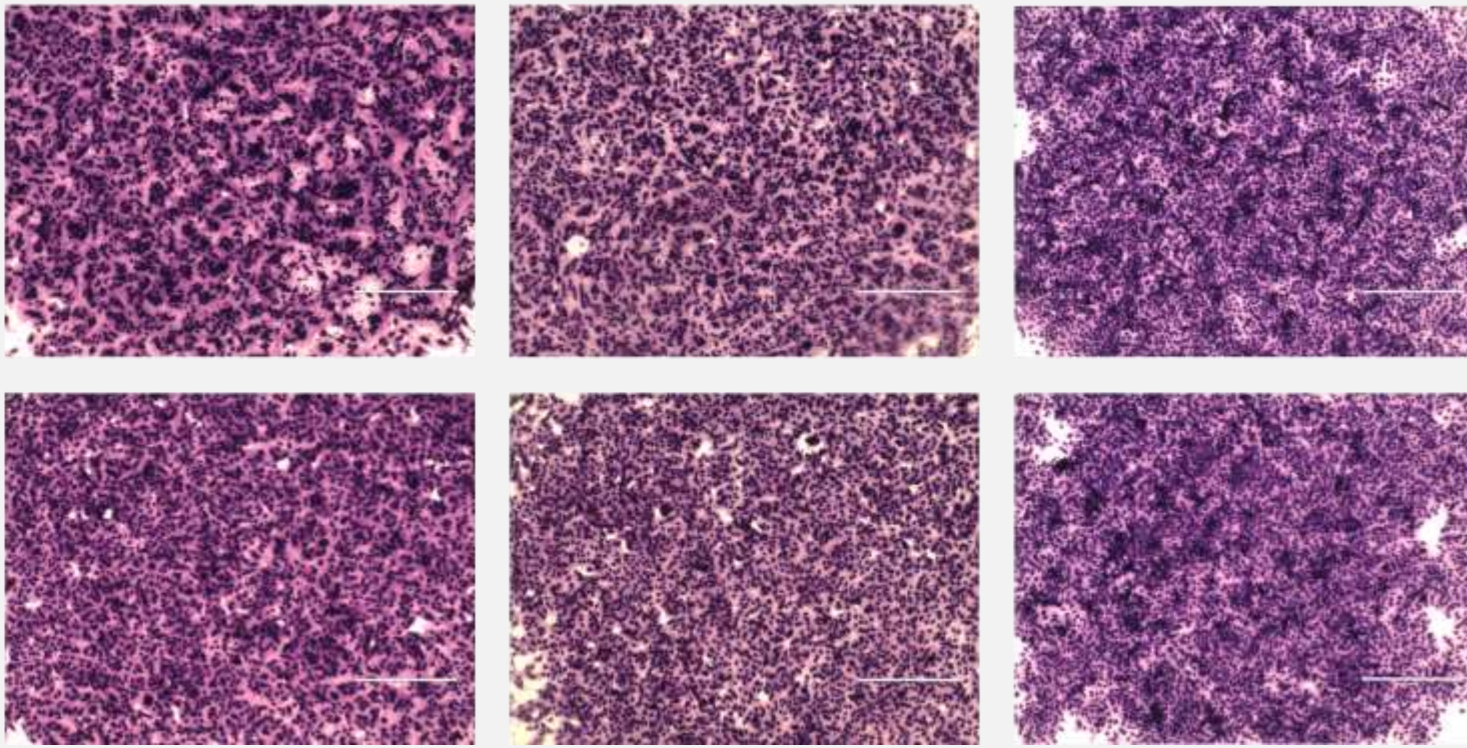
Pirbright

pH stability

Cattle | Goat | Control

pH 5.9

pH 6.0



Optimum pH fusion for human cells: <5.5

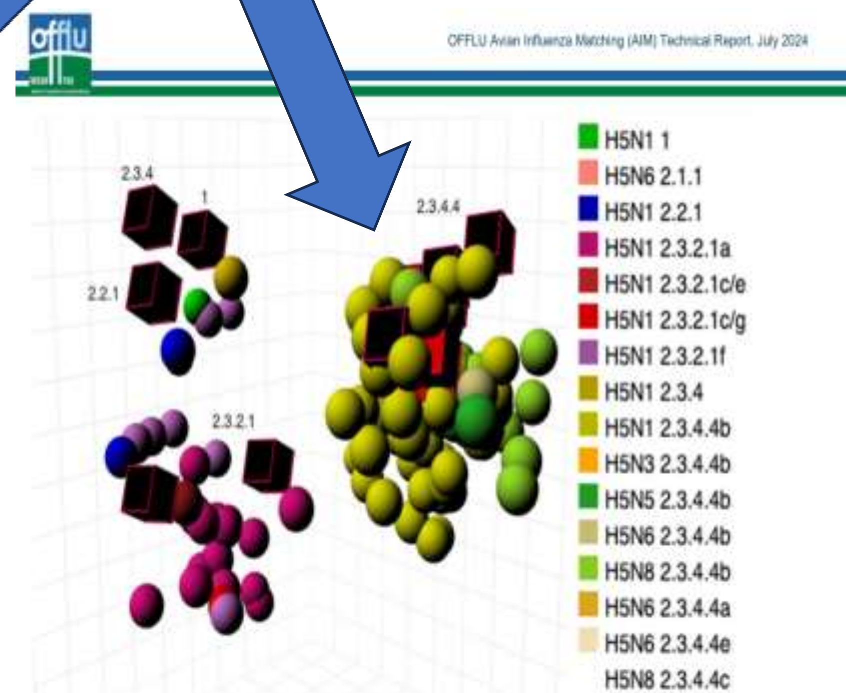
Optimum pH fusion for Avian cells: >5.5

Cattle and goat H5N1 viruses retained avian-like phenotype and showed membrane fusion at pH5.9.

Have the viruses changed antigenically in last two years :relevance for vaccines?

Year	Clade	Subtype	Region	A/Vietnam/1194/2004/1 A/chicken/Vietnam/C58/04	A/Turkey/turkey/2005 A/swan/Hungary/4999/2006	A/Anhui/1/2005 A/Duck/Anhui/1/2006	A/chicken/Nepal/T360/2014 A/duck/Guangdong/S1322/2010	A/mynah/Indonesia/13064792-010/201 A/duck/Sukoharjo/BBVW-1428-9/2012	A/duck/Cambodia/I4k241D3/2021 A/whooper swan/Shanxi/4-1/2020	A/mallard/Georgia/DT09382/2017 A/chicken/ME-2018	A/Mute_Swan/Croatia/102/2016 A/green-winged teal/Egypt/877/2016	A/gyrfalcon/Washington/41088/6/2014 A/Gyrfalcon/WA/41088-6/2014
			Subtype	H5N1	H5N1	H5N1	H5N1	H5N1	H5N8	H5N8	H5N8	[illegible]
			Clade	1	2.2	2.3.4	2.3.2.1a	2.3.2.1c[1]/g[2]	2.3.4.4b	2.3.4.4b	2.3.4.4b	[illegible]
2023	2.3.2.1a	H5N1	South Asia	4.8	4.8	5.6	3.9	2.7	7.5	6.6	7.2	[illegible]
2023	2.3.2.1a	H5N1	South Asia	6.3	6.4	7.2	5.0	3.8	8.3	7.5	8.0	[illegible]
2023	2.3.2.1a	H5N1	South Asia	5.3	4.8	5.8	2.9	2.3	7.3	6.5	[illegible]	[illegible]
2023	2.3.2.1a	H5N1	South Asia	4.5	3.9	4.8	2.5	1.1	4.9	[illegible]	[illegible]	4.0
2023	2.3.4.4b	H5N1	Africa	5.1	5.1	5.3	5.5	4.1	1.1	[illegible]	[illegible]	1.1
2023	2.3.4.4b	H5N1	Africa	5.9	5.9	6.5	5.4	3.3	3.7	[illegible]	[illegible]	2.8
2023	2.3.4.4b	H5N1	Africa	6.2	5.8	6.1	6.0	5.2	2.0	[illegible]	[illegible]	2.9
2023	2.3.4.4b	H5N1	Africa	6.0	6.3	6.9	6.0	3.7	4.0	[illegible]	4.7	2.9
2023	2.3.4.4b	H5N1	Africa	4.8	4.9	5.5	4.3	2.0	4.3	3.5	4.3	3.1
2023	2.3.4.4b	H5N1	Americas	5.1	5.7	6.1	6.0	3.6	4.0	3.3	5.1	2.6
2023	2.3.4.4b	H5N1	Americas	4.7	4.9	5.4	4.8	2.6	3.4	2.6	3.8	2.2
2023	2.3.4.4b	H5N1	Americas	5.0	5.3	5.7	5.7	3.7	2.4	1.7	3.6	1.1
2023	2.3.4.4b	H5N1	Americas	5.2	5.5	5.9	5.8	3.8	2.3	1.7	3.5	1.2
2023	2.3.4.4b	H5N1	Europe	5.0	5.3	5.7	5.5	3.5	2.4	1.7	3.4	1.2
2023	2.3.4.4b	H5N1	Europe	5.1	5.1	5.7	4.9	3.0	2.8	2.1	3.0	1.8
2023	2.3.4.4b	H5N1	Europe	4.7	4.8	5.1	5.3	3.7	1.5	0.7	2.4	0.7
2023	2.3.4.4b	H5N1	Europe	5.5	5.8	6.2	5.9	3.9	2.6	2.0	3.6	1.5
2023	2.3.4.4b	H5N1	Europe	4.9	5.0	5.4	5.2	3.4	2.0	1.3	2.6	1.1
2023	2.3.4.4b	H5N1	Europe	5.1	5.3	5.8	5.2	3.1	3.1	2.4	3.7	1.9
2023	2.3.4.4b	H5N1	Europe	5.0	5.1	5.4	5.6	4.0	1.3	0.6	2.5	0.6
2023	2.3.4.4b	H5N1	Europe	4.9	5.1	5.5	5.2	3.2	2.4	1.7	3.2	1.3
2023	2.3.4.4b	H5N1	Europe	5.0	5.4	5.8	5.6	3.5	2.7	2.0	3.8	1.4
2023	2.3.4.4b	H5N1	Europe	5.1	5.1	5.3	5.5	4.1	1.1	0.6	1.9	1.1
2023	2.3.4.4b	H5N1	Europe	5.1	5.3	5.7	5.6	3.7	2.1	1.4	3.1	1.0
2023	2.3.4.4b	H5N1	Europe	5.3	5.4	5.8	5.2	3.3	2.6	2.0	3.1	1.7
2023	2.3.4.4b	H5N1	Europe	4.5	4.6	4.9	5.2	3.6	1.5	0.7	2.3	0.8
2023	2.3.4.4b	H5N1	South Asia	4.6	4.4	4.9	4.3	2.7	2.6	1.8	2.3	1.8
2023	2.3.4.4b	H5N1	Southeast Asia	4.8	4.4	4.7	4.7	3.9	2.2	1.9	0.9	2.4
2023	2.3.4.4b	H5N1	Southeast Asia	4.9	5.5	5.6	6.2	4.2	2.1	1.5	3.8	0.8
2023	2.3.4.4b	H5N5	Europe	5.6	5.7	6.1	5.5	3.6	2.6	2.0	3.2	1.7

'Relatively' stable given established across the world



Multiple clades circulating; antigenic heterogeneity

- Despite transmission between hosts dominant 2.3.4.4b relatively stable

- Host specific adaptive changes not altering antigenic phenotype YET!

- Variation on how each host see's virus antigenically?

- Creates an environment for ease of vaccine strain selection
  - Regional variations
  - Multiple clades = multivalent

Key Conclusions

- Exceptional global spread; panzootic most continents affected
  - Continues to be a significant threat to biodiversity
- High infection pressure resulting in increased wild bird host range and continuing if not declining cases in domestic birds
- Mammalian infections: spillover to scavengers, some M2M transmission
- Dairy cattle infection in USA: continuing outbreak with spread (14 states); vaccination in future?
- H5 HPAI virus evolving with high fitness traits
- Antigenically clade 2.3.4.4b moderately stable

- Vaccination remains an important tool for prevention/control in some countries/regions

Acknowledgements

- OFFLU AIM project team (APHA, IZSVe)
- Ash Banyard, Joe James and Caroline Warren, APHA
- Lina Awada, WOAH for some graphics
- International partners sharing data

Thank you for your attention

Passion
Reliability
Innovation
Dignity
Excellence

Preventing and controlling viral diseases

Food and Agriculture Organization of the United Nations | World Health Organization | World Organisation for Animal Health

Updated joint FAO/WHO/WOAH assessment of recent influenza A(H5N1) virus events in animals and people

Assessment based on data as of 18 July 2024

14 August 2024

Key points

At the present time, based on available information, FAO-WHO-WOAH assess the global public health risk of influenza A(H5N1) viruses to be low, while the risk of infection for occupationally exposed persons is low to moderate depending on the risk mitigation measures in place. Transmission between animals continues to occur and, to date, a limited number of human infections have been reported. Although additional human infections associated with exposure to infected animals or contaminated environments are likely to continue to occur, the overall public health impact of such infections at a global level is minor.

90th General Session – World Organisation for Animal Health | World Assembly – Paris, 21-25 May 2023 | GS

Resolution 28: Strategic Challenges in the Global Control of High Pathogenicity Avian Influenza

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