

# Recent Changes in Patterns of Mammal Infection with Highly Pathogenic Avian Influenza A(H5N1) Virus Worldwide

## Appendix

**Appendix Table.** Mammals infected by H5N1 or H5NX in previous infection waves and current panzootic, conservation status, order, family, diet consumed, number of individuals affected, mutations found and country of origin

Order	Family	Species	Conservation status**	Diet***	Individuals affected	Mutations found****	Country	References
PREVIOUS INFECTION WAVES (2003–2019)								
Terrestrial and semi-aquatic mammals								
Carnivora	Canidae	Raccoon dog ( <i>Nyctereutes procyonoides</i> )	LC	O	At least 2	T/S156A, PB1-P13, PB1-Y436	China	(1)
	Canidae	Dog ( <i>Canis lupus familiaris</i> )	NC	C	At least 1	PB2-E627K, M2-Ser31Asn, M2-Leu261e	Thailand	(2,3)
	Mustelidae	Mink ( <i>Neovison vison</i> )	LC	C	At least 371	M2-S31N, NS1-G149A, NS1-D92E, HA-E513G	China, Sweden	(4–6)
	Mustelidae	Stone marten ( <i>Martes foina</i> )	LC	O	At least 1	—	Germany	(7)
	Viverridae	Owston's civet ( <i>Chrotogale owstoni</i> )	EN	O	At least 3	—	Vietnam	(8)
	Felidae	Tiger ( <i>Panthera tigris</i> )	EN	C	At least 150	PB2-E627K, 31(N; Asparagine), HA-Asp94Asn, HA-Ser133Ala, HA-Thr156Ala, HA-Thr188Ile, HA-Lys189Arg, NA-His254Tyr, PB2-Asp701Asn, M1-Asn30Asp, M1-Thr215Ala, M2-Ser31Asn, NS1-Leu98Phe, NS1-Ile101Met, HA-Ser155Asn, HA-Gln222Leu, HA-Gly224Ser, PB2-Lys627Glu, NS1-Pro42Ser, NS1-Asp87Glu	Thailand, China	(9–13)
	Felidae	Lion ( <i>Panthera leo</i> )	VU	C	At least 1	—	China	(14)

Order	Family	Species	Conservation status**	Diet***	Individuals affected	Mutations found****	Country	References
	Felidae	Leopard ( <i>Panthera pardus</i> )	VU	C	At least 2	PB2-E627K	Thailand	(11)
	Felidae	Cat ( <i>Felis catus</i> )	NC	C	At least 13	PB2-E627K, M2-Ser31Asn, M2-Leu261Ie	Austria, Thailand, Germany, Iraq	(2,15–18)
Lagomorpha	Ochotonidae	Plateau pikas ( <i>Ochotona curzoniae</i> )	LC	H	At least 5	—	China	(19)
Artiodactyla	Suidae	Pigs ( <i>Sus scrofa domestica</i> )	NC	O	At least 70	Ala134Ser-viral receptor	China, Nigeria, Indonesia	(20–22)
Perissodactyla	Equidae	Donkey ( <i>Equus asinus</i> )	NC	H	At least 3	HA-98(Y to N), HA-193(K to R), HA-216(E to K), HA-221(P to S)	Egypt	(23)
CURRENT PANZOOTIC (2020–2023)								
Terrestrial and semi-aquatic mammals								
Carnivora	Canidae	Red fox ( <i>Vulpes vulpes</i> )	LC	C/FS	At least 290	PB2-E627K, NP-G485R, PB2-A152T, PB2-T521I, PB1-M644V, NP-A336T, NA-L22S, NS-D209N, PB2-D701N, HA-S137A, HA-T160A, HA-A185E, HA-D195T, HA-V198I, HA-E268G, HA-V210A, PB2-V292I, PB1-D622G, PB1-N375S, PA-P28L, PA-A36V, HA-N101S, HA-V214A, NA-A395E, NA-S248N, NA-H155Y, NA-N366S, M1-N30D, M1-T215A, M2-S82N, NS1-V2261, NS1-P42S, NS1-I106M	Netherlands, Sweden, Finland, Estonia, Ireland, Norway, Belgium, UK, France, Italy, Japan, Germany, USA, Canada, Latvia, Denmark,	(24–46)
	Canidae	Arctic fox ( <i>Vulpes lagopus</i> )	LC	C/FS	At least 2048	—	Finland	(27,43,45)
	Canidae	Grey fox ( <i>Urocyon cinereoargenteus</i> )	LC	C/FS	At least 1	—	USA	(36)
	Canidae	Raccoon dog ( <i>Nyctereutes procyonoides</i> )	LC	C	At least 5	—	Japan, Finland	(27,28,33,37,39–41,43–45)
	Canidae	South American bush dog ( <i>Speothos venaticus venaticus</i> )	NT	C	At least 1	—	UK	(41,44,45)
	Canidae	Coyote ( <i>Canis latrans</i> )	LC	C/FS	At least 1	—	USA	(24,27,28,30,36,37,40,41,44,45)
	Canidae	Dog ( <i>Canis lupus familiaris</i> )	NC	C	At least 1	—	Canada	(27,41,44,45)

Order	Family	Species	Conservation status**	Diet***	Individuals affected	Mutations found****	Country	References
	Mustelidae	Otter ( <i>Lutra lutra</i> )	NT	C	At least 7	PB2-E627K	Finland,	(25–29,31,37,39–41,44–46)
	Mustelidae	Polecat ( <i>Mustela putorius</i> )	LC	C	At least 7	PB2-E627K, PB2-T271A	Netherlands, UK Netherlands, Slovenia, Belgium	(26–29,37–41,44,45)
	Mustelidae	Badger ( <i>Meles meles</i> )	LC	O	At least 1	—	Netherlands	(28,29,37,38,40,41,44,45)
	Mustelidae	Fisher cat ( <i>Pekania pennanti</i> )	LC	O/FS	At least 4	—	USA, Canada	(24,27,28,30,36,37,40,41,44,45)
	Mustelidae	Mink ( <i>Neovison vison</i> )	LC	C	>50000	HA-A185E, HA-D195T, HA-V198I, HA-E268G, HA-V210A, HA-S137A, HA-T160, PB2-T271A, PB1-388R, PB1-317V, PB1-F2–30L, NA-74S, NS2-13G, PA-56T, NA-163L	Canada, Spain, Finland	(24,27,28,35,37,40,41,43–45,47)
	Mustelidae	Stone marten ( <i>Martes foina</i> )	LC	O	At least 1	—	Netherlands	(41,44,45)
	Mustelidae	Pine marten ( <i>Martes martes</i> )	LC	O/FS	At least 1	—	Germany	(27,45)
	Mustelidae	Marine otter ( <i>Lontra felina</i> )	EN	C	At least 2	—	Chile	(27,41,44,45; Pardo Roa et al.†)
	Mustelidae	Huillin ( <i>Lontra provocax</i> )*	EN	C	At least 1	—	Chile	(27,44,45)
	Mustelidae	American marten ( <i>Martes americana</i> )	LC	O/FS	At least 1	—	USA	(27,30)
	Mustelidae	North American river otter ( <i>Lontra canadensis</i> )	LC	C	At least 2	—	USA, Canada	(24,27,30,41,44,45)
	Procyonidae	Raccoon ( <i>Procyon lotor</i> )	LC	O	At least 18	PB2-E627K	USA, Canada	(24,27,28,30,36,37,40,41,44,45)
	Procyonidae	South American coati ( <i>Nasua nasua</i> )	LC	O	At least 19	—	Uruguay, Germany	(27,44,45)
	Felidae	Bobcat ( <i>Lynx rufus</i> )	LC	C/FS	At least 6	—	USA	(24,27,28,30,36,37,40,41,44,45)
	Felidae	Lynx ( <i>Lynx lynx</i> )	LC	C	At least 1	PB2-E627K, PB2-D701N	Finland	(26,28,37,39–41,44–46)
	Felidae	Tiger ( <i>Panthera tigris</i> )	EN	C	At least 1	—	USA	(24,27,28,30,41,44,45)

Order	Family	Species	Conservation status**	Diet***	Individuals affected	Mutations found****	Country	References
	Felidae	Mountain lion ( <i>Puma concolor</i> )	LC	C	At least 21	—	USA	(24,27,28,30,41,44,45)
	Felidae	Lion ( <i>Panthera leo</i> )*	VU	C	At least 1	—	Peru	(27,45)
	Felidae	Caracal ( <i>Caracal caracal</i> )	LC	C	At least 1	—	Poland	(44,45)
	Felidae	Cat ( <i>Felis catus</i> )	NC	C	At least 35	PB2-E627K, NS2-E26G, PB2-K526R	USA, France, Canada, Korea (Republic of), Poland	(27,28,41,44,45,48–52)
	Felidae	Leopard ( <i>Panthera pardus orientalis</i> )	CE	C	At least 1	---	USA	(24,27,28,30,40,41,44,45)
	Mephitidae	Skunks ( <i>Mephitis mephitis</i> )	LC	O/FS	At least 90	HA-S137A, HA-T160A, HA-A185E, HA-D195T, HA-V198I, HA-E268G, HA-V210A	USA, Canada	(24,27,28,30,35–37,39–41,44,45)
	Ursidae	Asiatic black bear ( <i>Ursus thibetanus</i> )	VU	O/FS	At least 1	—	France	(41,44,45)
	Ursidae	American black bear ( <i>Ursus americanus</i> )	LC	O/FS	At least 7	PB2-D701N	USA, Canada	(24,27,28,30,37,40,41,44,45,53)
	Ursidae	Grizzly bear ( <i>Ursus arctos</i> )	LC	O/FS	At least 4	—	USA	(24,27,28,30,40,41,44,45,54)
Didelphimorphia	Didelphidae	Virginia opossum ( <i>Didelphis virginiana</i> )	LC	O/FS	At least 4	—	USA	(24,27,28,30,36,37,40,41,44,45)
Rodentia	Cricetidae	Muskrat ( <i>Ondatra zibethicus</i> )	LC	O	At least 1	—	USA	(24)
	Castoridae	Beaver ( <i>Castor canadensis</i> )	LC	H	At least 1	—	USA	(24)
Marine mammals Carnivora	Phocidae	Grey seal ( <i>Halichoerus grypus</i> )	LC	C	At least 40	PA-A70V, PA-V379M, HA-P152S, NP-M448V/1, NP-D455N, NA-M231, NS1-R67Q, NS1-S87T, PB2-E627K	USA, UK, Canada, Poland, Netherlands, Germany	(24,27,28,30,31,37,40,41,44,45,55,56)
	Phocidae	Harbor seal ( <i>Phoca vitulina</i> )	LC	C	At least 90	PB2-S12I, PB2-E627K, PB2-D701N, PB1-P135, PB1-R211K, PB1-M523L, PB1-V527I, PB1-1728V, PB1-R480K, PB1-N375T, PB1-F2-A56V	USA, Canada, UK, Denmark, Germany	(24,27,28,30,31,37,40,41,44,45,56)
	Phocidae	Caspian seal ( <i>Pusa caspica</i> )	EN	C	—	—	Russia	(41,44,45)

Order	Family	Species	Conservation status**	Diet***	Individuals affected	Mutations found****	Country	References
	Phocidae	Southern elephant seal ( <i>Mirounga leonina</i> )*	LC	C	At least 2	—	Argentina	(27,45)
	Otariidae	Northern fur seal ( <i>Callorhinus ursinus</i> )	VU	C	At least 1	—	Russia	(27,45)
	Otariidae	South American fur seal ( <i>Arctocephalus australis</i> )	LC	C	At least 35	—	Peru, Argentina, Uruguay, Brazil	(27,41,44,45)
	Otariidae	American sea lions ( <i>Otaria flavescens</i> )	LC	C	>10000	PB2-D701N, PB1-S515A, PA-R57Q, PA-T85V, PA- M861, HA-H355R, NP- Y289F, NA-A81I, NS1- D26K, PB1-L378M, PB2- Q591K	Peru, Chile, Argentina, Uruguay, Brazil	(27,28,41,44,45,57- 59; Pardo Roa et al.†)
Cetacea	Phocoenidae	Burmeister's porpoise ( <i>Phocoena spinipinnis</i> )	NT	C	At least 1	—	Chile	(41,44,45)
	Phocoenidae	Porpoise ( <i>Phocoena phocoena</i> )	LC	C	At least 3	—	Sweden, UK, Canada	(24,28,31,37,40,41, 44,45,60)
	Delphinidae	Chilean dolphin ( <i>Cephalorhynchus eutropia</i> )	NT	C	At least 1	—	Chile	(41,44,45)
	Delphinidae	White-sided dolphin ( <i>Lagenorhynchus acutus</i> )	LC	C	At least 1	—	Canada	(24,28,40,41,44,45)
	Delphinidae	Common dolphin ( <i>Delphinus delphis</i> )	LC	C	At least 3	PB1-L378M, PA-T85V, NA-A81I, NA-S339P, M1- N87T, NS1-D26K, NS1- E60V	Peru, UK,	(28,31,41,44,45,57)
	Delphinidae	Bottlenose dolphin ( <i>Tursiops truncatus</i> )	LC	C	At least 2	NA-S246N, HA-T192I	USA, Peru	(24,27,28,30,37,40, 41,44,45; Murawski et al.‡)

\* H5NX (H5 untyped).

\*\*Conservation status based on The IUCN Red List of Threatened species: LC (Least concern); NT (Near Threatened); VU (Vulnerable); EN (Endangered); CR (Critically Endangered), NC (Non-classified).

\*\*\* Diets based on MammalBase-Database of recent mammals and the IUCN Red List of Threatened species: C (Carnivorous); FS (facultative scavenger); O (Omnivorous); H (Herbivorous).

\*\*\*\* To view the complete list and details of mutations found, refer to the cited bibliography.

†Pardo Roa et al., unpub. data, <https://doi.org/10.1101/2023.06.30.547205>.

‡Murawski et al., unpub data, <https://www.researchsquare.com/article/rs-3065313/latest>.

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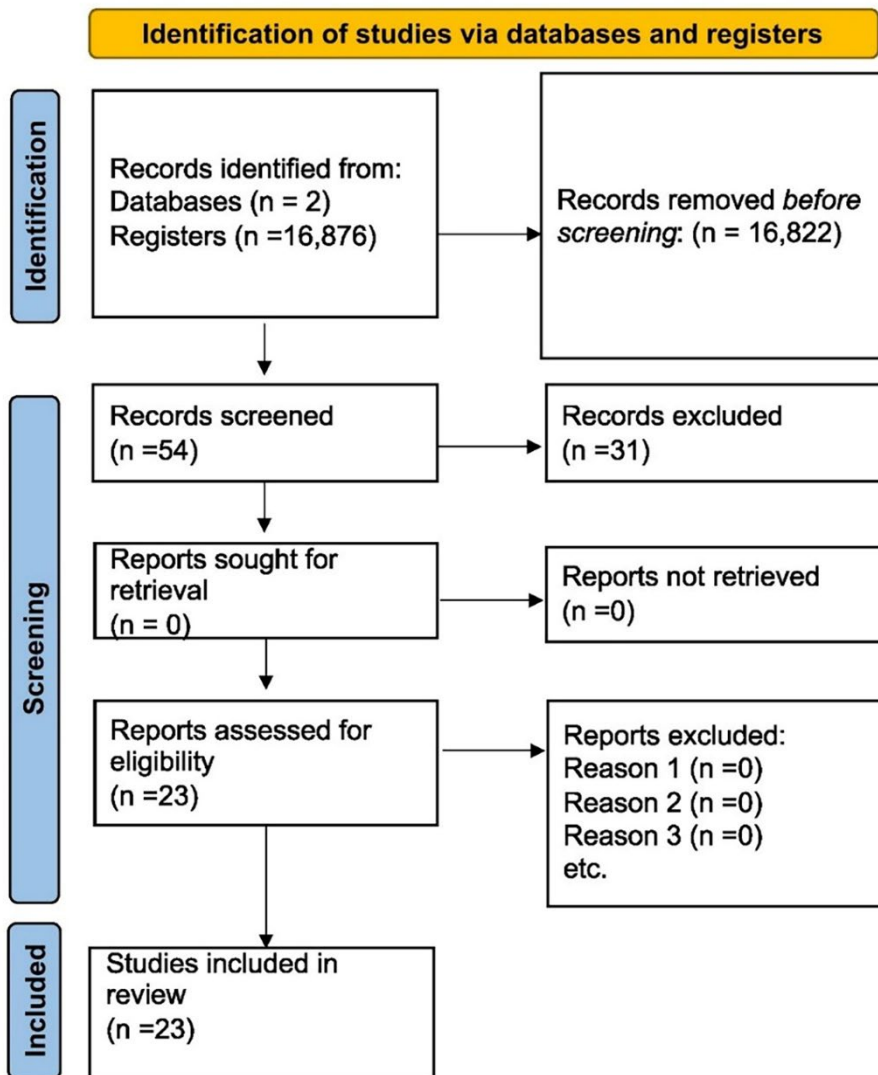


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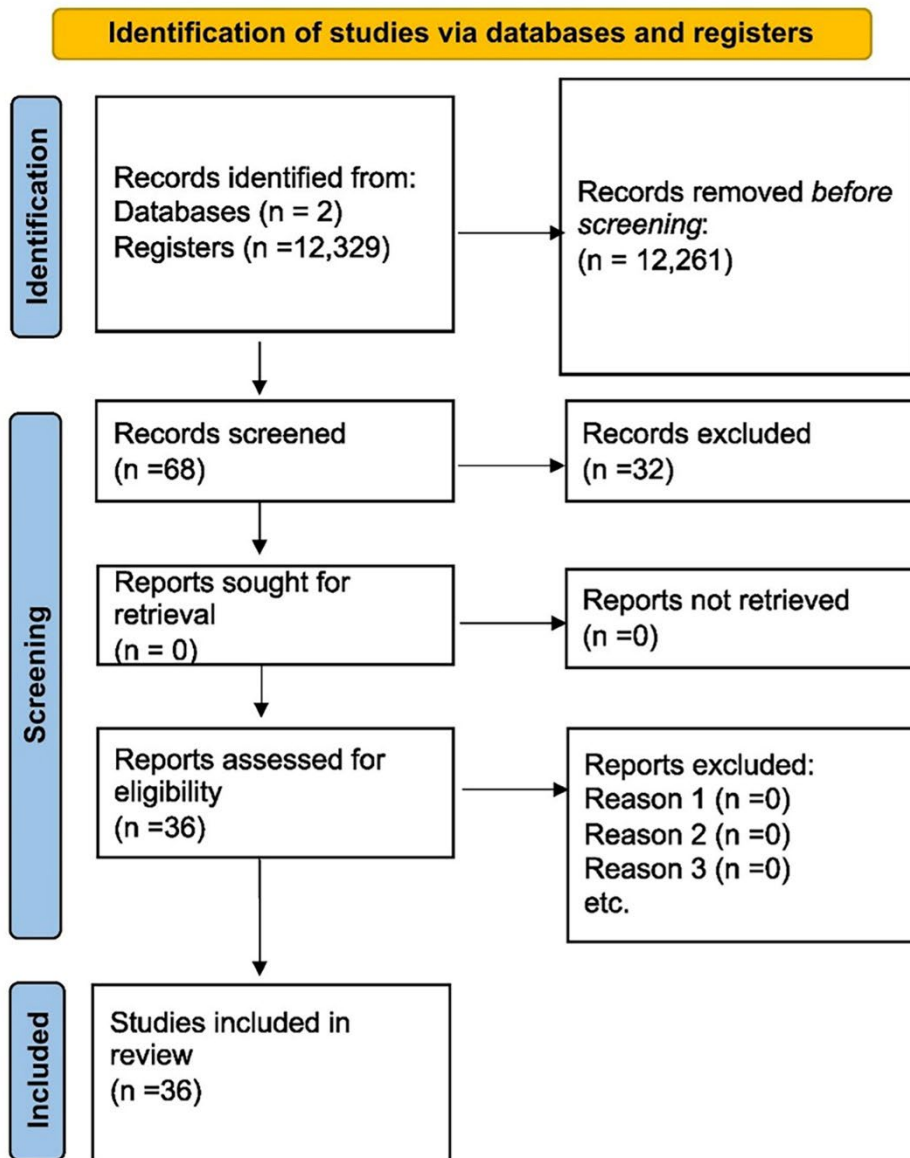
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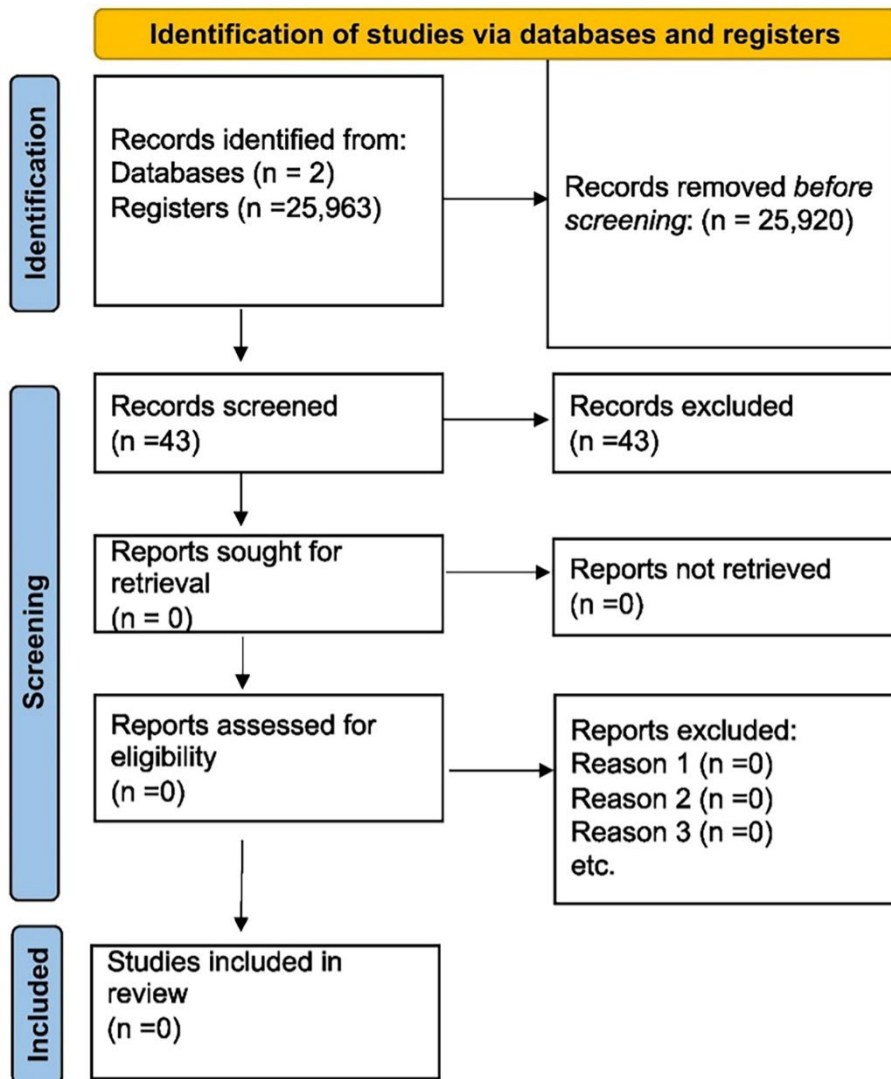
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**Appendix Figure 1.** Prisma flow diagram with the keywords “H5N1” and “Mammals” up to 2019 (Previous waves of H5N1 infection).



**Appendix Figure 2.** Prisma flow diagram with the keywords “H5N1” and “Mammals” 2020–2023 (Current panzootic 2020–2023).



**Appendix Figure 3.** Prisma flow diagram with the keywords “H5N1” OR HPAI OR Highly Pathogenic Avian Influenza AND “Mammals” OR Unusual Host.