KeAi CHINESE ROOTS GLOBAL IMPACT

International Journal of Innovation Studies

WATERFOWL FATTENING OPERATIONS AS POTENTIAL REINTRODUCTION AND AMPLIFICATION ENVIRONMENTS FOR HIGHLY PATHOGENIC AVIAN INFLUENZA

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Abstract— Highly pathogenic avian influenza (HPAI) is a rapidly mutating virus with pandemic potential that is primarily associated with wild waterfowl and has spilled over into dozens of land and marine mammal species, including humans. We examine evidence suggesting that intensive duck and goose fattening operations, particularly concentrated in France and Hungary, function as major reintroduction and amplification environments for HPAI. Surveillance records demonstrate a disproportionately large concentration of HPAI outbreaks in these regions, while studies document widespread asymptomatic influenza circulation within waterfowl fattening facilities. Evidence indicates that HPAI can persist in feathers for extended periods and disseminate beyond farm limits. As HPAI continues to expand globally, affecting agricultural workers, livestock, wildlife, and surrounding communities, identifying and eliminating sources of viral amplification is essential for pandemic prevention. Reducing production systems that industrially concentrate natural influenza reservoirs may be one of the most effective long-term strategies for protecting biodiversity, environmental preservation, and public health.

Keywords— highly pathogenic avian influenza (HPAI), foie gras, pandemic prevention, viral amplification, waterfowl fattening operations.

INTRODUCTION

Highly pathogenic avian influenza (HPAI) is a fever-resistant (1), rapidly mutating epizootic virus with pandemic potential. Waterfowl serve as the primary reservoir of the virus and often carry it asymptomatically, facilitating global dissemination to a wide variety of avian and mammalian species, including humans. Waterfowl fattening operations have been identified by authorities (2) as particularly vulnerable to HPAI outbreaks because they rely almost entirely on high-density concentrations of ducks and geese, require repeated handling and force-feeding throughout the fattening period, and generate substantial quantities of feces, wastewater, feathers, and other biological materials capable of facilitating viral transmission between birds and contaminating surrounding environments.

Infectious HPAI strain Hemagglutinin 5 Neuraminidase 1 (H5N1) virus has been shown to remain viable in detached duck feathers for up to 160 days in cooler temperatures (3). Because feathers can be released during molting, feeding, transportation, slaughter, and defeathering, they can be carried by the wind, water, vehicles, wild animals, and humans beyond farm boundaries, continually spreading the disease. The excessive waste and contaminated water can be carried away into nearby habitats by vehicles, footwear, supplies, equipment, and natural precipitation. This is exponentiated when farm waste is intentionally utilized as fertilizer for other crops (4).

Virus replication has led to spillover to varying mammalian hosts. A 2026 study on dairy cattle in California confirmed the presence of HPAI in the wastewater, mammary glands, milk and in the air. Genetic sequencing of these airborne samples revealed mutations associated with increasingly likely human to human transmissibility (5). According to the World Health Organization (WHO), once contracted, the mortality rate for humans is just over 50% (6). Mammal to human transmission cases have already been documented involving cats and domestic cattle (7,8).

Extensive outbreaks have caused significant economic impacts across poultry and game bird production systems, as well as related livestock and fur-bearing animal industries. Since 2020, HPAI has spread to livestock and other farmed animals in agricultural settings, including: Chickens (Gallus gallus domesticus), Ducks (Anas platyrhynchos domesticus), Geese (Anser anser domesticus), Turkeys (Meleagris gallopavo domesticus), Bovine (Bos taurus), Swine (Sus scrofa domesticus), Sheep (Ovis aries) ,Mustelids, such as farmed mink (Neovison vison), Canids, such as foxes (Vulpes vulpes) and Game birds, including: Quail (Coturnix coturnix), Pheasants (Phasianus colchicus), Partridges (Perdix perdix), Guinea fowl (Numida meleagris).

This perspective reviews surveillance records, epidemiologic reports, and survey studies to examine potential drivers of HPAI reintroduction and amplification within these particular agricultural systems.

I. Observational Data

A. Surveillance Evidence

Available data indicates that HPAI outbreaks are disproportionately concentrated in France and Hungary, where waterfowl fattening operations with the purpose of inducing hepatic steatosis (fatty liver) account for approximately 75% of reported global production, with France being the principal driver of market demand. This contributes to transmission cycles involving migratory birds and global food production systems. Out of the 27 member countries of the European Union (EU), over 80% have already restricted waterfowl fattening or its products. Poultry outbreak notifications reported through the European Commission Animal Disease Information System (ADIS) and summarized in European Food Safety Authority (EFSA) surveillance reports from 2020 to 2024 indicate that France and Hungary, the world's two largest producers of fattened waterfowl products, reported outbreaks 65% more frequently than all of the other 25 EU member states combined (9) (Figure 1,2).

POULTRY HPAI OUTBREAKS REPORTED IN EUROPEAN UNION MEMBER STATES, 2020 - 2024

Member State	Outbreaks	Member State	Outbreaks
France	**2309**	Slovakia	10
Hungary	**1009**	Croatia	10
Poland	638	Lithuania	9
Germany	449	Austria	9
Italy	401	Sweden	7
Netherland	111	Ireland	6
Czech Republic	101	Finland	5
Bulgaria	72	Estonia	5
Spain	38	Cyrpus	2
Belgium	25	Slovenia	1
Romania	23	Latvia	1
Greece	20	Luxembourg	1
Denmark	12	Malta	0
Portugal	11		

FRANCE AND HUNGARY: 3318 **ALL 25 OTHER EU STATES: 2010**

65.1% MORE POULTRY HPAI OUTBREAKS THAN REST OF EU COMBINED

Fig. 1 Poultry HPAI outbreaks reported in France and Hungary compared with all other EU member states combined, 2020-2024 (9).

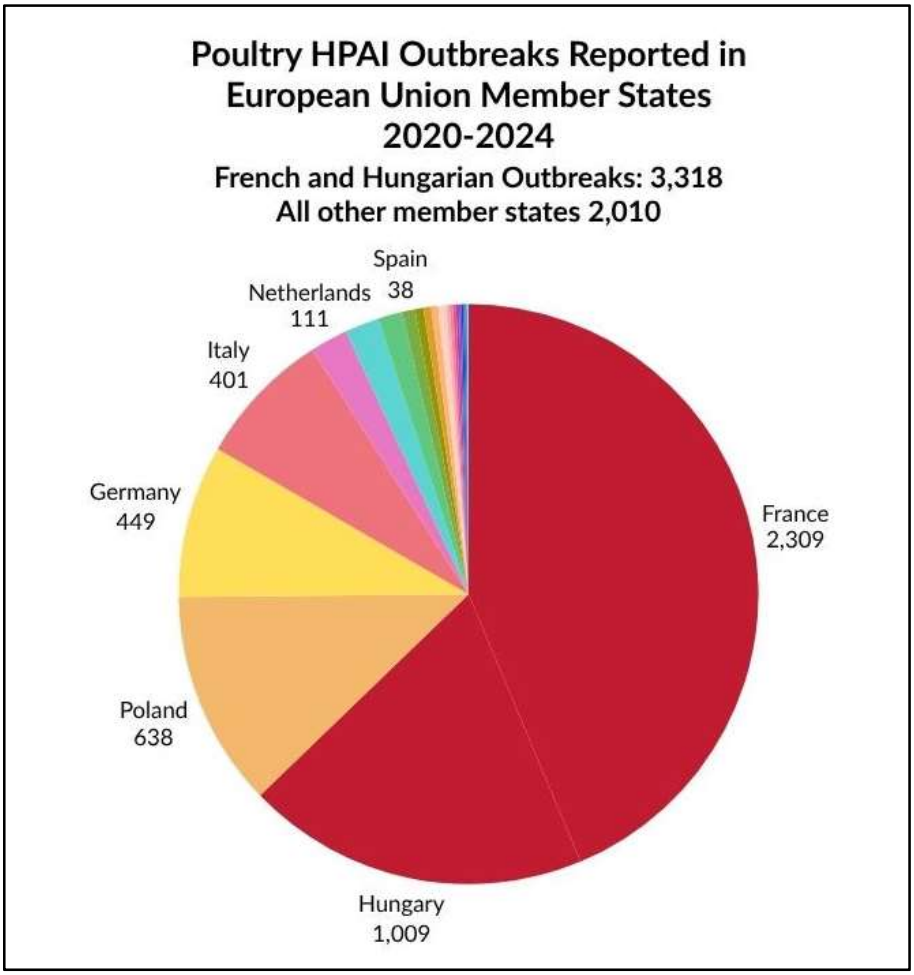

Fig. 2 Poultry HPAI outbreaks reported in European Union member states 2020-2024 (9).

During the explosive 2020-2021 period, one county, Landes, France, was responsible for over 30% of all recorded European continental outbreaks due to the concentration of waterfowl force-feeding operations. Landes accounted for over 75% of all French national occurrences (9). In Hungary, 77% of 2024 outbreaks occurred in Bács-Kiskun, a region concentrated with fattening operations (10). In 2026, Hungary reported being free from HPAI for three months, but it was recorded as resurfacing in waterfowl fattening farms (11).

A four-year surveillance study of 52 Bulgarian forcefully over-fed duck farms performed between 2008-2012 found evidence of varying influenza A virus strains circulating on 46 facilities (88.5%), while only 11.5% remained influenza-free throughout the study period (12). Because infected flocks remained asymptomatic, researchers concluded that fattened duck production systems serve as an "optimal niche" for avian influenza reassortment and transmission of viruses without obvious signs of disease or reported outbreaks.

Despite dramatically less dense production than France and Hungary, correlative evidence from Spain demonstrates geographic overlap between HPAI outbreaks in wild and commercial animals and regions with documented waterfowl fattening facilities. In 2026 the Spanish Ministry of Agriculture documented HPAI-positive wild birds in Navarra, home to fattening operation Martiko (10 outbreaks), Girona, home to Collverd and Imperia (2 outbreaks), Palencia, home to Selectos

de Castilla (1 outbreak), and the Basque provinces of Álava, Bizkaia, and Gipuzkoa, where foie gras production also occurs (20 outbreaks combined) (13).

B. Transcontinental Transmission Pathways

Migratory bird flyways enable transportation of the virus from France and Hungary on the East Atlantic and Black Sea/Mediterranean flyways that cross over to the Atlantic Americas and Mississippi Americas flyways, enabling spreading throughout the United States and elsewhere (14) (Figure 3). Migratory birds have spread HPAI worldwide to other animals, jumping to over 200 different mammals according to the Centers for Disease Control and Prevention (CDC) (8).

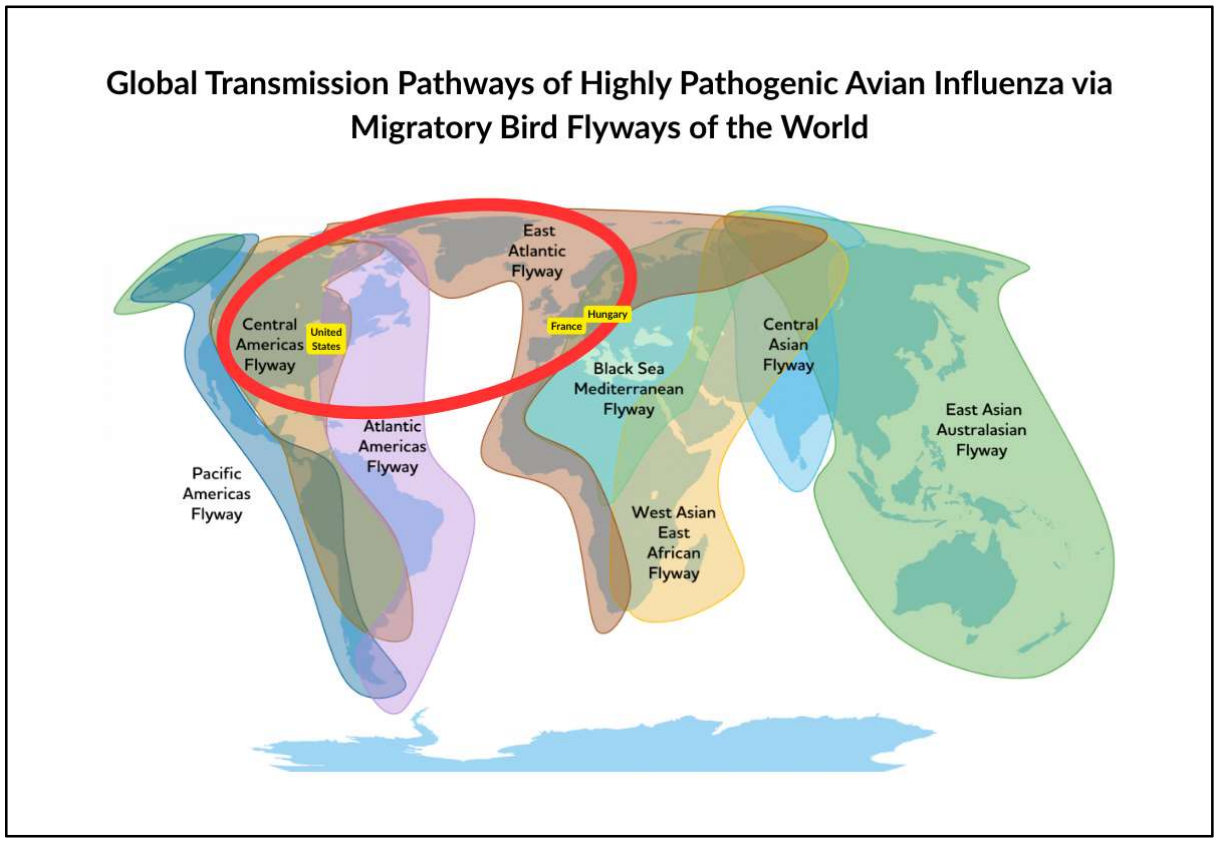

Fig. 3 Major migratory bird flyways linking Europe and North America. Adapted from Wadden Sea Flyway Initiative (14).

C. Broad Socioeconomic Impacts

Outbreaks have infected over 200 million poultry birds (15) across all 50 United States (U.S.) (16) and cost over $1.4 billion dollars in biomitigation practices including cullings and livestock indemnity payouts to farm owners (17). In 2025, the United States Department of Agriculture USDA announced an additional $1 billion in federal funding for biosecurity and mitigation efforts (17). Beyond livestock, at least 34 outbreaks have occurred on U.S. commercial upland game bird farms as of 2025 as well, highlighting systemic threats across various industries (18).

These economic burdens are distributed internationally despite the fact that production and consumption of force-fed waterfowl products remains highly concentrated. France and Hungary account for approximately 75% of the global marketplace. Consequently, jurisdictions with negligible participation or benefit in the production or consumption of fattened waterfowl products frequently bear a high portion of the costs associated with recurring HPAI outbreaks.

D. Public Opinion

Recent U.S. nationally representative survey data indicates that a clear majority of the public supports prohibiting force-feeding practices for waterfowl production. A recent Colorado University study of 5,665 respondents across ten states and Washington, D.C. found that 89.09% moderately or strongly supported a state-level ban on the practice of force feeding ducks and geese (19).

Support for related regulatory measures remains consistently high. Approximately 86.90% supported bans on the sale of products derived from force-feeding practices, and 81.36% supported broader product bans. When policy language specifies the underlying production method, support increases by approximately 1-10%, indicating stronger public alignment with production-focused prohibitions rather than product-specific restrictions.

Across all policy categories evaluated, support to eliminate fattened products exceeded 80% with minimal variation across states, generally within a 1-5% range, demonstrating consistency across jurisdictions. Exposure to additional information further increased support by 2-12%, reinforcing that public backing strengthens when the production process is clearly defined.

Consumer preference data indicate a measurable shift toward establishments that remove products derived from force-feeding practices. In a controlled menu experiment, respondents were 12% more likely to choose a restaurant when forcefully fattened products were absent (40.1% vs. 28.1%), and 60.6% reported they would be more likely to dine at a restaurant that removed these products due to production concerns.

III. Results and Discussion

The available evidence indicates that waterfowl fattening operations are not incidental contributors to HPAI spread, but appear to function as consistent sources of reintroduction and amplification. Surveillance data demonstrates that outbreaks are disproportionately concentrated in regions where these operations are present, with repeated re-emergence events occurring even after vaccination and periods of apparent disease absence. The findings suggest that apparently healthy waterfowl may continue contaminating surrounding environments through wastewater, feathers, feces, transport activities, and slaughter byproducts long after infection, creating ongoing opportunities for exposure of wild birds and other animals.

In France and Hungary, where waterfowl fattening operations are heavily concentrated, outbreak frequency significantly exceeds that of other regions. These locations act as persistent sources of continued viral circulation and spillover into surrounding environments. The structure of these operations, characterized by high-density populations, repeated handling, and over feeding, creates conditions that increase viral load, environmental contamination, and opportunities for cross-species transmission.

These localized amplification dynamics are further extended through migratory bird pathways. Waterfowl act as natural reservoirs of avian influenza, and the intersection between wild populations and concentrated farming operations enables bidirectional transmission. Once introduced into migratory systems, the virus is capable of transcontinental spread, linking localized agricultural practices to global outbreak patterns.

France and Hungary account for approximately three quarters of the recorded global fattened waterfowl marketplace, yet the costs associated with HPAI surveillance, livestock indemnity payments, mass depopulation efforts, trade restrictions, and emergency response efforts are distributed worldwide. In the United States alone, federal expenditures related to HPAI response have exceeded $2.4 billion, while additional compensation programs have been implemented

across Europe, Asia, Africa and South America. Taxpayers finance disease-control efforts and producer indemnities, while consumers experience increased prices for eggs, turkey, chicken, and other poultry products following the destruction of millions of birds and resulting supply shortages. Jurisdictions with little or no fattened waterfowl production or consumption harbor a substantial portion of the economic burden generated by recurring outbreaks associated with concentrated waterfowl fattening systems.

These catastrophic outcomes are avoidable. The concentration of outbreaks within specific production systems indicates that risk is structurally driven rather than random. The repeated association between waterfowl fattening operations and outbreak events demonstrates that these systems function as predictable points of containment failure.

This pattern supports the identification of waterfowl fattening operations as high-risk amplification environments. Eliminating these sites represents a direct method of interrupting transmission cycles at their source, reducing both the frequency and scale of future mutations and outbreak events.

IV. Policy Implications

The data indicates that waterfowl fattening operations function as both reintroduction sources and amplification points for highly pathogenic avian influenza (HPAI). These operations are geographically concentrated, repeatedly associated with outbreak clusters, and uniquely positioned to sustain transmission cycles through interaction with migratory bird pathways and high-density production environments.

The economic benefits of forced overfeeding waterfowl production are concentrated primarily within France and a small number of producing regions, while the costs of responding to recurring HPAI outbreaks are socialized internationally. Governments fund surveillance and disease control programs, farmers absorb losses from trade restrictions and market disruptions, and consumers face increased prices for poultry products. Populations with little or no participation in fattened waterfowl production or consumption frequently face the cost associated with maintaining a luxury food market driven predominantly by demand in France and other European markets.

From a policy perspective, this imbalance raises questions regarding whether continued public subsidization of outbreak response is justified when the principal economic benefits accrue to a comparatively small segment of localized producers and consumers.

Given these characteristics, targeted regulatory intervention is both feasible and necessary. Jurisdictions with existing waterfowl fattening operations should implement a phased-in prohibition on forced fattening practices to eliminate active amplification sites. In regions where such fattening operations are not currently established, pre-emptive prohibitions are recommended to prevent the introduction of pandemic-level disease amplifying production systems.

To ensure effectiveness and avoid regulatory gaps, policy measures should apply not only to production practices but also to the sale and distribution of all products derived from waterfowl force-feeding systems. Limiting restrictions to a single product category allows for continued economic incentive and does not fully eliminate the underlying risk.

Regulatory action on forced fattening practices has already been implemented across a wide range of jurisdictions, demonstrating both feasibility and international alignment on this issue. Prohibitions on forced fattening or items related to fattening production practices have been proposed or implemented across multiple regions, including in the U.S.: California, Washington, New Jersey, Ohio, Massachusetts, New York City, New York, Brookline, Massachusetts, Pittsburgh, Pennsylvania, Portland, Oregon, in the EU: Germany. Netherlands, Regions of Belgium, Luxembourg, Ireland, Denmark, Sweden, Finland, Poland, Czech Republic, Slovakia,

Austria, Slovenia, Croatia, Estonia, Latvia, Lithuania, Italy, Greece, Portugal, Romania, Cyprus, Malta, in Asia: India, Israel, Türkiye, in the United Kingdom: England, Northern Ireland, Scotland, Wales, In other European Countries: Norway, Switzerland, in Oceana: Australia, New Zealand and South America: Argentina, and São Paolo, Brazil.

These actions indicate that prohibiting forced fattening practices is not a novel regulatory concept, but an established approach adopted across diverse legal and economic systems. This existing framework reduces implementation barriers and supports immediate adoption in jurisdictions currently lacking such measures.

Public opinion data further indicate strong and consistent support for prohibiting the forced over-feeding of waterfowl, with support levels exceeding 80% across varying jurisdictions. Consumer behavior data also demonstrate a measurable preference for businesses that remove such products, indicating alignment between regulatory action, public sentiment, and market behavior.

The evidence supports a production-focused regulatory approach that eliminates high-risk amplification environments and reduces the likelihood of future HPAI reintroduction events.

V. Conclusions

The available evidence indicates that concentrated waterfowl fattening operations function as recurring reintroduction and amplification environments for highly pathogenic avian influenza. These systems combine dense concentrations of the virus's natural reservoirs with repeated handling, environmental contamination, and direct interfaces with migratory bird populations, creating conditions that facilitate viral persistence, dissemination, and cross-species transmission. As HPAI continues to expand into mammalian hosts, infect agricultural workers, and impose substantial ecological and economic costs, addressing amplification sources becomes increasingly urgent.

The repeated concentration of outbreaks within major waterfowl fattening regions suggests that these risks are structurally driven rather than incidental. Continued reliance on surveillance, vaccination, biosecurity measures, and mass culling addresses the consequences of disease emergence but does not eliminate the underlying conditions that enable amplification. A phased global transition away from waterfowl fattening systems would remove a major source of HPAI amplification and reduce risks to wildlife, agriculture, biodiversity, and public health. Public opinion and consumer behavior data further indicate broad support for policies that prohibit force-feeding practices and the products derived from them, demonstrating that effective disease prevention, animal welfare, and public preferences are increasingly aligned.

Acknowledgement

The authors wish to thank the anonymous peer reviewers and the contributions of the researchers and governmental agencies whose scientific publications and publicly accessible databases and reporting formed the foundation of this project.

References

[1] University of Cambridge. “Bird flu’s surprising heat tolerance has scientists worried.” ScienceDaily. 2025 Nov 28. https://www.sciencedaily.com/releases/2025/11/251128050503.htm

[2] Trompiz G. “France reports bird flu on two farms, losing disease-free status.” Reuters. 2024 Dec 31. https://www.reuters.com/business/healthcare-pharmaceuticals/france-reports-bird-flu-two-farms-losing-disease-free-status-2024-12-31/

[3] Yamamoto Y, Nakamura K, Yamada M, Mase M. "Persistence of avian influenza virus (H5N1) in feathers detached from bodies of infected domestic ducks." Appl Environ Microbiol. 2010;76(16):5496–5499. https://doi.org/10.1128/AEM.00563-10
[4] Robayo P. "Special report: foie gras ban faces legal challenge as NYC sues state over animal welfare concerns on Sullivan County farms." Radio Catskill. 2023 Mar 11. https://wjffradio.org/special-report-foie-gras-ban-faces-legal-challenge-as-nyc-sues-state-over-animal-welfare-concerns-on-sullivan-county-farms/
[5] "Infectious H5N1 virus detected in dairy farm air. News Medical." 2026 May 8. https://www.news-medical.net/news/20260508/Infectious-H5N1-virus-detected-in-dairy-farm-air.aspx
[6] World Health Organization. "Avian influenza weekly update number 1028" [cited 2026 May 26]. https://cdn.who.int/media/docs/default-source/wpro---documents/emergency/surveillance/avian-influenza/ai_20250131.pdf
[7] Linden J. "CDC confirms cat-to-human transmission of avian influenza." WATTAgNet. 2026 May 13. https://www.wattagnet.com/poultry-meat/diseases-health/avian-influenza/news/15825765/cdc-confirms-cattohuman-transmission-of-avian-influenza
[8] Centers for Disease Control and Prevention. "Current situation: bird flu in dairy cows" [cited 2026 May 26]. https://www.cdc.gov/bird-flu/situation-summary/mammals.html
[9] European Centre for Disease Prevention and Control. "Avian influenza overview December 2020–February 2021." Stockholm: European Centre for Disease Prevention and Control; 2021. https://www.ecdc.europa.eu/sites/default/files/documents/avian-influenza-overview-december-2020%E2%80%93february-2021.pdf
[10] Linden J. "More Hungarian foie-gras farms hit by avian flu." WATTAgNet. 2025 Apr 28. https://www.wattagnet.com/poultry-meat/diseases-health/avian-influenza/article/15744160/more-hungarian-foiegras-farms-hit-by-avian-flu
[11] Linden J. "Avian flu reappears in commercial poultry in Hungarian, Polish states." WATTAgNet. 2026 Feb 9. https://www.wattagnet.com/poultry-meat/diseases-health/avian-influenza/news/15816623/avian-flu-reappears-in-commercial-poultry-in-hungarian-polish-states
[12] Marinova-Petkova A, Georgiev G, Petkov T, Darnell D, Franks J, Kayali G, et al. "Influenza surveillance on foie gras duck farms in Bulgaria, 2008–2012." Influenza Other Respir Viruses. 2016;10(2):98–108. https://doi.org/10.1111/irv.12377
[13] Ministerio de Agricultura, Pesca y Alimentación. "Influenza aviar." Madrid (Spain): Ministerio de Agricultura, Pesca y Alimentación; 2026 Apr 16. https://www.mapa.gob.es/es/ganaderia/temas/sanidad-animal-higiene-ganadera/sanidad-animal/enfermedades/influenza-aviar/
[14] Wadden Sea Flyway Initiative. "Flyway conservation" [cited 2026 May 19]. https://flyway.waddensea-worldheritage.org/flyway-conservation
[15] "U.S. poultry losses to HPAI top 200M birds 2022–2026." AviNews. 2026 May 13 [cited 2026 May 29]. https://avinews.com/en/u-s-poultry-losses-to-hpai-top-200m-birds-2022-2026/
[16] American Veterinary Medical Association. "Novel bird flu strain continues to threaten animal, public health." 2025 Jan 17. https://www.avma.org/news/novel-bird-flu-strain-continues-threaten-animal-public-health
[17] American Veterinary Medical Association. "USDA announces additional $1B toward H5N1 efforts." 2025 Mar 4. https://www.avma.org/news/usda-announces-additional-1b-toward-h5n1-efforts

[18] St. Charles KM, Ssematimba A, Bonney PJ, Cardona CJ. "Evaluation of transmission metrics in a slow-spreading highly pathogenic avian influenza (HPAI) outbreak in a commercial upland game bird system." Can J Microbiol. 2026;72:1–8. https://doi.org/10.1139/cjm-2025-0203

[19] Niemiec R. AHPC "study finds strong public support for and limited impacts to restaurants from foie gras bans." Fort Collins (CO): Animal-Human Policy Center, Colorado State University; 2026 Feb 17. https://sites.warnercnr.colostate.edu/animalhumanpolicy/ahpc-study-finds-strong-public-support-for-and-limited-impacts-to-restaurants-from-foie-gras-bans/