# H5N1 highly pathogenic avian influenza-biology of the recent outbreak


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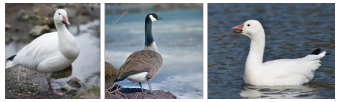
USDA Agricultural Research Service
U.S. DEPARTMENT OF AGRICULTURE

# H5Nx clade 2.3.4.4c HPAI in the U.S. (2014-15)


- 50.4M poultry. **21** backyard and 211 commercial flocks, 21 states affected.
- A total of **98** HPAIV positive wild birds detected between December 2014 and June 2015.
- The majority were hunter-harvested waterfowl collected in the Pacific Flyway, but 16 were associated with three wild bird mortality events. involving snow geese and ringed-necked ducks.
- Virus was eradicated from poultry (6/2015) and disappeared from wild birds in North America by end of 2016.

# H5N1 clade 2.3.4.4b HPAI in the US

- 190 Commercial flocks, **218** BY flocks, 40.18M birds affected, 39 states (August 24,2022)
- **2,276** wild bird detections; >35 species



- **Anseriformes** represent more than 70% of the positive wild bird cases (Dabbling ducks, diving ducks, geese, and swans)
- **Corvidae**
  - American crows, magpies, raven
- **Raptors** (Birds of Prey)
  - Accipitriformes: Black and Turkey vultures, Bald Eagle, Red-shoulder Hawk, Red-tailed Hawk, Coopers Hawk
  - Strigiformes: Snowy Owl, Great-horned Owl

- **Charadriiformes**
  - Scolopacidae: Sanderling
  - Laridae: Herring Gull, Ringed-billed Gull
- **Pelecaniformes**
  - Pelecanidae: Brown Pelican, White Pelican
  - Ardeidae -Great Blue Heron

Source: https://www.aphis.usda.gov/aphis/ourfocus/animalhealth/animal-disease-information/avian/avian-influenza/hpai-2022/2022-hpai-wild-birds

| Common Name | # of detections | Mortality | Hunter harvest or live |
|---|---|---|---|
| Snow goose | 225 | +++ | ++ |
| Mallard | 209 | + | +++ |
| Canada goose | 200 | +++ | ++ |
| American wigeon | 66 | + | +++ |
| Ross's goose | 63 | +++ | ++ |
| American green-winged teal | 47 | | +++ |
| Gadwall | 33 | | +++ |
| American black duck | 32 | | +++ |
| Wood duck | 48 | ++ | + |
| Lesser scaup | 24 | ++ | + |
| Hooded merganser | 14 | +++ | |
| Northern shoveler | 14 | | ++ |
| Blue-winged teal | 11 | | ++ |
| Redhead duck | 9 | +++ | + |
| Cinnamon Teal | 9 | | +++ |
| Lesser snow goose | 8 | ++ | |
| Muscovy duck | 7 | ++ | |
| Ring-necked duck | 5 | + | |
| Tundra swan | 5 | + | |
| Trumpeter swan | 4 | + | |
| Northern pintail | 4 | | + |
| Mute swan | 3 | + | |
| Ruddy duck | 1 | + | |
| Greater white-fronted goose | 1 | | |

Sep 19, 2022

# HPAI in chickens and turkeys

## Field cases

2015 H5N2 HPAIV outbreak

- 211 commercial poultry farms were affected. Most were commercial turkey operations (n = 160)

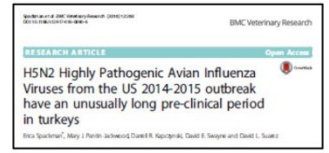
2022 H5N1 HPAIV detections (as of 7/25/22)

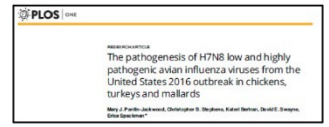
| **Commercial Chickens** | **# of incidents** | **Commercial Turkeys** | **# of incidents** |
|---|---|---|---|
| Table Egg Layer | 21 | Meat | 120 |
| Table Egg Pullets | 4 | Breeder Hens | 10 |
| Table Egg Breeder | 2 | Breeder Toms | 1 |
| Broiler Production | 12 | Poult Supplier | 1 |
| Broiler Breeder | 2 | | |
| **Total incidents** | **41** | | **132** |

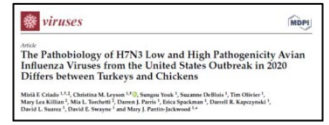
[USDA APHIS | 2022 Confirmations of Highly Pathogenic Avian Influenza in Commercial and Backyard Flocks]

## Experimental studies

- HPAIVs were highly infectious and transmitted easily in turkeys. In contrast, chickens needed higher amounts of the virus to become infected and transmission was poor.
- Infected turkeys and chickens had high mortality and birds excreted high amounts of virus from the oropharyngeal and cloacal route.


*Gallus gallus*

≠

| | |
|---|---|
| Class: | Aves |
| Order: | Galliformes |
| Family: | Phasianidae |
| Genus: | ***Meleagris*** |
| | ***Gallus*** |

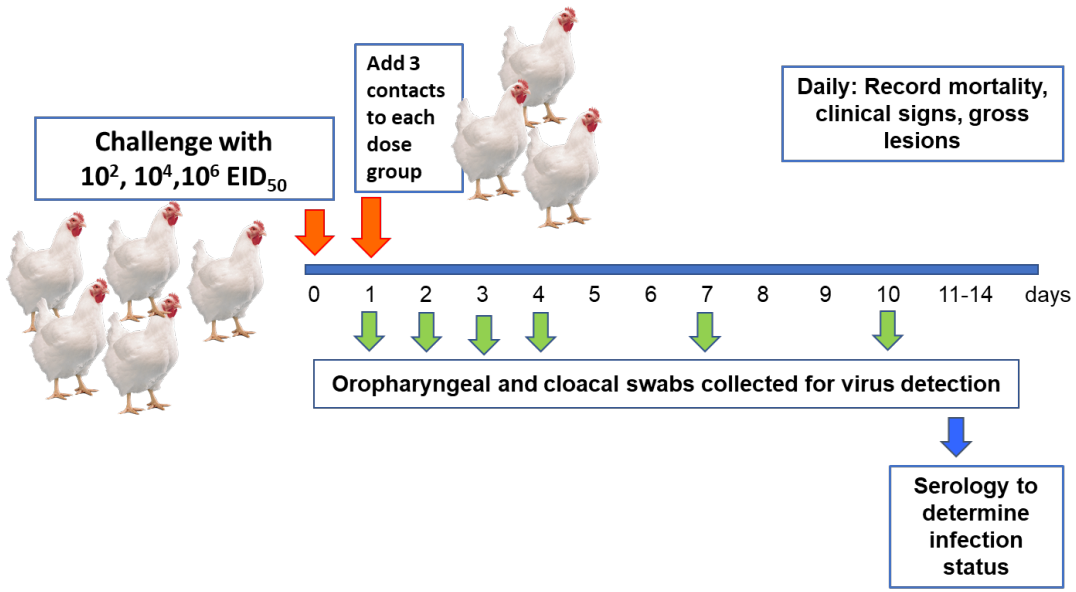
*Meleagris gallopavo*

# Infectivity and transmissibility of Gs/GD H5Nx clade 2.3.4.4 HPAIV in different avian species

# Studying the infectivity and transmissibility of H5N1 HPAIV

**Virus:** A/American widgeon/SC/22-000345-001/2022 (H5N1) - H5 clade 2.3.4.4b – A/AW/SC/2022 (H5N1)

- SPF White Leghorn chickens
- Commercial broad-breasted white turkeys



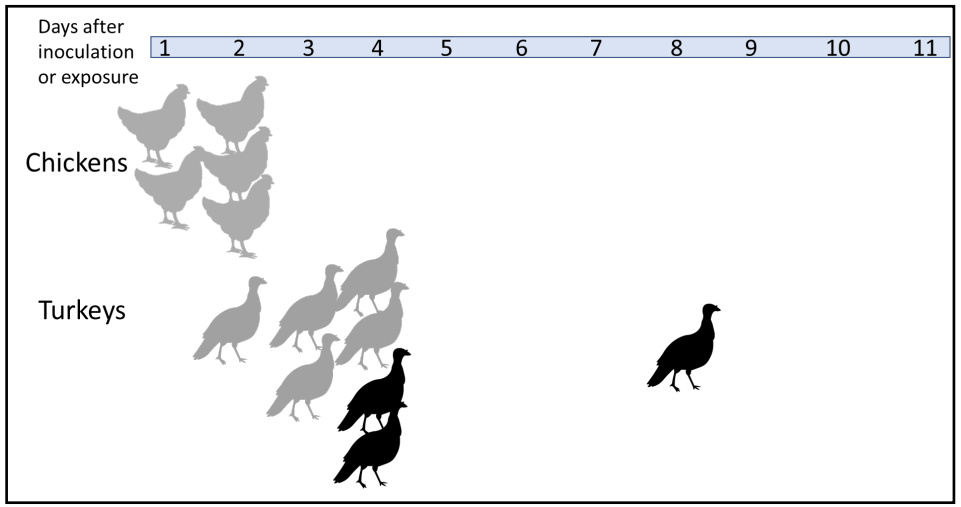

| | Virus dose | Inoculated dead/total (MDT) | $BID_{50}$ ($log_{10}$ $EID_{50}$) | Contact dead/total |
|---|---|---|---|---|
| Chickens | low | 3/5 (2.7) | ≤3.5 | 0/3 |
| | medium | 5/5 (2) | | 0/3 |
| | high | 5/5 (1) | | 0/3 |
| Turkeys | low | 5/5 (4.6) | <3.5 | 3/3 |
| | medium | 5/5 (3.4) | | 3/3 |
| | high | 5/5 (2.6) | | 3/3 |

MDT = mean death time, $BID_{50}$ = 50% bird infective dose.
$EID_{50}$ = 50% egg infective dose.

***Pantin-Jackwood and Spackman, preliminary results***

# A/AW/SC/2022 (H5N1) 5.5 $\log_{10}$ $EID_{50}$

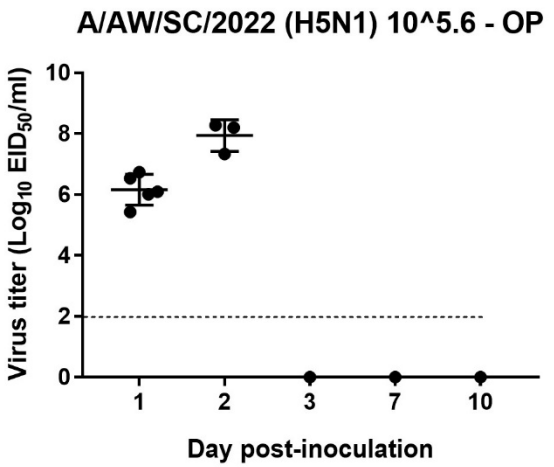
## Mortality

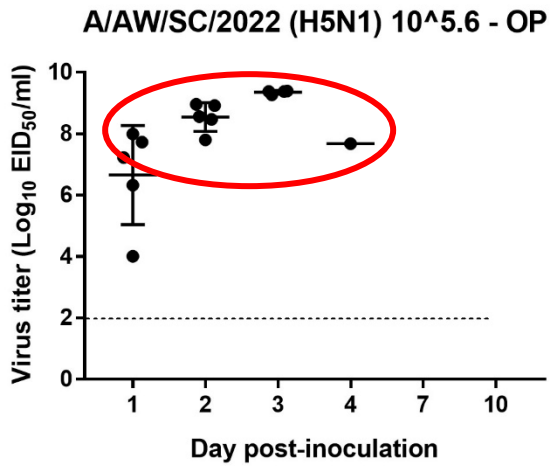



= inoculated = contact

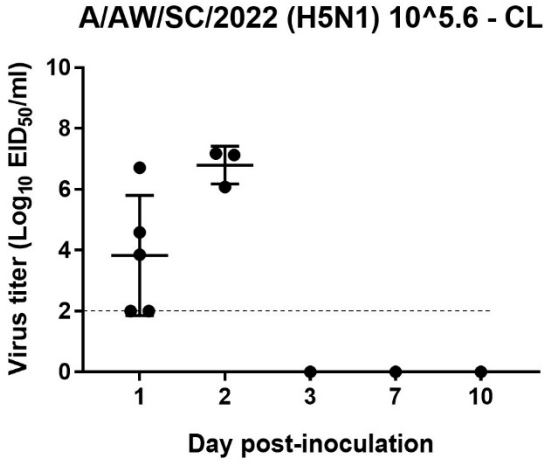
## Virus shedding

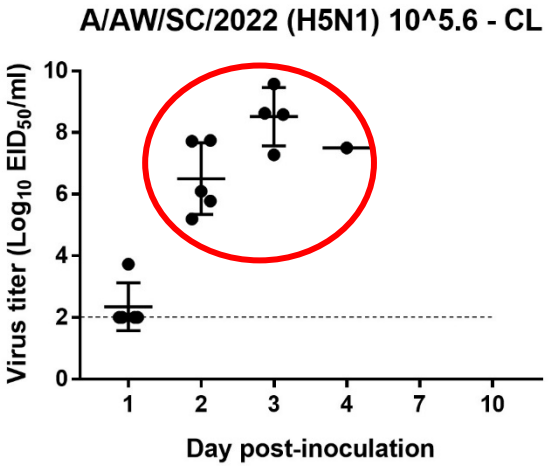
### Oropharyngeal




### Cloacal

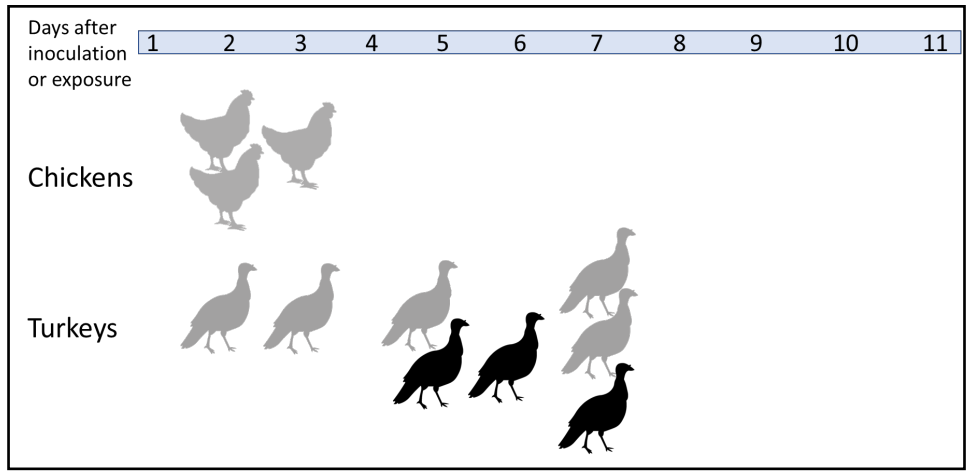



***Pantin-Jackwood and Spackman, preliminary results***

# A/AW/SC/2022 (H5N1) 3.5 $\log_{10}$ $EID_{50}$

## Mortality

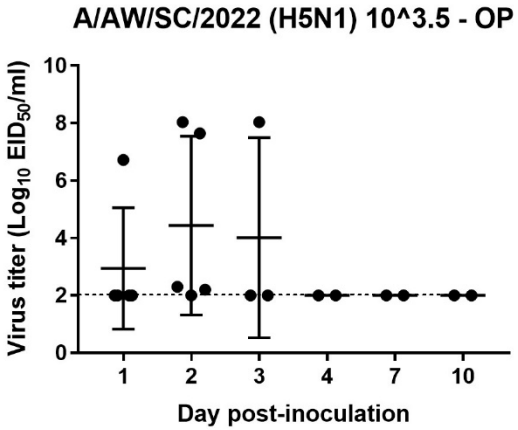


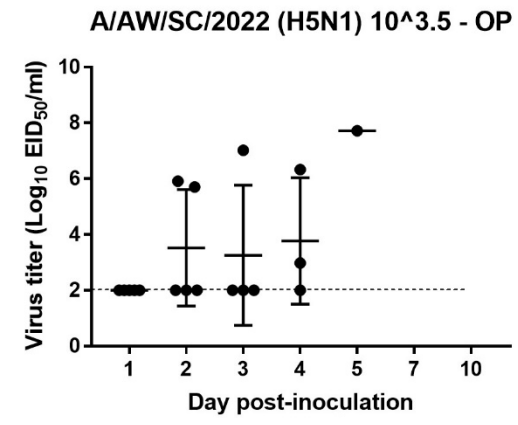

= inoculated = contact

Turkeys are more susceptible to virus infection, take longer to die, and transmit the virus better

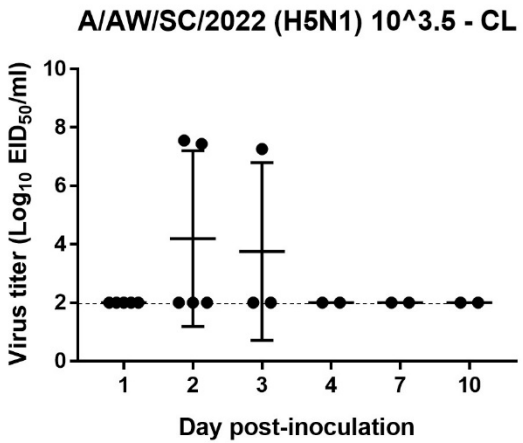
## Virus shedding

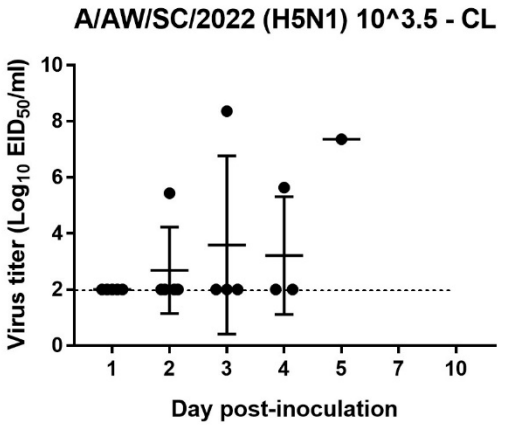
### Oropharyngeal




### Cloacal




***Pantin-Jackwood and Spackman, preliminary results***

# Comparing A/AW/SC/2022 (H5N1) with A/Northern pintail/WA/2014 (H5N2)

| | Virus | Dead/total (MDT) | $BID_{50}$ ($log10\ EID_{50}$) | Transmission |
|---|---|---|---|---|
| Chickens | H5N1 | 5/5 (1.4) | ≤3.5 | No |
| | H5N2[a] | 3/5 (3.0) | 5.7 | No |
| Turkeys | H5N1 | 5/5 (3.2) | <3.5 | Yes, with all doses |
| | H5N2[b] | 5/5 (5.3) | 5.0 | Only in the high dose group |

MDT = mean death time, in *5.6-6.6 $log_{10}$ $EID_{50}$ dose group*
$EID_{50}$ = 50% egg infective dose. $BID_{50}$ = 50% bird infective dose

[a] *Bertran et al. Vet Res (2019)*
[b] *Spackman et al. BMC Veterinary Research (2016)*

The 2022 H5N1 HPAIV is more infectious than the index 2014 H5N2 HPAIV

# Infectious dose in chickens: H5N2 HPAIVs (March-May 2015)

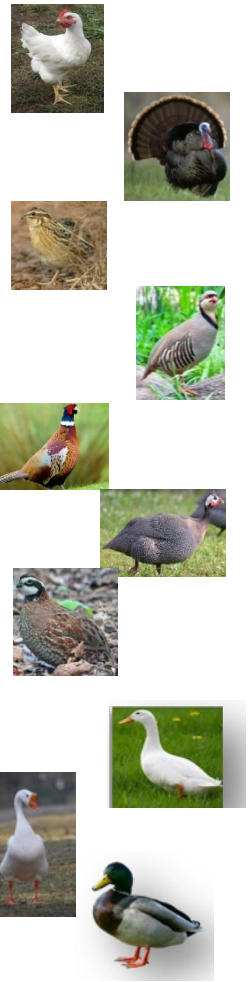
| Virus | % Mortality | $BID_{50}$ ($log_{10}$) |
|---|---|---|
| A/Northern Pintail/Washington/40964/2014 | 60 | 5.7 |
| A/Tk/South Dakota/12511/2015 | 100 | 3.2 |
| A/Tk/Minnesota/12582/2015 | 100 | 3.6 |
| A/Ck/Iowa/13388/2015 | 100 | 3.5 |

- Midwest H5N2 viruses were better chicken-adapted (April-May 2015)

The longer a HPAIV circulates in poultry, the more infectious it becomes

*Bertran et al. 2016*
*DeJesus et al. 2016*

# A/northern pintail/WA/2014 (H5N2)



| | % Mortality | MDT at highest dose (days) | $BID_{50}$ | Transmission |
|---|---|---|---|---|
| **Chickens** | **60** | **3** | **5.7** | No |
| **Turkeys** | **100** | **9** | **5.0** | Only in the high dose group |
| **Japanese quail** | | **3.0** | **3.7** | In the medium and high dose groups |
| **Chukar partridges** | | **5.2** | **3.6** | |
| **Ring-necked pheasants** | | **4.8** | **3.6** | |
| **Guinea fowl** | | **3.8** | **3.0** | In low, medium, and high dose groups |
| **Bobwhite quail** | | **4.9** | **<2** | |
| **Pekin ducks** | **0** | **-** | **3** | |
| **White Chinese Geese** | **25** | **7** | **<2** | |
| **Mallards** | **0** | **-** | **<2** | |

*Modified from Bertran et el. 2019*

# Pathogenicity of H5Nx HPAIV in ducks:
## Differences between species - *Wild ducks*

**Virus: A/Whooper Swan/Mongolia/244/ 2005 (H5N1)**

| | Mortality | Oral* | Cloacal* |
|---|---|---|---|
| Wood Ducks | **3/6** | **4.96 / 5** | **3.30 / 3** |
| Mallards | 0/6 | 2.57 / 2 | 0.97 / 1 |
| Redheads | 0/6 | 2.70 / 2 | 1.23 / 1 |
| Northern Pintails | 0/6 | 3.14 / 2 | 0.97 / 1 |
| Blue-winged Teal | 0/6 | 1.32 / 1 | 1.21 / 1 |

*Avg. viral titers (log10 EID50/ml) / Avg. duration (days)


*Aix sponsa*


*Anas platyrhynchos*


*Aythya americana*

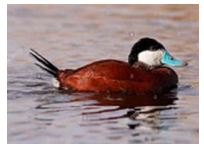

*Anas acuta*

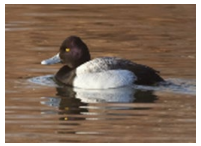

*Anas discors*

Brown, et al.J. Wildl Dis, EID, 2008

**A/GF/WA/14 (H5N8) HPAIV and A/NP/WA/14 (H5N2) HPAIV**

| | Virus | Mortality | $BID_{50}$ |
|---|---|---|---|
| **Ruddy Duck -juvenile** | H5N8 | 3/5 | <2 |
| **Ruddy Duck -adult** | H5N2 | 1/5 | |
| **Lesser Scaup-juvenile** | H5N8 | 0% | 3 |
| | H5N2 | 0% | <4 |


(*Aythya affinis*)


(*Oxyura jamaicensis*)

Spackman et al. J. Wildlife Diseases 2017

Infectivity and transmissibility of HPAIV can be affected by the species, age, and health status of the birds

# Pathogenicity of H5N1 HPAIV in Geese and Swans

| Species | Virus | Sick/Dead /Total | MDT | Ages and References |
|---|---|---|---|---|
| **Embden goose** *(Anser anser domesticus)* | A/Ck/HK/220/97 | 5/0/11 | - | 2 wks-old; *Perkins, 2002* |
| **Chinese white goose** (*Anser cygnoides*) | A/Gs/HK/437-4/99<br>A/Gs/HK/485-3/00 | 3/3/3<br>3/0/3 | 7-8<br>- | 3-4 wks-old; *Webster, 2002* |
| **Chinese goose** | A/Dk/SH/04 | 5/5/5 | 7 | 5 wks-old *Tian, 2005* |
| **Cackling goose** *(Branta hutchinsii)* | A/W.sw/Mong/05 | 4/3/4 | 6.0 | 12 wks-old; *Brown, 2008* |
| **Bar-headed goose** *(Anser indicus)* | A/W.sw/Mong/05 | 5/2/5 | 6.5 | |
| **Canada Goose** *(Branta canadienziz)* | A/Ck/VN/14/05 | 5/5/5 | 5.0-20 | 13 wks-old, adults; *Pasick, 2007* |
| **Geylag goose** (*Anser anser*) | A/Ck/S.Korea/06 | 2/0/2 | - | 7 wks-old *Kwon, 2010* |
| **Chinese goose** | A/Ck/Indonesia/07 | 9/9/12 | 5.1 | 4 wks-old *Eggert,2010* |

Note: previous exposure to AIV can modulate the outcome of HPAIV infection

# Comparing clade 2.3.4.4 Gs/GD H5 HPAIV's in mallards

**$BID_{50}$ <2 log10**

*DeJesus et al. 2016*
*Leyson et al. 2019*

| Virus | % infected | % mortality | # of days virus positive | % of contacts infected |
|---|---|---|---|---|
| A/Gf/WA/2014 (H5N8) | 100 | 0 | 11 | 100 |
| A/Np/WA/2014 (H5N2) | 100 | 0 | >14 | 100 |
| A/Tk/MN/2015 (H5N2) | 100 | 10 | >14 | 100 |
| A/Ck/IA/2015 (H5N2) | 100 | 0 | 11 | 100 |
| A/Td/Denmark/2016 (H5N8) | 100 | 88 | 5 | 100 |
| A/AW/SC/2022 (H5N1)** | 100 | 23 | >14 | 100 |

**Clinical signs: 7/34 (20%) neurological signs (euthanized), 6/34 (18%) corneal opacity, 1/34 (3%) mortality.
Shed high titers of virus orally and cloacally.
***Spackman et al. preliminary results***

# Virus shedding

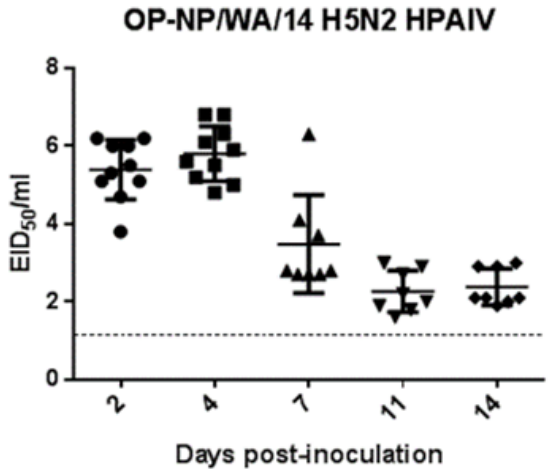
A/northern pintail/WA/2014
(H5N2 clade 2.3.4.4c)
0% mortality

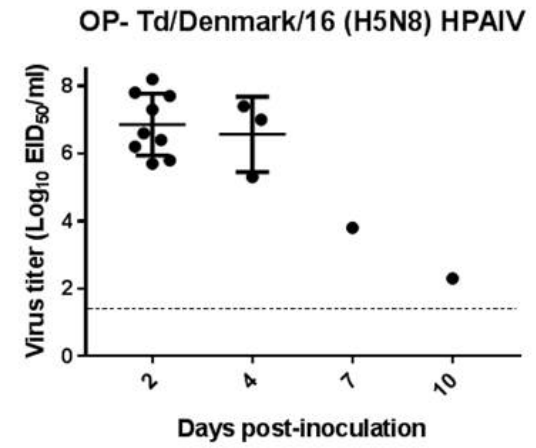
A/American wigeon/SC/2022
(H5N1 clade 2.3.4.4b)
23% mortality

A/Tufted-duck/Denmark/2016
(H5N8 clade 2.3.4.4b)
88 % mortality

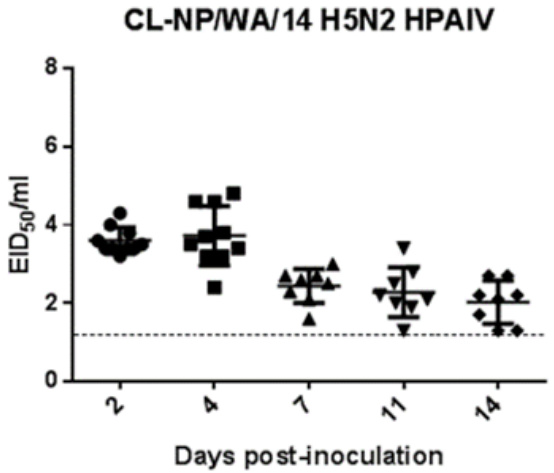
Decreased disease severity compared to the 2016 virus could help the virus spread more easily in the wild waterbird population.

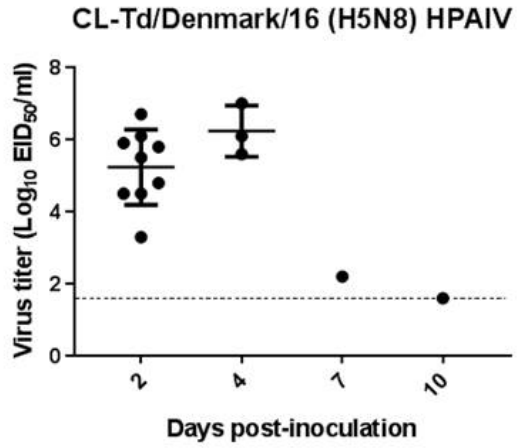
**Oropharyngeal**




**Cloacal**



# A/AmWigeon/SC/345/2022 H5N1 in Mallards

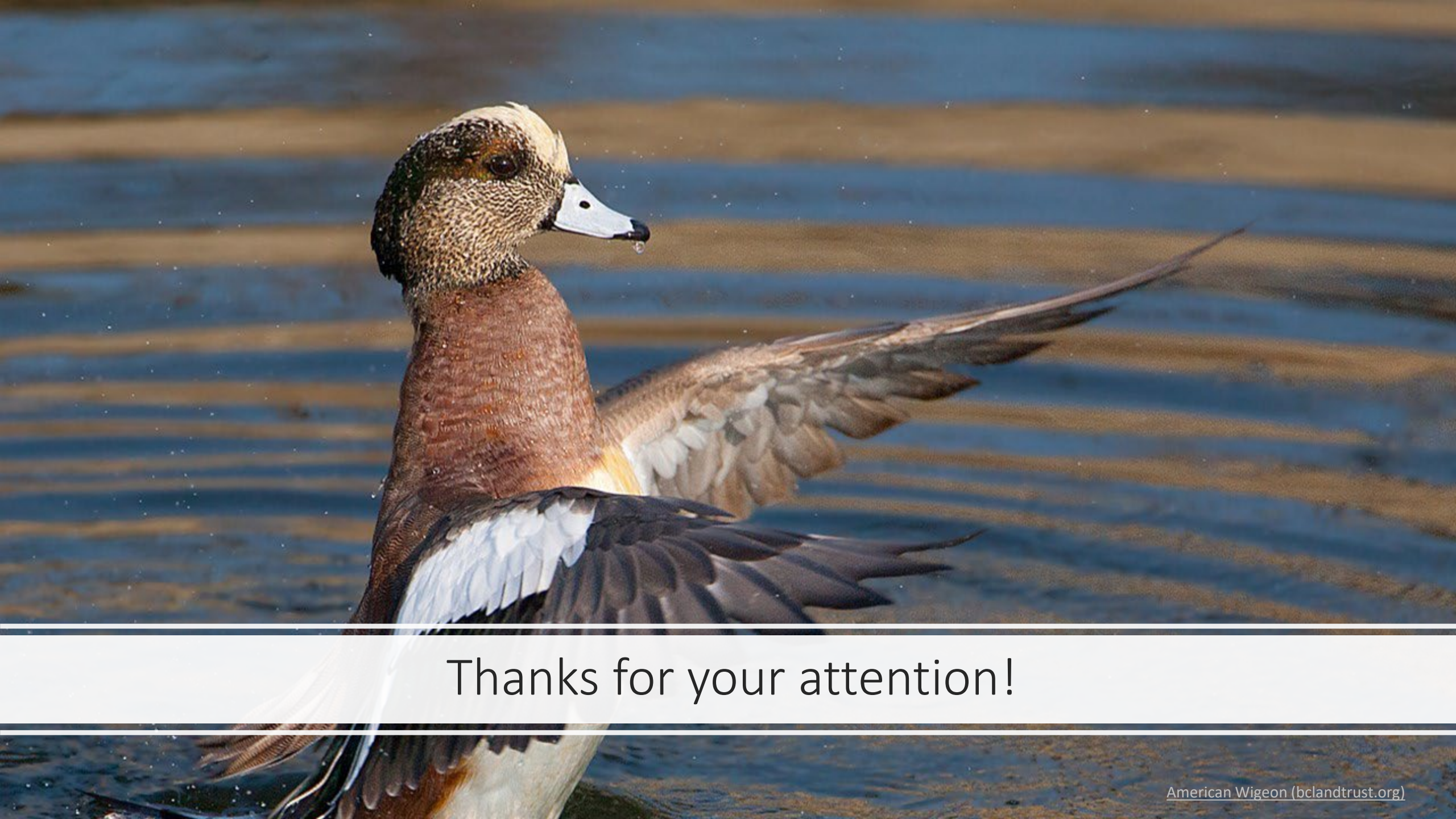
- $BID_{50}$ <$2log_{10}$
- Transmitted to all contact exposed ducks
- Shed high titers orally and cloacally
  - Ducks still positive for shed 14DPC (mostly cloacal)
- Clinical signs:
  - Most ducks no signs
  - ~20% had neurological and corneal opacity, mild lethargy
- IHC and rRT-PCR on tissue: virus systemic replication- similar to other 2.3.4.4 HPAIVs

# Summary

- The infectivity, transmissibility, and pathogenicity of HPAIVs in avian species is affected by the strain of the virus and the species, age, health, and immune status of the birds.
- Once infected, Gallinaceous species will become severely sick. Turkeys are highly susceptible to HPAIV infections. This high susceptibility, coupled with a longer mean death time and high amounts and duration of virus excreted, can favor HPAIV spread.
- Wild birds show variable susceptibility to disease, with some wild migratory waterfowl being key contributors in the spread of H5N1 HPAIV.
- Some infected wild bird species can show clinical signs and mortality, which would limit spread of the virus, but these birds might act as sentinels of viral circulation.
- This information is important for surveillance efforts and help clarify epidemiological data from outbreaks of H5Nx HPAIV in poultry and wild bird populations.

Photograph by Lyuba Filatova (fineartamerica.com)


HOW'S IT
GOING
TO END?



# Thanks for your attention!

American Wigeon (bclandtrust.org)