

## Avian influenza in wild birds

**Thijs Kuiken**

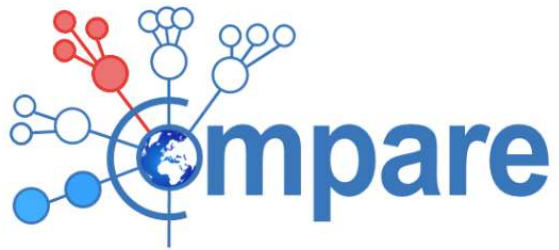
*2020 Waterfowl Conservation Workshop, Aeres MBO Barneveld*

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## Outline

- Low pathogenic avian influenza virus in wild birds
- Highly pathogenic avian influenza virus in poultry
- Highly pathogenic avian influenza virus in wild birds

## Funding



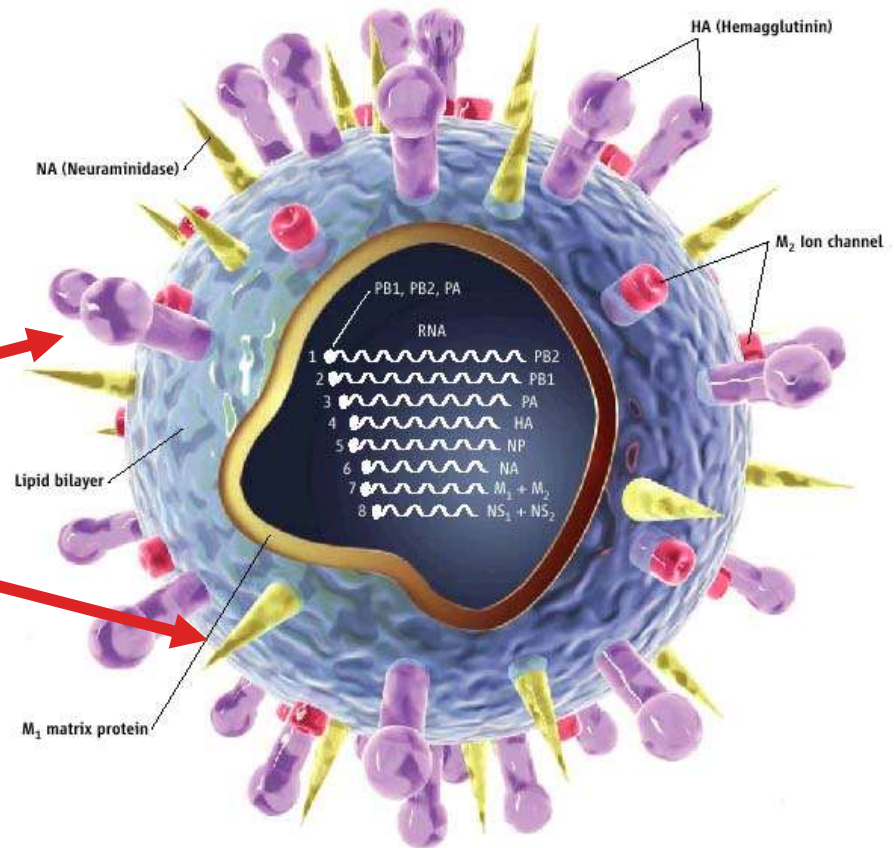
**ΔELTA-FLU**



<http://platform.gisaid.org/>

# Avian influenza virus

- Negative strand RNA virus
- Segmented genome allows reassortment during mixed infection
- Two viral surface proteins:
  - Haemagglutinin (HA)
  - Neuraminidase (NA)
- Host enzyme splices precursor HA0 into active HA1 and HA2
- Categorized according to:
  - HA subtype (1 to 16)
  - NA subtype (1 to 9)



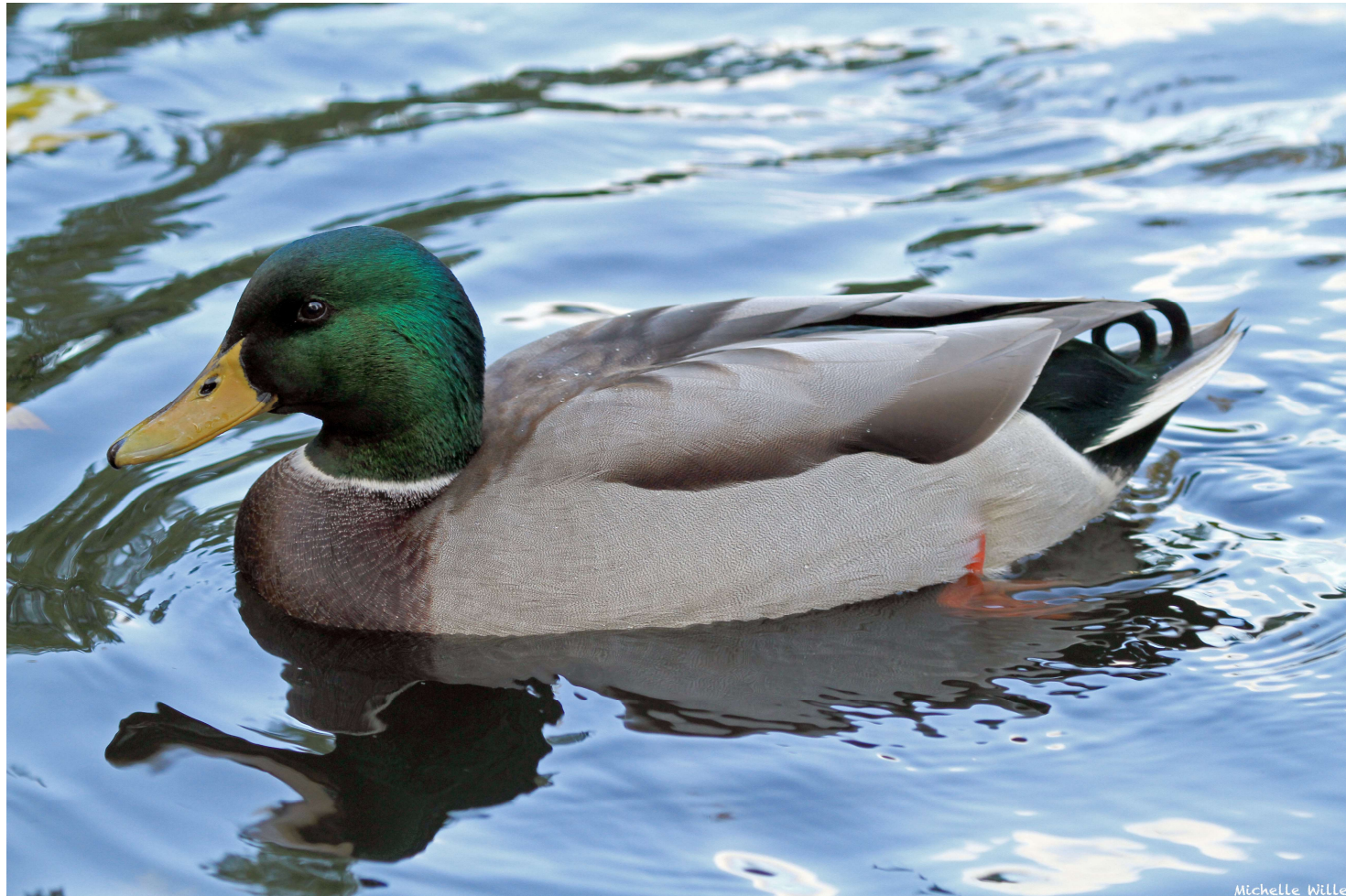
*Kaiser 2006, Science*

## Wild bird hosts of influenza A viruses *(Olsen et al. 2006, Science)*

- Anseriformes
  - Anatidae
    - Anserinae: swans and geese
    - Anatinae: dabbling ducks
    - 8 other subfamilies
  - 2 other families
- Charadriiformes
  - Laridae: gulls
  - Charadriidae: plovers and lapwings
  - 18 other families



## What does influenza virus do in ducks?



*Courtesy of Michelle Wille*

## Materials and methods *(Daoust 2011 J Wildlife Dis)*

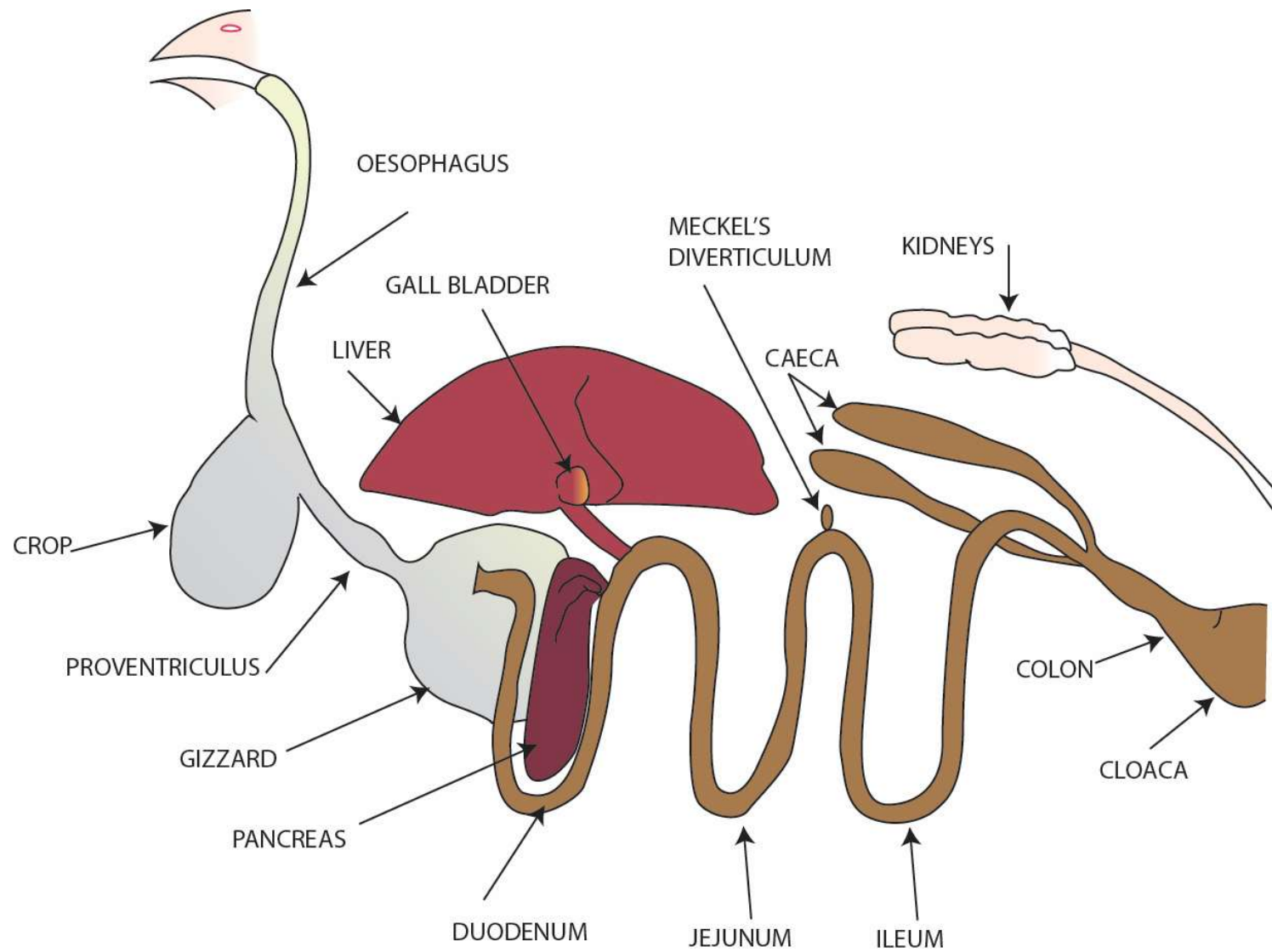
- 50 hatch-year mallards swabbed (combined oropharyngeal and cloacal) and held 24 hr until matrix gene RRT-PCR performed
- 19 positive birds and 4 negative birds euthanized
- Full autopsy including histology samples of
  - Digestive: pharynx, oesophagus, proventriculus, gizzard, duodenal loop, jejunum, ileum, ceca colon, cloaca, cloacal bursa
  - Respiratory: nasal gland, ethmoid bone, trachea, primary bronchus, lung
- Virology samples of
  - Lung
  - Colon/cloaca
  - Cloacal bursa

## Results of PCR-positive mallards

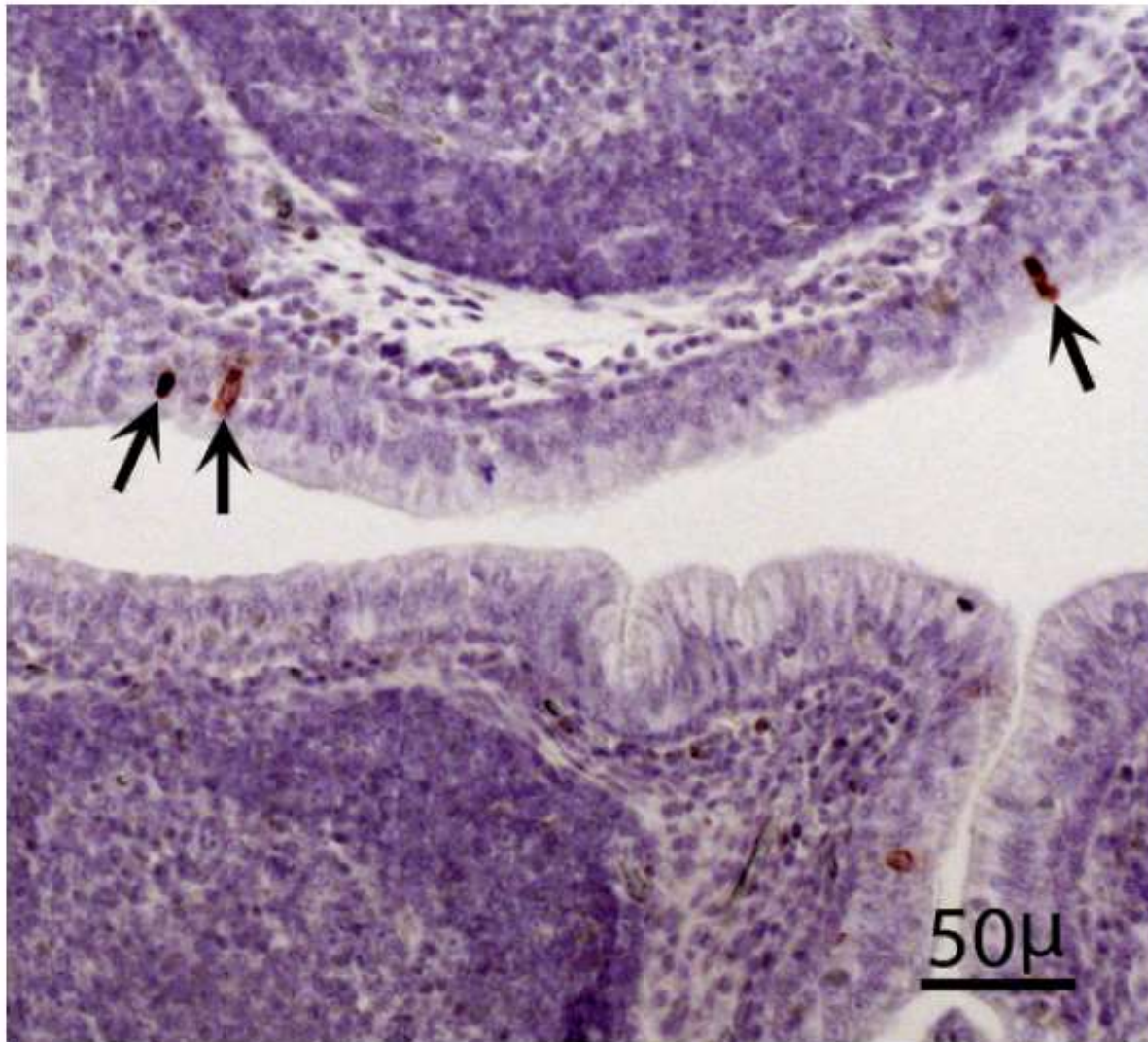
- Respiratory tract
  - 0 of 19 birds positive by IHC
- Digestive tract
  - 9 of 19 birds positive by IHC
  - Virus isolates
    - 4 x negative
    - 2 x H2N3
    - 1 x H?N3
    - 1 x H4N6
  - Positive digestive tract tissues
    - 8 x cloacal bursa
    - 3 x colon
    - 2 x caecum
    - 1 x ileum



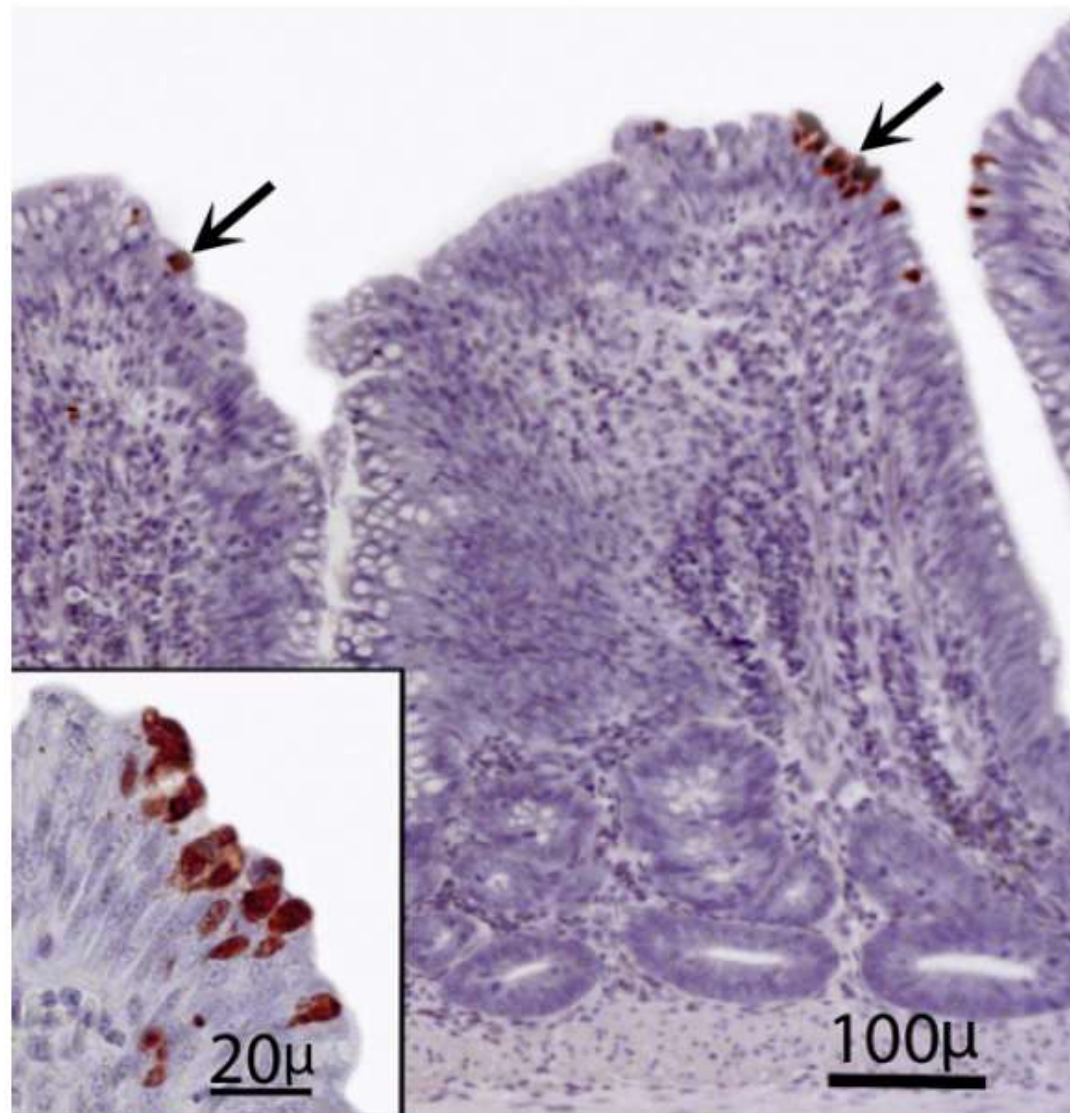
# Avian digestive tract



## Cloacal bursa of mallard infected with LPAIV H2N3



## Colon of mallard infected with LPAIV H2N3



**Conclusion 1: Avian influenza virus in mallards infects the intestine and does not cause disease**

\*Kuiken T. Is low pathogenic avian influenza virus virulent for wild waterbirds? Proc Biol Sci. 2013



## What does influenza virus do in chickens?

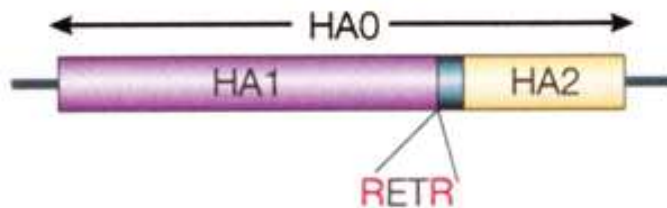


# Infection with low pathogenic influenza virus (LPAIV) versus highly pathogenic influenza virus (HPAIV)

*(Horimoto & Kawaoka 2005 Nature Rev Microbiol)*

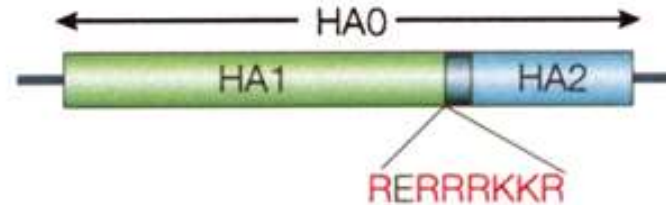
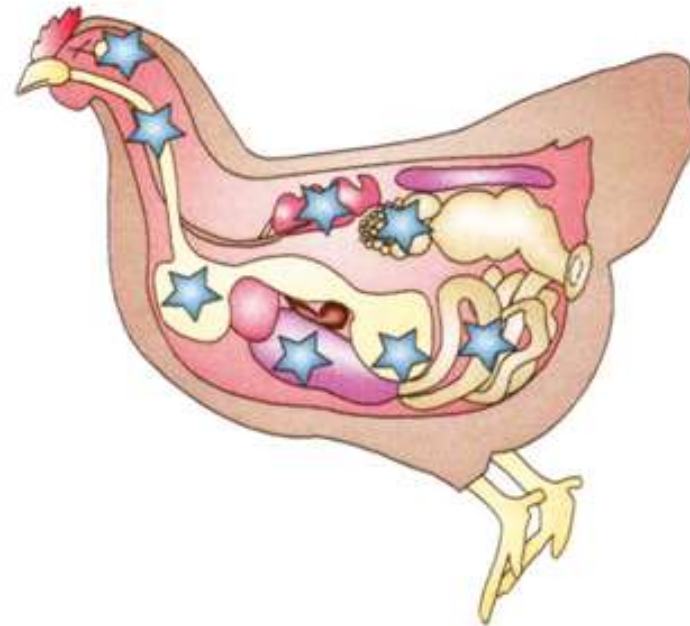
## LPAI

Proteases localized in respiratory and intestinal organs



## HPAI

Ubiquitous proteases



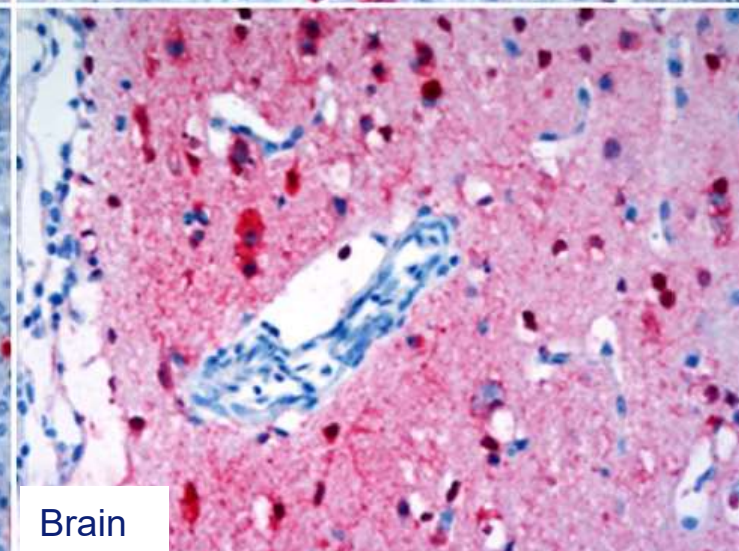
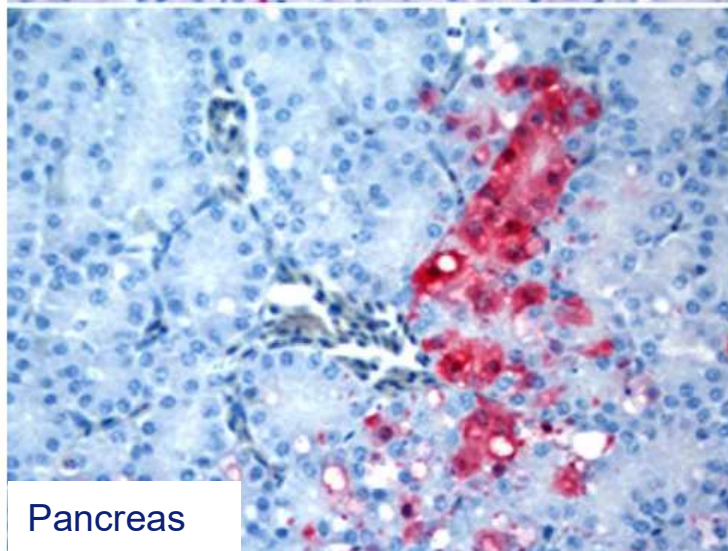
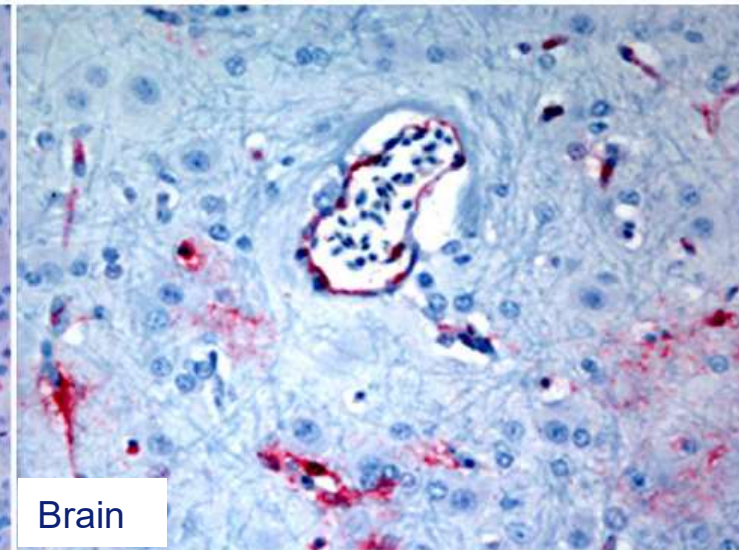
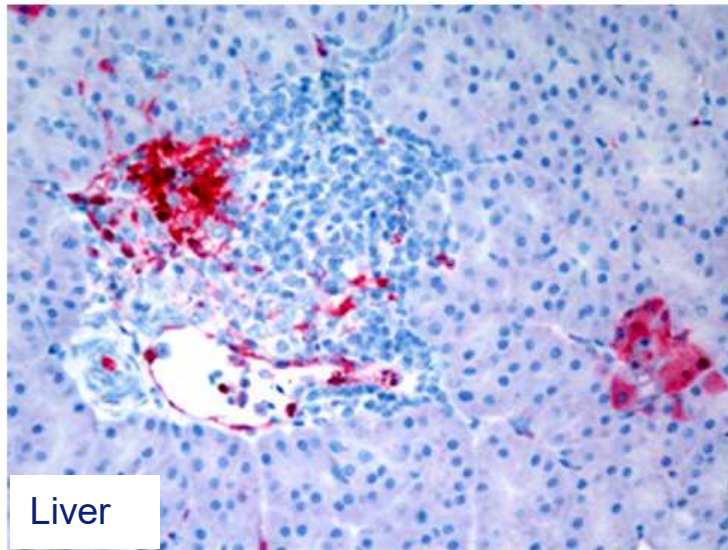


## Disease description HPAIV infection in poultry

- Clinical signs
  - Death without clinical signs
  - Nervous signs
  - Severely decreased egg production
- Pathologic changes
  - Oedema, haemorrhage, necrosis
  - Skin and visceral organs



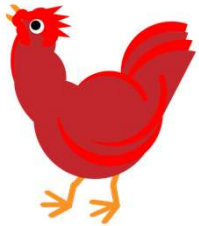
## HPAIV expression in tissues of poultry (Kuiken et al. 2010 Vet Pathol)



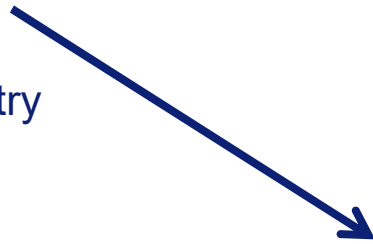
**Conclusion 2: HPAIV in chickens infects all organs and causes high mortality**

# How does HPAIV spread among poultry farms?

*(Pepin et al. 2014, Prev Vet Med)*



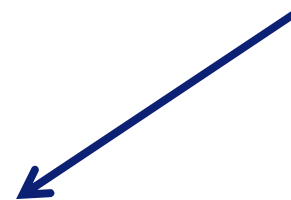
Infected poultry



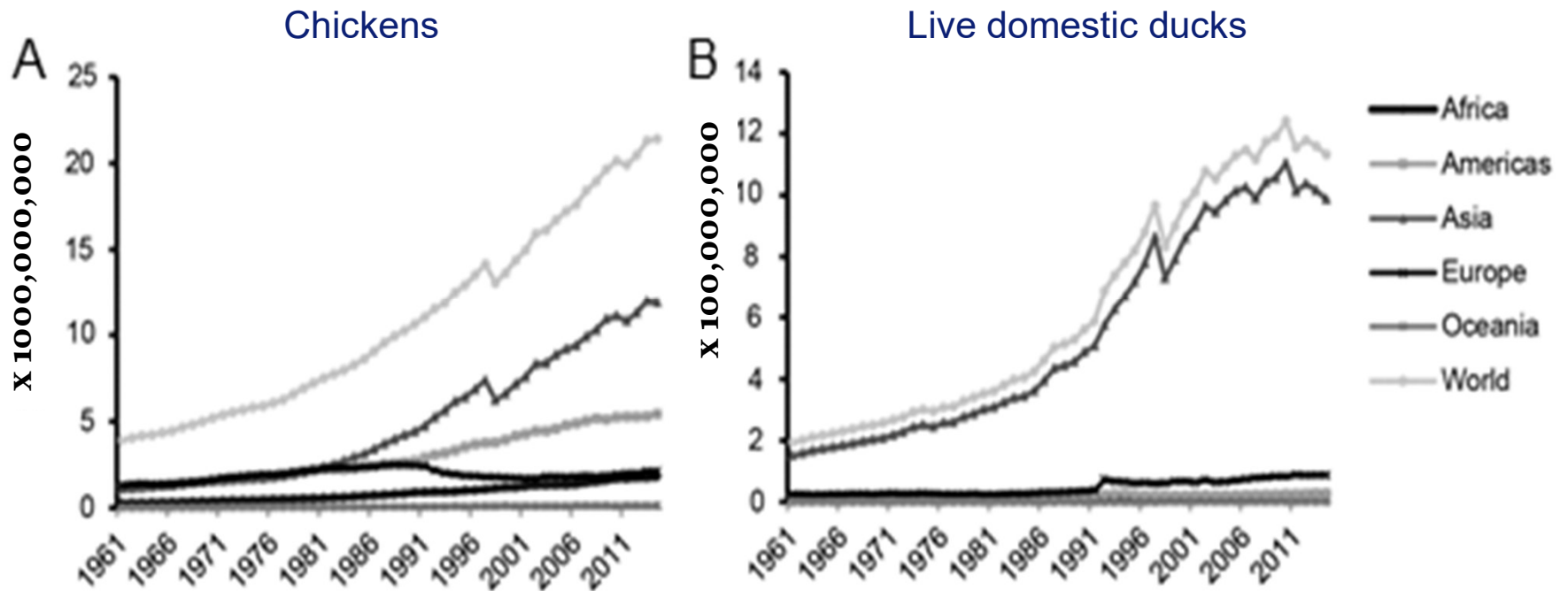
Poultry farm



Farm workers  
(footwear, clothing,  
vehicles)



## Growth of poultry populations per continent from 1961 to 2014 ([www.fao.org/faostat/](http://www.fao.org/faostat/))





# Large domestic duck populations are risk factor for spill-back of HPAIV from poultry into wild birds

*(Gilbert et al. Emerg Infect Dis. 2006; Cappelle et al. Ecohealth 2014)*

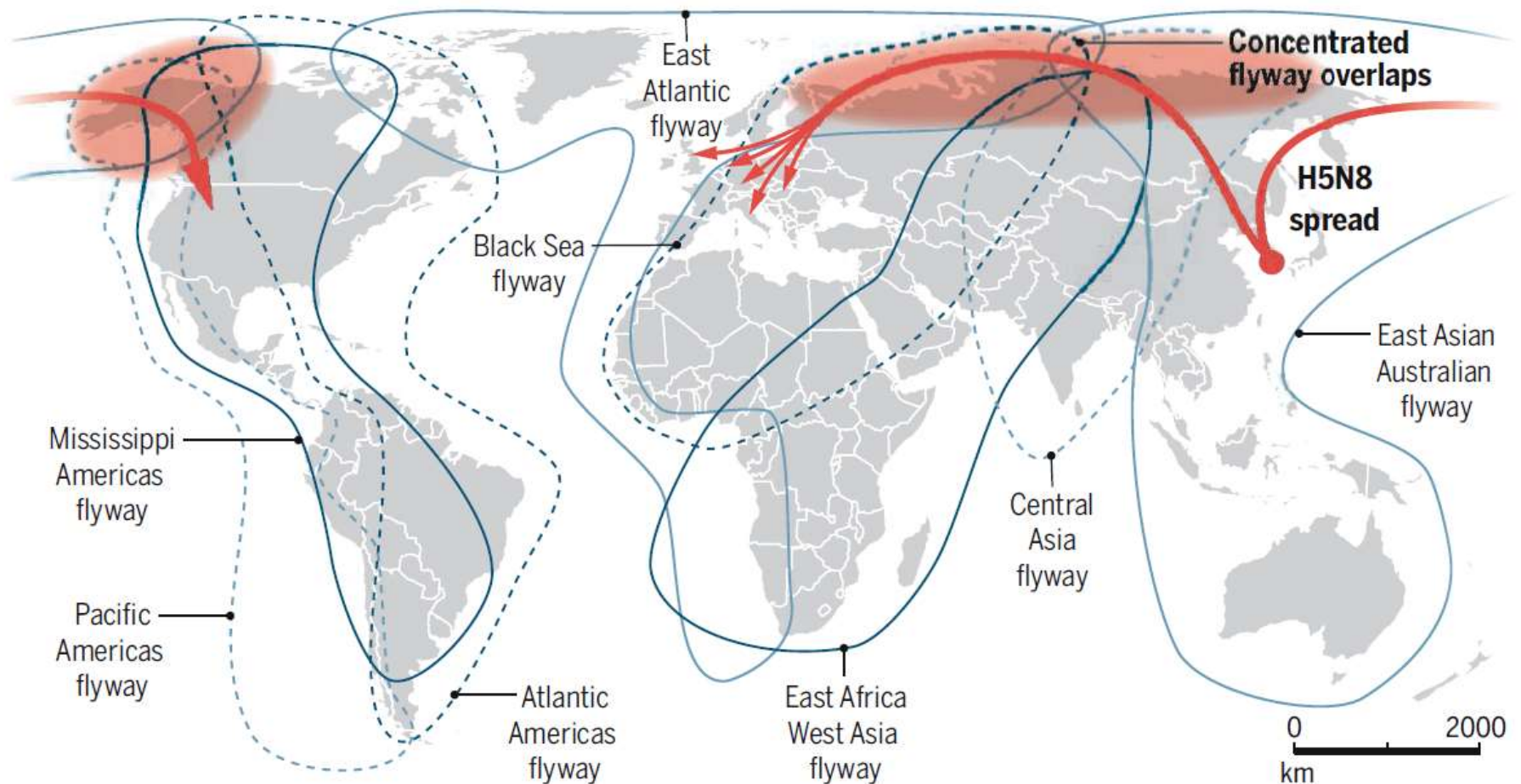


Photo courtesy of Maciek Boni

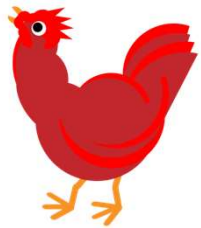


# Spread of HPAIV via long-distance migration of migratory waterbirds

(Lycett et al. 2016, Science: Russell, 2016, Science)



# Current pathways of spread of HPAIV among commercial poultry operations *(Pepin et al. 2014, Prev Vet Med)*



Infected poultry



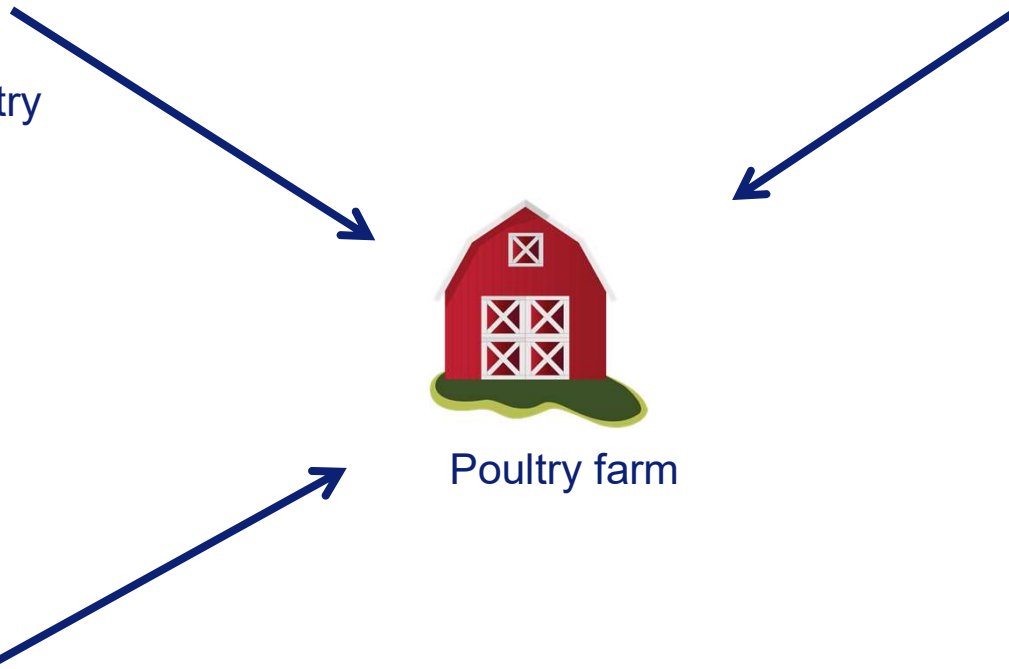
Farm workers  
(footwear, clothing,  
vehicles)



Poultry farm



Wild birds



## Overview of HPAIV “eruptions” in wild birds, 2005-2020

Year	Main subtype	Continental spread
2005/06	H5N1	Asia-Europe-Africa
2006/2013		No major eruptions
2014/15	H5N8	Asia-Europe-Africa-North America
2015/16		No major eruption
2016-2017	H5N8	Asia-Europe-Africa
2017-2018	H5N8/H5N6	Asia-Europe-Africa
2018-2019	H5N8/H5N6	Asia-Europe-Africa
2019-2020	H5N8	Asia-Europe-Africa

**Conclusion 4: Currently, wild birds also may spread HPAIV over long distances**

# What is the impact of HPAIV on wild waterbirds?

Animal diseases » Germany: White stork tests positive for H5N8 avian flu at Rostock Zoo

## Germany: White stork tests positive for H5N8 avian flu at Rostock Zoo

Posted by Robert Herriman on January 8, 2015 // 2 Comments

A day following reports of two cases of H5N8 avian influenza in mallard ducks at Saxony-Anhalt, the Ministry of Agriculture in Schwerin report an additional case in a white stork at the Rostock Zoo (computer translated).



White stork  
Image/Ltshears

The infected stork and eight others were killed to prevent the spread of the virus.

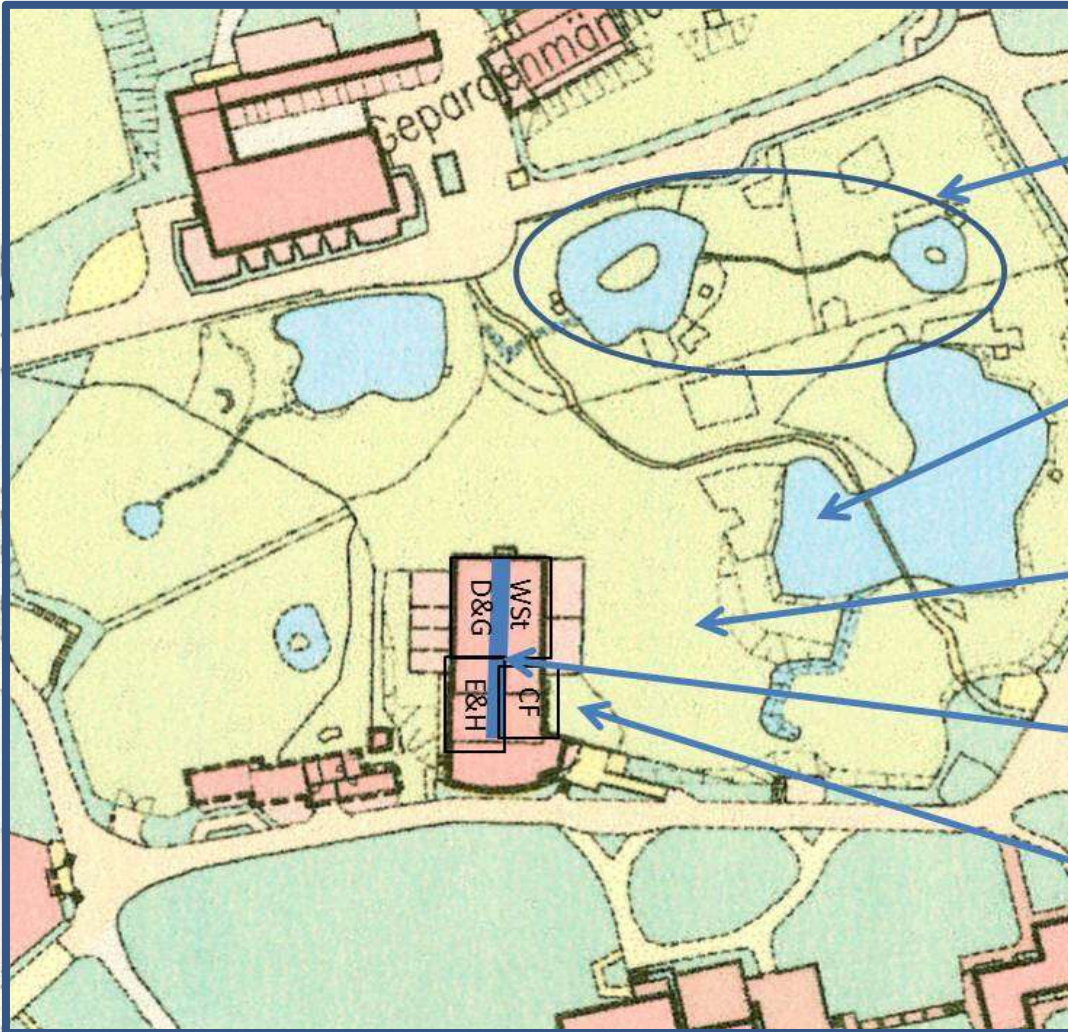
This discovery has prompted the zoo to close today. Agriculture Minister, Dr. Till Backhaus, announced he would be discussing the case further at a press conference today.

On Wednesday, bird flu was detected in northern Saxony-Anhalt in two wild ducks. The animals had been shot during the game monitoring on 31 December. In both animals, the Friedrich-Loeffler-Institut detected the H5N8 virus.

In Mecklenburg-Vorpommern bird flu was (district of Vorpommern-Greifswald) erupted with the same pathogen in early November in an farm operation in Heinrichswalde with around 31, 000 turkeys. About 2,000 animals died, the others were killed.



## Location of birds at Rostock Zoo



Area of zoo ducks and geese during summer and autumn; since Nov 2014 indoors; artificial ponds, Temporarily without water

Natural pond (wild Mallard ducks, gulls, Moorhen observed)

White storks outside with access to the natural pond 18.-28.12.

Supply corridor (blue line)

Small outdoor area for flamingos

WSt=White storks, CF=Chilean flamingos, D&G=ducks and geese (e.g. Hooded merganser); E&H= egrets and heron



# Wader house



Outdoor area storks

Outdoor  
area

Flamingos  
(19)

Glossy  
ibises &  
egrets  
(18)

Storks  
(12)

Ducks &  
geese  
(30)

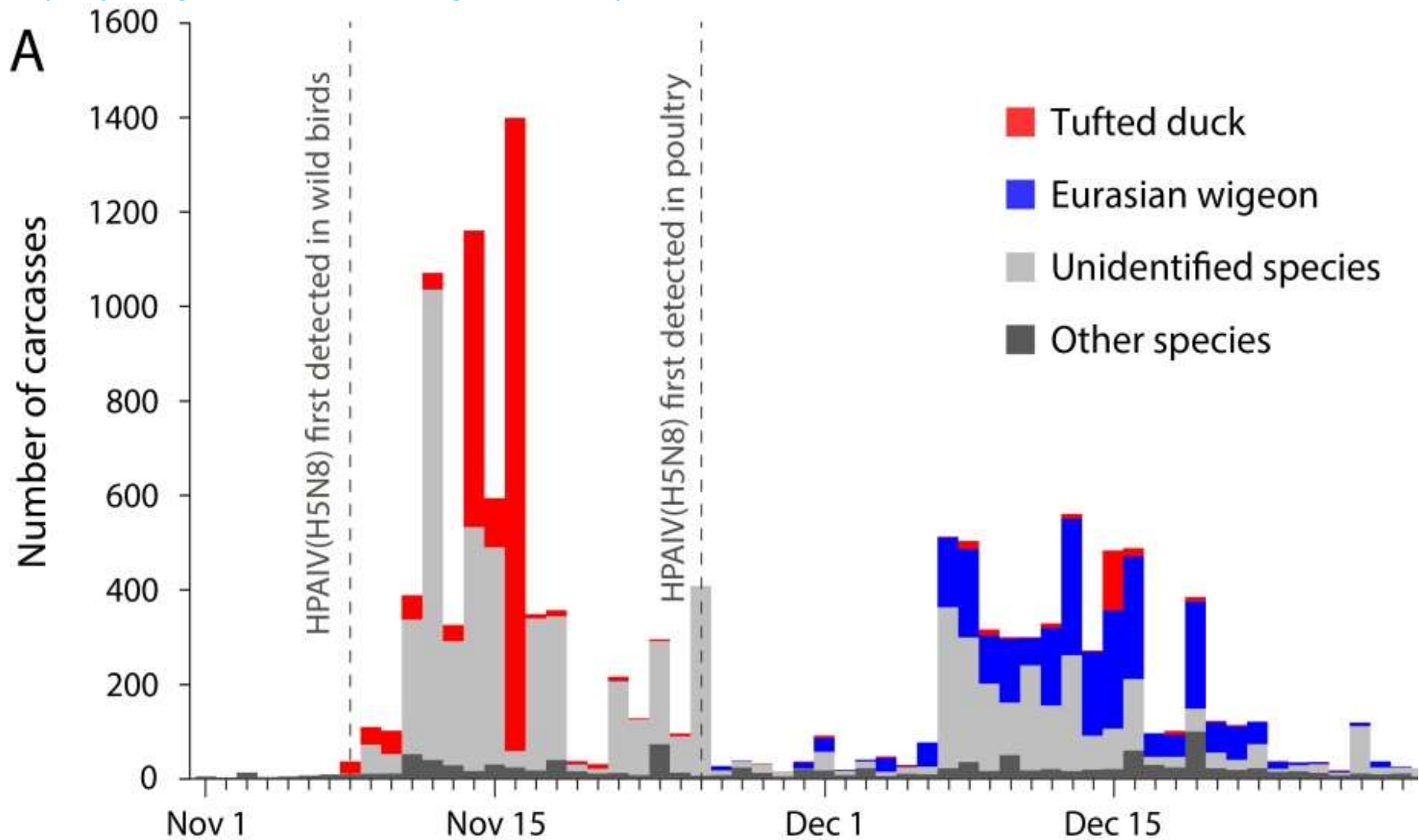


## Effective management of outbreak to rescue valuable avifaunistic collection *(Globig et al. Transbound Emerg Dis. 2017)*

- Storks in wader house euthanized
- Exception from culling all of the 500 remaining zoo birds granted
- Zoo birds grouped into 8 epidemiological units and tested repeatedly
- Two other groups in wader house (ducks and geese: ibises, egrets, and night herons) found positive and euthanized
- Most likely source of introduction: direct or indirect contact of white storks with infected wild birds on small pond frequented by wild mallards and other wild waterbirds

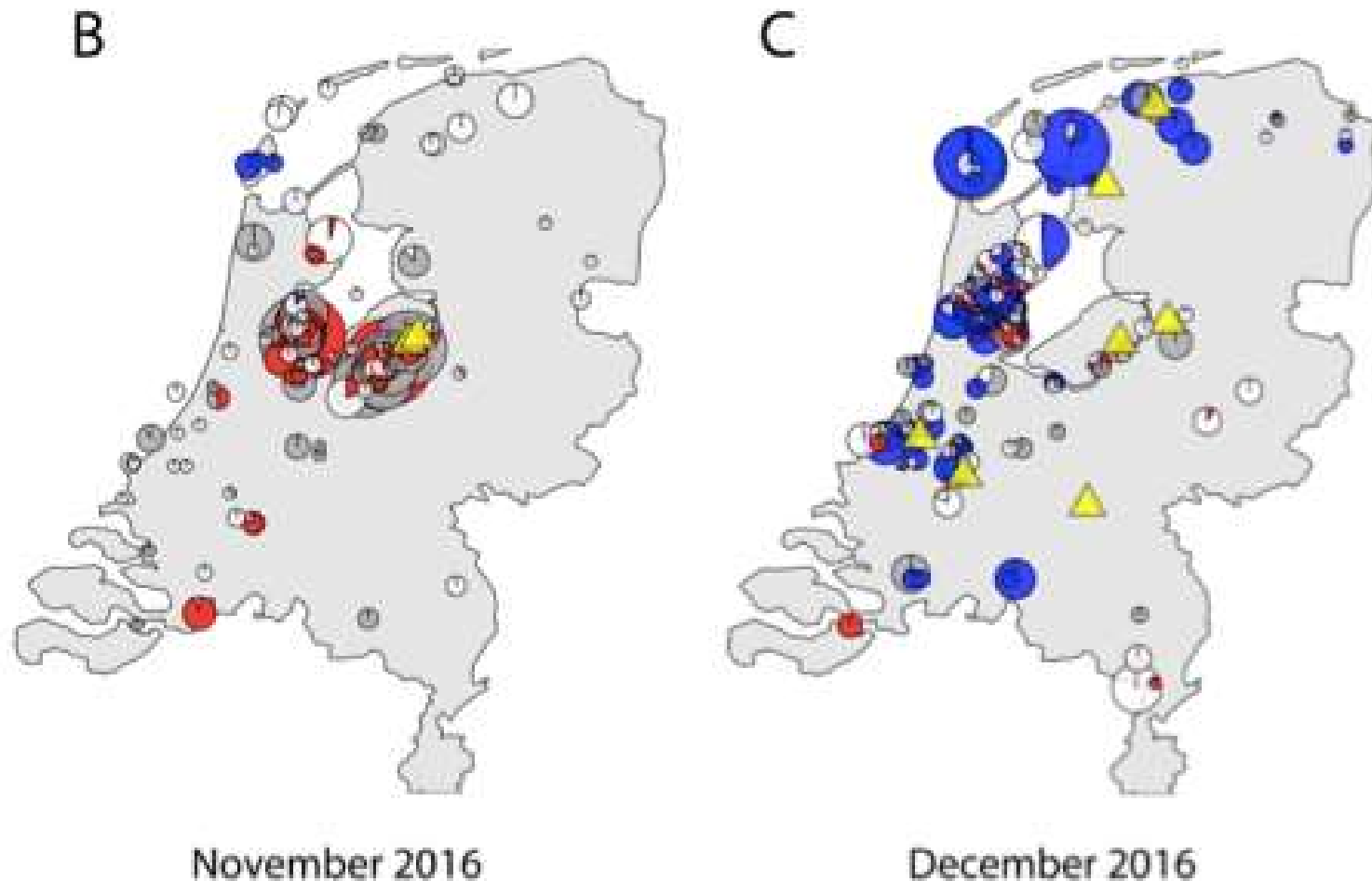
# 2016-2017 HPAIV H5N8 outbreak caused mass die-off of free-living wild birds in the Netherlands

(Kleyheeg et al. 2018 Emerg Infect Dis)



# Spatial pattern of wild bird mortality during the HPAIV H5N8 in the Netherlands, Nov-Dec 2016

*(Kleyheeg et al. 2018 Emerg Infect Dis)*



## Overall conclusions

- Wild waterbirds natural reservoir of influenza A virus: low pathogenic forms
- Highly pathogenic avian influenza is mainly a disease of poultry
- Frequency and magnitude of outbreaks in poultry have increased in recent years and are associated with the growth of the poultry industry
- H5N8 and related avian influenza viruses are unusual because
  - Efficient spread by wild birds
  - Extensive mortality of wild birds





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