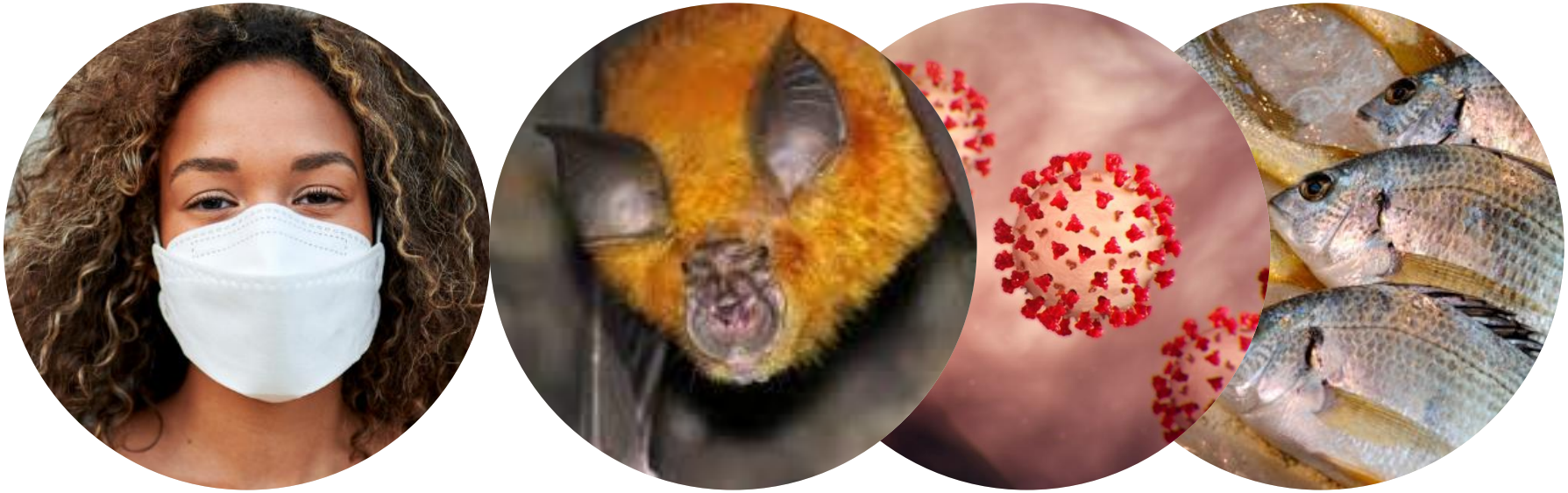
Driving Forces of the Emergence of Zoonoses

Wim H. M. van der Poel,

Nov 2021



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100years
1918 — 2018

Wageningen University, Campus Wageningen

Wageningen Bioveterinary Research, Lelystad

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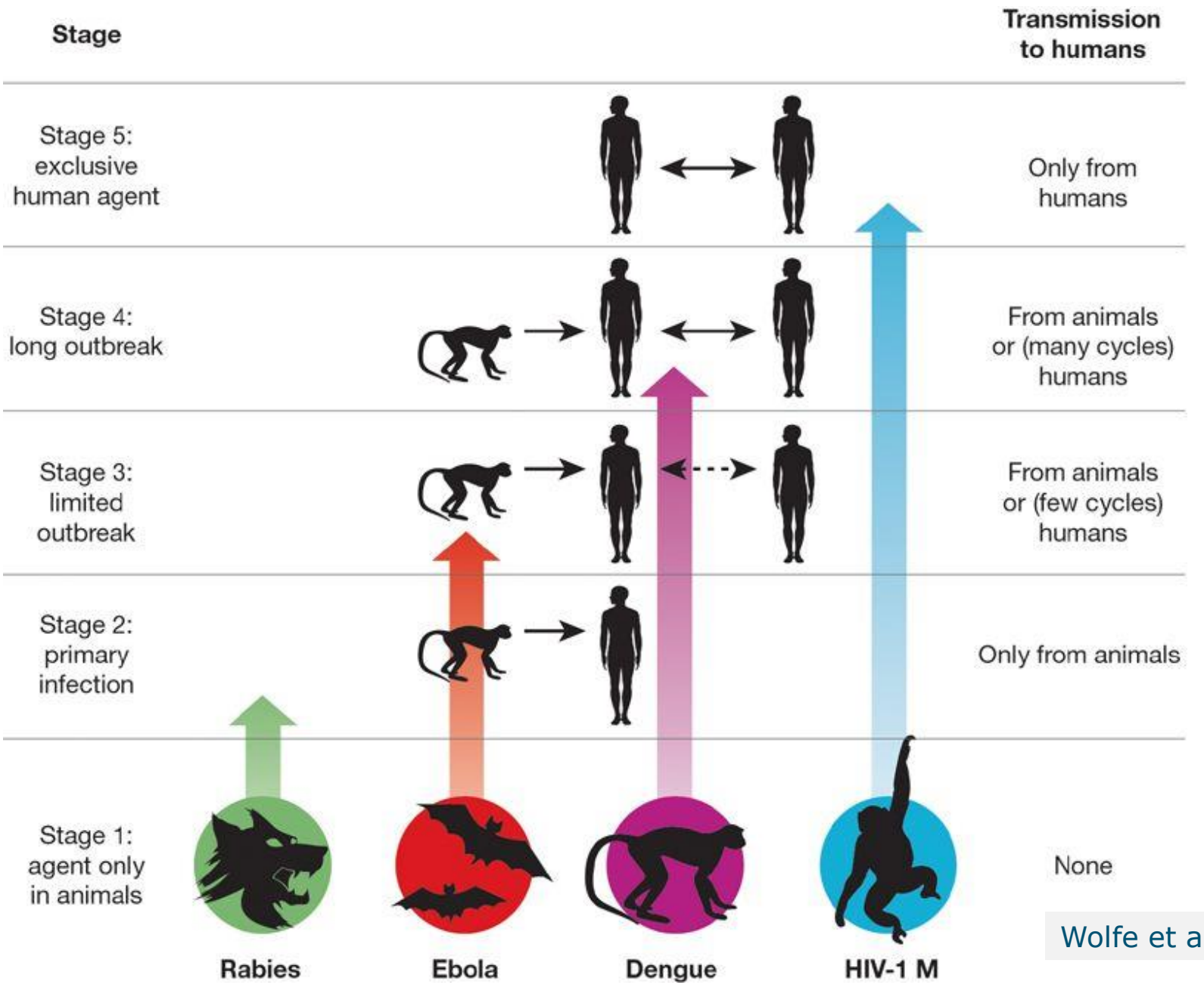
Presentation outline

- Emerging zoonotic viruses, introduction
- Zoonotic disease reservoirs
- Animal to human spill-over of pathogens
- Drivers of emerging zoonotic infections
- Biodiversity loss and climate change
- The SARS-CoV2 case, an emerging zoonotic virus
- Preparedness future pandemics
- Global One Health Approach

Zoonoses – infectious diseases transmitted from animals to humans

Stages of zoonotic virus adaptation



Wolfe et al., 2007

NL Expert group Zoonoses Preparedness

Henk Bekedam

Arjan Stegeman

Fred de Boer

Ron Fouchier

Jan Kluytmans

Sander Koenraadt

Thijs Kuiken

Wim van der Poel

Ria Reis

Gerdien van Schaik

Leo Visser

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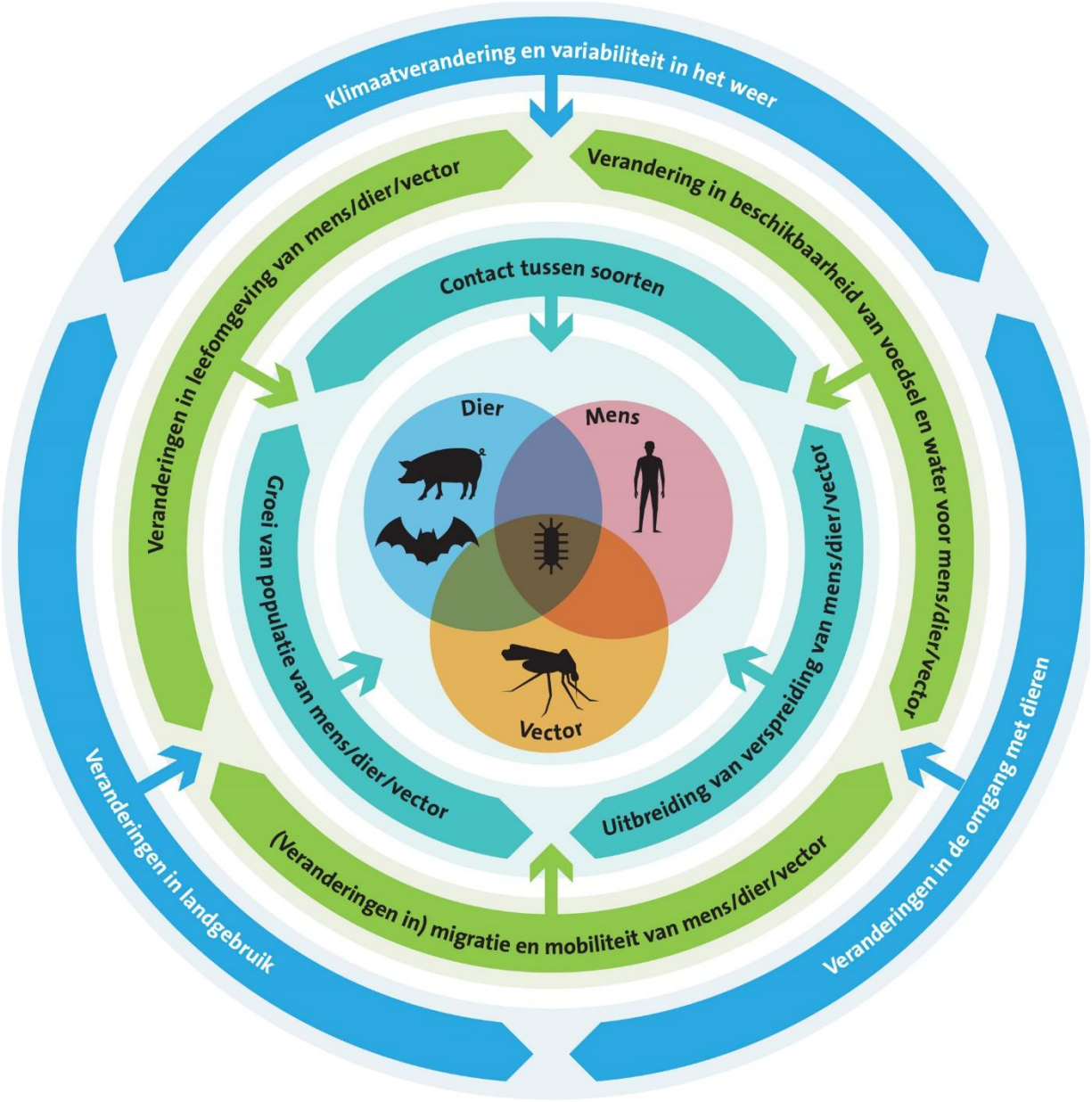
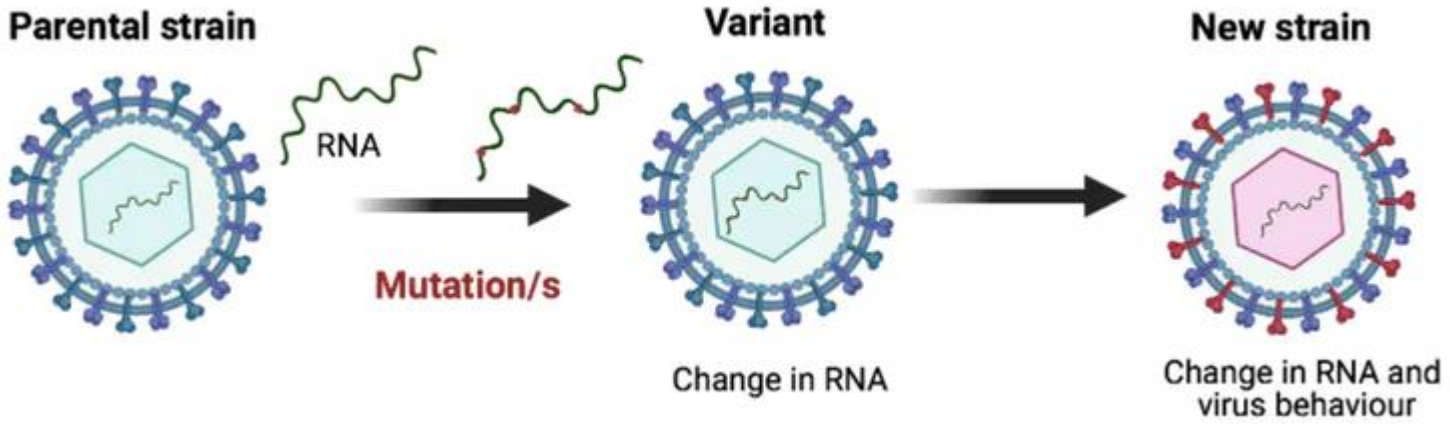
Drijvende krachten achter het ontstaan van zoonosen



Aangepast naar Gortazar et al. (2014)

Pathogen intrinsic drivers emerging infections

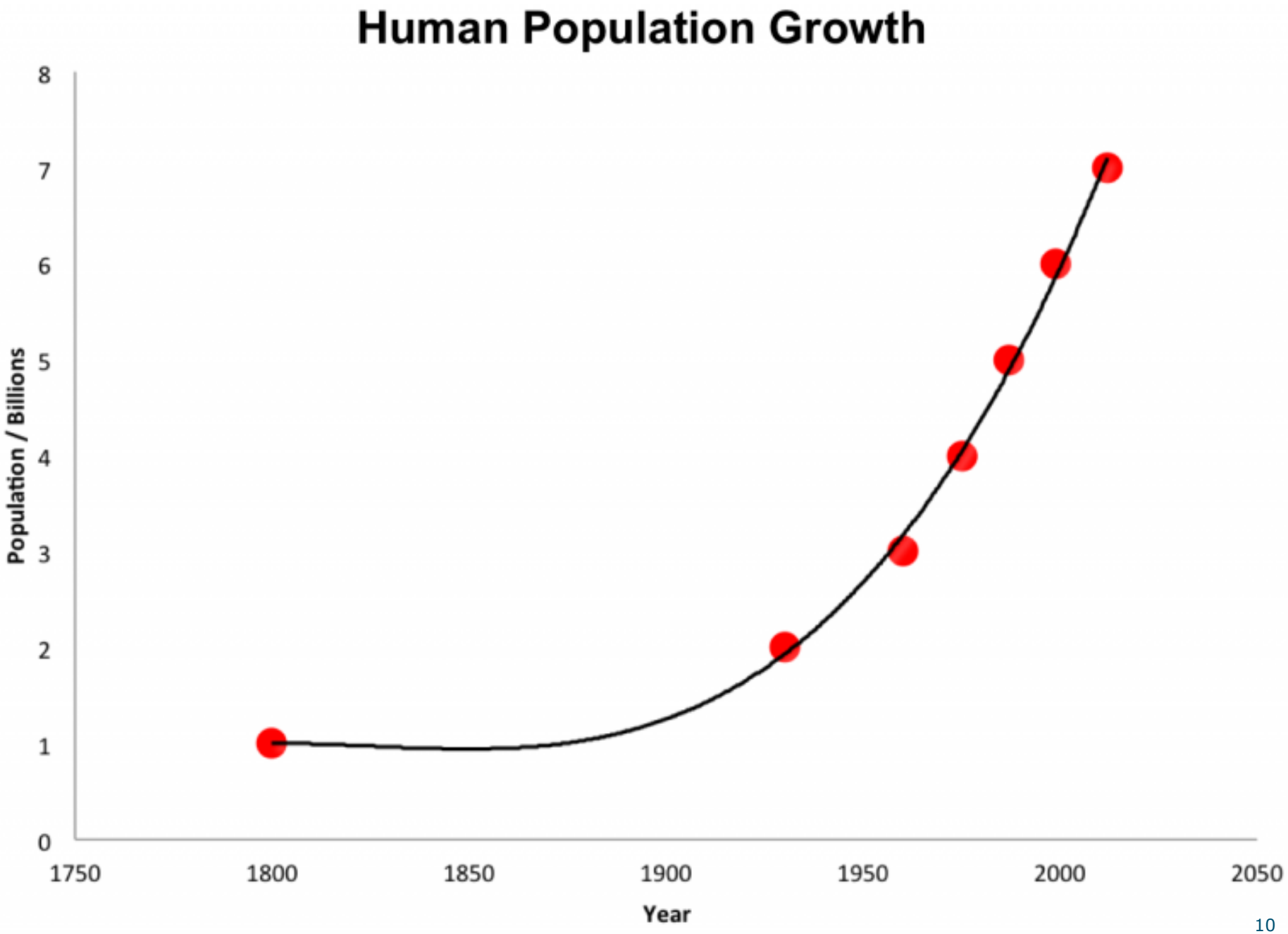
- Pathogen traits
- Pathogen adaptation to the host
- Pathogen acquisition of new virulence traits
- Pathogen changing transmission rates



Main Drivers for Zoonotic Disease

United Nations Environment Program, UNEP 2020

1. Increasing demand for animal production
2. Unsustainable agricultural intensification
3. Increased use and exploitation of wildlife
4. Unsustainable utilization of natural resources
5. Travel and transportation
6. Changes in food supply chains
7. Climate change


Human Population Growth
Population / Billions
0
1
2
3
4
5
6
7
8
1750
1800
1850
1900
1950
2000
2050
Year

Human behavior driving emerging zoonoses

- Changes in land use
- Alterations in livestock management
- Translocation of animals
- Exotic foods
- Exotic animals
- Travel and tourism

Daszak et al., EID 2000
Cutler, Fooks & Van der Poel, EID, 16; 2010
Cortazar et. al., 2014

Global changes
driving emerging infectious disease risks

Global warming

Changing vector abundance

Growing world population

Intensive animal production

Increased travel and transport

Changing land use

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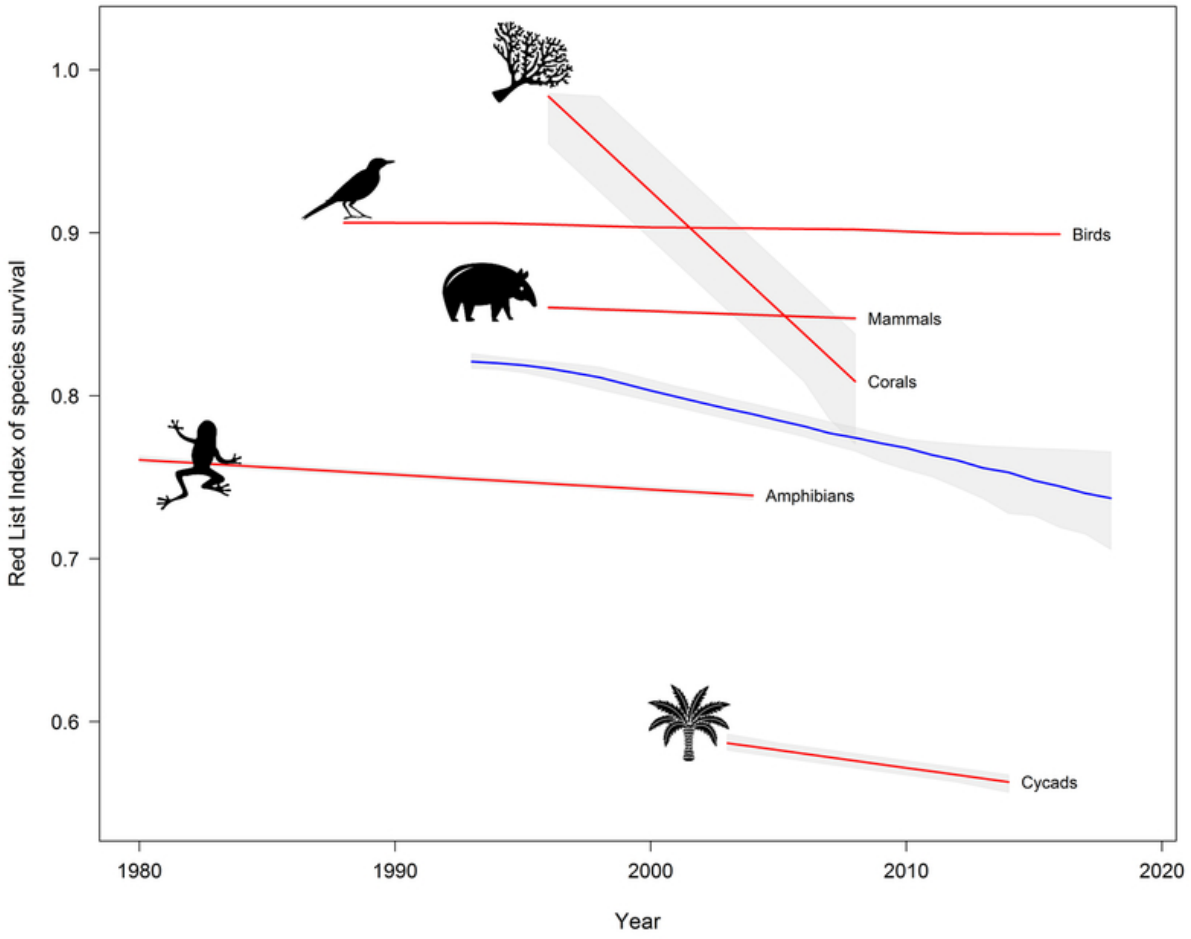
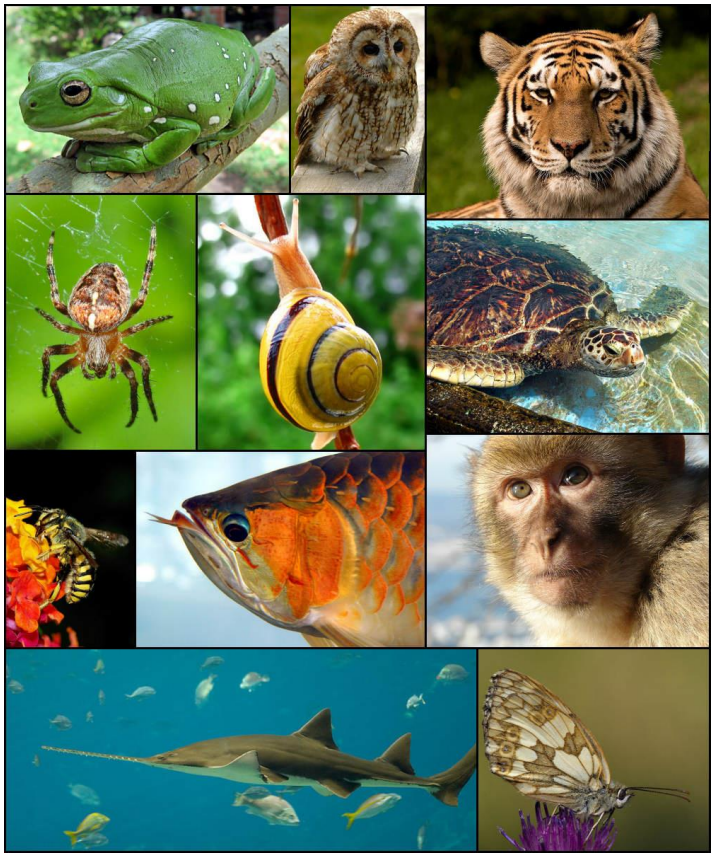
Loss of species



Biodiversity related risk factors of zoonoses

- Increased **pool of potential pathogens** due to increased biodiversity
- **Dilution** effect due to higher number of species
- **Contact structure** between susceptible species
- Number of competent **reservoir species**
- Species **densities**

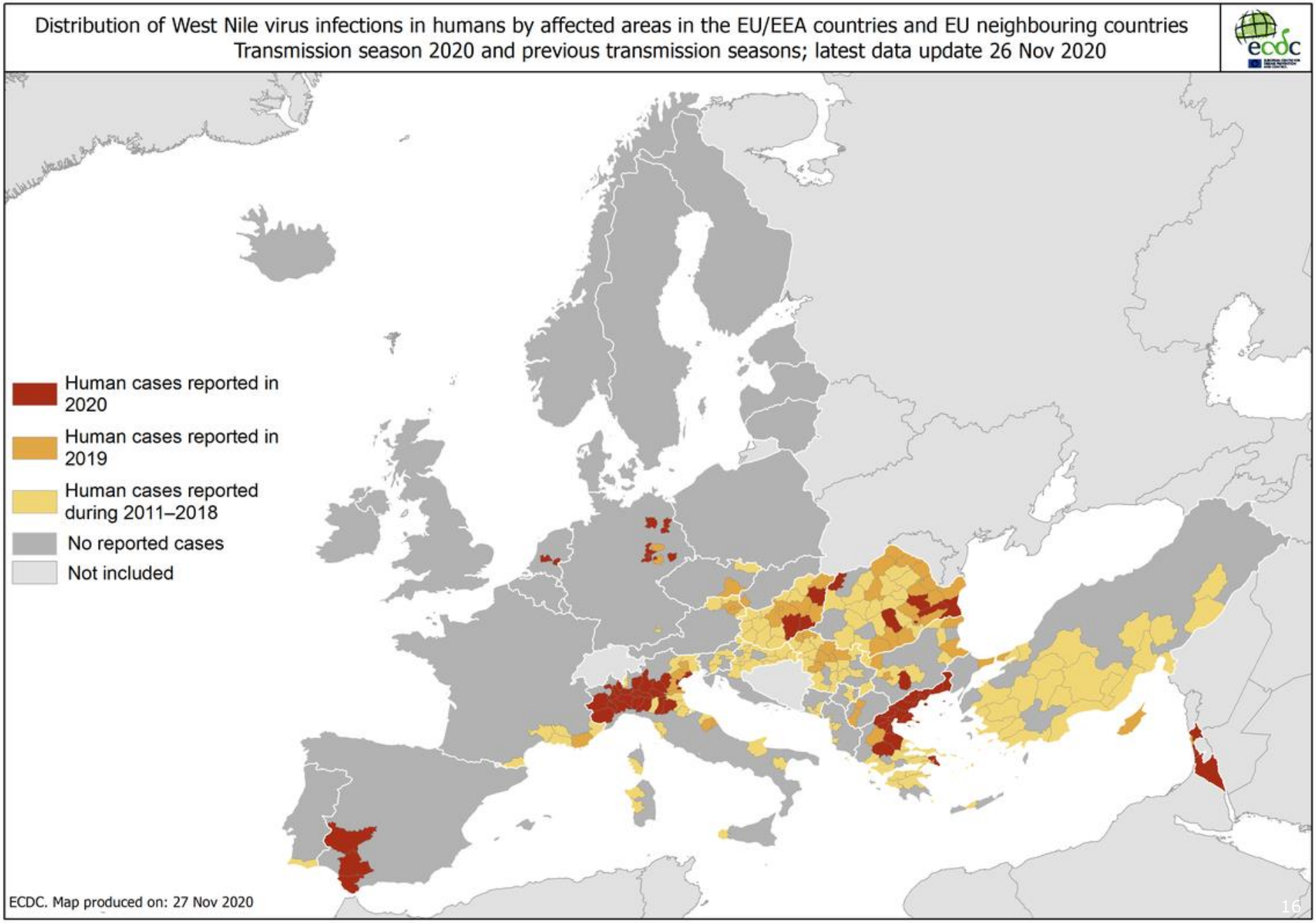


Global warming

Melting pole ice

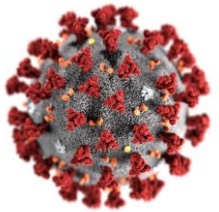
Arctic greening

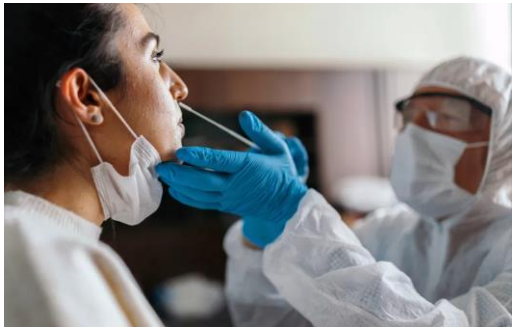
Drought


Distribution of West Nile virus infections in humans by affected areas in the EU/EEA countries and EU neighbouring countries
Transmission season 2020 and previous transmission seasons; latest data update 26 Nov 2020
ecdc
Human cases reported in 2020
Human cases reported in 2019
Human cases reported during 2011–2018
No reported cases
Not included
ECDC. Map produced on: 27 Nov 2020

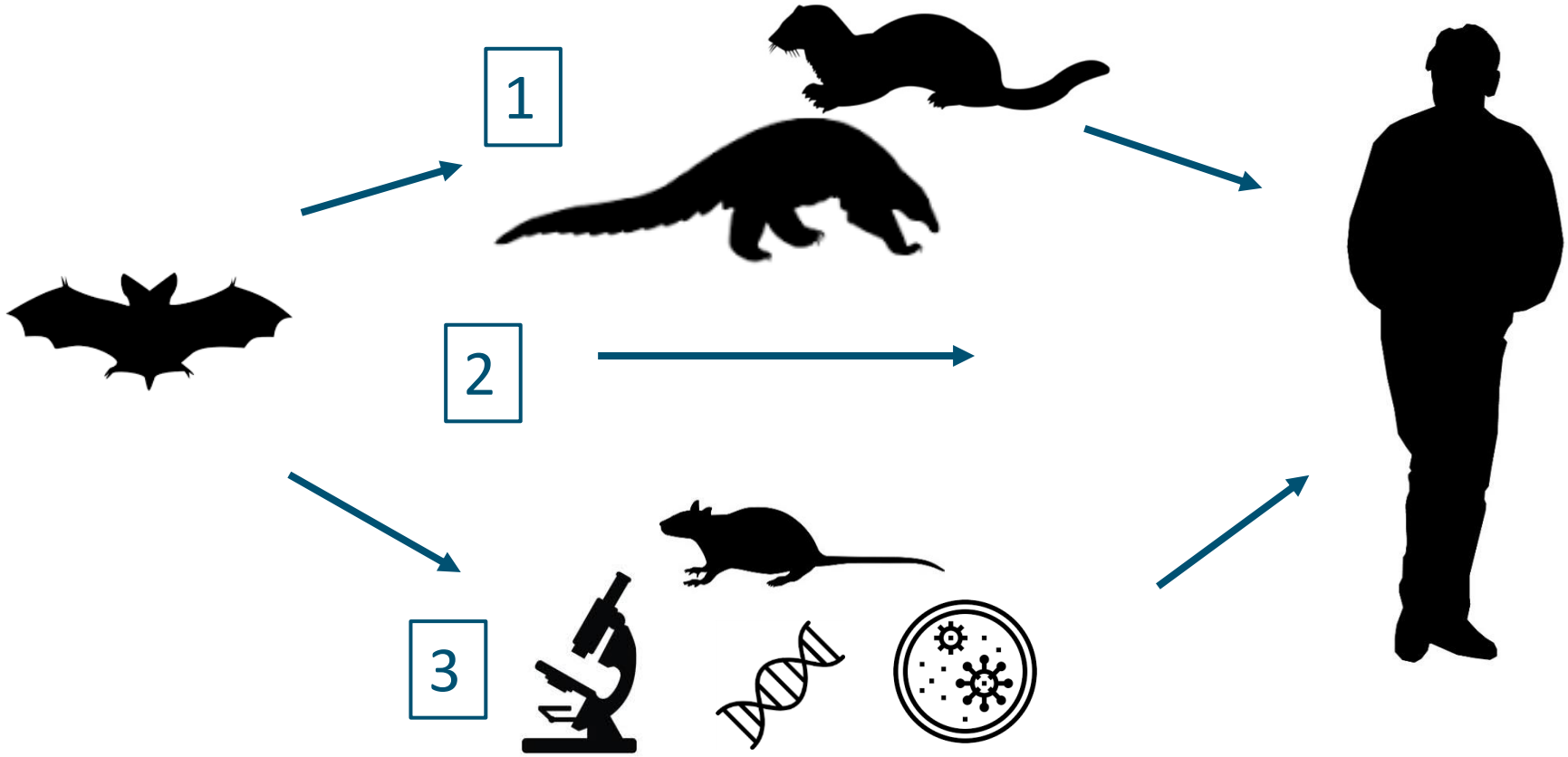
Covid-19 Pandemic

2019-nCoV Wuhan, China





Origin SARS-CoV2?



Animal sales Wuhan wet markets

immediately prior to the COVID-19 pandemic

a) King rat snake

b) Chinese bamboo rat

c) Amur hedgehog

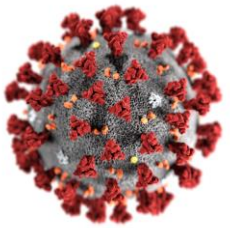
d) Raccoon dog

e) Marmot

f) Hog badger

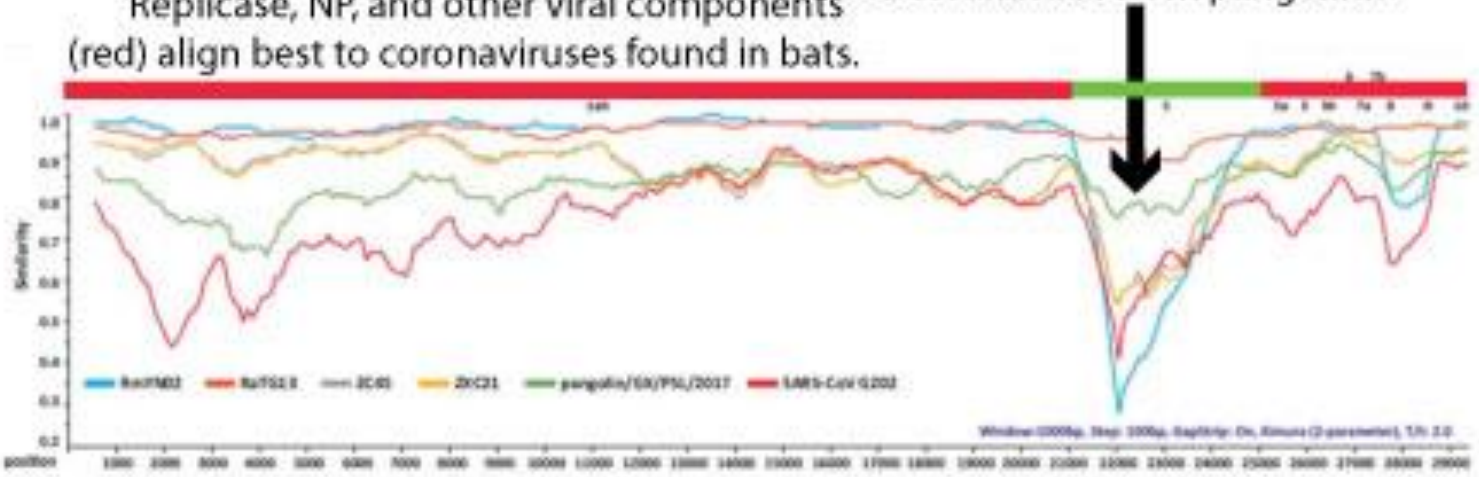
Xiao et al., Nature 2021

SARS-CoV2 alignment with animal coronavirus



Spike attachment protein (green) does not align well to bat coronaviruses but instead looks like it came from a coronavirus from pangolins.

Replicase, NP, and other viral components (red) align best to coronaviruses found in bats.



SARS-CoV2 susceptibility animals

Animal species	Clinical signs	Virus replication	Excretion infectious virus
Non human primates	✓	✓	✓
Cats	✓	✓	✓
Ferrets, Mink	✓	✓	✓
Raccoon dogs		✓	✓
Hamsters	✓	✓	✓
Fruit bats		✓	✓
Cattle		(✓)	
Swine		(✓)	
Rabbits		✓	✓
Dogs		✓	
Chicken			





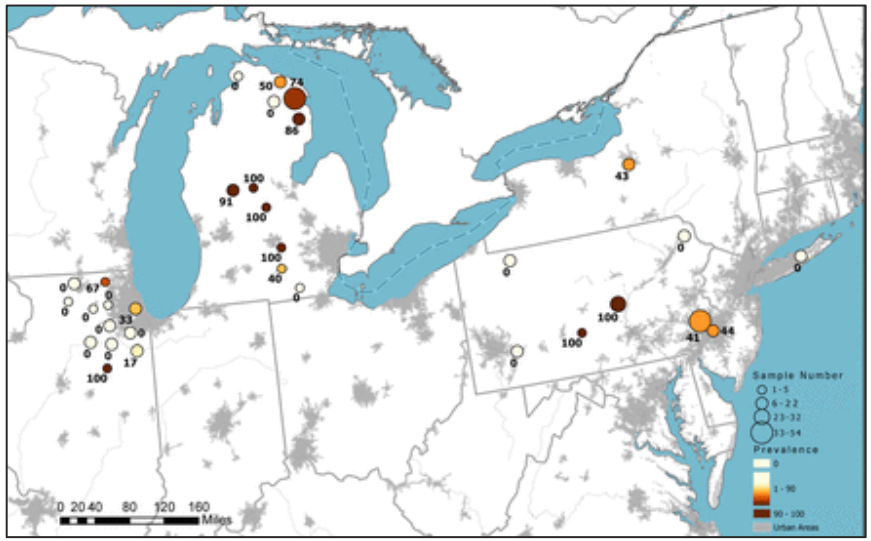


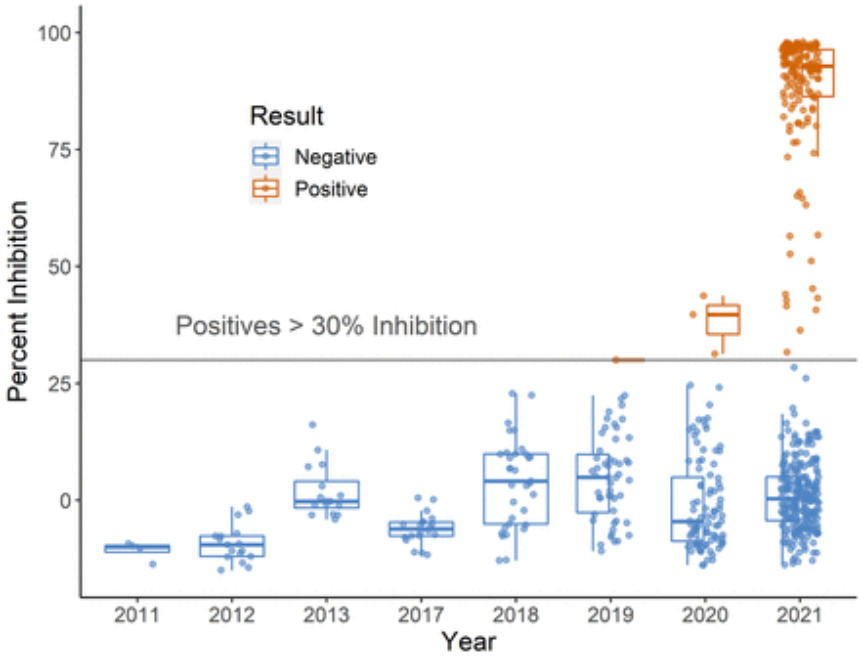



SARS-CoV2 in white-tailed deer, N Am

- 40% (152/624) seropositives, N America

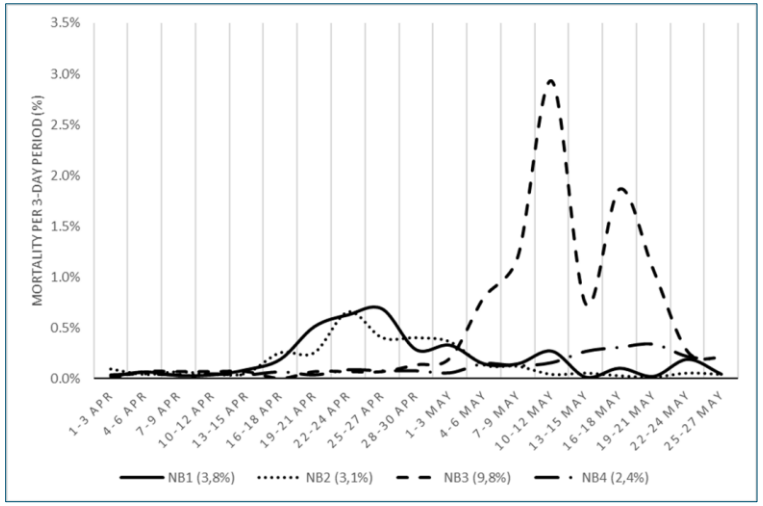
commercially available surrogate virus neutralization test (sVNT, Genscript cPass).

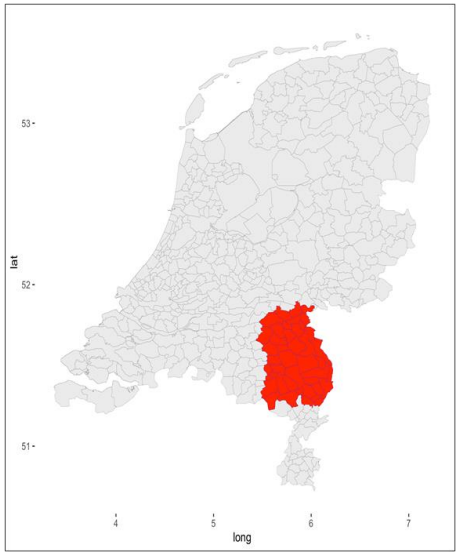


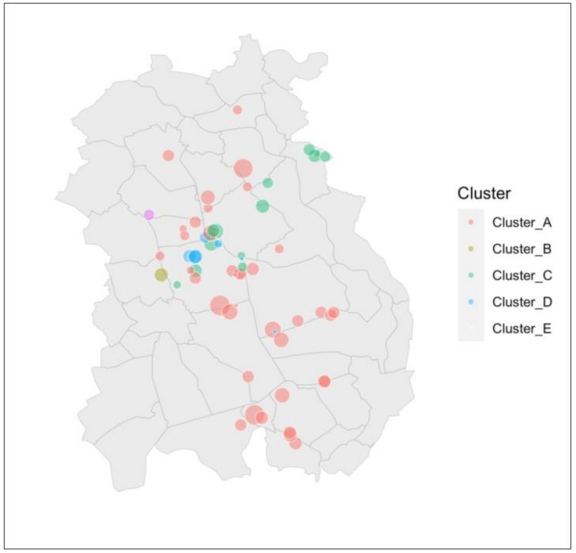


Chandler et al., 2021

SARS-CoV2 in farmed mink, Netherlands







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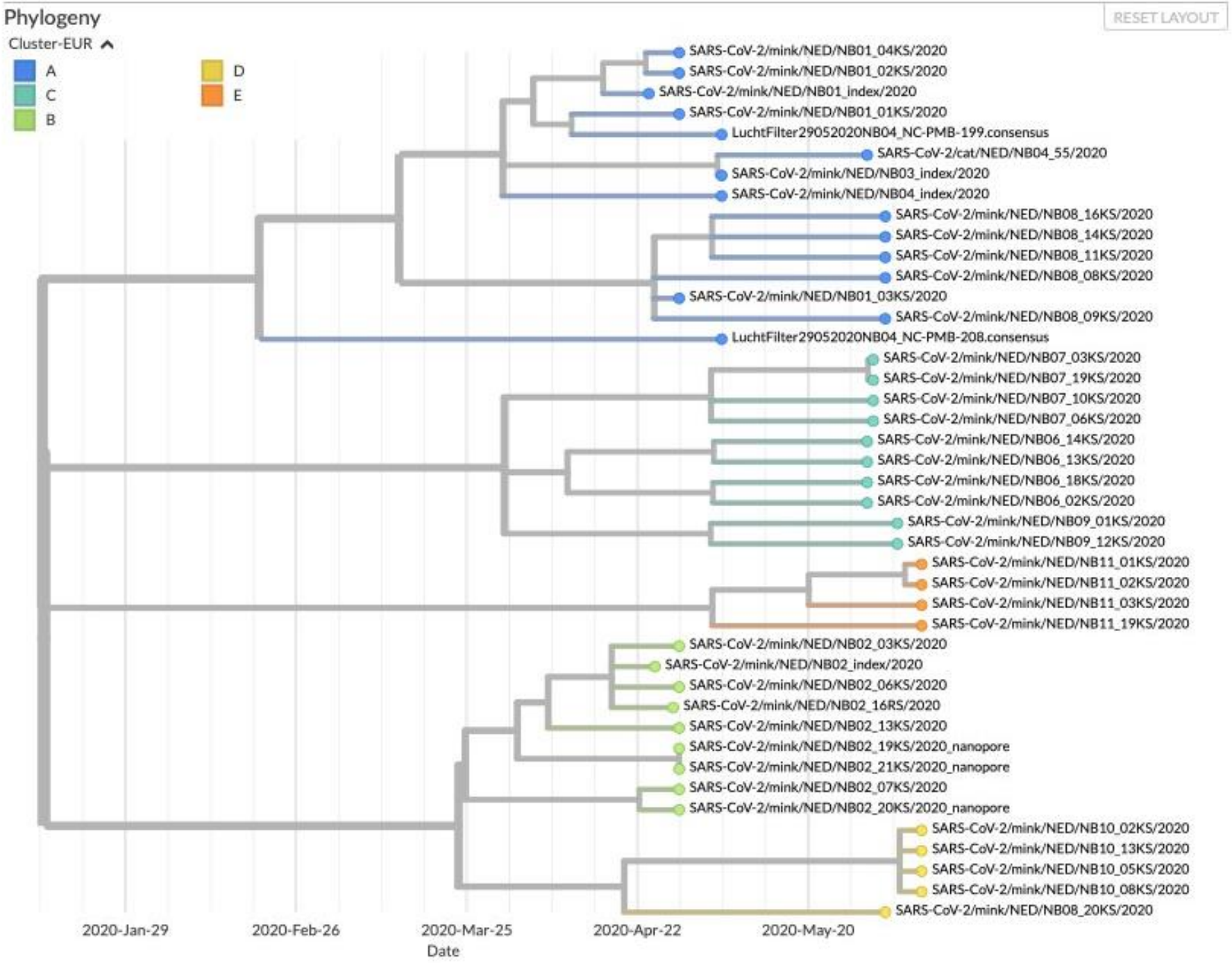

Phylogeny
RESET LAYOUT
Cluster-EUR
A
C
B
D
E
SARS-CoV-2/mink/NED/NB01_04KS/2020
SARS-CoV-2/mink/NED/NB01_02KS/2020
SARS-CoV-2/mink/NED/NB01_index/2020
SARS-CoV-2/mink/NED/NB01_01KS/2020
LuchtFilter29052020NB04_NC-PMB-199.consensus
SARS-CoV-2/cat/NED/NB04_55/2020
SARS-CoV-2/mink/NED/NB03_index/2020
SARS-CoV-2/mink/NED/NB04_index/2020
SARS-CoV-2/mink/NED/NB08_16KS/2020
SARS-CoV-2/mink/NED/NB08_14KS/2020
SARS-CoV-2/mink/NED/NB08_11KS/2020
SARS-CoV-2/mink/NED/NB08_08KS/2020
SARS-CoV-2/mink/NED/NB01_03KS/2020
SARS-CoV-2/mink/NED/NB08_09KS/2020
LuchtFilter29052020NB04_NC-PMB-208.consensus
SARS-CoV-2/mink/NED/NB07_03KS/2020
SARS-CoV-2/mink/NED/NB07_19KS/2020
SARS-CoV-2/mink/NED/NB07_10KS/2020
SARS-CoV-2/mink/NED/NB07_06KS/2020
SARS-CoV-2/mink/NED/NB06_14KS/2020
SARS-CoV-2/mink/NED/NB06_13KS/2020
SARS-CoV-2/mink/NED/NB06_18KS/2020
SARS-CoV-2/mink/NED/NB06_02KS/2020
SARS-CoV-2/mink/NED/NB09_01KS/2020
SARS-CoV-2/mink/NED/NB09_12KS/2020
SARS-CoV-2/mink/NED/NB11_01KS/2020
SARS-CoV-2/mink/NED/NB11_02KS/2020
SARS-CoV-2/mink/NED/NB11_03KS/2020
SARS-CoV-2/mink/NED/NB11_19KS/2020
SARS-CoV-2/mink/NED/NB02_03KS/2020
SARS-CoV-2/mink/NED/NB02_index/2020
SARS-CoV-2/mink/NED/NB02_06KS/2020
SARS-CoV-2/mink/NED/NB02_16RS/2020
SARS-CoV-2/mink/NED/NB02_13KS/2020
SARS-CoV-2/mink/NED/NB02_19KS/2020_nanopore
SARS-CoV-2/mink/NED/NB02_21KS/2020_nanopore
SARS-CoV-2/mink/NED/NB02_07KS/2020
SARS-CoV-2/mink/NED/NB02_20KS/2020_nanopore
SARS-CoV-2/mink/NED/NB10_02KS/2020
SARS-CoV-2/mink/NED/NB10_13KS/2020
SARS-CoV-2/mink/NED/NB10_05KS/2020
SARS-CoV-2/mink/NED/NB10_08KS/2020
SARS-CoV-2/mink/NED/NB08_20KS/2020
2020-Jan-29
2020-Feb-26
2020-Mar-25
2020-Apr-22
2020-May-20
Date

Screening of human contacts

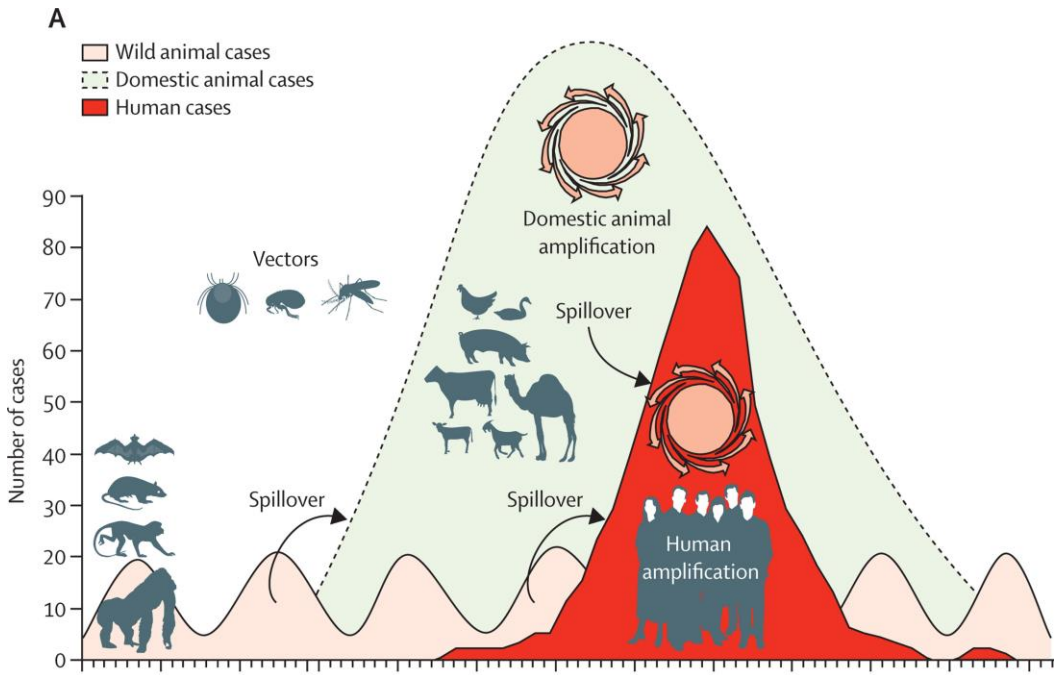
PCR and serology of employees/family in 16 mink farms

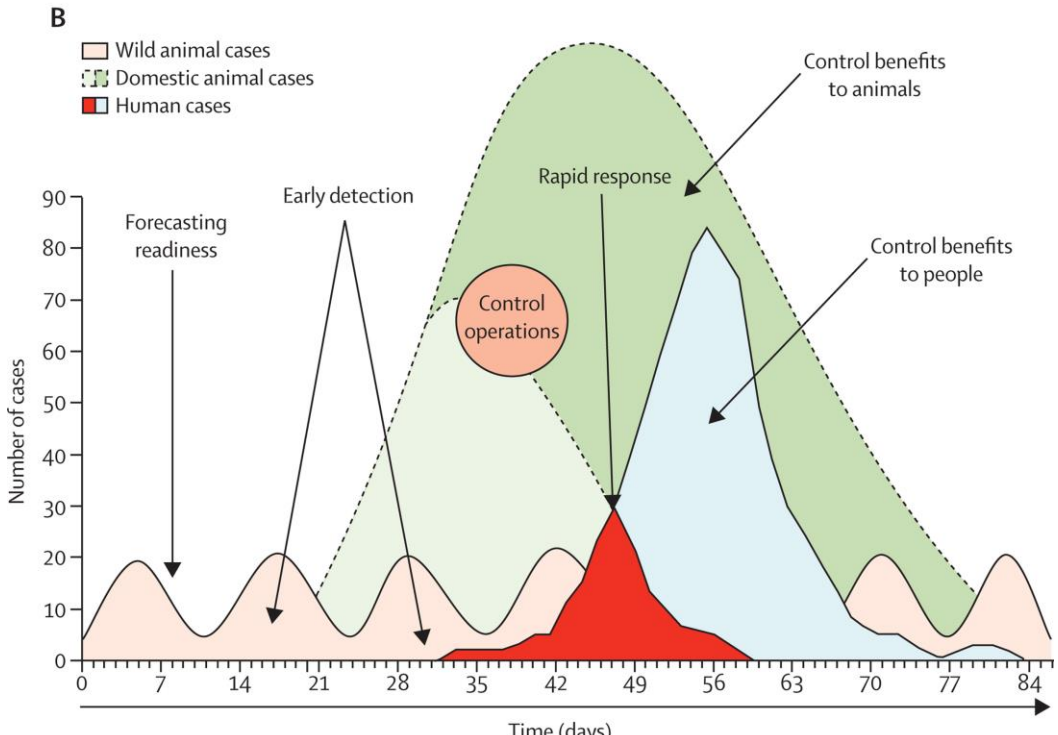
- 43/88 (49%) PCR positives
- 38/75 (51%) seropositive
- 66/97 (68%) PCR positive and/or seropositive
- Virus sequences obtained of 7 infected people
- All sequences related to mink sequences

Oudemunnik et al, Science 2020

Ecology of Zoonoses

Karesh et al., 2012





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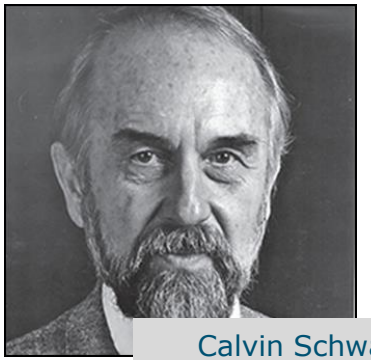
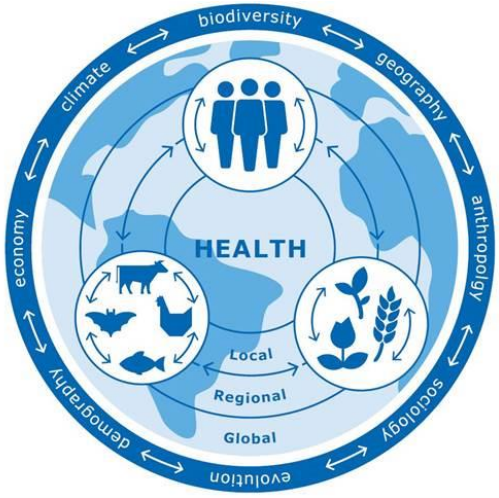
Global One Health

Rudolf Virchow
1821-1902
Comparative medicine



Calvin Schwabe
1927-2006
One Health

Jeffrey Koplan
(1935)
Gobal Health



"Global one health is the combined effort of multiple disciplines to improve health of humans, animals and plants within sustainable ecosystems by using an integrated systems approach to come to transnational solutions".

"Global One Health – a new integrated approach"
by Fresco L.O. et al. 2015, published by the Trilateral Commission.

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WHO Blueprint List of Priority Diseases

- Crimean-Congo haemorrhagic fever (CCHF)
- Ebola
- Lassa fever
- MERS-Coronavirus, SARS-Coronavirus
- Nipah and henipaviral diseases
- Rift Valley fever (RVF)
- Zika
- ***Disease X***

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Early Response and Rapid Action Zoonotic Emergencies

- Enable early warning
- Rapid characterisation of novel pathogens
- Developing plug-and-play vaccines and therapeutics
- Developing contingency plans

- Testing & tracing
- Biosecurity
- Drug and vaccine availability
- Interventions & control
- Tailored risk communication

- Emerging pathogens
- Global agri-food systems
- Ecosystems & - resilience
- Human behavioural systems

- Rapidly assess impact
- Local & global AF systems
- Short, medium, long term
- Scenario analyses
- Knowledge on internal feedback mechanisms and external spillover effects

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Thank you

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