Impact of low temperature on African swine fever virus transmission through contaminated environments

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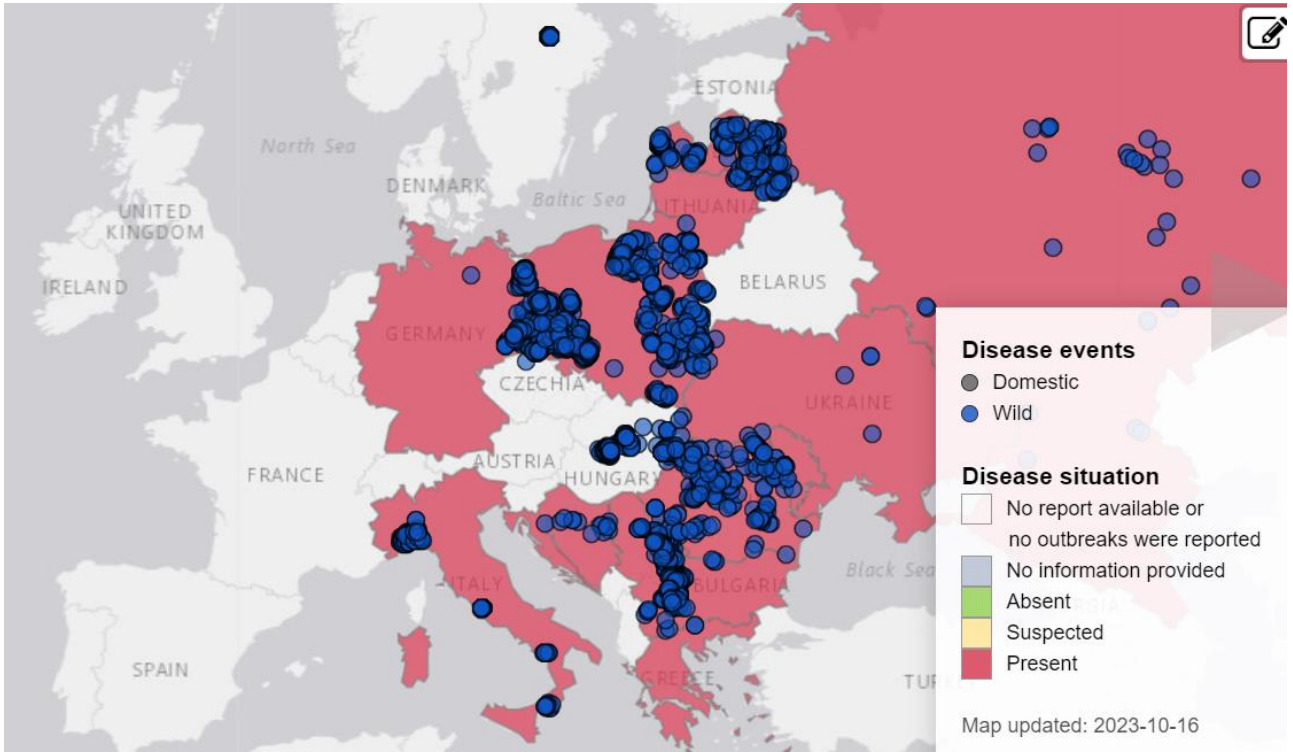
African swine fever

- African swine fever virus (ASFV) is a **highly contagious and lethal virus** that affects both domestic pigs and wild boar
  - **Humans** are **not affected**
- Introduction of ASFV to a new area has serious **negative consequences**
  - On livestock industry, agriculture, food industry, trade and tourism
- There are **multiple transmission routes**
  - Including direct contact, indirect contact, aerosol route and contaminated environment



Role of the environment for spreading?

- ASFV has a **long viability** on several contaminated materials
  - Especially at **low temperatures**

- Therefore, when pigs are exposed to a **contaminated environment**, new infections could occur
  - E.g., a contaminated, poorly washed, **empty livestock vehicle** poses a risk to the next load of pigs

- In Denmark, thousands of vehicles **move livestock out** of the country every year
  - Of interest to **livestock industry** to know the probability of introduction through livestock vehicles
  - And to estimate effect of wash & disinfection or quarantine of returning livestock vehicles

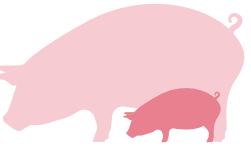
Denmark is a major pig exporter

- Introduction of ASFV would have **significant economic consequences**
  - For DK: **loss of export** of live pigs and products thereof
  - Therefore, need for a high level of **biosecurity**
  - **EU requirement** reg. washing & disinfection of vehicles after unloading
    – but vehicles are not always fully clean

- DK livestock **sector** has established **DANISH Transport standard**
  - Washing and disinfecting **stations in place** for returning livestock vehicles
  - All vehicles returning to DK must be washed and disinfected at the stations
  - First, the vehicles are inspected – if dirty, they will be sent back to the border
  - Service is **free of charge** and data show **high compliance**

Currently, the only country in which such a private standard applies
- High compliance and in principle voluntary

Modelling approach



- We decided to model the **environmental transmission processes**
  - Using published data for calculation of the epidemiological parameters

- **Lack of experimental data** on environmental transmission at **low temperatures**
  - Therefore, we performed a non-linear **fit of the decay** rate parameter with temperature based on a **literature review**
  - Modelling the inverse of the "survival" in the environment at different temperatures.

- Scenarios created to illustrate **probabilities of new infections** after the environment has been contaminated covering combinations of conditions:
  - **Temperature** at 20 °C, 10 °C, 0 °C, or – 10 °C
  - **Empty period** of 1, 3, 5, 7 or 14 days before new animals are allowed to enter the contaminated environment

Livestock vehicle scenario

- We assumed that initially the **vehicle** was completely **clean**
  - Transporting a full load of pigs of which 1, 4, or 20 pigs were infectious for 24 hours
  - Reflecting the contamination degree “I” (1, 4 or 20)

- After unloading all pigs, the **vehicle** was assumed to be **washed and disinfected**
  - Followed by a **quarantine** of 1, 3, 5, or 7, or 14 days – corresponding to the empty period
  - At **temperatures** of 20°C, 10°C, 0°C or -10°C

- Then, assumed that new full load of susceptible pigs were loaded and transported for 1 day
  - We used the **mathematical models** developed for the scenarios
  - Outcome: required relative effect of washing and disinfecting w (from 0=no effect to 1=full effect)
    - to avoid that **1 pig** or at least 1 pig from the truck environment become infected
    - After **varying assumptions** on contamination degree

Results: Required minimum effect of washing "w" to avoid that one susceptible pig would become infected

Interpretation of results:

The effect of **washing and disinfection is more important that quarantine** when temperatures are below 10°C

Required minimum w for $p < 0.005$												
Quarantine period (days)	Temperature											
	-10°C			0°C			10°C			20°C		
	I=1	I=4	I=20	I=1	I=4	I=20	I=1	I=4	I=20	I=1	I=4	I=20
1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3	1.00	1.00	1.00	1.00	1.00	1.00	0.99	1.00	1.00	0.97	0.99	1.00
5	1.00	1.00	1.00	0.99	1.00	1.00	0.96	0.99	1.00	0.76	0.94	0.99
7	0.99	1.00	1.00	0.98	0.99	1.00	0.82	0.96	0.99	0.00	0.44	0.89
14	0.98	1.00	1.00	0.57	0.89	0.98	0.00	0.00	0.00	0.00	0.00	0.00

Discussion – Lessons learnt from modeling

- Results shown are **conditional probabilities**…..
  - So, they refer to a situation, after infected pigs excreting ASFV have been transported
- The **unconditional** probability of a vehicle becoming contaminated is expected to be minute
  - However, thousands of vehicles are transporting pigs out of Denmark every year
  - And **introduction into a free country has huge implications**
- Therefore, of interest to assess to which extent existing **washing and disinfecting effectiveness and quarantine** reduce probability of infection in next load of pigs
  - If/when this worst-case scenario happens, involving transport of infectious pigs

Discussion – Activities taken by the Danish pig sector

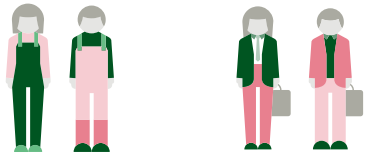
- **Risk assessments** and **SWOT** analysis are conducted *ad hoc*
  - Newest analysis from 2023: **Washing and disinfection**, as required and undertaken at the designated stations, **judged** as the **most important** among all risk-reducing measures identified for the livestock transportation system

- **Recommendations** are to:
  1. Ensure quality of washing and disinfection through **staff training**
  2. Find new, safe, and more **efficient disinfectants**, while considering labour safety

     → Glutaraldehyd cannot be used
  3. Ensure the **required temperature**, and therefore effect of disinfectant and water

Discussion – Other activities taken…

- No established population of wild boar in DK
  - 68 km long wildlife **fence** erected on border to Germany – as public-private-partnership (PPP)
  - **Shooting** of free–range **wild boar** - PPP
- **Information campaigns** for **foreign workers** in DK pig production
  - Provided in several languages, corresponding to most frequent nationalities of migrant workers in DK pig production
  - To avoid **private imports of meat** from countries where ASF is endemic



- Requirements to **feed** specified in **DANISH Product Standard**
  - See presentation by Jan Dahl

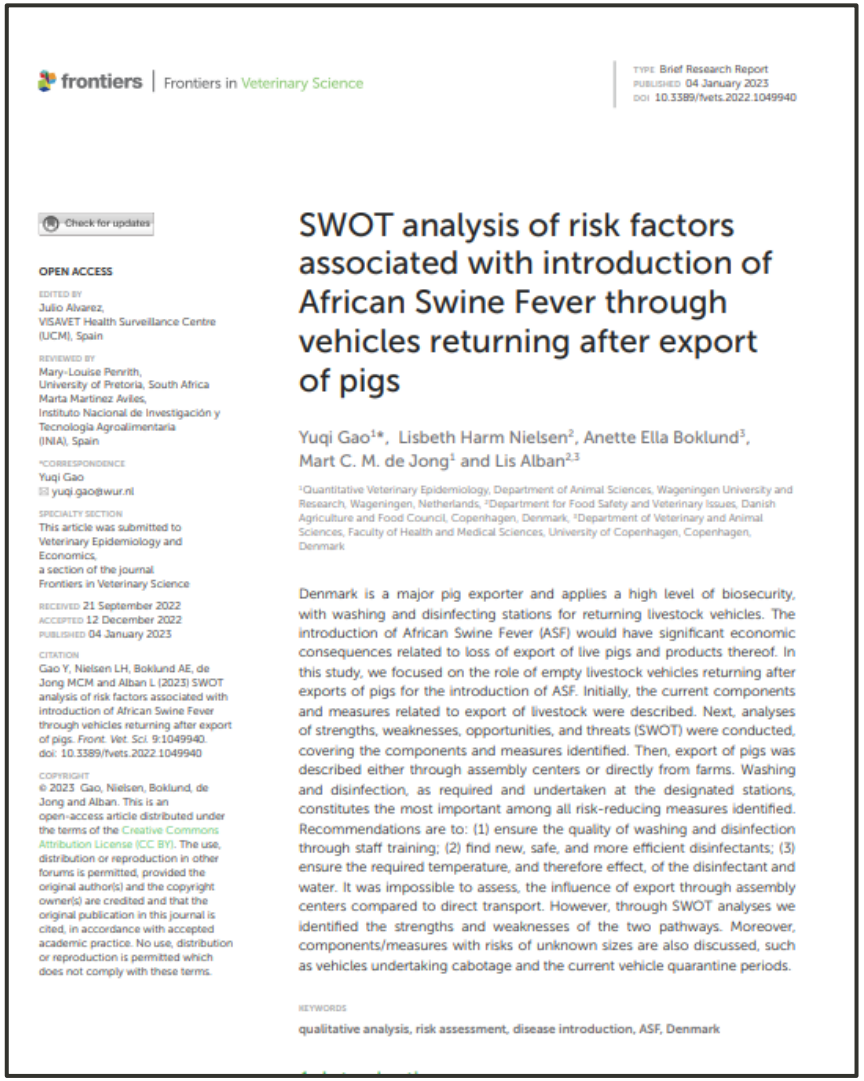
- **Risk assessment** undertaken *ad hoc* for different questions

Tak.

The work presented was made by the project group consisting of:

Yuqi Gao & Mart C.M. de Jong, Wageningen University
Lisbeth Harm Nielsen & Lis Alban, Danish Agriculture & Food Council
Anette Boklund, University of Copenhagen

If you are interested in more details about our work



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SWOT analysis of risk factors associated with introduction of African Swine Fever through vehicles returning after export of pigs

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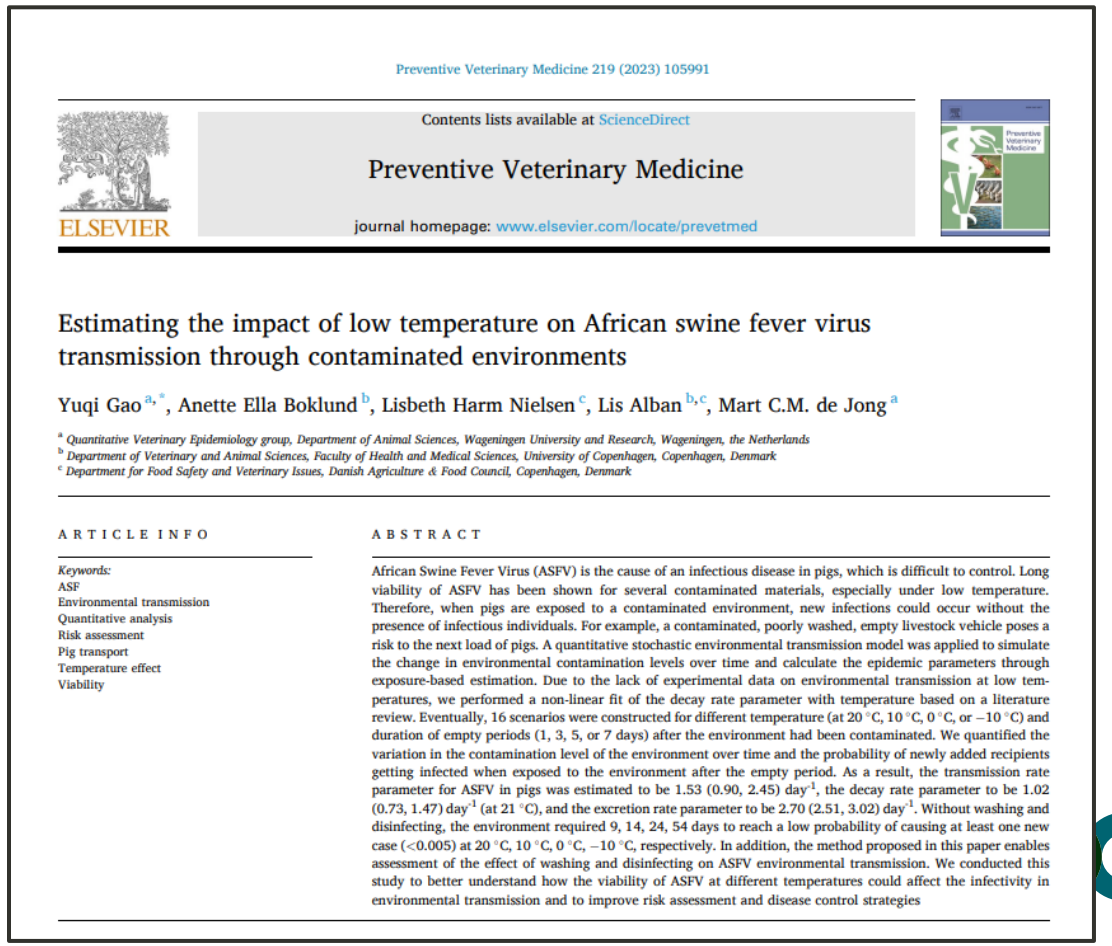
Denmark is a major pig exporter and applies a high level of biosecurity, with washing and disinfecting stations for returning livestock vehicles. The introduction of African Swine Fever (ASF) would have significant economic consequences related to loss of export of live pigs and products thereof. In this study, we focused on the role of empty livestock vehicles returning after exports of pigs for the introduction of ASF. Initially, the current components and measures related to export of livestock were described. Next, analyses of strengths, weaknesses, opportunities, and threats (SWOT) were conducted, covering the components and measures identified. Then, export of pigs was described either through assembly centers or directly from farms. Washing and disinfection, as required and undertaken at the designated stations, constitutes the most important among all risk-reducing measures identified. Recommendations are to: (1) ensure the quality of washing and disinfection through staff training; (2) find new, safe, and more efficient disinfectants; (3) ensure the required temperature, and therefore effect, of the disinfectant and water. It was impossible to assess, the influence of export through assembly centers compared to direct transport. However, through SWOT analyses we identified the strengths and weaknesses of the two pathways. Moreover, components/measures with risks of unknown sizes are also discussed, such as vehicles undertaking cabotage and the current vehicle quarantine periods.

KEYWORDS
qualitative analysis, risk assessment, disease introduction, ASF, Denmark



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Estimating the impact of low temperature on African swine fever virus transmission through contaminated environments

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ABSTRACT

African Swine Fever Virus (ASFV) is the cause of an infectious disease in pigs, which is difficult to control. Long viability of ASFV has been shown for several contaminated materials, especially under low temperature. Therefore, when pigs are exposed to a contaminated environment, new infections could occur without the presence of infectious individuals. For example, a contaminated, poorly washed, empty livestock vehicle poses a risk to the next load of pigs. A quantitative stochastic environmental transmission model was applied to simulate the change in environmental contamination levels over time and calculate the epidemic parameters through exposure-based estimation. Due to the lack of experimental data on environmental transmission at low temperatures, we performed a non-linear fit of the decay rate parameter with temperature based on a literature review. Eventually, 16 scenarios were constructed for different temperature (at 20 °C, 10 °C, 0 °C, or −10 °C) and duration of empty periods (1, 3, 5, or 7 days) after the environment had been contaminated. We quantified the variation in the contamination level of the environment over time and the probability of newly added recipients getting infected when exposed to the environment after the empty period. As a result, the transmission rate parameter for ASFV in pigs was estimated to be 1.53 (0.90, 2.45) day^{-1}, the decay rate parameter to be 1.02 (0.73, 1.47) day^{-1} (at 21 °C), and the excretion rate parameter to be 2.70 (2.51, 3.02) day^{-1}. Without washing and disinfecting, the environment required 9, 14, 24, 54 days to reach a low probability of causing at least one new case (<0.005) at 20 °C, 10 °C, 0 °C, −10 °C, respectively. In addition, the method proposed in this paper enables assessment of the effect of washing and disinfecting on ASFV environmental transmission. We conducted this study to better understand how the viability of ASFV at different temperatures could affect the infectivity in environmental transmission and to improve risk assessment and disease control strategies