African Swine Fever: Modelling the silent release from Small Scale Farms and Consequences for Disease Persistence in Affected Areas

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Background

- Most outbreaks in backyard and small-scale farms
- ASF persistence in domestic pig populations:

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- European boar
  - Ornithodoros spp.
  - Domestic pigs
    - Ornithodoros spp.
  - African wild suids
    - Ornithodoros spp.
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Background

- Most outbreaks in backyard and small-scale farms
- ASF persistence in domestic pig populations:
  - Movement of infected pigs (or products) between farms
  - African wild suids
  - Ornithodoros spp.
  - European boar
  - Ornithodoros spp.
• In Afr. (and R.F.), suspected outbreaks usually not reported:
  – Dead pig discarded of (nearby farms, rivers...);
  – Pigs with clinical signs sold for slaughter;
  – Pigs without detected signs sold to traders at farm gate.

• Problem:
  – Incubation and latency period
  – Farmers & traders’ imperfect clinical diagnosis
  => risk of release of infected pigs via emergency sale of pigs without symptoms
Objectives

• Estimate the risk of ASF “silent release” from small scale farms - i.e. emergency sale of ASFV infected pigs without (detected) signs

• Assess if increasing farmers’ awareness of ASF (i.e. improve clinical diagnosis) can reduce this risk
time

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[Diagram of pigs]

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[Diagram of a rectangle with pigs inside]
Within herd transmission

ASF

time
Within herd transmission
Within herd transmission
Within herd transmission
Within herd transmission

1st clinical case

ASF
Within herd transmission

1st clinical case

ASF
Within herd transmission

1st clinical case

ASF
Within herd transmission
Within herd transmission

Detection and sale

1\textsuperscript{st} clinical case

ASF

traders

abattoir
Materials and Methods

• Within-farm spread:
  Stochastic, individual-based, discrete time (1d), state transition model

   - Susceptible (S)
   - Infected not infectious (E)
   - Infectious No clinical signs (L)
   - Infectious & Clinical signs (I)
   - Dead or Recovered (DR)

   Effective contacts
   Incubation period & latent period
   Time from infectiousness to onset of clinical signs
   Disease duration

   Transition times: simulation for each pig
   Distributions for incubation & latent periods and disease duration, based on literature
   Weibull distributions: re-parameterised using percentiles and minimum

Binomial process
Density dependant
R0 based on literature
• Action by farmer when disease suspected:
  At decision (detection and sale) time $t$,
  – removal of animals that farmers consider diseased
  – sale of others to traders

Diagram:

- Susceptible (S)
- Infected not infectious (E)
- Infectious No clinical signs (L)
- Infectious & Clinical signs (I)
- Dead or Recovered (DR)

Decision time & (1-specificity)
Decision time & sensitivity
• Action by farmer when disease suspected:
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Diagram:

- Pig
  - Susceptible (S)
    - Infectious (I)
      - Infectious & Clinical signs (I)
        - Clinical signs noticed and pig removed
        - Clinical signs not noticed and pig sold to traders
    - Infectious No clinical signs (L)
      - Clinical signs perceived and pig removed
      - No clinical sign perceived and pig sold to traders
• Scenarios:
  – Herd size: 5, 10, 30 pigs
  – $R_0$: 3 (ML), 1.5 (min) and 15 (max)
  – Decision time: 5 – 35 days
  – Sensitivity and Specificity of clinical diagnosis: 0.5, 0.75, 0.9

• Simulation of
  – Probability of silent release of infected pigs
  – Number of infected pigs released
Results: Probability of silent release from farm

- Probability of releasing at least 1 infected pig
- Decision time (days)

**Se: 0.75**

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<th>R₀</th>
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**Se: 0.90**

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• Overall, high risk of ASF “silent release” from small scale farms:
  – linked to within-herd disease spread
  – for very small (5 or less), decrease for decision times >15 days
  – for others, remains above 0.5. Higher risk observed for larger herds and longer decision times

• Little impact of Se/Sp
Proportion of herd infected and released to traders \((R_0=3)\)

- Clinical signs not noticed
- No clinical signs

Herd size vs. proportion of herd infected and released to traders

Decision time = 10 days
Proportion of herd infected and released to traders \((R_0=3)\)

- **Clinical signs not noticed**
- **No clinical signs**

**Herd size**
- 5
- 10
- 30

**Decision time** = 15 days
Proportion of herd infected and released to traders ($R_0=3$)

Decision time = 25 days

- Clinical signs not noticed
- No clinical signs

Herd size

5 10 30
Putting it into context - Madagascar

- Background:

  - ASF endemic since intro in late 1990s
  - Pig production important for cultural and economic reasons
  - Serious impact on smallholder farmers
  - Diagnosis / control not implemented by vet authorities (resources scarce)
  - Farmers follow behaviour described in present study

- Contribution of different herds to local ASF spread via emergency sale to traders:

  - Scenario considered: $R_0=3$ and decision time=10 and 20 days
  - Assumptions:
    - No control measure implemented nor reporting
    - Same risk of infection for all herds in Madagascar,
    - Same percentage of herd infected within each herd size interval.
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Conclusions

• Emergency sale:
  – Common because limits immediate financial losses for affected farmers
  – Risk of selling infected animals high, suggesting it contributes to ASFV persistence in domestic pig populations.

• Mitigation strategies for ASF:
  – Training to improve farmers’ ASF diagnostic not effective
  – Alternative control measures required (involvement of other actors; integrative / certification approaches, etc.)
Acknowledgements

• Partners: CIRAD, RVC, Epix Analytics
  DSAPS, MPE, FOFIFA (Madagascar)

• Study funded by the Wellcome Trust