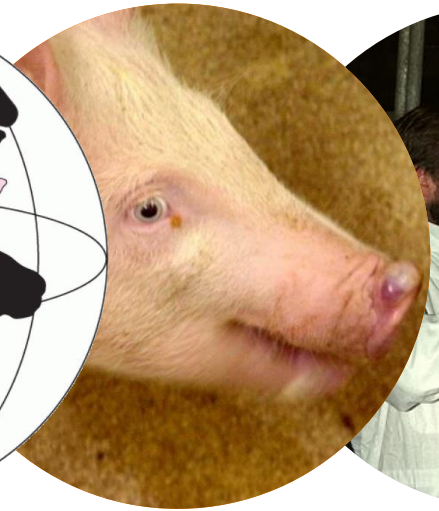
Low estimate of R_0 for FMDV from surveillance data in endemic settings

Aldo Dekker and Thomas Hagenaars



WAGENINGEN
UNIVERSITY & RESEARCH

100years
1918 — 2018

Outline: Is FMDV "highly" contagious

- Comparison of R_0 of various diseases
- Results animal experiments with FMDV
- Calculate R_0 from prevalence
- Results literature search
- Conclusion

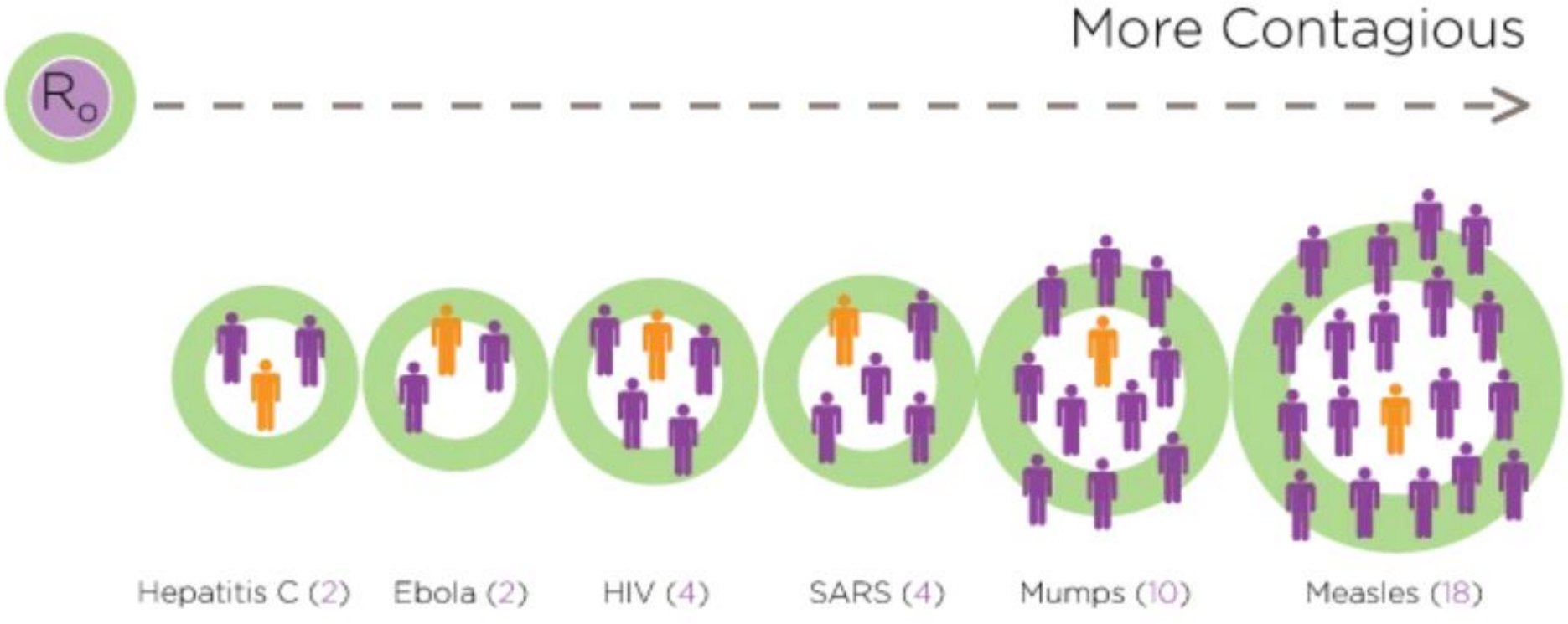
Reproduction ratio

- R_0 = Average number of new infection per average infectious individual during its full infectious period in a fully susceptible population
- If R_0 <1 only small outbreaks occur
- If R_0 = 4 and 75% of the population is protected by vaccination

  then effective R_e = 1
- 75% protection by vaccination is sufficient (OIE standard)

  so R_0 is most likely <4

Higher R_0 → more contagious



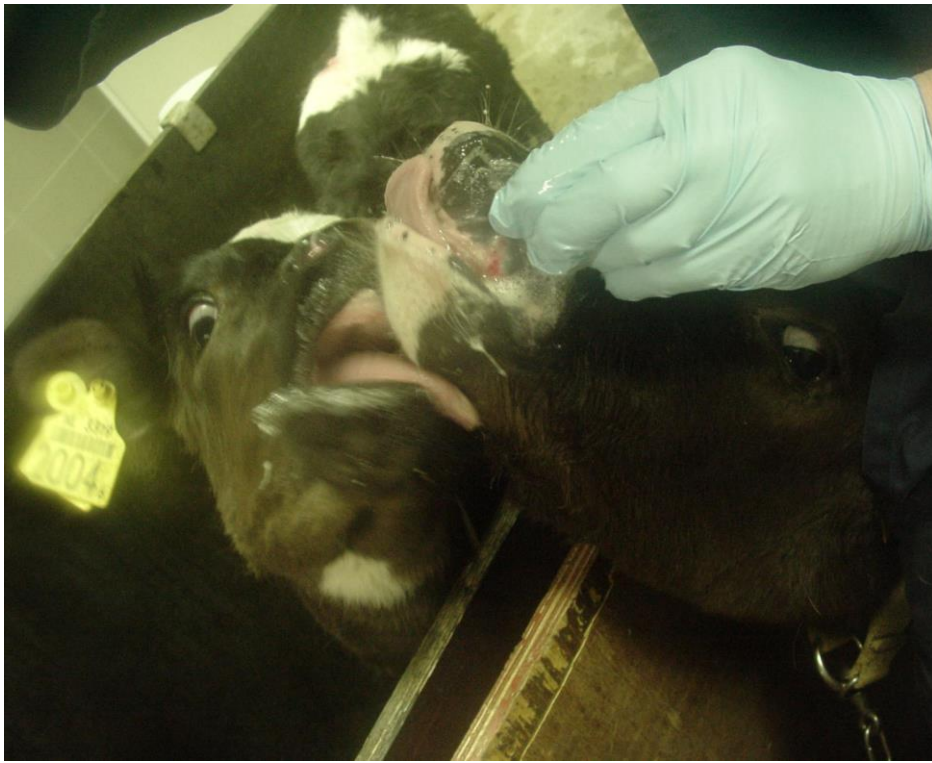
R_0 characteristic of infectious agent and the interaction with the environment

FMDV transmission studies non-vaccinated animals

Species	Contact	R_0 (95% CI)	Referentie
Porcine	Within pen	∞ (0.67–∞)	Eblé et al. 2004
Porcine	Within pen	∞ (1.2-∞)	Orsel et al. 2007a
Porcine	Within pen	∞ (1.3-∞)	Orsel et al. 2007a
Porcine	Within pen	∞ (2.35-∞)	Eblé et al. 2008
Porcine	Within pen	668 (0–∞)	Fukai et al. 2011
Porcine	Between pen (0 cm)	1.10 (0.34–2.56)	van Roermund et al. 2010
Porcine	Between pen (40 - 70 cm)	0.0 (0.0-0.08)	van Roermund et al. 2010
Bovine	Within pen	2.5 (1.1 - 52)	Orsel et al. 2005
Bovine	Within pen	∞ (1.3-∞)	Orsel et al. 2007b
Bovine	Within pen	∞ (1.3-∞)	Bravo de Rueda et al. 2015
Bovine	Between pen	0 (0 - 1.4)	Bouma et al. 2004
Bovine	Indirect by environment	1.9 (1.0 - 3.8)	Bravo de Rueda et al. 2015
Ovine	Within pen	1.1 (0.3 - 3.3)	Orsel et al. 2007c
Ovine	Within pen	1.1 (0.29 - 3.8)	Eble et al. 2015

Bouma et al. 2004

- Between pen transmission study
- No transmission
- Calf with lesions can have contact
- No transmission by air!



Conclusion animal experiments

- High reproduction ratio in cattle and pigs in direct contact
- Extremely strong reduction of R_0 by separation

Estimation of reproduction ratio from prevalence

- R_0 = Average number of new infection per average infectious individual during its full infectious period in a **fully susceptible** population
- Assumptions
  - Population in a country is freely mixing
  - The effective reproduction ratio in the endemic state is 1
  - FMD circulates only between non-infected animals
    - $R_e = (1 - \text{prevalence}) \times R_0 = 1$

      $\rightarrow R_0 = 1/(1 - \text{prevalence})$

Data search

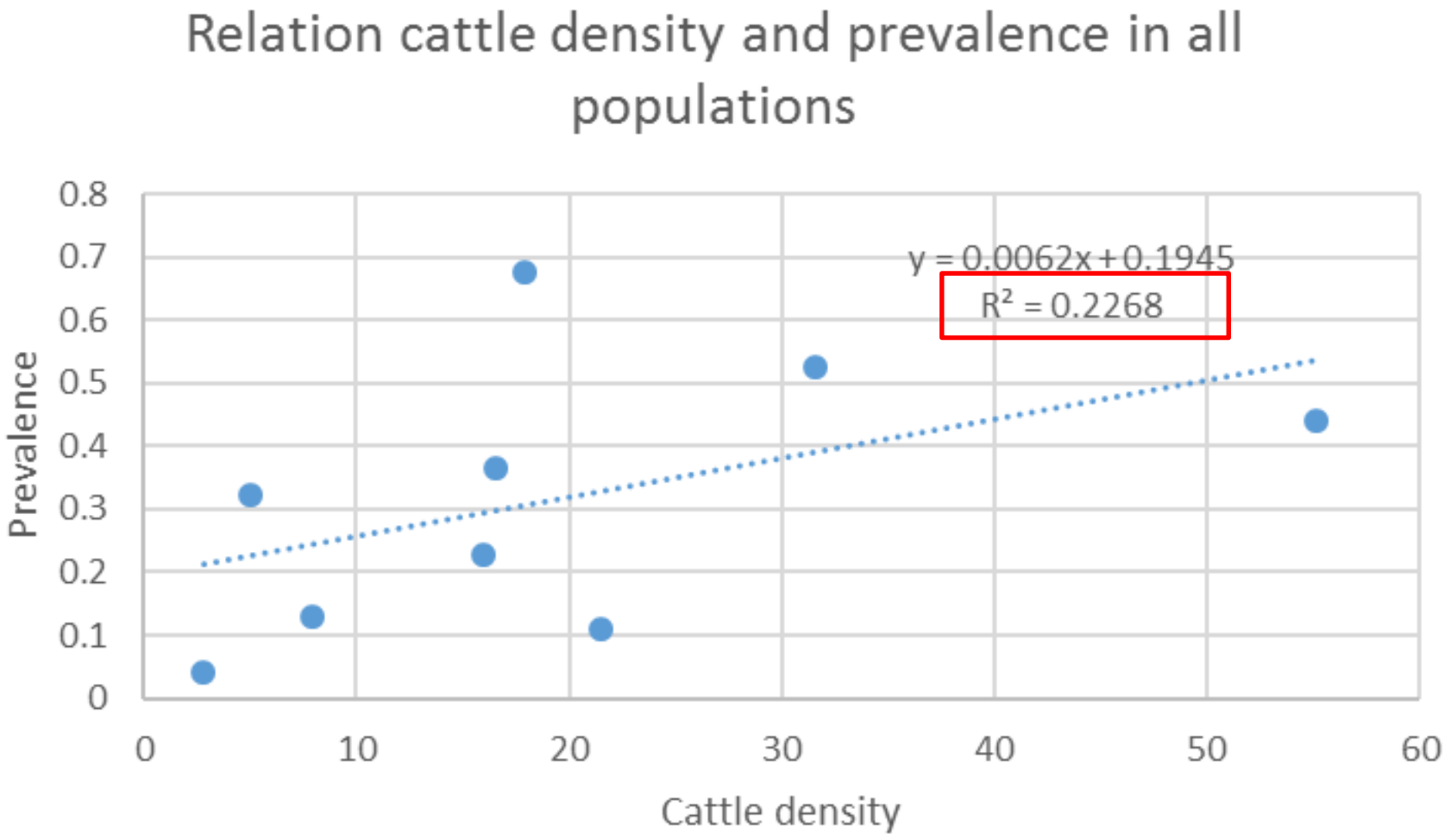
- Published articles with FMDV NSP antibody prevalence
- EuFMD and GFRA report/presentations with NSP prevalence
- FAOSTAT data on cattle density

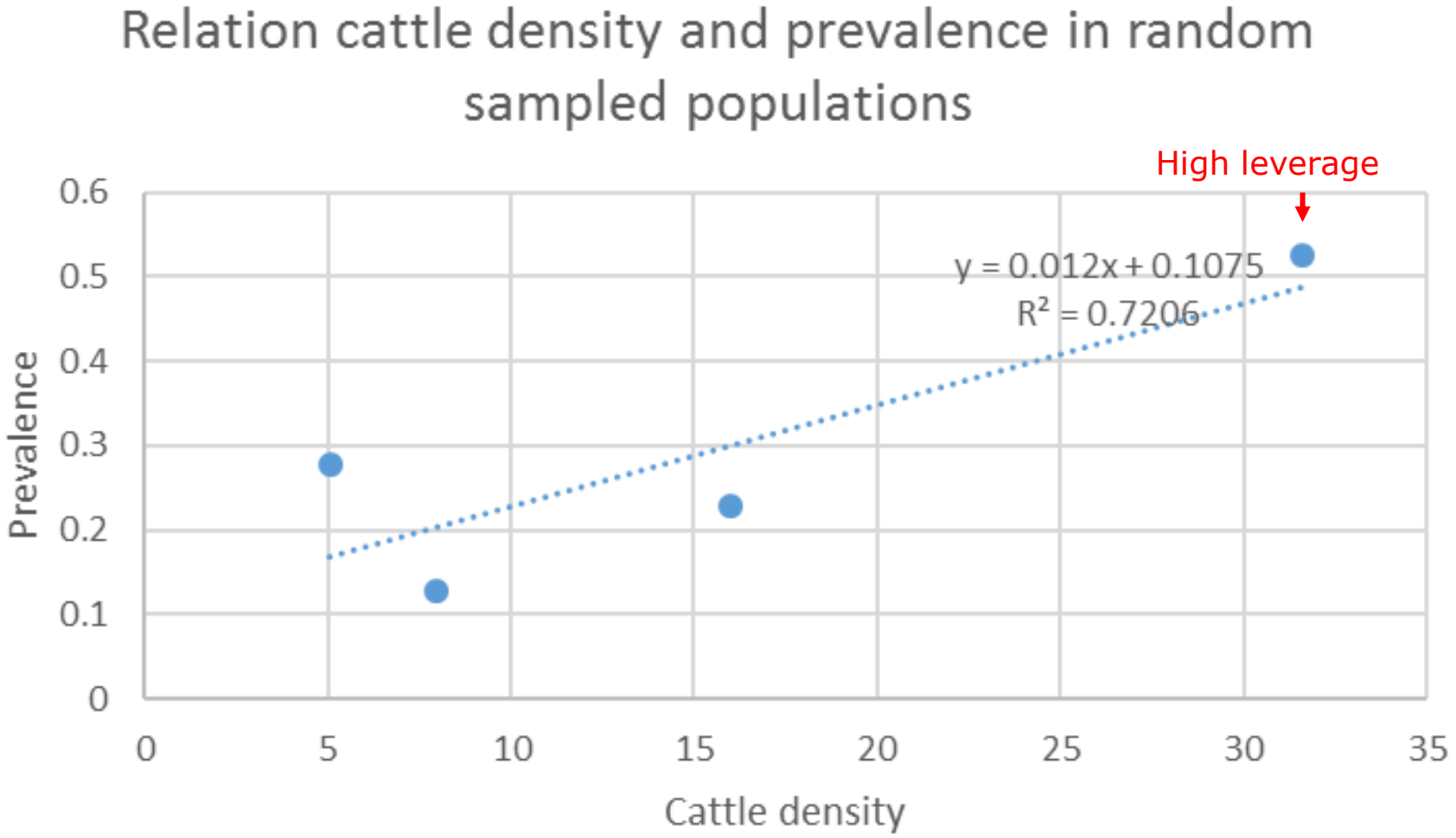
Limited number of studies found

country	species	vaccination	cattle density (per km^2)	random	prevalence	R_0
Eritrea	cattle	no	17.9	no	67%	3.1
Eritrea (central part)	cattle	no	16.0	yes	23%	1.3
Mongolia (Dornod)	gazelle	no	2.8	yes	12%	1.1
Mongolia (Dornod)	sheep	yes	2.8	no	1%	1.0
Mongolia (Dornod)	goats	yes	2.8	no	1%	1.0
Mongolia (Dornod)	Bactrian camels	yes	2.8	no	1%	1.0
Mongolia (Dornod)	cattle	yes	2.8	no	5%	1.1
Nigeria (Kano/Sokoto)	dromedaries	no	21.5	slaughter	11%	1.1
Nigeria (north central)	cattle	no	8.0	yes	13%	1.1
Ethiopia (Amhara)	cattle	sporadic	55.2	no	44%	1.8
Egypt	cattle	yes	5.1	yes	28%	1.4
Egypt	Buffalos	no	5.1	yes	37%	1.6
Sudan	Unknown	no	16.5	Unknown	37%	1.6
Kenya	Cattle	ring vaccination	31.6	yes	52%	2.1

Summary R_0

- In 12 out 14 studies R_0 estimate <2 (in fact close to 1)
- High R_0 estimate (3.1) in a targeted study in Eritrea, later estimate after random sampling was lower (1.3)
- High estimate in Kenya, which has a high cattle density
    - Is the NS antibody prevalence related to cattle density?


Relation cattle density and prevalence in all populations
Prevalence
Cattle density
y = 0.0062x + 0.1945
R² = 0.2268
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0
10
20
30
40
50
60


Relation cattle density and prevalence in random sampled populations
High leverage
y = 0.012x + 0.1075
R² = 0.7206
Prevalence
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
15
20
25
30
35
Cattle density

Relation of NSP prevalence with density

- Experimental transmission studies in Aujeszky disease show strong relation between R_0 and density (Bouma et al. 1995)
- Limited number of serosurveillance studies seem to confirm the relation between prevalence and cattle density
- Many other studies were performed but not reported, so not yet included

Bouma, A., M. C. M. de Jong, et al. (1995). "Transmission of pseudorabies virus within pig populations is independent of the size of the population." Preventive Veterinary Medicine **23(3): 163-172.**

Final conclusion

FMDV is NOT "highly" contagious, it also depends on the contact structure

In most endemic countries correlation between density and reproduction ratio

NB! Homogenous mixing assumption is probably not valid