Regional spread of BVDV
Contribution of between-herd trade movements & geographical proximity

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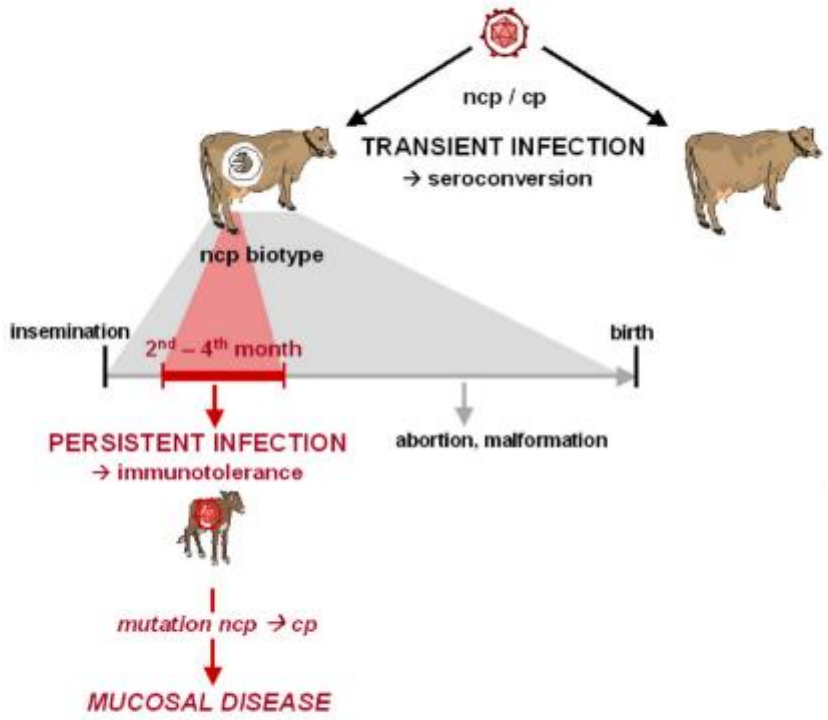
Bovine Viral Diarrhea



Peterhans E, Bachofen C, Stalder H, et al. Cytopathic bovine viral diarrhea viruses (BVDV): emerging pestiviruses doomed to extinction. Vet Res. 2010;41(6):44.

- worldwide endemic disease
- welfare and productivity (reproduction, milk production,...)
- permanently infected (PI) animals (50% chance of dying per year)

Control strategies at herd level:

- vaccination
- test and cull of calves
- hygiene

Regional spread

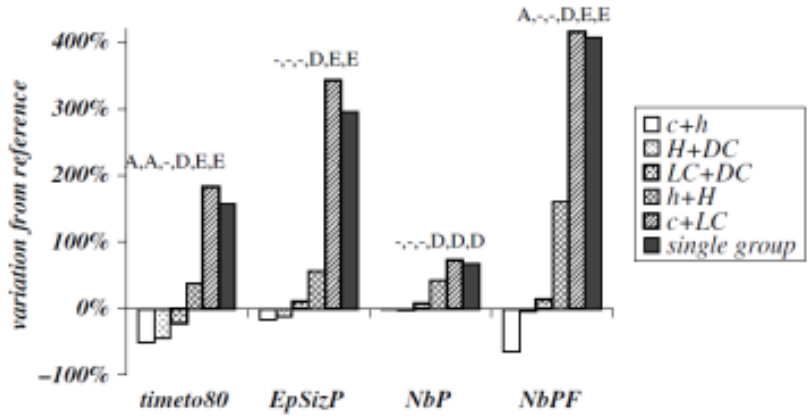
- Trade movements
- Proximity contacts

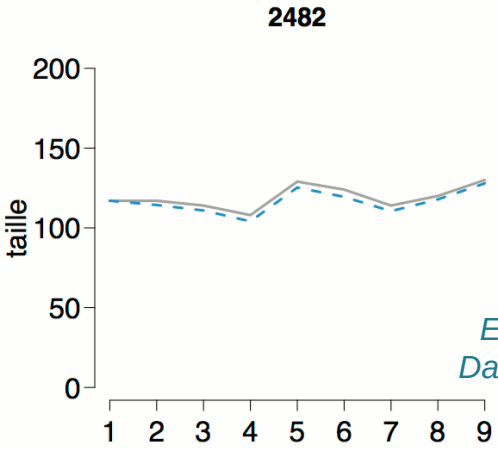
➔ Fade-out at farm scale & regional control but still circulating: contribution of trade / proximity contacts?

Flexible and realistic within-herd models

Coupling herd dynamics & BVDV transmission

- Vertical transmission & PI
- Horizontal transmission
- Contact structure & seasons
- Herd size, management & location calibrated on data
  (births, culling, etc per age per herd)





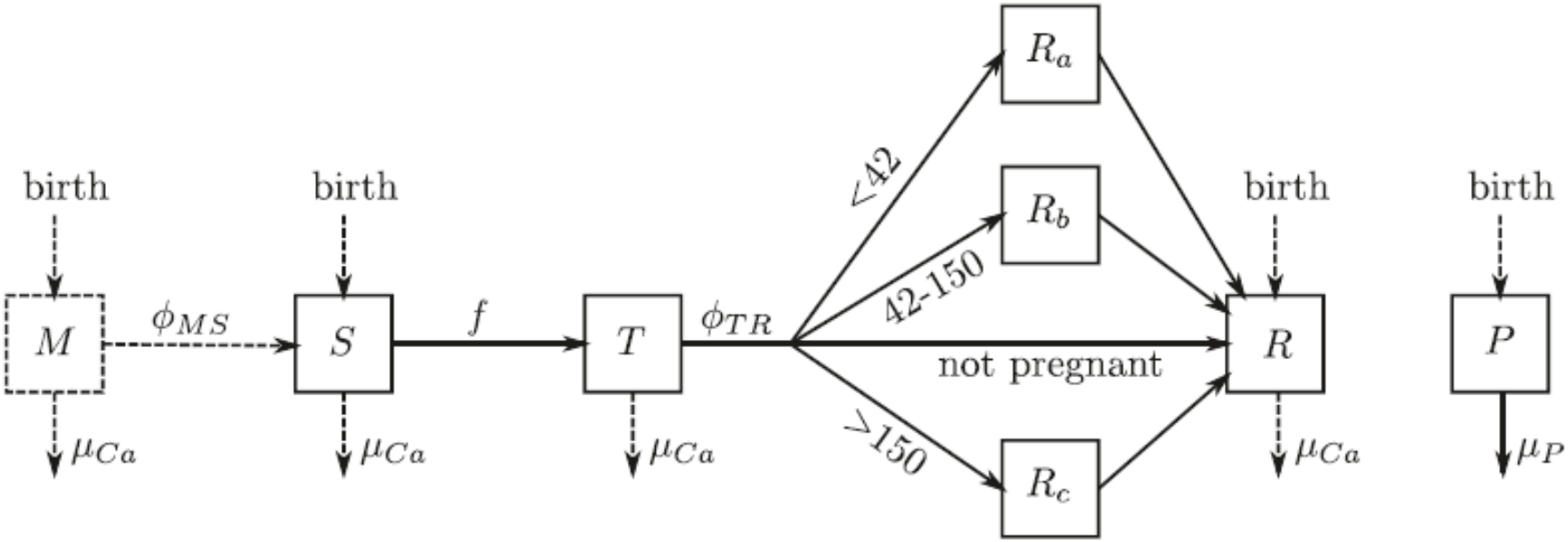
Viet et al., PVM 2004
Ezanno et al., PVM 2008
Ezanno et al., Vet Res 2009
Damman et al., Vet Res 2015
Qi et al., Epidemics subm.

Flexible and realistic within-herd models

Health states

Horizontal transmission in groupe *g*

$$p_{\text{inf}}^{herd}(g,t) = \beta_w^P \frac{P(g,t)}{N(g,t)} + \beta_w^T \frac{T(g,t)}{N(g,t)} + \sum_{a \neq g} \beta_b^P \frac{P(a,t)}{N(a,t)N(g,t)}$$



A data-based regional model

Couples within dairy herd dynamics through observed trade movements & proximity contacts

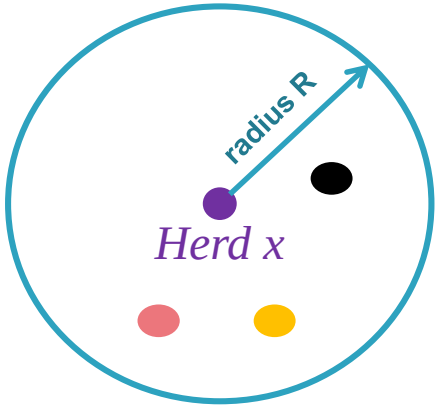
Trade movements

- Date, source, destination, age ➔ data
- Infection ➔ f(prevalence in source herd)

Proximity contacts

$$p_{inf}^{neigh}(g,t) = \frac{\beta_{BN}^{P}}{N(g,t)} \frac{PI\ animals\ in\ neighborhood}{Total\ animals\ in\ neighbourhood}$$

$$prob_{\text{inf}}(g,t) = 1 - e^{-\Delta\left\{p_{\text{inf}}^{herd}(g,t) + p_{\text{inf}}^{neigh}(g,t)\right\}}$$



Neighbors of herd x

Cattle trade movement data & herd location

- French cattle identification database
  - ID, type & age of animals exchanged
  - ID and type of holdings in contact
  - Date of movements
  - Town borders

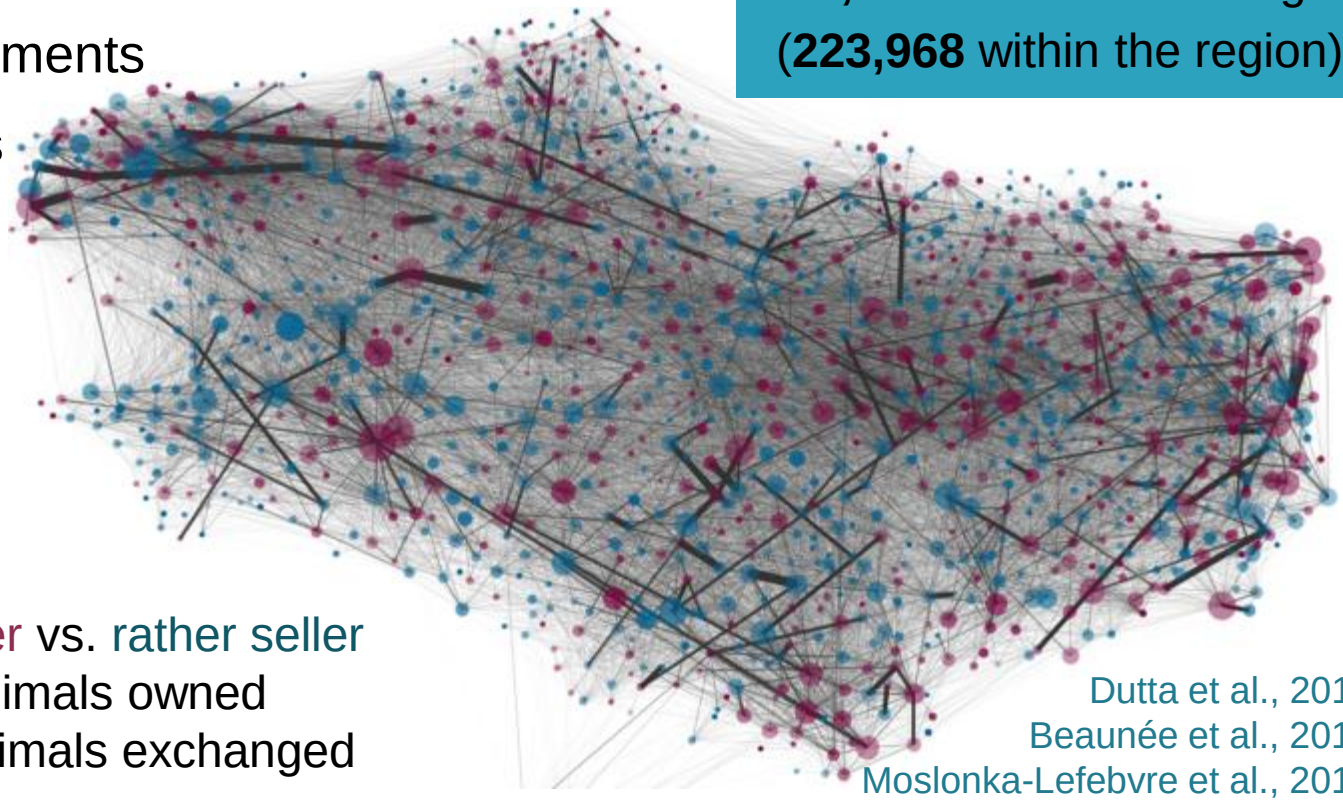
Brittany (France)

2005-2013

12,857 active farms

919,304 animals exchanged

(**223,968** within the region)



Nodes = rather buyer vs. rather seller
Size ~ number of animals owned
Link ~ number of animals exchanged

Dutta et al., 2014
Beaunée et al., 2015
Moslonka-Lefebvre et al., 2016

Simulation setting

Parameters

[a] Calibrated using data

[b] Experts knowledge

[c] Publications

[d] Assumptions

	Description	Value	Ref.
$r^*(g)$	Outgoing rate per age group:death, consumption, cull		a
rb	Birth rate per age group per year		a
rs	Sex-ratio	0.5	b
rm	rate of mortality of PI animals	0.026	c
rmPI	rate of mortality of PI calves at birth:	0.01	c
β_W^P	Within-group transmission rate for PI animals	0.5	c
β_W^T	Within-group transmission rate for T Ianimals	0.03	c
$\beta^P{}_B$	Between-group transmission rate for PI animals	0.1	d
β_B^T	Between-group transmission rate for T Ianimals	0	d
β_{BN}^P	Between-neighbor transmission rate for PI animals	0,03	d
R	Neighborhood circle radius	2km	d

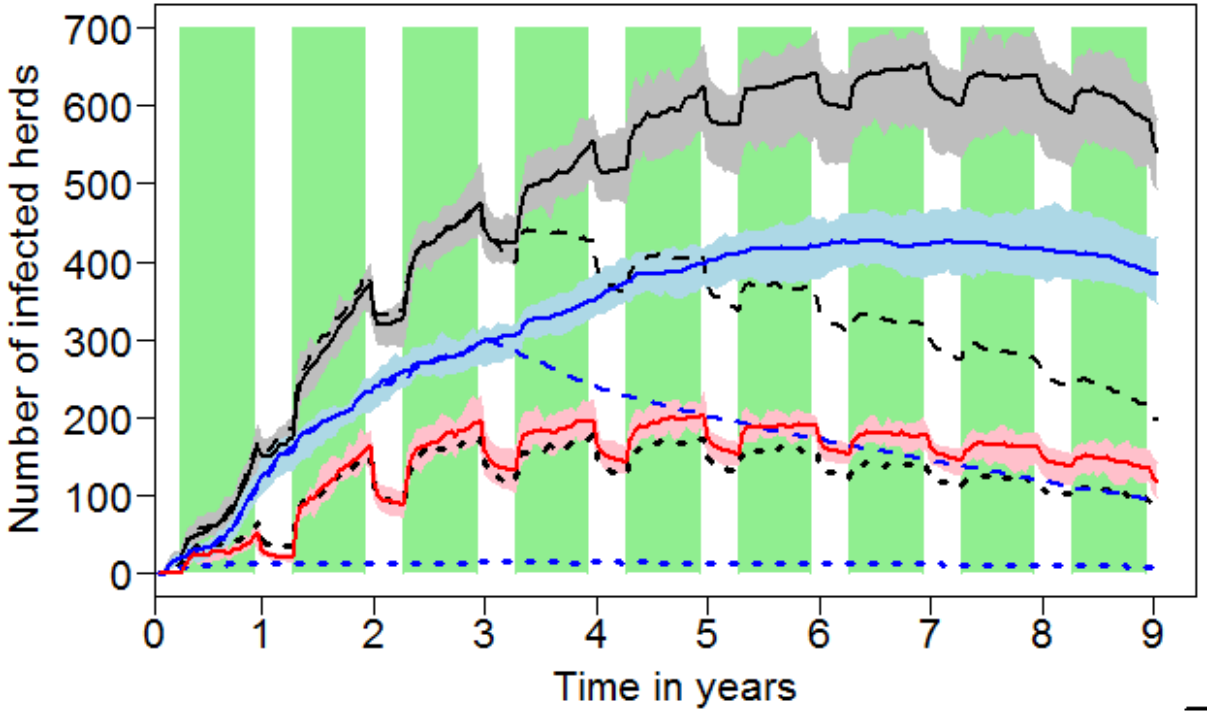
Simulated farms

- Herds active over 9 years (2005-13), ≥ 10 heifers + cows ➔ 12,750 herds

Initial conditions : 2 situations

- 10% randomly chosen farms, each with 1 PI cow, all others free
- Endemic situation (i.e. 9 years after the previous case)

BVDV spread at a regional scale



- - - Control starts at the end of the 3rd year

….. Control starts at the beginning of the 1st year

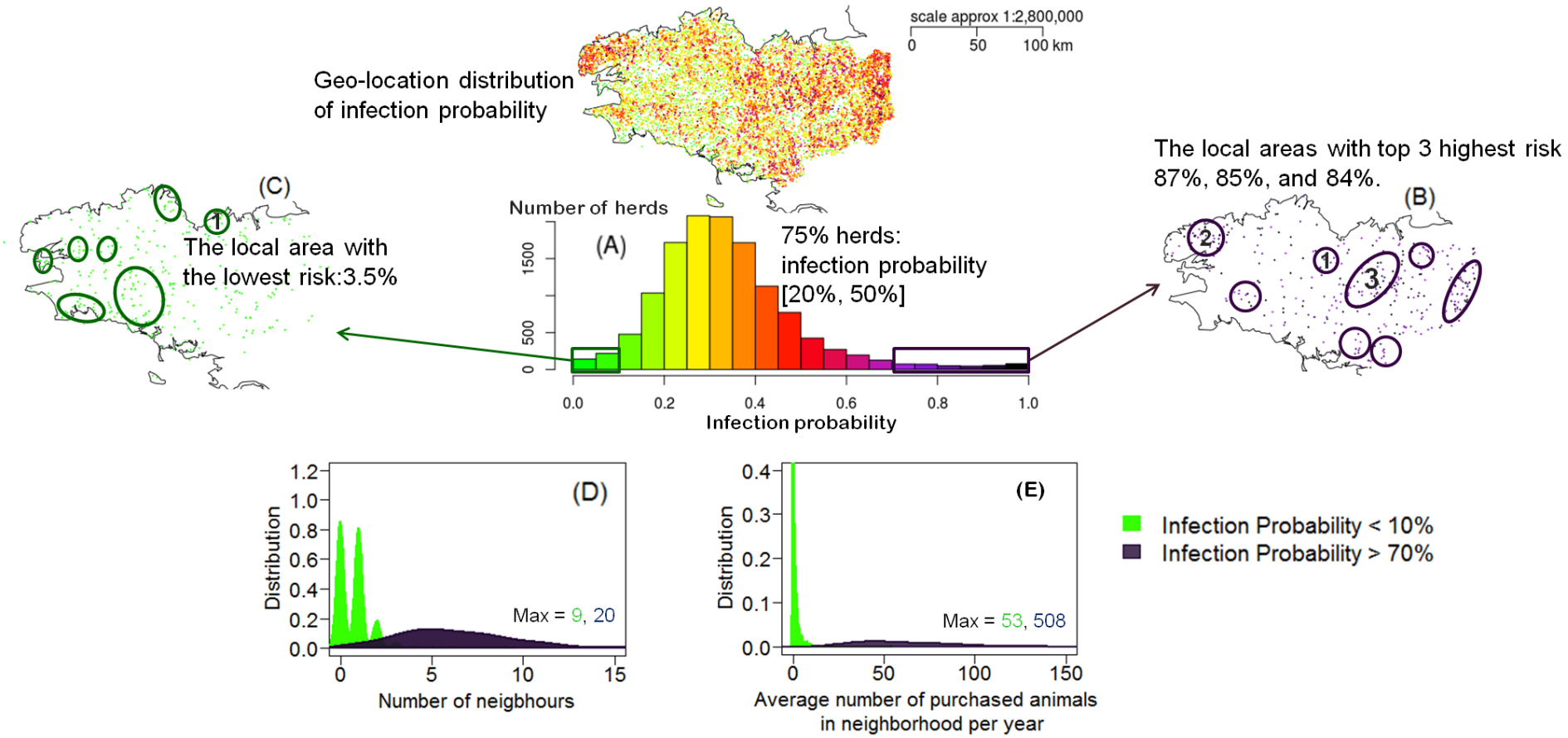
NB+MV

NB

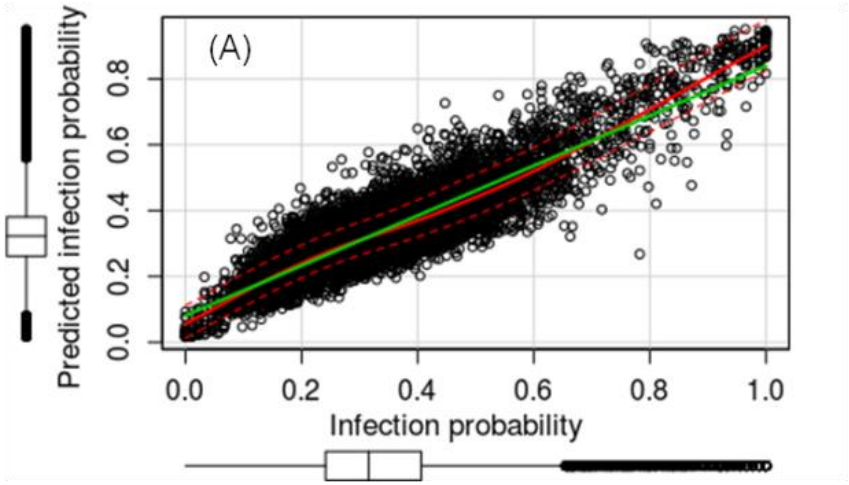
MV

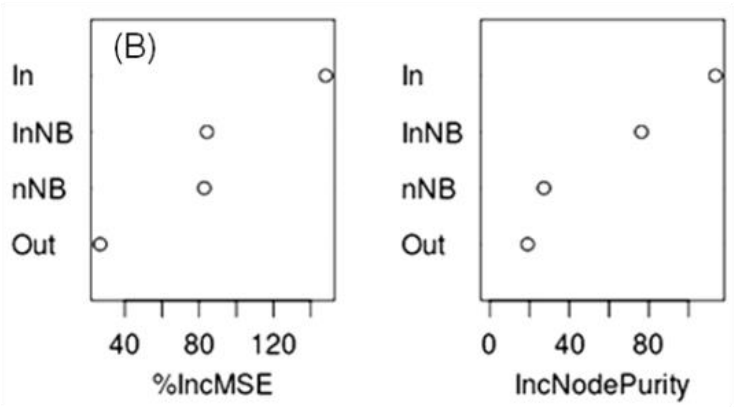
- NB and MV both increase infected herds in the metapopulation
- Perfect test & cull of traded PIs NOT enough to eradicate BVDV

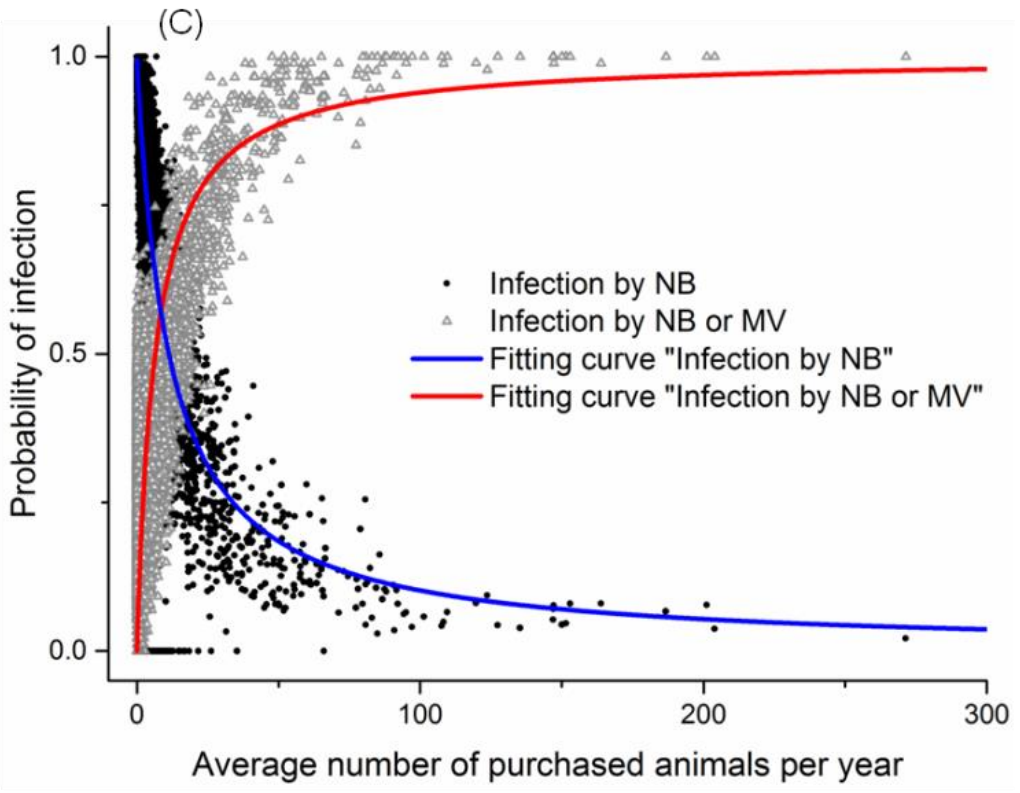
Herd infection probability: spatial distribution & contribution of NB and MV



Herd infection probability



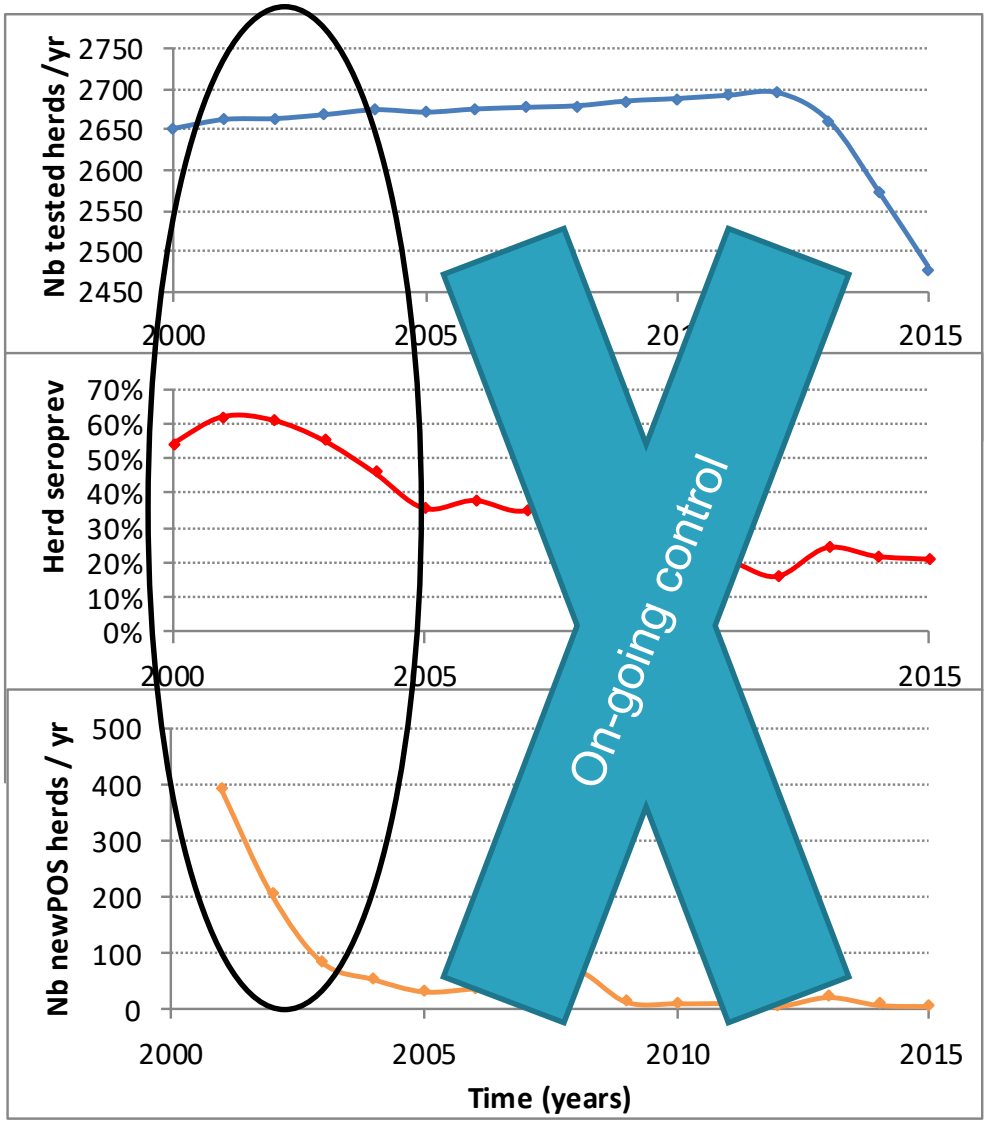




Comparison to observed data

Finistere (Brittany)

- Observations
  - ~2650 herds / ~3000 herds
  - ~50-60% seroprevalence
  - ~100-400 newly infected herds

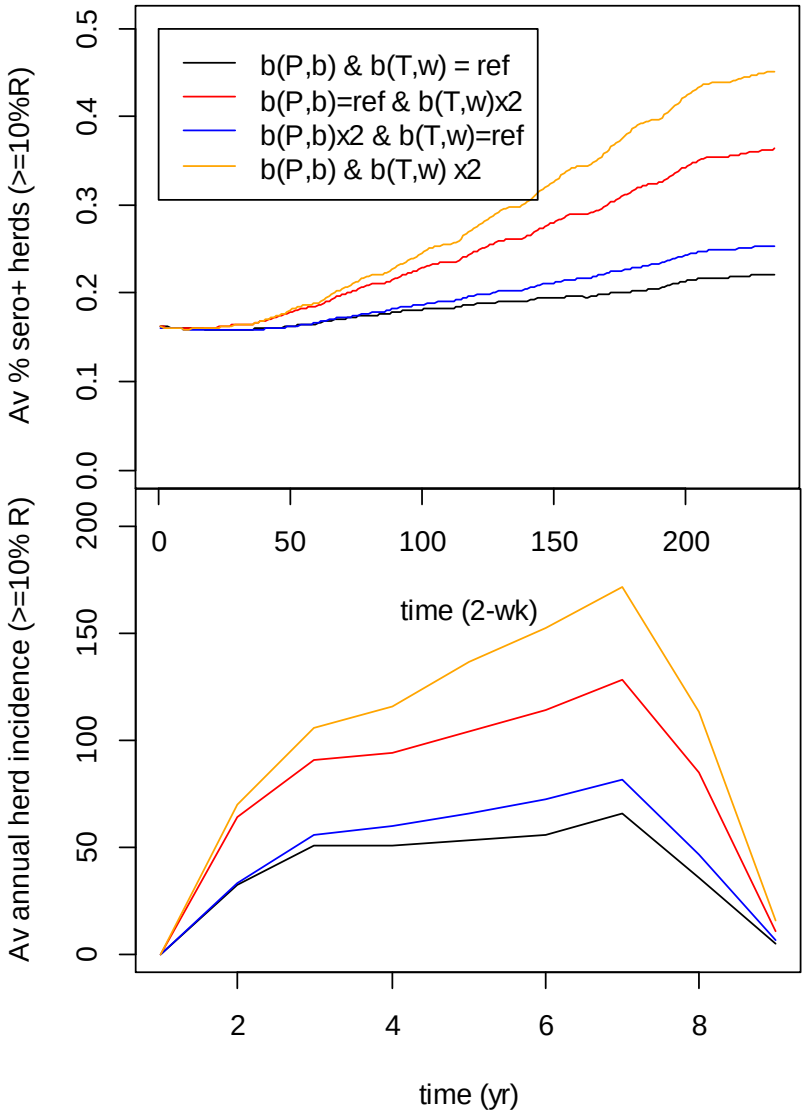


Comparison to observed data

Finistere (Brittany)

- Observations
  - ~2650 herds
  - ~50-60% seroprevalence
  - ~100-400 newly infected herds
- Simulations
  - ~20% seroprevalence
  - ~50 newly infected herds

To reach 50-60% seroprev & 100-400 incidence
➔ increase transmission rates



Take-home message & discussion

A data-driven multiscale model to better understand regional BVDV spread

- Realistic framework, flexible & efficient
- Lacks fattening unit and beef herds & needs calibrations
- Accounting for territorial specificities ➔ A tool for managers to evaluate control strategies

Perspectives

- Model simplification: vertical transmission using calf-dam data
- Better structure for input data
- Inclusion of beef herds & fattening units
- Inclusion of control measures other than tests at purchase

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