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Combination of a new experimental approach and a mathematical model for a more realistic description of population dynamics of *Dermanyssus gallinae*

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INTRODUCTION AND OBJECTIVES

Dermanyssus gallinae = Poultry Red Mite (PRM)
- ✓ economic importance worldwide
- ✓ obligatory hematophagous avian parasite
- ✓ **life spent at a distance of the bird host**

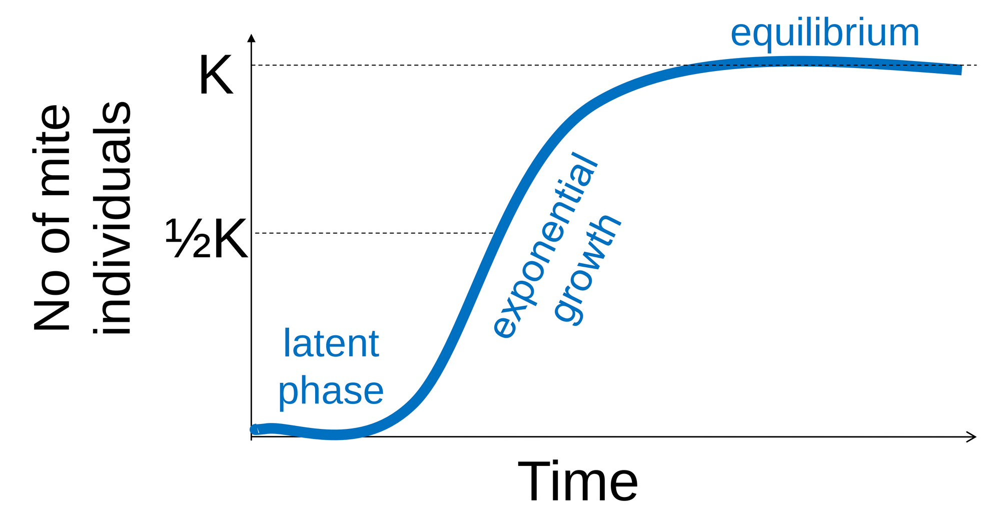
Mites hidden in the environment
→ 'iceberg' populations

→ infestation level hard to estimate

General objective: refining knowledge on PRM population dynamics and improving its estimate by a model to make possible definition of critical thresholds for treatment decision.

HYPOTHESES

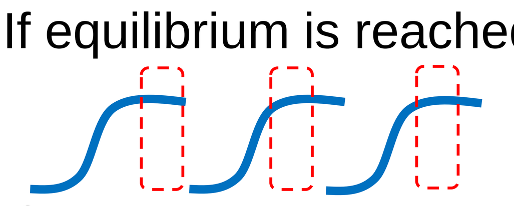
Logistic population growth



K ≈ maximum no of individuals

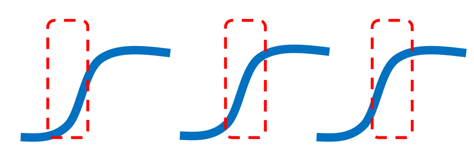
Expected distribution of PRM abundance at the end of experiments

- If equilibrium is reached in most mesocosms



Nf ≈ K → normal distribution

- If most mesocosms are not yet at equilibrium, high discrepancy expected with frequent low values



Ni < *Nf* < K → Poisson distrib°

Nf = mean final no of PRM, *Ni* = initial no of PRM

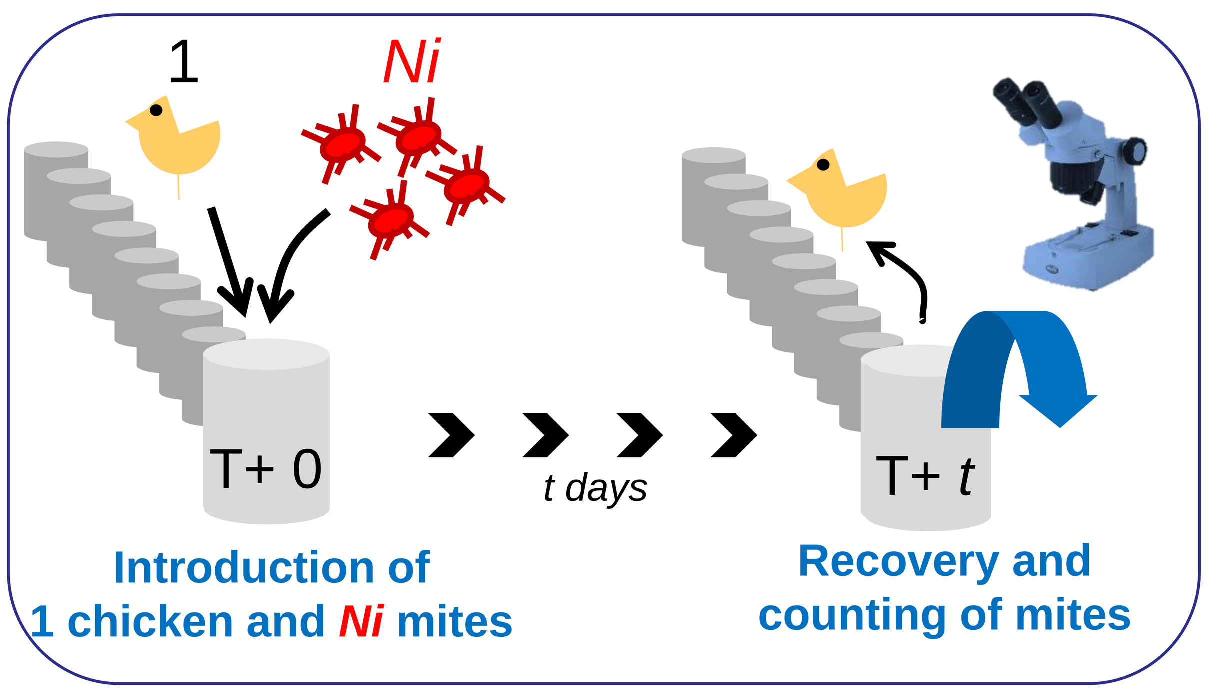
MATERIALS AND METHODS

Mathematical model published in Huber et al. (2011)

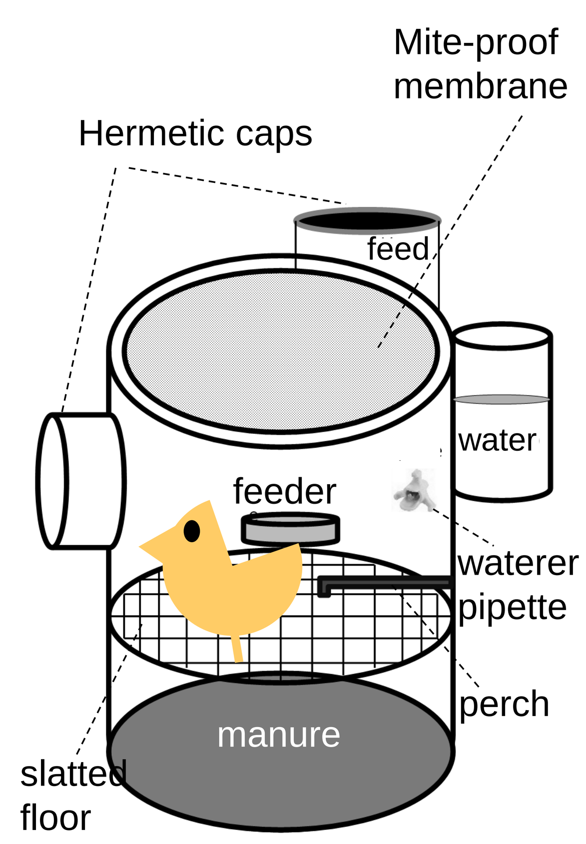
- ✓ stochastic delayed differential equations for cohort individuals
- ✓ simulations conducted in R using the dede function (deSolve)

Experimental device = 'poultry mesocosms'

- ✓ mite-proof units that mimic the poultry farm ecosystem
- ✓ PRM populations growing from known initial numbers on isolated chickens with feed and water available *ad libitum*
- ✓ *One shot information (increase of pop° at T+t)*:



1 experiment = dozens of mesocosms run together (same period, same duration)



Experiment ID	No of mesocosms	Initial no of PRM (*Ni*)	Duration of mite-chick contact (days)
exp1	40	400	42
exp2	50	25	50

RESULTS AND DISCUSSION

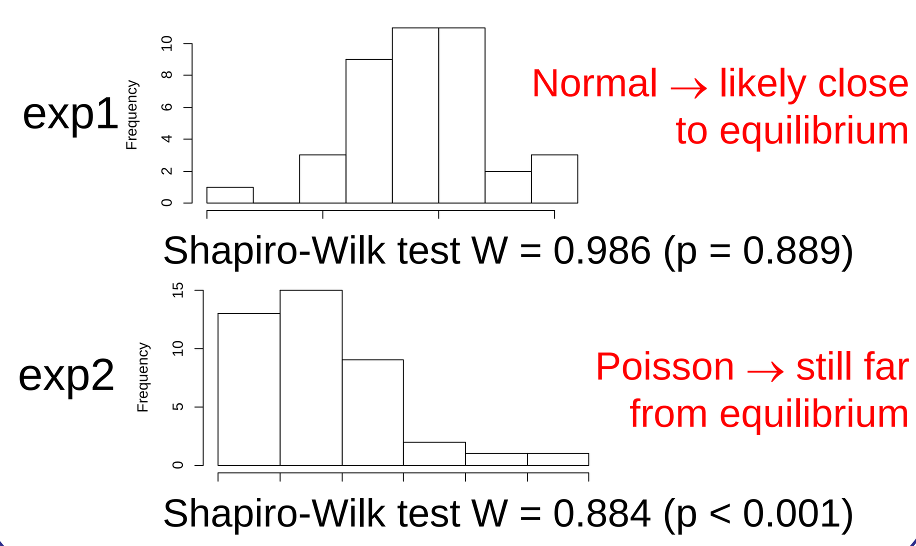
PRM abundance at the end of experiments

run ID	Observed *Nf*
exp1	93,119 PRM* (sd ± 28,750)
exp2	31,115 PRM* (sd ± 23,053)

- Huge mite growth (233-fold and 1245-fold increase of PRM in exp1 and exp2 resp.)
- High heterogeneity among mesocosms well explained by inter-individual variations (different mite ages at start, different chicks…)

* *Counted PRM = adults + nymphs*

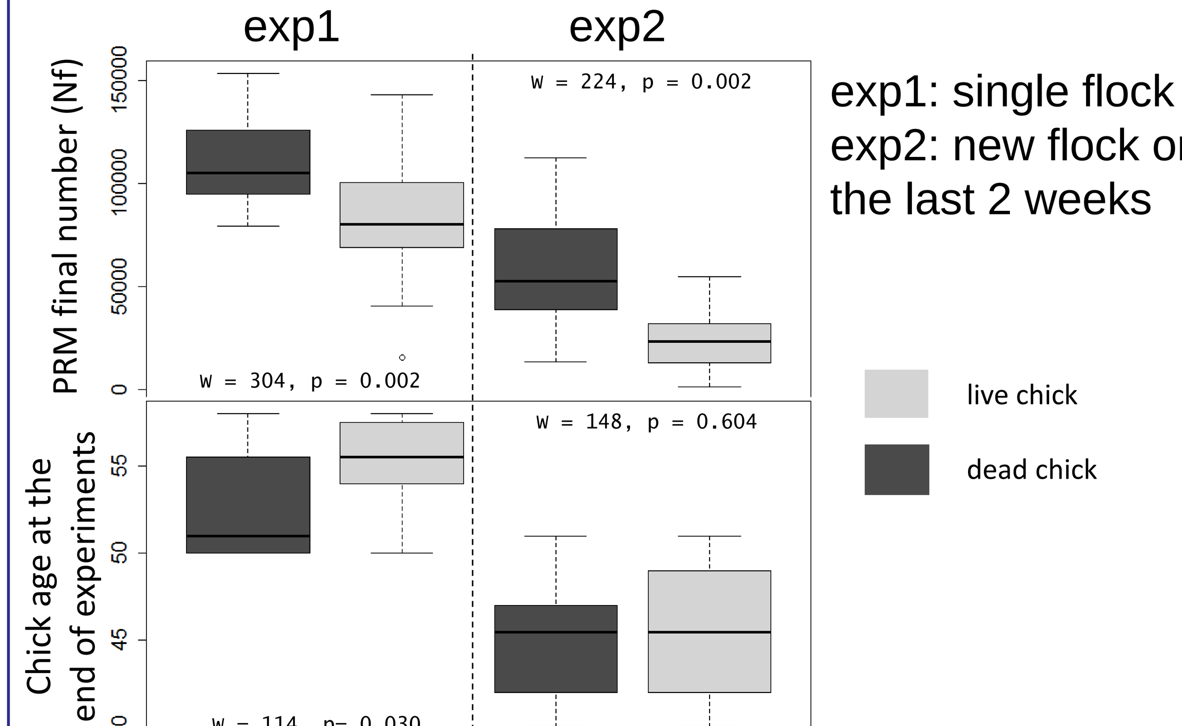
Distribution of observed data and growth phase at experiment end



Relationship between chick mortality and PRM infestation

Peak of chick mortality on the last 2 weeks of experiments

Each experiment:
Flocks of chicks hatched at the same time + same duration
Different start & end dates



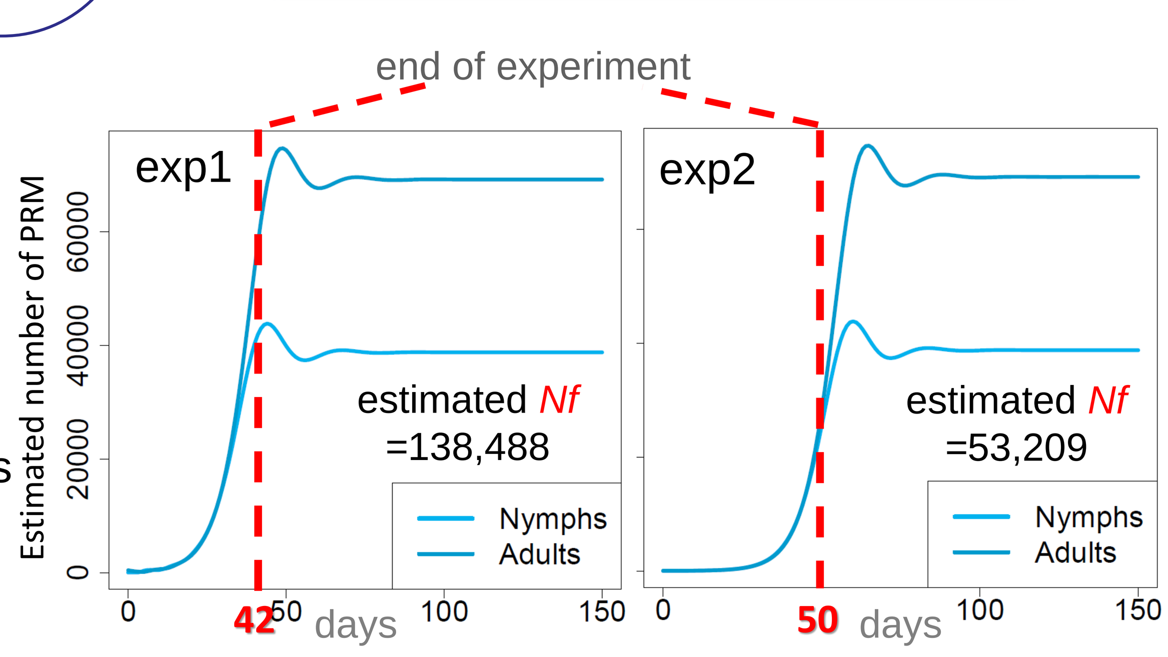
exp1: single flock
exp2: new flock on the last 2 weeks

Evidence for chick mortality induced by PRM infestation: tolerance threshold close to 100,000 PRM per exposed 54-day old chick (exp1) and to 50,000 per naive 45-day old chicks (exp2)

Modeling the population growth of PRM in our mesocosms:

- Initial model settings led to a striking underestimation of population growth

⟶ Tentative adjustment of the parameters to obtain an estimate of the increase in PRM closer to that observed



Conclusions and perspectives

Effective growth of mites was much higher than expected. The data obtained suggest that different phases of population dynamics have been captured. However one-shot information on temporal evolution of the mite population is insufficient to definitely adjust the model. There is a need for fitting multi-temporal data with model estimates to check the model adjustment and thus refine parameters. Given that invasive treatments are required to count mites, we'll need to concomitantly conduct runs with several different end dates in order to get a view of how the growth curve is and state the K value in our experimental design.
The present results show that the tolerance threshold for poultry depends on age x exposure (immunity). Further experiments to determine the tolerance threshold according to age in older poultry may provide a better understanding of the physiological effect of PRM infestation in layer farms.

Literature cited: Huber K, Zenner L. Bicout D. 2011. Veterinary Parasitology 176 (2011) 65–73

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