



OCalm: A new dynamic model to simulate the fate of calcium and phosphorus in laying hens

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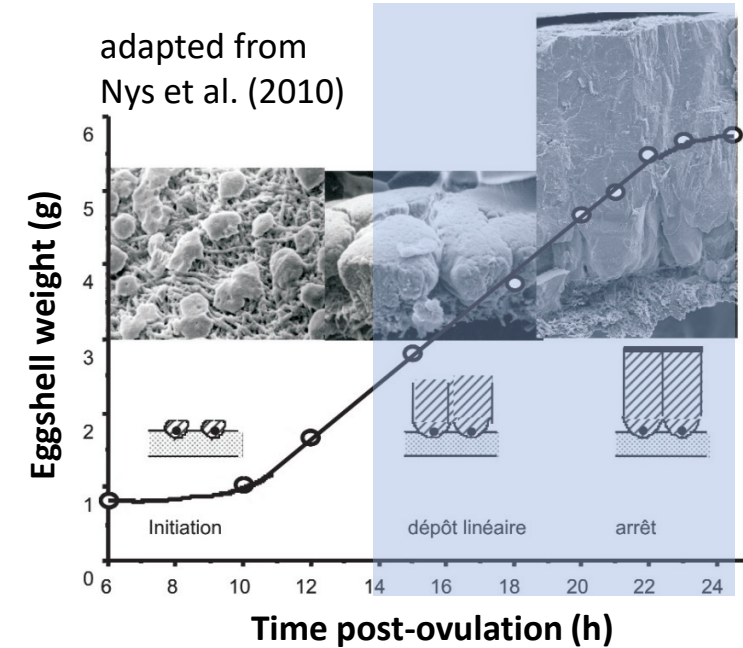
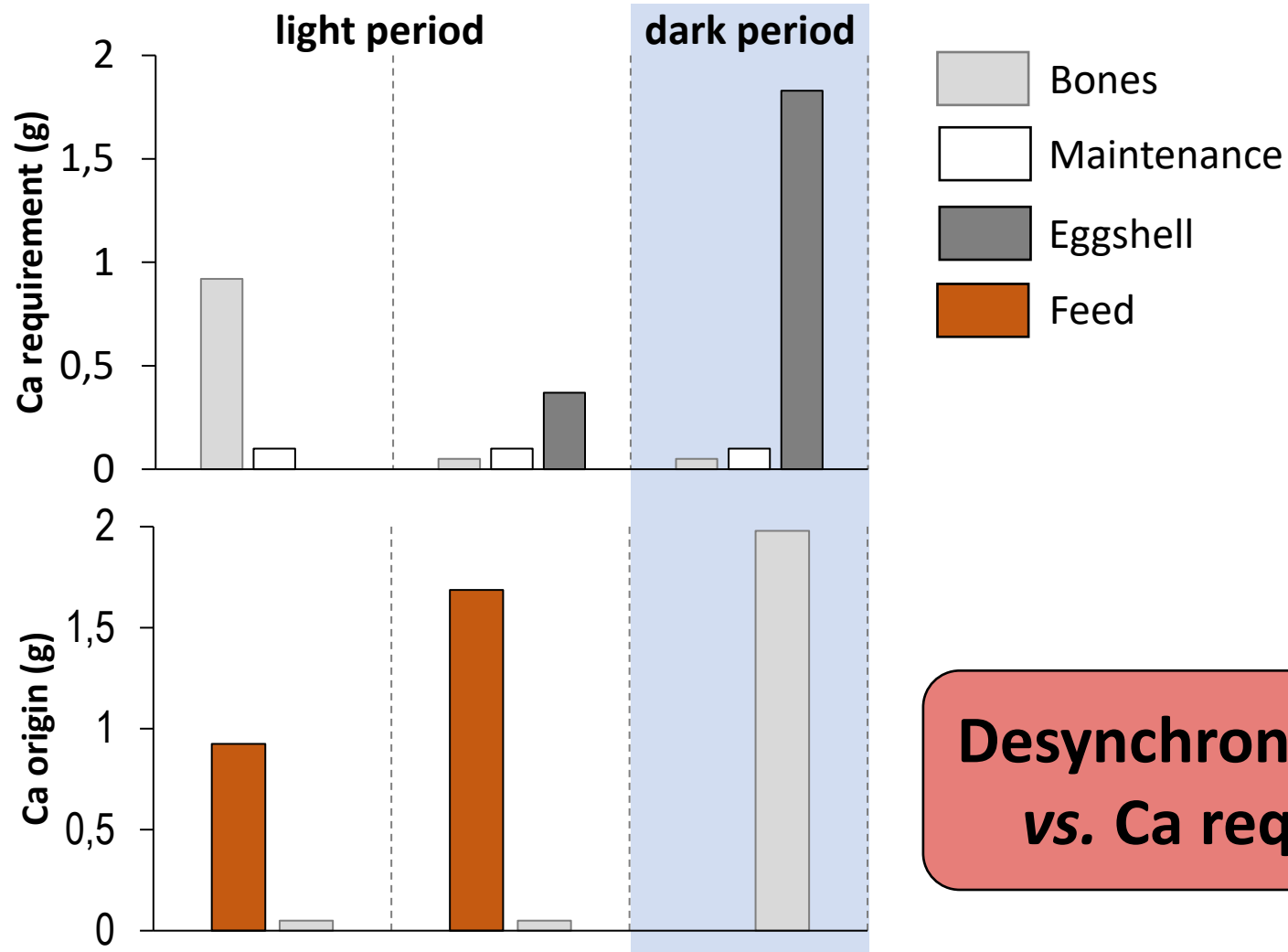
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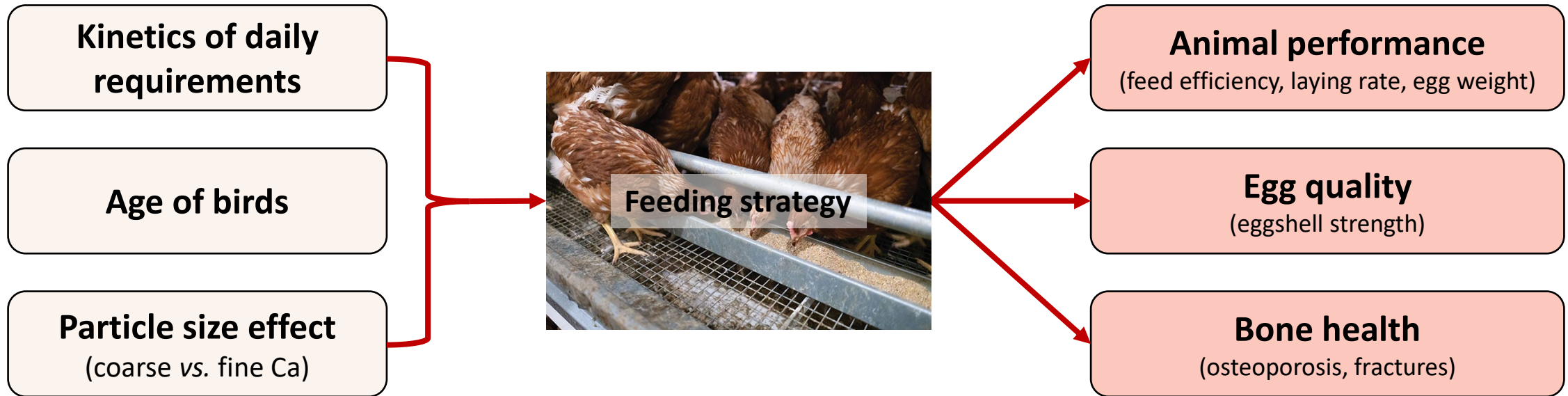
Session 19 - Nutritional models development and applications in livestock farming

Calcium dynamics in laying hens



Desynchronization between dietary Ca intake vs. Ca requirement for eggshell synthesis

Mineral nutrition of hens: The nutritionist's nightmare?



Objective: Devellopping a simulation model of Ca & P fluxes in laying hens
⇒ Studying the effects of mineral feeding strategies

Overview of the OCalM* model



**"Animal"
model**



Ca & P fluxes for 1 animal over 24h

**"Carrier"
model**



Ca & P fluxes for 1 animal over its whole career

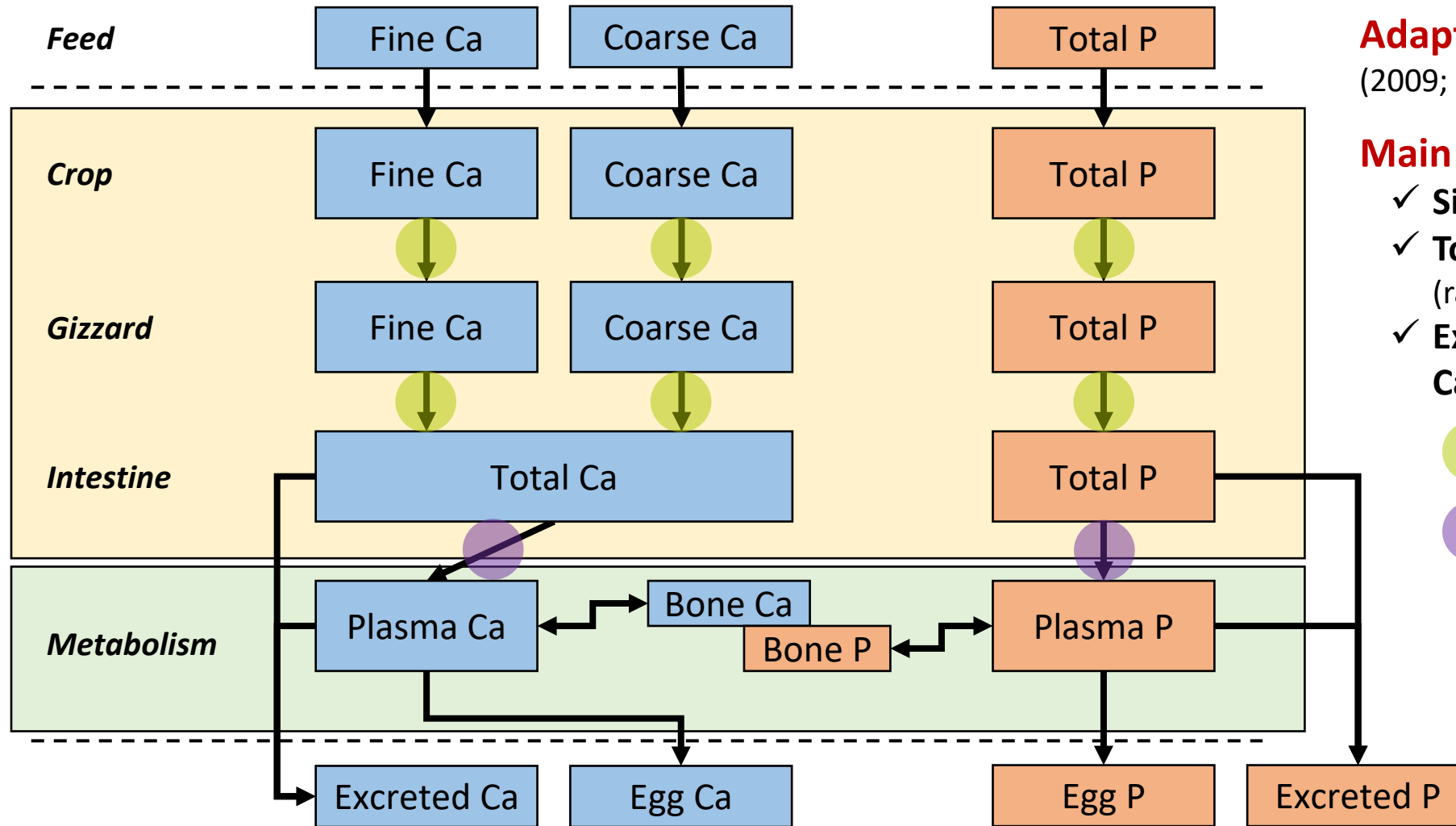
**"Flock"
model**



Ca & P fluxes for the flock over the entire production cycle

*OCaLM: Optimizing Calcium supply with Modelling

Animal model : Concepts



Adaptation of Kebreab *et al.*

(2009; Poultry Science, 88: 680-689)

Main adaptations

- ✓ **Size of Ca particles** (fine vs. coarse)
- ✓ **Total P in digestive tract** (rather than available P)
- ✓ **Explicit representation of Ca & P in bones** = $f(\text{body weight})$



Transfer rate (h^{-1})



Absorption rate (%)



Parameter values?

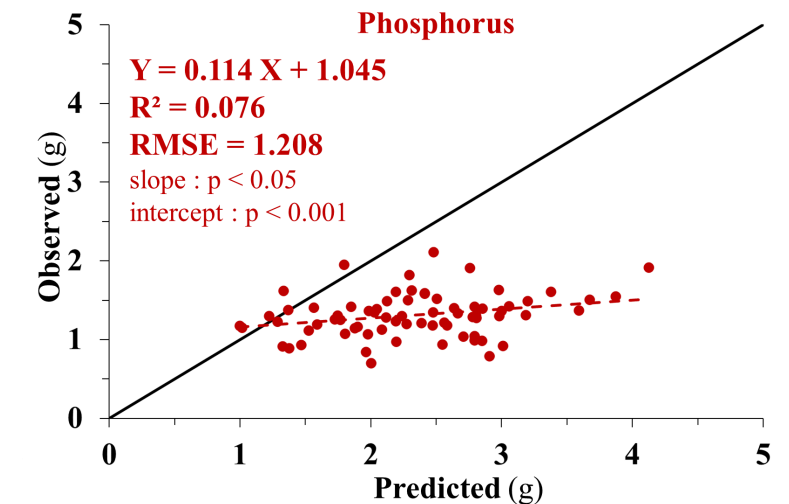
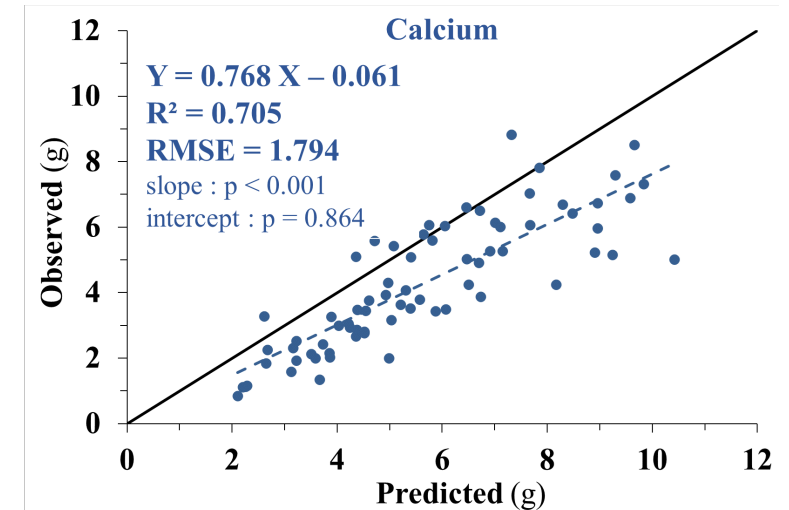
Animal model: Parametrization



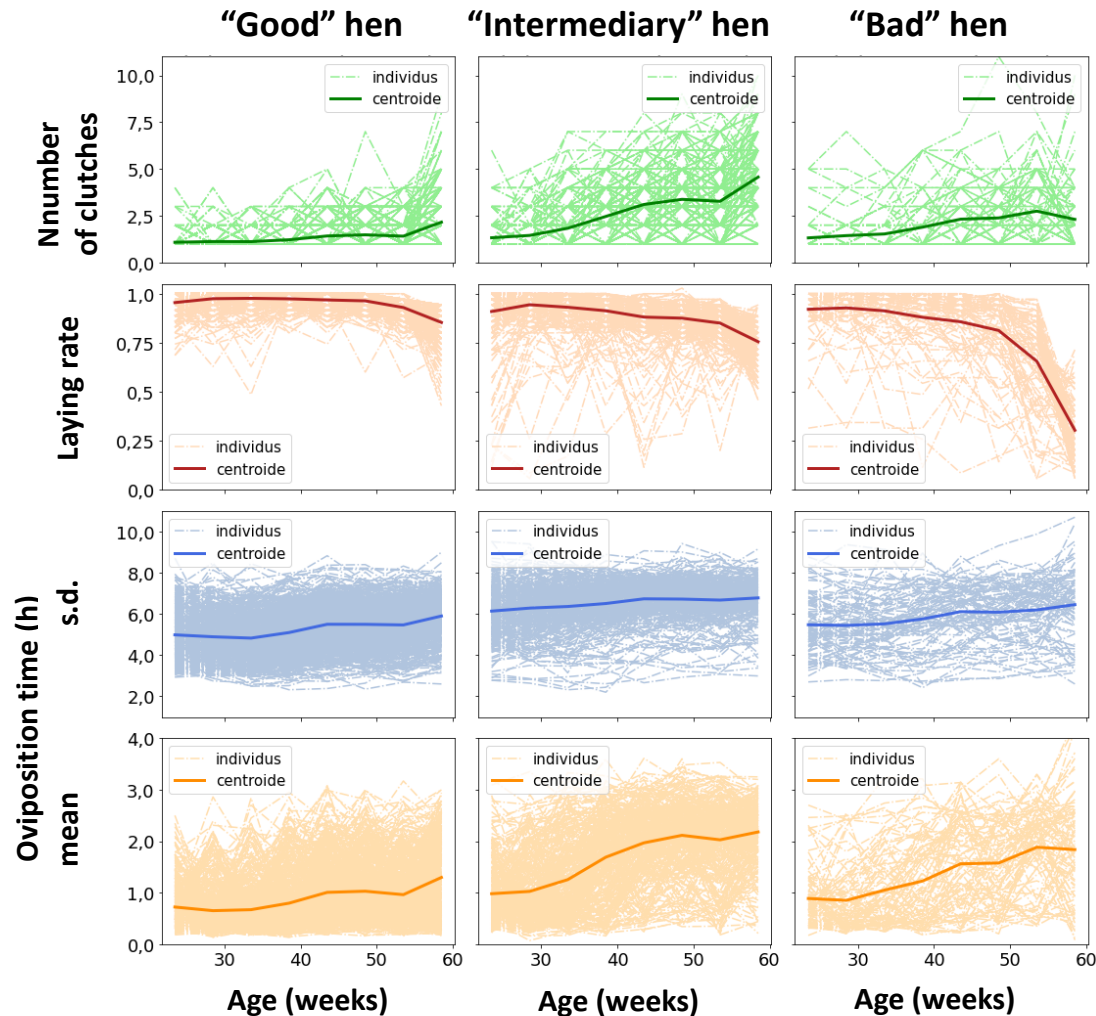
Parameter	Kebreab <i>et al.</i> (2009) model	OCalm model	Hervo <i>et al.</i> (2024) trial*
k crop-stomach fine Ca (h ⁻¹)		2.41	2.07
k crop-stomach coarse Ca (h ⁻¹)	0.44	0.50	0.92
k crop-stomach P (h ⁻¹)		1.15	1.84
k stomach-intestine fine Ca (h ⁻¹)		4.20	3.75
k stomach-intestine coarse Ca (h ⁻¹)	0.90	0.29	0.37
k stomach-intestine P (h ⁻¹)		3.78	3.33
Absorption rate of P (%)	100	75	-

The higher k, the faster the transfer from one compartment to another

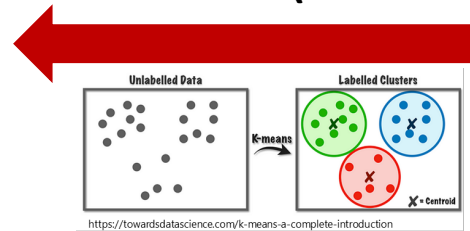
- **Specific parameters for the two forms of Ca** (*i.e.* coarse Ca is “slower” than fine Ca)
- **Overestimation (≈ 20%) of excreted Ca**
- **Poor predictive capacity of the model for P excretion**



Carrier model: Laying parameters = f(time)



Multivariate clustering of time series (*K-means*)

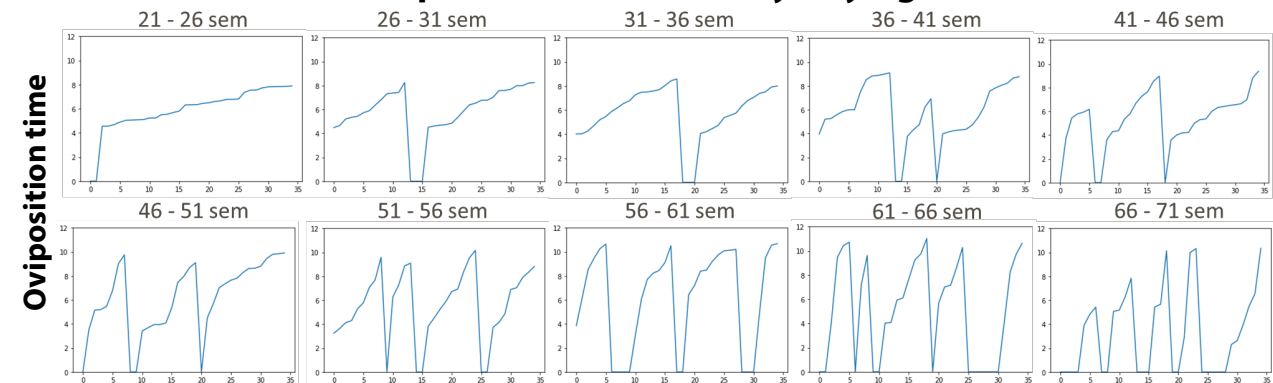


NOVOGEN

- 976 individual laying trajectories
- 4 variables measured during 8 periods of 35 d from 21 wk of age

Laying sequence regenerated for each hen profile

Example for a "intermediary" laying hen

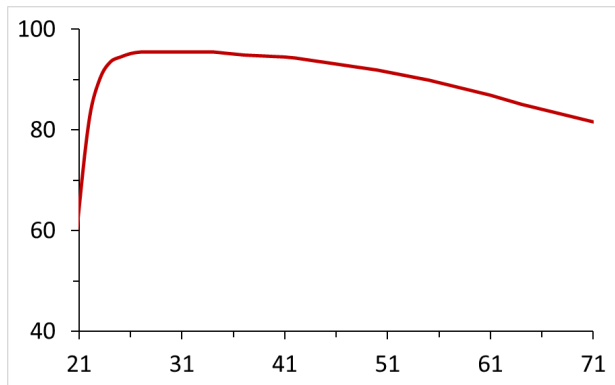


Flock model: Integration of the flock laying rate



Input data (user)

Observed laying rate (%) of the flock
between 21 and 71 weeks of age

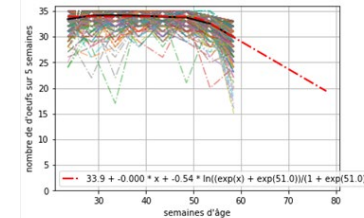


optimization

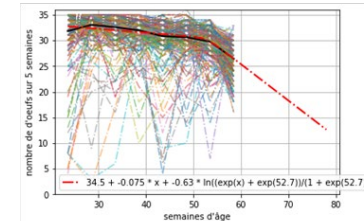
Finding X, Y & Z...

- No variability among individuals with a same laying profile
⇒ Simulation of an “average” hen per profile
- The “average” hen of the flock is recalculated with the weighted average of each profile (using X, Y & Z values)

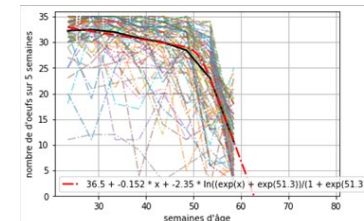
...so that $X + Y + Z = 100\%$



X% of “good” hens



Y% of “intermediary” hens



Z% of “bad” hens

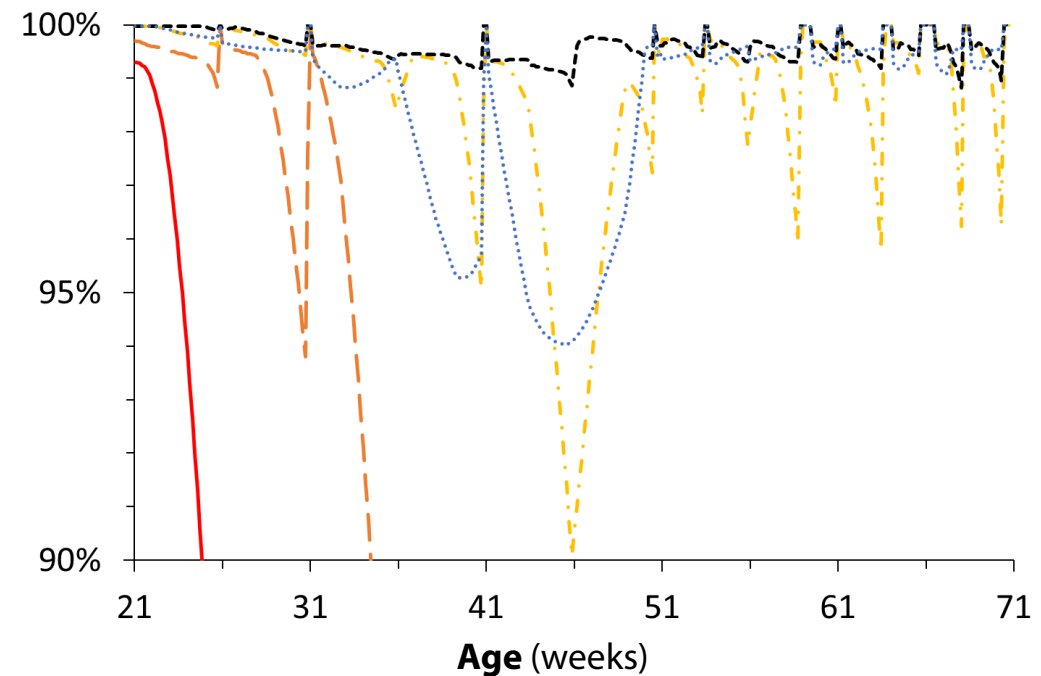
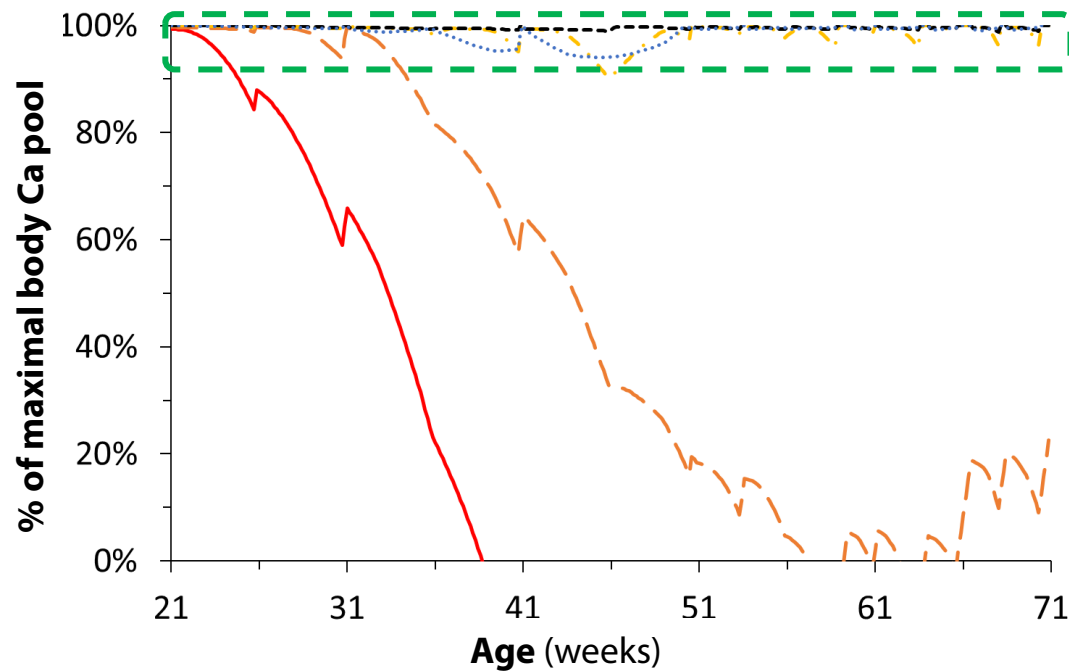


Example of simulations



Effect of the percentage of coarse Ca in the feed (% total Ca) in “good” laying hens:

0% 25% 50% 75% 100%



- **Importance of coarse Ca to preserve bone reserves over time**
(*i.e.* slower absorption $\Rightarrow$ lower mobilization during dark period)
- **A need for “fine” Ca for the rapid reconstitution of bone reserves**

Future improvements



Digestive sphere:

- ✓ Interactions between P, Ca & phytase in digestive tract

Metabolic sphere:

- ✓ Representation of medullary & cortical bone
(*i.e.* Ca storage vs. skeleton structure)
- ✓ Feedback on egg production (eggshell quality, laying rate)
- ✓ “Bone status” indicator $\Rightarrow$ fracture risks?

Evolution of an existing model:

- ✓ New concepts (2 Ca forms, explicit bone reserves)
- ✓ Re-parametrization (transfer rates of Ca in digestive tract)

“Carrier” & “Flock” approaches:

- ✓ Ageing of the hen
- ✓ Simplified version of inter-individual variability (3 profiles)

Investigating innovative feeding strategies:

- ✓ Ca forms & levels in diet
- ✓ Supply dynamics during the day (“chrono-nutrition”)

Thank you for your attention!



Thank you to EAAP team!



- Organising committee
- Scientific committee
- Session chairs



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***Online prototype
(in French)***

