Using a dairy cow model to interpret in vivo individual data and to upscale results at herd level through *in silico* experiments

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Extended lactation

- Milk yield (MY) ↑ in the last decades => extended lactation (EL)

- EL : the cow is rebreed later in her lactation. Objectives:
  - ✓ maintain the lactation > 10 months
  - ✓ facilitate rebreeding
  - ✓ and a lower milk yield at the time of drying-off

- Need of more information about EL but
  - ✓ experiments are time consuming
  - ✓ number of animals are restricted

⇒ Prediction models to give output of a management in terms of production and reproduction in a short time.

⇒ GARUNS model (Martin and Sauvant 2010)

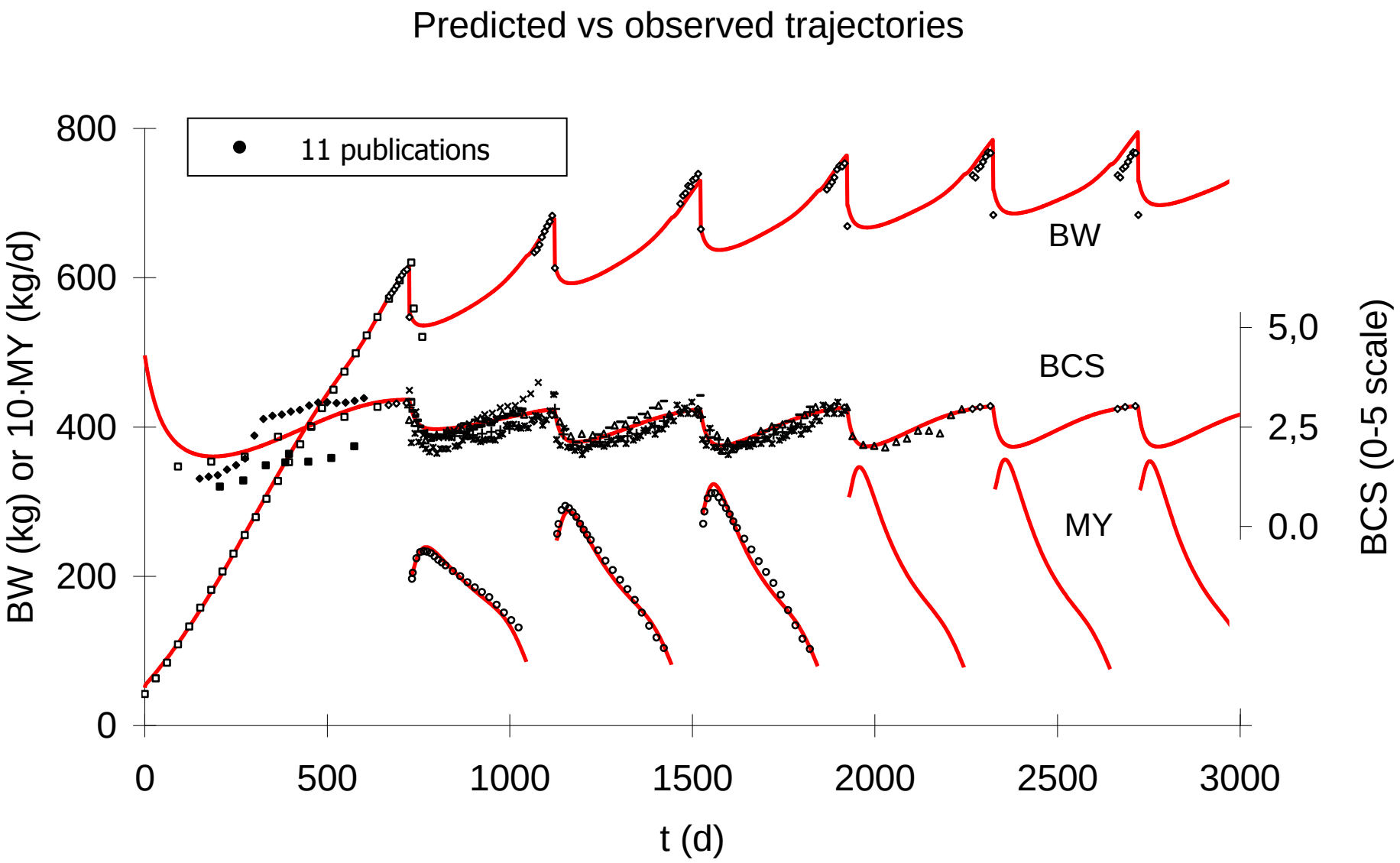
Objectives

1) to determine if GARUNS is able to fit individual curves of milk yield, BW, BCS, DMI, milk fat, milk protein, milk lactose, of cows managed for **16 months lactation**

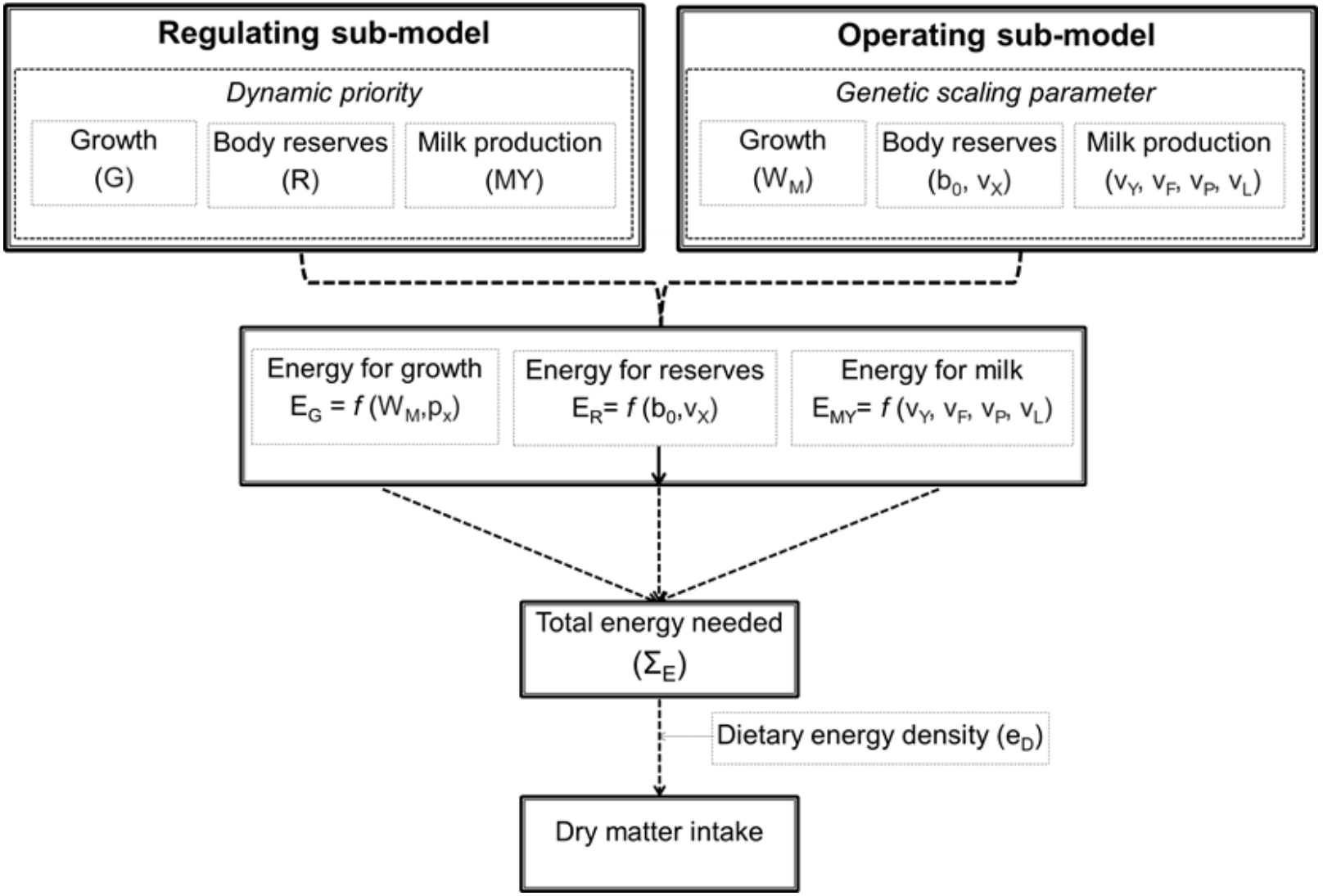
2) to simulate individual variability in milk yield, milk compositions and body weight, and

3) to predict which lifetime scenarios will be beneficial, in terms of performance and reproduction, regarding the lactation number and length (10 or 16 months lactation) as well as the energy density in the ration

GARUNS model (Martin and Sauvant 2010)



Schematic diagram of the GARUNS model



Data

- Experimental trial on extended lactation conducted from 2012 to 2015 at the Danish Cattle Research Centre in Aarhus University (Denmark):
  - ✓ 62 Holstein cows
  - ✓ 30% first parity cows
  - ✓ Automatic milking robot
  - ✓ Fed *ad libitum* partially mixed ration
  - ✓ Energy density ~ 11.8 MJ ME/kg DM

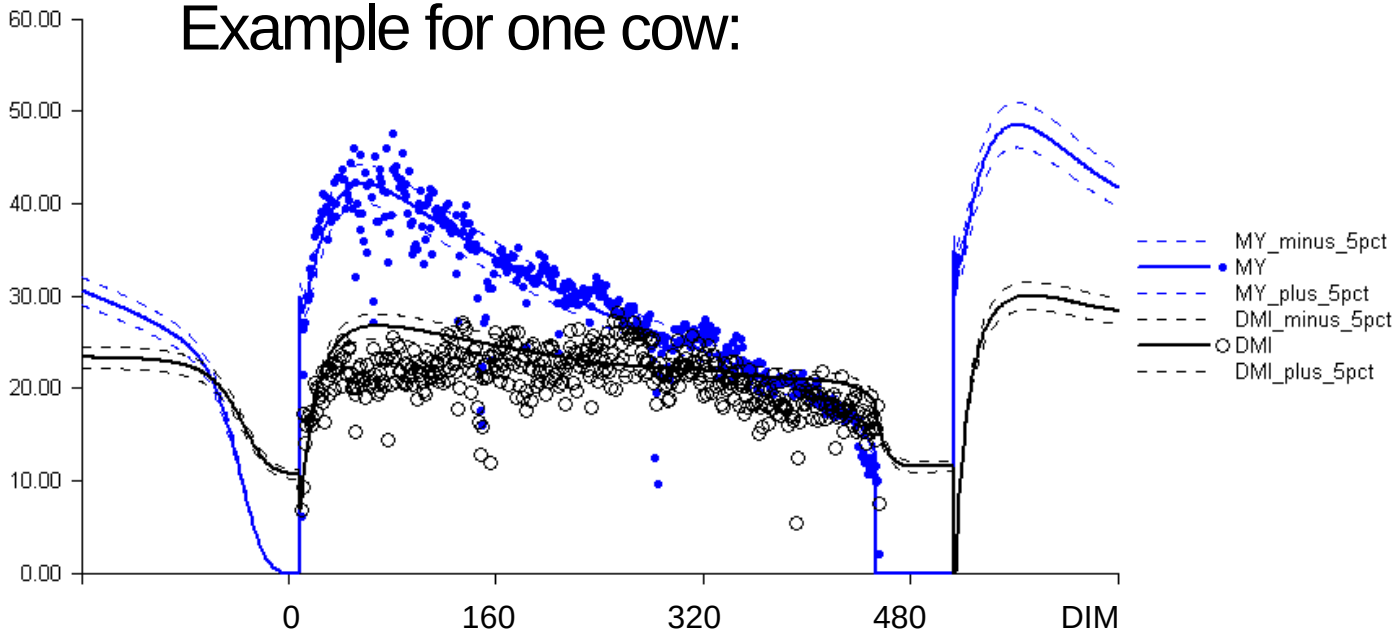
- Records: insemination and parturition times, diet energy, BW, BCS, DMI, MY, and milk composition.

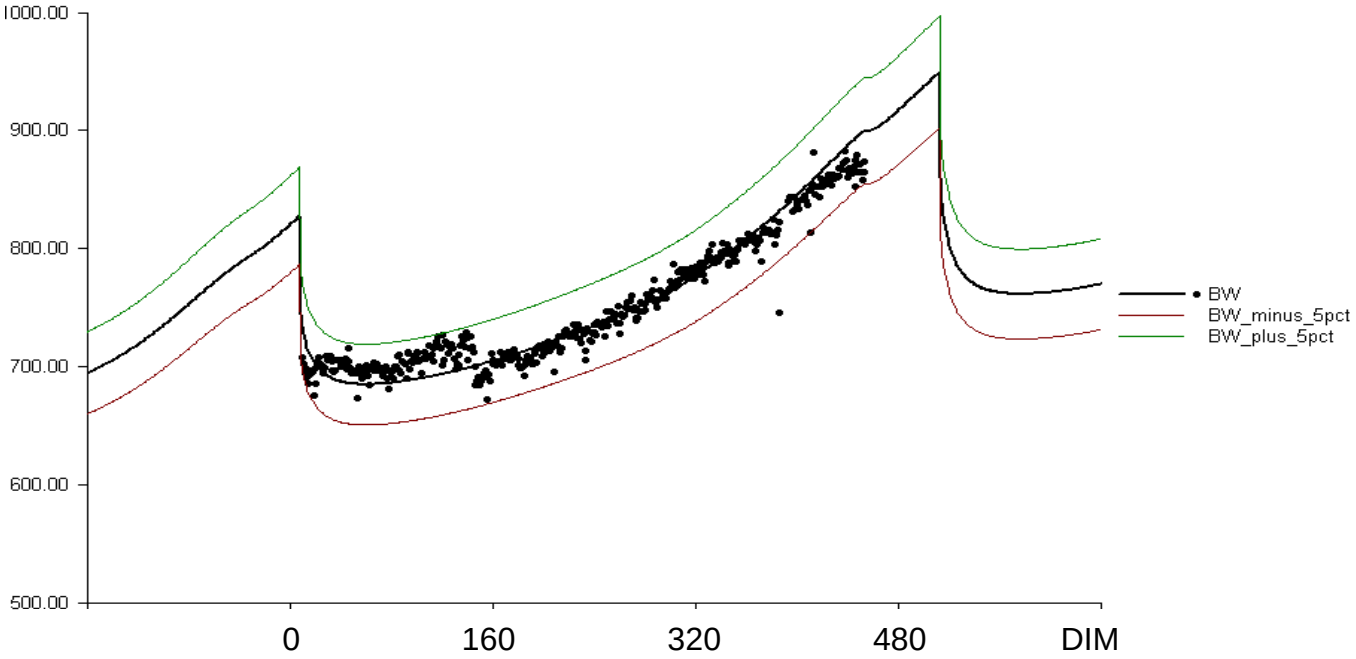
Fitting procedure

- Fitting on individual cow data with a step-by-step fitting procedure

- Each of the 62 cows characterized by an adjusted version of the model with a specific set of 12 parameters.

Example for one cow:





Results fitting

Parameter	Description	Mean	sd
w_M	Mature size	543.8	50.0
μ_Y	Level of production	1.4	0.2
λ_0	Persistency	0.001	0.0006
v_L	Milk lactose secretion	0.99	0.01
v_F	Milk fat secretion	1.1	0.11
v_P	Milk protein secretion	1.04	0.07
v_X	Ability of mobilizing	1.4	0.8

$\Rightarrow$ **GARUNS can be used to fit extended lactation curves**

Results comparison EL and N

		Extended lactation		Normal lactation*		T test
Parameter	Description	Mean	sd	Mean	sd	P value
w_M	Mature size	543.8	50.0	521	59	0.07
μ_Y	Level of production	1.4	0.2	1.25	0.25	0.004
λ_0	Persistency	0.001	0.0006	0.0017	-	-
v_L	Milk lactose secretion	0.99	0.01	1.0	0.04	0.03
v_F	Milk fat secretion	1.1	0.11	1.2	0.1	0.02
v_P	Milk protein secretion	1.04	0.07	1.0	0.1	0.56
v_X	Ability of mobilizing	1.4	0.8	1.2	0.6	0.08

* Phuong et al. 2015. Deriving estimates of individual variability in genetic potentials of performance traits for 3 dairy breeds, using a model of lifetime nutrient partitioning. Journal of Dairy Science 98, 618-632

- Small significant differences in level of production
- Different groups, years, energy density diet (11.8 MJ ME for EL vs. 11.1 MJ ME in Normal)

⇒ Delayed conception and later gestation is the main effect on the lactation shape for EL relative to Normal

Prediction for different management scenarios

- Virtual herd of 1000 cows created with rnorm (R) from the previous parameters

- Virtual herd managed for different life scenario involving the length of the lactation:

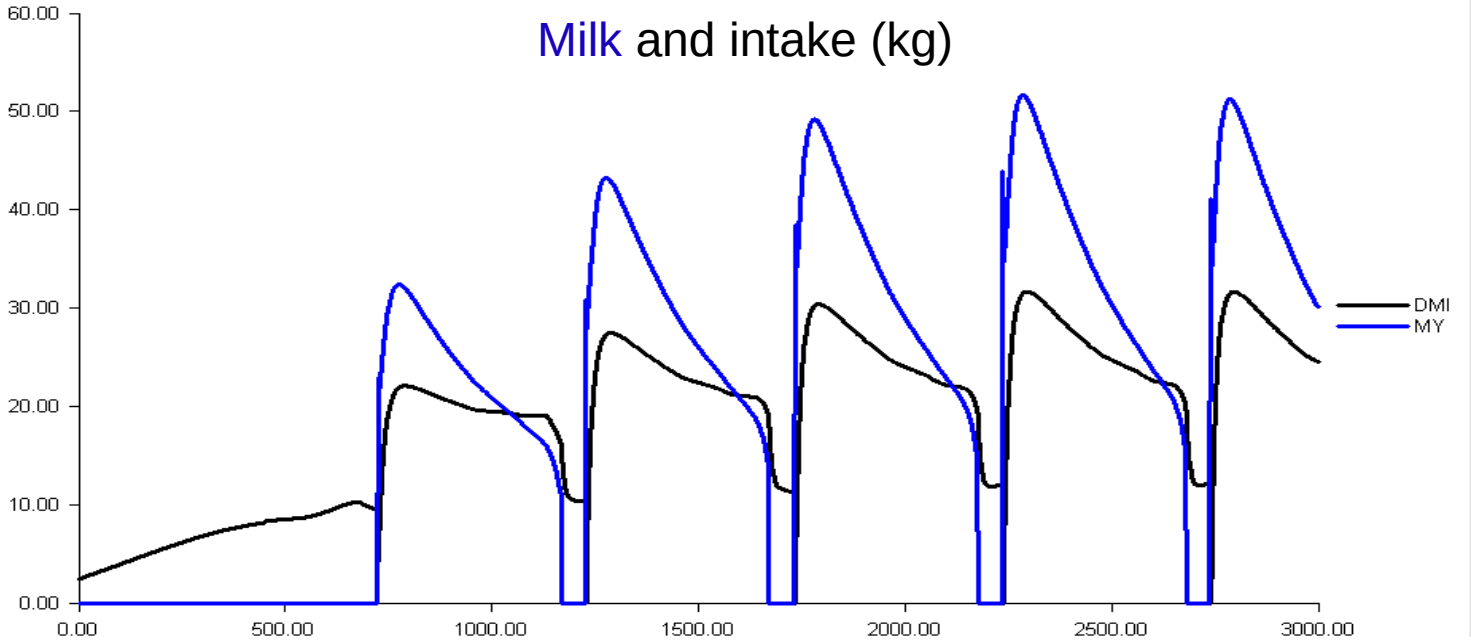
Scenario	PCl[0]	PCl[1]	PCl[2]	PCl[2]	PCl[4]	PCl[5]	PCl[6]	PCl[7]
EL	450	**224**	**224**	**224**	**224**	**224**	**224**	**224**
N	450	60	60	60	60	60	60	60
PEL	450	**224**	60	60	60	60	60	60
PN	450	60	**224**	**224**	**224**	**224**	**224**	**224**

PCI[0] age at first conception

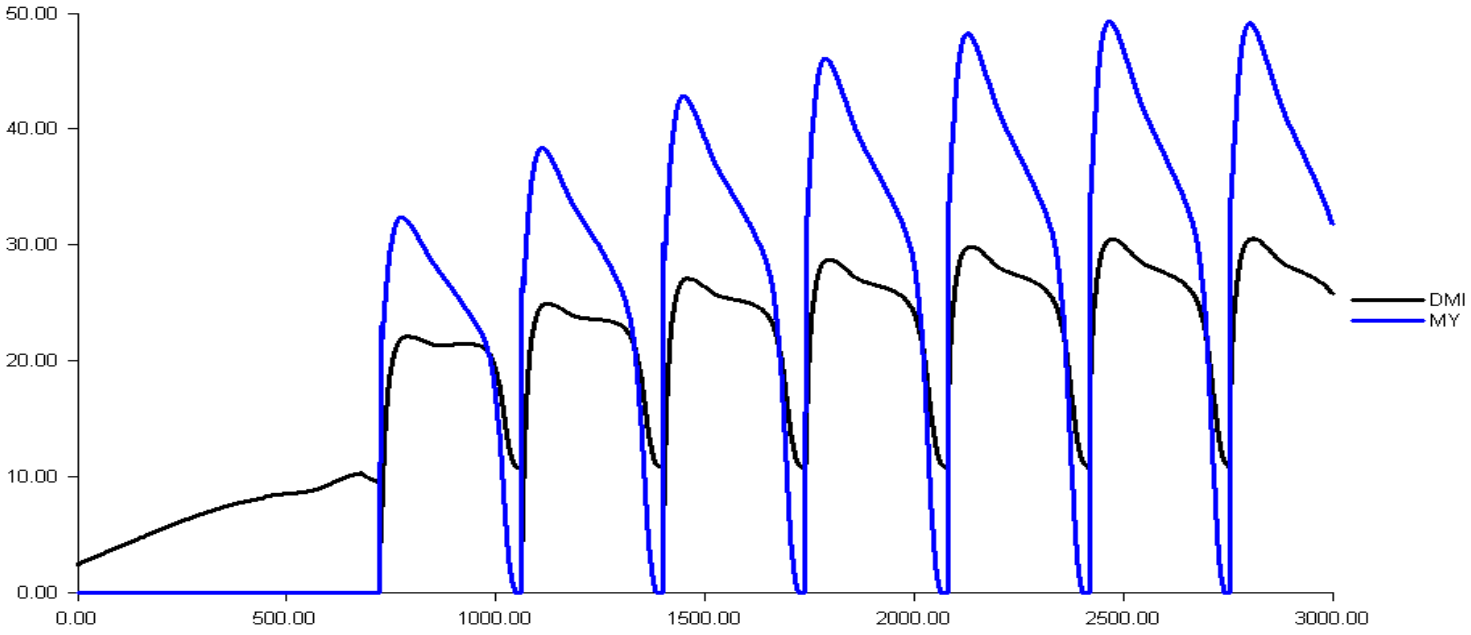
PCI[c] parturition to conception interval, where c is reproductive cycle number

Milk and intake (kg)

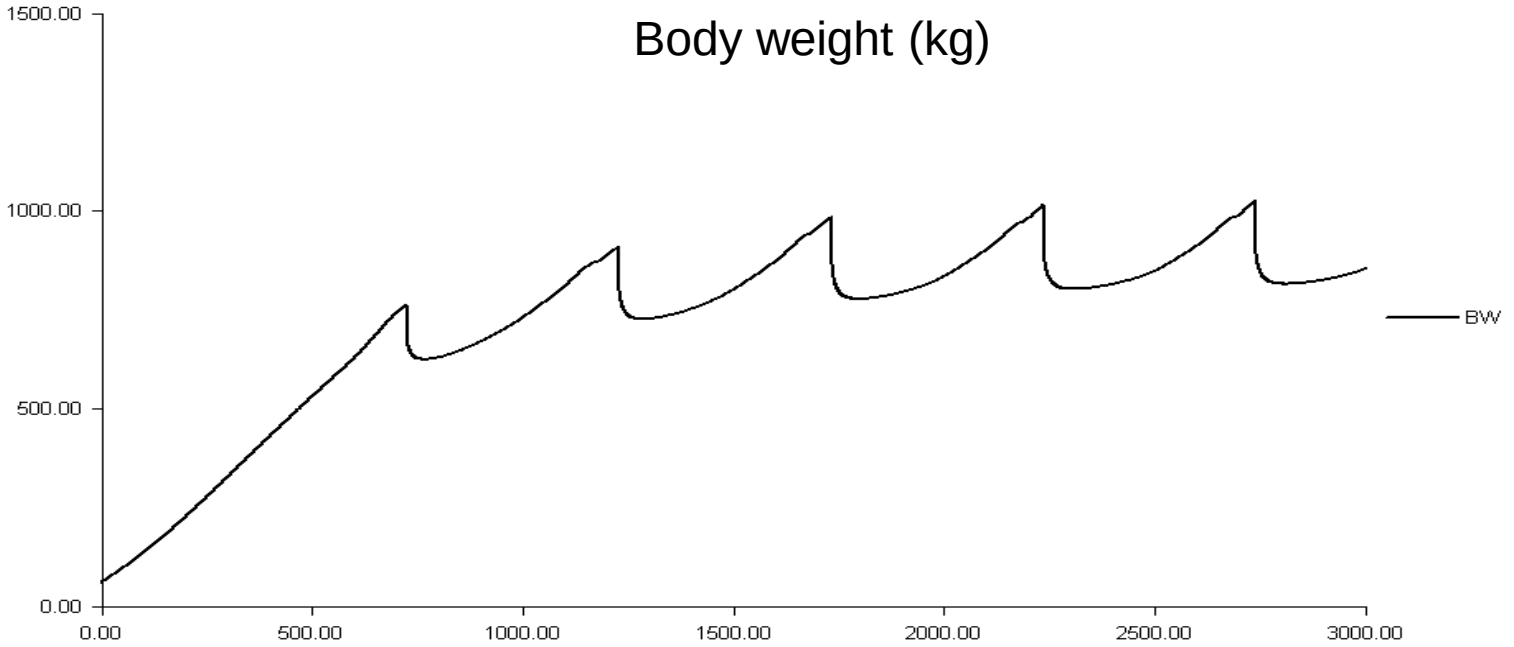
EL



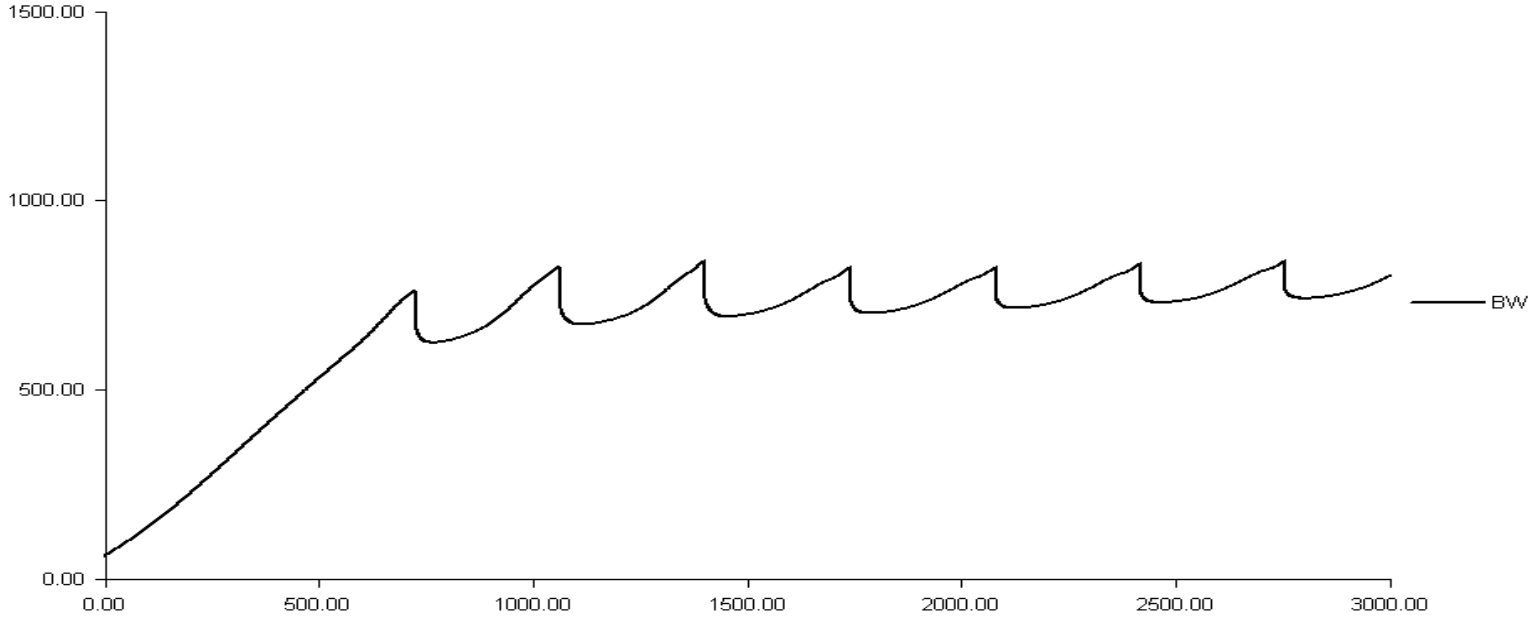
N



EL


Body weight (kg)
1500.00
1000.00
500.00
0.00
0.00
500.00
1000.00
1500.00
2000.00
2500.00
3000.00
BW

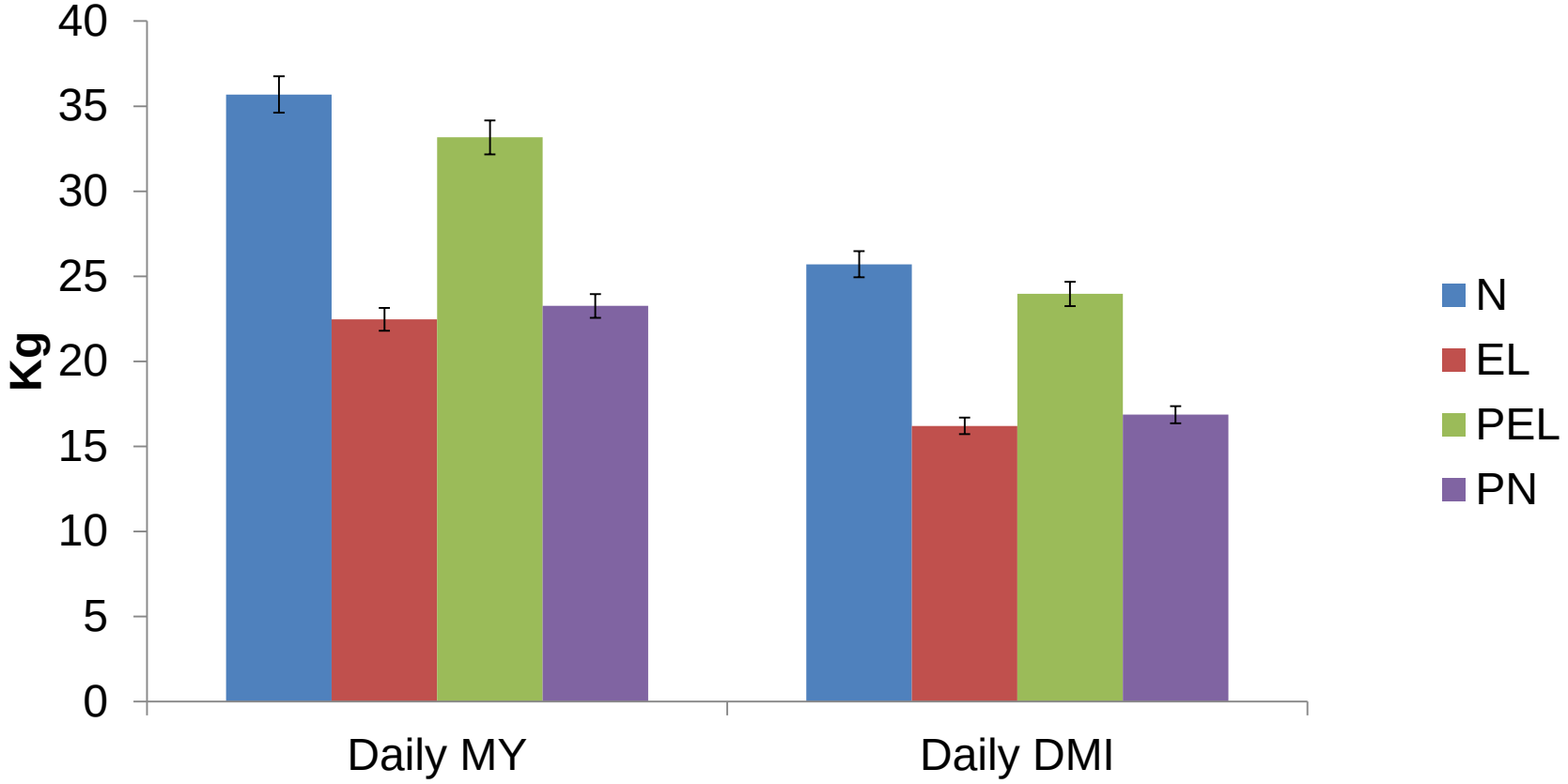
N


1500.00
1000.00
500.00
0.00
0.00
500.00
1000.00
1500.00
2000.00
2500.00
3000.00
BW

Preliminary results

Differences regarding daily MY and DMI

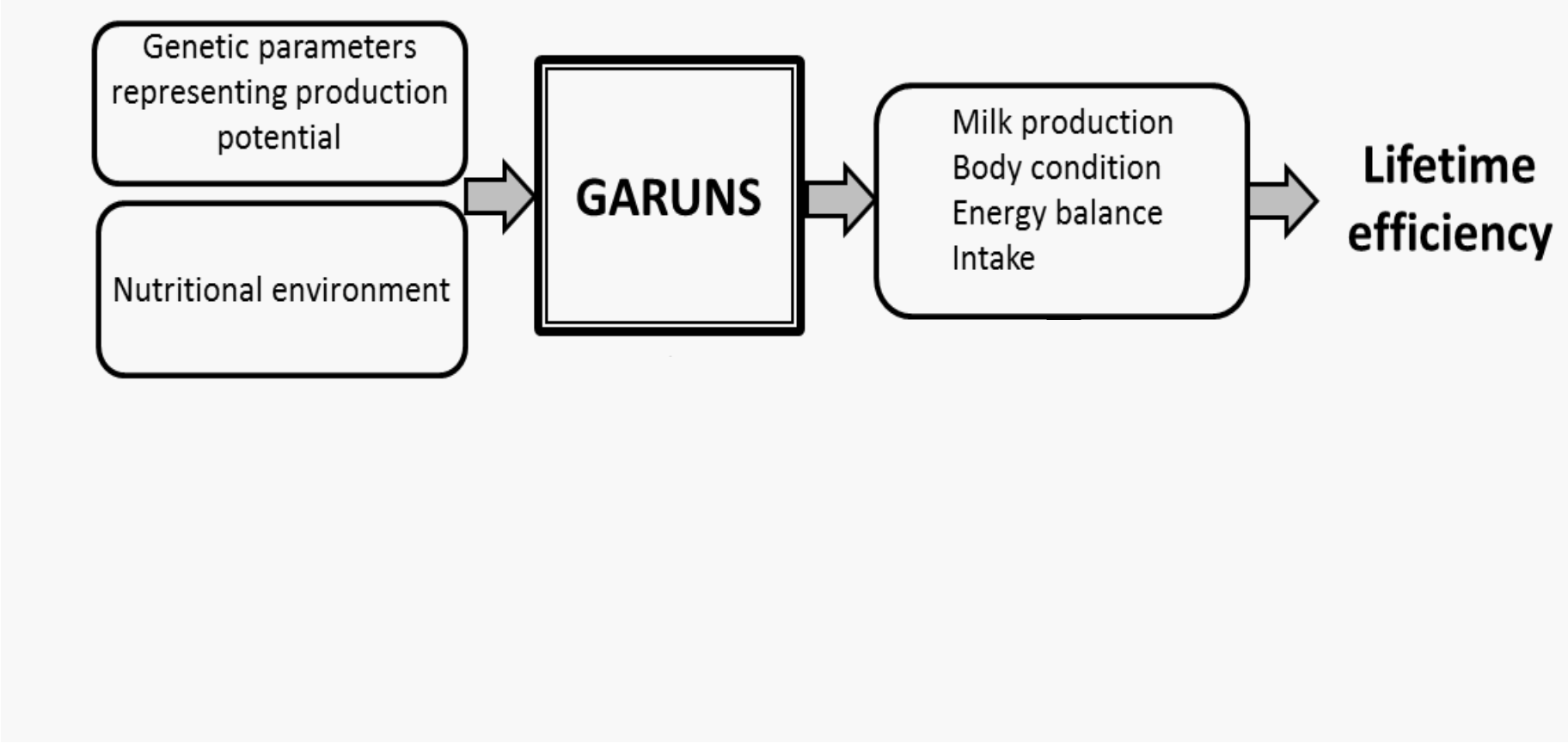
> it shows that **N > PEL > > PN > EL**



⇒ EL for primiparous cows seems interesting

Next steps …

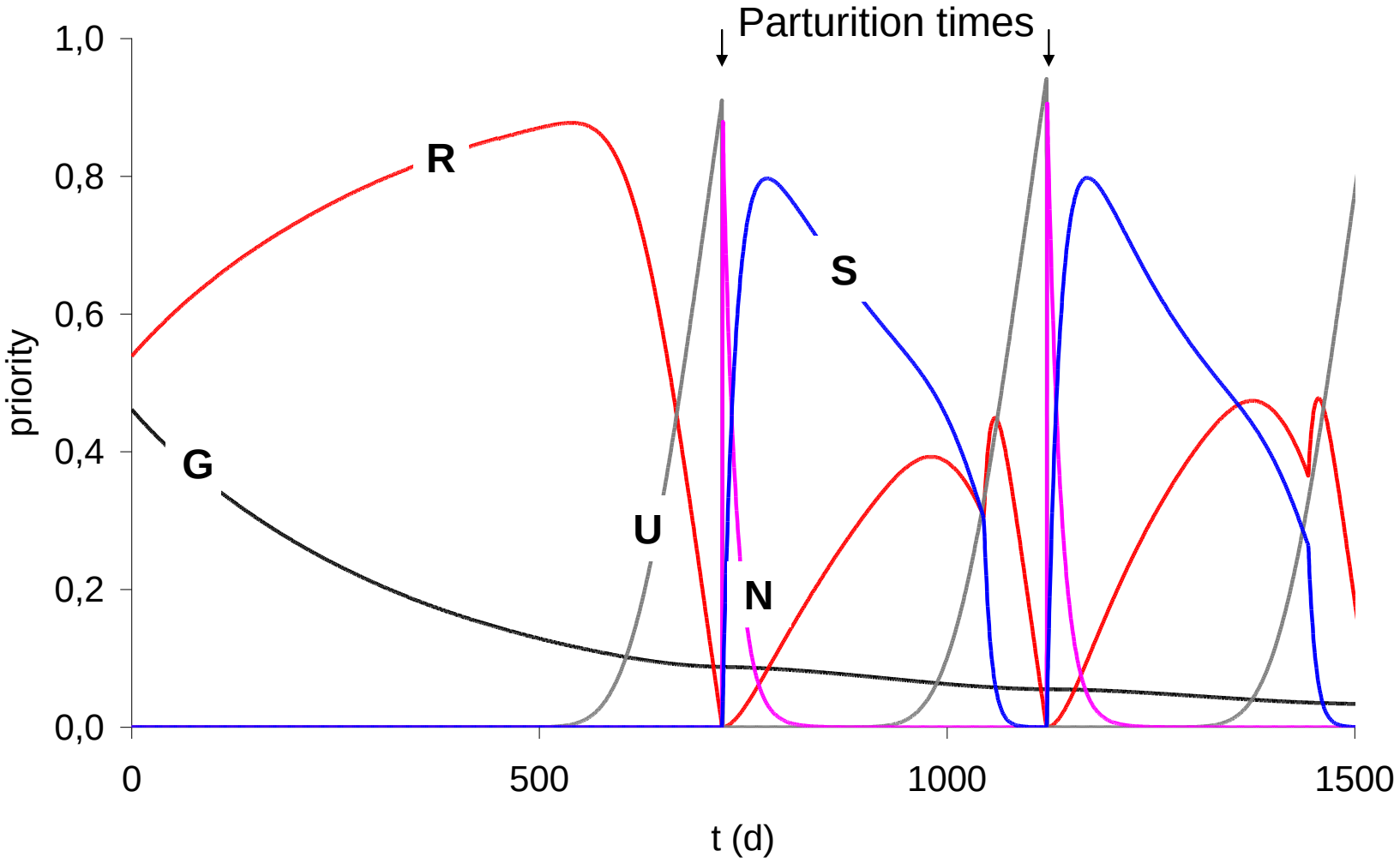
- A reproductive module to adjust productive lifespan for the effects of performance on reproductive success



Thank you for your attention!

Relative priorities: GARUNS model

(Martin and Sauvant, 2010)



Results comparison EL and N

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Parameter	Description	Mean	sd	Mean	sd
w_M	Mature size	543.8	50.0	521	59
μ_Y	Level of production	1.4	0.2	1.25	0.25
λ_0	Persistency	0.001	0.0006	0.0017	-
y_N	Start of the lactation	0.68	0.27	-	-
Uwea	End of the lactation	3.7	1.2	-	-
γ	End of the lactation	0.79	0.38	0.032	-
v_L	Milk lactose secretion	0.99	0.01	1.0	0.04
v_F	Milk fat secretion	1.1	0.11	1.2	0.1
v_P	Milk protein secretion	1.04	0.07	1.0	0.1
v_X	Ability of mobilizing	1.4	0.8	1.2	0.6
ϕ	Weight of uterus/fetus	0.58	0.02	0.58	-

* Phuong et al. 2015. Deriving estimates of individual variability in genetic potentials of performance traits for 3 dairy breeds, using a model of lifetime nutrient partitioning. Journal of Dairy Science 98, 618-632

Preliminary results

Over **8 lactations**

> no differences in total MY and total DMI