Development of a daily stochastic dynamic dairy simulation model including the 12 traits in the Net Merit index

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Our main objective was to incorporate 12 different genetic traits of economic interest for each individual animal in an existing dynamic, stochastic dairy simulation model. **Specific objectives** were simulation of:

A. True Breeding Values
B. Environmental Components
C. Phenotypic Performance
D. Estimated Breeding Values

A. True Breeding Values (TBV)

- $TBV_{ik} = ½ (TBV_{sk} + TBV_{dk}) + √(0.5*(1-(F_s+F_d)/2)) * m_{ik}$, for each animal (i) with sire (s) and dam (d) for each trait (k). m_{ik} was the Mendelian sampling effect for k^{th} trait of the animal i. F_s and F_d were the inbreeding coefficient of the sire and the dam respectively.
- TBV_{sk} and TBV_{dk} were computed by multiplying 12 * 12 Cholseky decomposed genetic covariance matrix from table 1, times a 12 * 1 matrix of inverse of random numbers (~ N(0, 1)).

B. Environmental Components

- The Cholesky decomposition of the environmental covariance matrix (12 by 12) multiplied by a 12 * 1 matrix of inverse of random numbers (~ N(0, 1)) yielded environmental component for each of the twelve traits (from Table 1).
- Environmental component was split into a permanent (PERM) and a temporary (DAILY) component.

C. Phenotypic performance

- Phenotypes were based on a) average herd performance and b) phenotypic deviation (ΔP).
- ΔP = TBV + PERM + DAILY.
- In the dairy model, a cow's production, fertility and survival risk depended on ΔP, as well as on herd performance.

D. Estimated Breeding Values (EBV)

- EBV is used for selection decisions.
- EBV_{ik} = Norm.Inv (Corr. $Rand_{tk}$, $condMean_{ik}$, $condStd_{ik}$) * $corr_{EBVk\ vsTBVk}$
  where Corr. $Rand_{tk}$ was the correlation between the random number used for estimation of a trait k to a 13^{th} random number (t), $condMean_{ik}$ = $TBVMean_{pk}$ + $corr_{EBVk\ vsTBVk}$ * (TBV_{ik} - $TBVMean_{pk}$), $condStd_{ik}$ = √ (1- Reliability) * Std_k and $TBVMean_{pk}$ is the average TBV of animals in each parity (p) for each trait (k) at the start of the updating day. ($corr_{EBVkvsTBVk}$) was the correlation between the EBV and TBV of each trait k.

Illustration of Model Behavior

- Simulation of 1000 cow dairy herd, 100 replicates.
- Monthly removal of 20% surplus young females based on either lowest EBV of milk or lowest EBV of fertility (DPR).

Table 1. Genetic (above diagonal) and phenotypic correlations between twelve traits

	Traits												Units
	Milk	Fat	Protein	PL	SCS	Body size	Udder	Feet/legs	DPR	HCR	CCR	CA$	
Milk	**1.00**	0.43	0.83	0.10	0.02	-0.10	-0.10	-0.02	-0.23	-0.03	-0.16	0.19	Kilogram
Fat	0.69	**1.00**	0.59	0.15	-0.09	-0.07	-0.07	0.01	-0.15	0.03	-0.10	0.13	Kilogram
Protein	0.90	0.75	**1.00**	0.13	0.04	-0.17	-0.14	-0.01	-0.18	-0.07	-0.15	0.22	Kilogram
PL	0.15	0.17	0.16	**1.00**	-0.45	-0.27	0.18	0.14	0.64	0.32	0.62	0.40	Months
SCS	-0.10	-0.10	-0.10	-0.40	**1.00**	-0.07	-0.23	-0.15	-0.27	-0.12	-0.25	-0.14	Log
Body size	0.06	0.05	0.05	-0.20	-0.11	**1.00**	0.45	0.38	-0.12	-0.02	-0.15	-0.16	Composite
Udder	-0.02	-0.05	-0.06	0.15	-0.30	0.45	**1.00**	0.45	0.09	0.03	0.04	0.10	Composite
Feet/legs	-0.14	-0.11	-0.18	0.08	-0.02	0.35	0.40	**1.00**	0.03	-0.01	-0.04	-0.01	Composite
DPR	-0.10	-0.10	-0.10	0.20	-0.05	0.00	0.00	0.00	**1.00**	0.41	0.87	0.35	Percent
HCR	-0.05	-0.05	-0.05	0.10	-0.04	-0.02	-0.05	-0.05	0.10	**1.00**	0.54	0.16	Percent
CCR	-0.10	-0.10	-0.10	0.40	-0.20	-0.10	0.03	-0.04	0.70	0.45	**1.00**	0.34	Percent
CA$	0.02	0.02	0.02	0.20	-0.03	-0.10	0.00	-0.02	0.09	0.16	0.20	**1.00**	Dollars

Table 2. Change in average TBV in a decade and phenotypes at end of simulation for cows

	Milk	DPR
Milk	1103	901
Fat	54	50
Protein	36	32
PL	10.05	10.65
SCS	-0.55	-0.59
BodySize	-1.50	-1.51
Udder	0.41	0.51
Feet Legs	0.75	0.80
DPR	2.91	4.31
HCR	1.32	1.88
CCR	1.56	2.83
CA$	43.31	44.26
NM$	1183	1161
Pregnancy rate	30.09%	31.47%
Days open	115	112
Milk yield/cow/yr	12577	12395
Profit/cow/yr	1163	1116
Annual cull rate	34%	35%

Outlook and future work

- Evaluation of dairy herd reproductive programs on genetic progress and profitability.