USDA Milk Study: Analyzing the Association of Milk Production and Calf Growth

Oliver Titus

Department of Statistics, University of Nebraska-Lincoln

Background

- With reduced land available for grazing, and high production costs, cow herd production efficiency must increase to meet the projected increase in beef consumption .
- Selection for growth-oriented traits including milk production has been a focus in the beef industry in order to maximize output [2].
- As milk production potential increases in cows, cow maintenance requirements during gestation and lactation increase [1].
- Energy requirements for high milk cows required 11% more energy to support an increased level of milk production compared to low milk cows [1].

Objective

- Determine the impact of milk production level on cow/calf performance.
- Cow calf performance measures include cow body weight, body condition score, as well as calf weights.

Data

- Data included 30 cow/calf pairs for each herd: March 2020, May 2020, March 2021, and May 2021.
- The AUC (30-210 days of lactation) of the estimated milk production was calculated using a trapezoidal summation method.
- Cow body weight and body condition score given at pre calving, pre breeding, breeding, and weaning.
- Calf body weights at birth, 30, 60, 90, and 120 days old and at weaning.

Model

To analyze the association of milk production and calf weight across all time points, a repeated measures linear mixed model was used:

$$y_{ijklmn} = \mu + \delta_i + \gamma_j + (\gamma\delta)_{ij} + \alpha_k + (\alpha\delta)_{ik} + \beta_{1i}x_l + \beta_{2i}x_m + \psi_n + \epsilon_{ijklmn}$$

where,

- y_{ijklm} is the calf weight at the ith date, for jth calf sex, at kth cow age, for lth calving date, for mth milk AUC, and nth season/year,
- μ is overall intercept,
- δ_i is the effect of ith day the calf was weighed,
- γ_j is the effect of jth gender of calf,
- $(\gamma\delta)_{ij}$ is the interaction of ith day and jth gender,
- $\alpha_k$is the effect of kth cow age,
- $(\alpha\delta)_{ik}$ is the interaction effect of ith day and kth cow age,
- β_{1i} is the linear regression coefficient for calving date at ith day,
- $\beta_{2i}m$ is the linear regression coefficient for milkAUC at ith day,
- x_l is the calving date at lth date,
- x_m is the milkAUC at the mth level of milkAUC,
- ψ_n is a random effect of nth season/year,
- ϵ_{ijklmn} is the residual,
- $\psi_n \sim N(0, \sigma^2_\psi)$,
- $\epsilon_{ijklmn} \sim N(0, \sigma^2_e)$.

Because the spacing of the measures were not equal, only the unstructured and ANTE(1) covariance structures were considered.

Unstructured was the best covariance structure based on the fit statistics (AIC, AICc, and BIC).

Five univariate modes were also fit to compare the results with the repeated measures model.

Univariate Results

Solutions for Fixed Effects (univariate models)

Effect	Estimate	Standard Error	DF	t Value	Pr > |t|
milkAUC at birth	-0.00213	0.001952	109	-1.09	0.2769
milkAUC at day 30	0.01808	0.004626	108	3.91	0.0002
milkAUC at day 60	0.02377	0.005416	109	4.39	<.0001
milkAUC at day 60	0.1476	0.05500	109	2.68	0.0084
milkAUC at day 90	0.03434	0.006955	109	4.94	<.0001
milkAUC at day 120	0.04043	0.008074	109	5.01	<.0001
milkAUC at weaning	0.04956	0.009792	109	5.06	<.0001

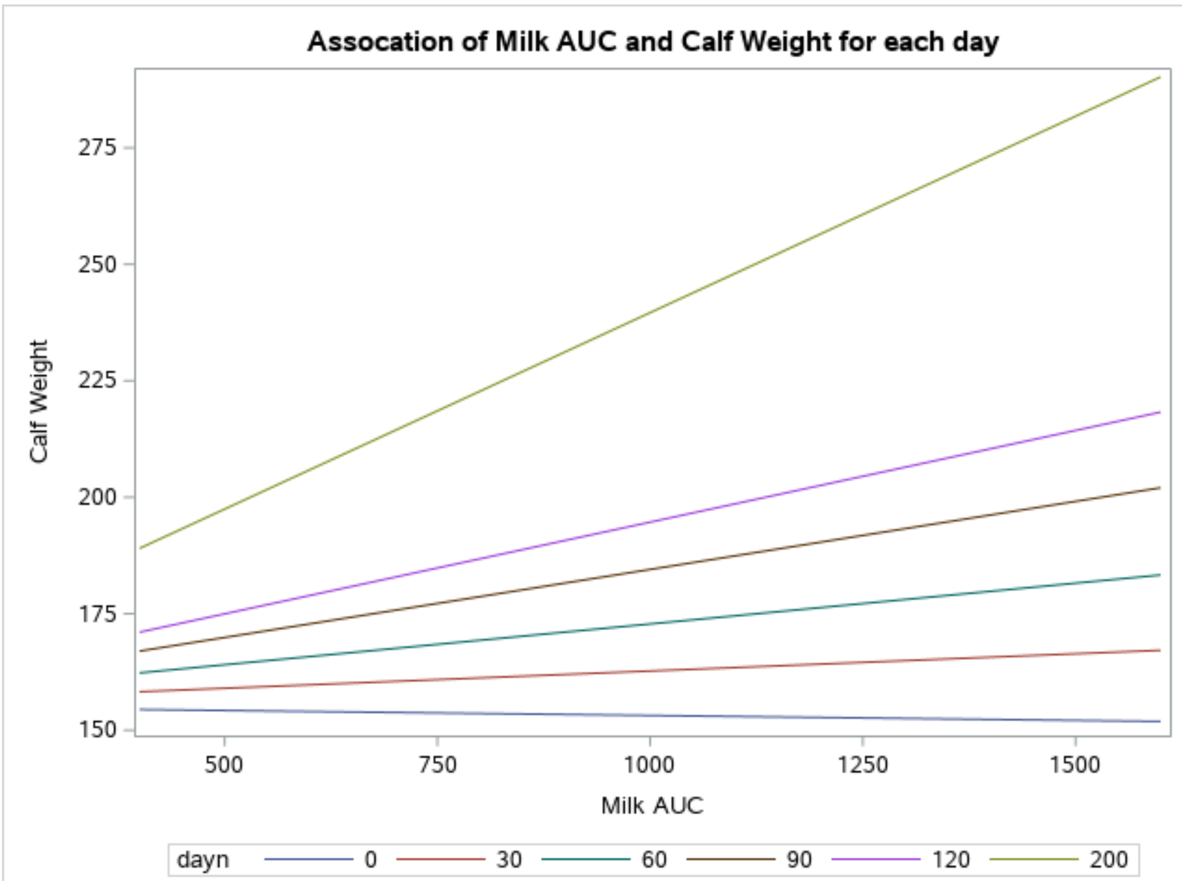
Repeated Measures Results

Type I Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
dayn	5	112	2946.19	<.0001
calfsex	1	112	2.48	0.1183
calfsex*dayn	5	112	2.46	0.0371
cowagen	2	112	1.85	0.1621
cowagen*dayn	10	112	1.34	0.2162
cdate	1	112	1.32	0.2525
cdate*dayn	5	112	8.41	<.0001
milkAUC	1	112	24.13	<.0001
milkAUC*dayn	5	112	16.01	<.0001

Solutions for Fixed Effects

Effect	calfsex	cowagen	dayn	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept				155.30	14.3149	112	10.85	<.0001
milkAUC				0.08432	0.01156	112	7.29	<.0001
milkAUC*dayn			0	-0.08645	0.01091	112	-7.93	<.0001
milkAUC*dayn			30	-0.07691	0.01481	112	-5.19	<.0001
milkAUC*dayn			60	-0.06681	0.01514	112	-4.41	<.0001
milkAUC*dayn			90	-0.05511	0.01378	112	-4.00	0.0001
milkAUC*dayn			120	-0.04496	0.01299	112	-3.46	0.0008
milkAUC*dayn			200	0	.	.	.	.



Conclusions

- Overall, there was a significant positive association of milkAUC with calf weight. The association was positive for all time points, except for at birth which showed a slight negative association.
- Univariate model did not capture the significant negative association between milkAUC and calf weight at birth.
- Repeated measures model provides more accurate estimates since it accounts for the correlation for each time the calf was weighed.
- Univariate models were fit for the cow body weight and body condition scores, but there was no significant association between these variables and the milkAUC.

Future Directions

- Fitting a repeated measures model with average daily calf weight gain as the response variable.
- Running repeated measures models for cow body weights and body condition score.
- Analysis of other data sets including a grazing behavior dataset, as well as an acetate challenge dataset.

Consulting Reflection

- Most challenging aspects of the consulting experience: trying to gather all relevant information from the initial meetings.
- My favorite parts of the consulting experience: being able to learn about different areas of research and being given the opportunity to solve different types of problems.

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References

[1] Montaño-Bermudez, M., Nielsen, M. K., & Deutscher, G. H. (1990). Energy requirements for maintenance of crossbred beef cattle with different genetic potential for milk. *Journal of Animal Science*, 68(8), 2279-2288.

[2] Mulliniks, J. T., Beard, J. K., & King, T. M. (2020). Invited review: effects of selection for milk production on cow-calf productivity and profitability in beef production systems. *Applied Animal Science*, 36(1), 70-77.