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USING FOETAL AGE ESTIMATES TO SUBSTITUTE BIRTH DATE RECORDING IN BEEF CATTLE EVALUATIONS

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SUMMARY

We investigated whether foetal age estimates can be used in beef cattle evaluations, primarily as the substitute for birth dates when applying pre-adjustment for the analyses of growth traits. By comparing different models that involve age calculated with conception dates (i.e., inferred based on the foetal age) and birth dates, we found that foetal age estimates can be used to adjust weaning weights without undermining the goodness of fit of statistical models.

INTRODUCTION

Birth dates are used in beef cattle evaluations for several purposes, including as fixed-effect age adjustments for early life traits (e.g., weights, carcase scans) and as part of the definition of traits for fertility (e.g., days to calving/calving date) and gestation length (Graser *et al*. 2005). Due to logistical challenges and labour requirements, data for birth dates are often unavailable from commercial (non-seedstock) herds. This, together with the lack of pedigree information, is one of the key limiting factors preventing wider utilisation of data from commercial herds in genetic evaluations.

An alternative is to use ultrasound scans to determine foetal age during early pregnancy, to estimate conception date (Beal *et al*. 1992). This can be combined with pedigree information (specifically dam-calf match, obtained using genomics) to provide an estimate of age of the calf from conception (rather than from birth) without any observations at calving. An argument can be made that date of conception, if known with sufficient accuracy, could potentially be an alternative to account for variation in weight due to age rather than birth date. The calf has a growth trajectory from conception, and birth date represents the switch from pre-natal to post-natal growth which may or may not be a significant point of inflexion on the growth curve. An immediate question is whether conception dates can be used to replace birth dates in genetic analyses, especially in genetic evaluations of growth.

Animals that were bred by artificial insemination (AI) may have different birth dates even though their conception dates are known to be the same. Consequently, these animals should have the same age from conception (AfC) but slightly different age from birth (AfB). In practice, one common approach is to pre-adjust weaning weights (WWs) based on AfB, where the WWs of calves with different AfB are projected onto the same linear model. Now, provided that AI-sired animals were conceived on the same dates (with identical AfC), it is questionable whether applying such pre-adjustment still makes sense.

To address these two questions, we analysed a small data set with both birth dates and foetal ages available and modelled WWs using age adjustments calculated from birth and conception dates, respectively.

MATERIALS AND METHODS

Data. Foetal age data was collected on 1,151 beef cattle from two New Zealand farms (Table 1). An experienced operator used rectal ultra-sound to age foetuses to approximately 5-day increments, with foetal aging conducted within a window of 42 to 140 days. A subset of 223 calves were bred by AI, and so true conceptions dates of these AI-sired animals are known. Otherwise, for those animals that were bred by natural service (NS), their conception dates were estimated by subtracting the foetal ages from the scan date. Additionally, birth and weaning dates of calves, as well as their WWs, were recorded. Subsequently, age from conception (AfC) and age from birth (AfB) at weaning were determined based on the estimated (or known for AI animals) conception and observed birth dates. Both estimated and observed AfC are highly correlated with AfB ($r = 0.81$ and 0.92). Gestation length (GL), effectively the difference between AfB and AfC, for animals that were bred by AI and NS were almost identical, with means equal to 280.4 and 280.8. Meanwhile, dam information, such as age and management group, was also available. Note that management groups are generally confounded with the age of dam for younger cows (i.e., management groups represented yearling heifers, two-year-old heifers and mixed age older cows).

Table 1. Sample size, mean and standard deviation of foetal age and weaning data collected from animals that were bred by artificial insemination (AI) and natural service (NS)

Calf Year of Birth	**Sample Size**		**Age From Birth**	**Age From Conception**		**Gestation Length**		**Weaning Weight**
	AI	**NS**		**AI**	**NS**	AI	NS	
2015	39	39	189.3 (±13.5)	481 (±0)	470.7 (±13.2)	281.8 (±6.3)	281.3 (±5.1)	217.9 (±30.8)
2018	37	207	202.6 (±15.2)	493.3 (±2.5)	484.1 (±13.7)	280.7 (±10.7)	281.5 (±5.5)	258.4 (±33.0)
2019	35	241	196.4 (±14.5)	485.1 (±1.9)	476.4 (±14.2)	281.4 (±3.9)	280.1 (±5.9)	257.5 (±33.2)
2020	82	183	183.6 (±13.0)	472.9 (±3.1)	462.7 (±11.1)	279.6 (±3.4)	279.2 (±5.7)	254.8 (±32.4)
2021	30	260	188.8 (±14.9)	482.3 (±7.6)	471.1 (±13.9)	280.0 (±4.4)	282.3 (±6.8)	265.6 (±32.8)
Total	223	928	192.3 (±15.9)	480.9 (±8.0)	473.2 (±15.2)	280.4 (±5.8)	280.8 (±6.1)	256.4 (±34.5)

Analyses. Two set of statistical analyses were carried out to study the effects of both age from conception (AfC) and age from birth (AfB) on the scaled WWs (WW_{sc}), by fitting a group of three nested linear models using the data from 1. AI animals only 2. all animals (both AI and NS), such that:

$$WW_{sc} = \beta_0 + \beta_1 CG_{WW} + \beta_2 AGE_{DAM} + \beta_3 AfC + \epsilon \qquad (1)$$

$$WW_{sc} = \beta_0 + \beta_1 CG_{WW} + \beta_2 AGE_{DAM} + \beta_3 AfB + \epsilon \qquad (2)$$

$$WW_{sc} = \beta_0 + \beta_1 CG_{WW} + \beta_2 AGE_{DAM} + \beta_3 AfC + \beta_4 AfB + \epsilon \qquad (3)$$

where CG_{WW} represents the weaning contemporary group (CG_{WW}), defined by the combination of birth year, birth contemporary group ($CG_{BW} = \text{calf year of birth} \times \text{dam herd} \times \text{sex}$), weaning management group (i.e., farm A or B) and the sex of calves (i.e., male and female); scaled weaning weight (WW_{sc}) of each animal is calculated by multiplying raw weaning record by the population average (i.e., 256 kg) and then dividing it by its own contemporary mean; and AGE_{DAM} is the age of dam, with dam aged ten years and above were combined into the same class (i.e., "10+"). Subsequently, hypothesis testing was performed to determine whether there is any significant contribution by each factor, all models were further compared based on the adjusted R-squared values and residual standard errors (RSE).

RESULTS AND DISCUSSION

Results showed that fitting age from birth (AfB) and fitting age from conception (AfC) provided very similar results (Table 2). Including AfB (model 2) explained more variation than including AfC (model 1), but the difference was small. The estimated coefficients associated with AfC from model 1 and AfB from model 2 were very close (1.02 and 0.94). Interestingly, estimated coefficients of AfC and AfB from model 3 seemed to partition the coefficient provided in model 1, even though its standard errors were much higher. In fact, all models performed similarly, with the adjusted R-squared values range from 0.433 to 0.442 and the residual standard error range from 25.93 to 26.13. To summarise, there is only subtle difference between fitting AfC and AfB into the model when analysing WWs, and if AfC is already fitted into the model, little benefit was observed after adding AfB.

For AI animals that were conceived on a known and uniform date within a contemporary group, our results suggest that adding AfC and/or AfB failed to improve the fitted models when analysing WWs, with insignificant p-values associated with both terms (Table 3). Note that the standard errors of these estimated coefficients, especially for AfC (1.16 and 118), are relatively high; also indicating a lack-of-fit. Besides, all three models yielded very similar adjusted R-squared values (0.036 - 0.037) and residual standard error (26.03 - 26.07). In this case, neither AfC nor AfB was significantly contributing towards the predictions of WWs. In this case, applying pre-adjustment based on birth date is likely to introduce bias in the analyses. However, this needs to be further investigated once more data become available.

Although estimated conception dates are prone to measurement errors, its impact on breeding value (BV) predictions should only be noticeable at per individual level. In practice, animals that have an error of ± 5 days within their estimated AfC are likely to receive an estimated BV inflated (or deflated) by approximately half unit (obtained by multiplying the errors within AfC (5 days) to the coefficient of AfC (1.02 from Table 2) and the heritability of weaning weight (0.14, Weik *et al*. 2021). However, such impact is expected to be minimal when predicting sire BVs as errors in AfC are averaged out across multiple progenies. Overall, AfC should be considered as a practical alternative to AfB for pre-adjustment in genetic evaluations for beef cattle.

Table 2. Analyses of weaning weights (all animals) using different models that incorporate age from conception (AfC) and age from birth (AfB)

Model	Coefficient		*p*-value		Adjusted R-squared	Residual Standard Error
	AfC	AfB	AfC	AfB		
1	1.02 (± 0.06)	-	< 2e-16	-	0.221	26.13
2	-	0.94 (± 0.06)	-	< 2e-16	0.227	26.02
3	0.45 (± 0.15)	0.57 (± 0.13)	0.0027	1.61e-5	0.232	25.93

Table 3. Analyses of weaning weights (AI animals only) using different models that incorporate age from conception (AfC) and age from birth (AfB)

Model	Coefficient		*p*-value		Adjusted R-squared	Residual Standard Error
	AfC	AfB	AfC	AfB		
1	0.56 (± 1.16)	-	0.626	-	0.036	26.06
2	-	-0.25 (± 0.32)	-	0.438	0.037	26.03
3	0.77 (± 1.18)	-0.29 (± 0.33)	0.513	0.373	0.036	26.07

CONCLUSION

In this study, we compared different models to investigate whether it is feasible to use foetal age estimates in beef cattle evaluations. Our results showed that conception dates, inferred from foetal age data, could effectively substitute birth dates in the analyses of weaning weights. Moreover, careful consideration should be given if using birth dates to pre-adjust traits where animals are conceived on the same day (e.g., from fixed time AI programs), as applying pre-adjustments may introduce rather than reduce unwanted variation.

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