Predicting carcass quality associated with variation in growth path of crossbred cattle

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Abstract

Body weights and carcass quality traits: hot carcass weight (HCWt), fat depth (P8), eye muscle area (EMA) and intramuscular fat (IMF) of 1141 heifers and steers from seven crossbreeds were used to to develop equations for predicting carcass quality associated with variation in growth path. The model potentially provides nine outputs: median and mean of carcass quality traits, prediction means, lower and upper confidence as well as prediction intervals of carcass quality traits (95%). Input to the model consisted of sex (heifer and steer), sire breed (Jersey, Wagyu, Hereford, Angus, South Devon, Belgian Blue and Limousin), age (days)-weight (kgs) pairs and slaughter age (500 days for heifer and 700 days for steers). The prediction model was able to accommodate different sexes across seven sire breeds and various post-weaning management groups at any slaughter age. Its strength lies in its simplicity and flexibility required by producers with varying situations.

Introduction

Today, in the beef industry, it is a challenge to design the “best” management strategy for individual breeder, backgrounder and finisher operations to get optimum end products under different circumstances. In the face of these issues, it is suggested to develop the flexible and feasible models to predict carcass quality resulting from specific growth path under a variety of management regimes that consequently lead to those cattle to be marketed at the optimum time. Many attempts have been made in developing beef cattle growth and body composition models (Keele et al., 1992 and Williams et al., 1995 and Hoch and Agabriel, 2004). However, so far the empirical models to predict carcass quality based on the longitudinal body weights at various stages of growth have not been published. Thus, the objective of this study was to develop an empirical model to predict carcass quality traits of crossbred steers and heifers given a growth path.

The Model

A successful prediction of the carcass quality following specific growth path requires estimation of variation in growth traits, carcass traits and association between both of them over growth path.

Consider the growth and carcass traits both modelled on the log-scale. The underlying normal distribution used in the modelling mean that if $\mathbf{y}_w$ is log-weight for an animal and $\mathbf{y}_c$ is the log-carcass quality

$$\begin{bmatrix} y_w \\ y_c \end{bmatrix} \sim N\left(\begin{bmatrix} \mu_w \\ \mu_c \end{bmatrix}, \begin{bmatrix} \Sigma_{ww} & \Sigma_{wc} \\ \Sigma_{cw} & \Sigma_{cc} \end{bmatrix}\right)$$

where $\mu_w = E(y_w), \mu_c = E(y_c)$ and Σ_{ww} is the variance-covariance matrix for log-weight, Σ_{cc} is the the variance-covariance matrix for log-carcass traits and Σ_{wc} $(=\Sigma_{cw}{}^T)$ is the cross-covariance matrix between log-weight and log-carcass traits. Of interest is to“predict” y_c given y_w at the first level, this is to consider the distribution of y_w y_c, namely $y_c|y_w \sim N\left(\mu_c + \Sigma_{cw}\Sigma_{ww}{}^{-1}(y_w - \mu_w), \Sigma cc - \Sigma_{cw}\Sigma_{ww}{}^{-1}\Sigma_{wc}\right)$

Thus we can provide an estimate of the mean log-carcass quality by

$$\mu_{cw} = \mu_c + \Sigma_{cw}\Sigma_{ww}{}^{-1}(y_w - \mu_w)$$

We have estimates of μ_c, Σ_{cw}, Σ_{ww} and μ_w from the joint model (Mirzaei et al., submitted). Thus given a growth path specified by y_w, we can estimate the log-carcass traits by

$\hat{\mu}_{cw} = \hat{\mu}_c + \hat{\Sigma}_{cw}\hat{\Sigma}_{ww}{}^{-1}(y_w - \hat{\mu}_w)$. This is also our prediction.

Implementation of the model. With respect to the accessibility and the potential users of the model at this stage, it was decided to implement the model in the R program (2004). The model has three phases, i.e. input of data, calculation of predictions and presentation of the results.

Model input. Input to the model is in four components:

1- Sex, steer (as a default) and heifer, 2- Breed (default is Hereford), H = (Hereford x Hereford), S = (South Devon x Hereford), A = (Angus x Hereford), J = (Jersey x Hereford), B = (Belgian Blue x Hereford), W = (Wagyu x Hereford), L = (Limousin x Hereford), 3- Slaughter age (default is 700 days for Steers and 500 days for Heifers), 4- Age (days)-weight (kgs) pairs

Model results. The model potentially provides nine outputs: median and mean of carcass quality traits, prediction means, lower and upper confidence as well as prediction intervals of carcass quality traits (95%).

Results and discussion

Steers and heifers were alike with respect to breed differences in carcass traits, a result that follows not having sire by growth path interactions in the random effects model. All carcasses of crosses were grouped into heavy and light groups (Table 1).

Table 1. Results for "average scheme" of heifers

	Jersey	Wagyu	Angus	Hereford	Sth Dev	Limousin	Bel Blue
Median of carcass quality traits							
HCWt	186.45	194.19	224.86	213.47	225.73	222.49	230.57
P8	10.11	10.73	13.26	11.4	9.22	9.49	7.79
EMA	68.34	73.24	76.37	72.61	81.16	84.16	90.12
IMF	3.85	3.57	3.81	3.07	3.15	2.59	2.46
Mean of carcass quality traits							
HCWt	186.48	194.22	224.89	213.51	225.77	222.52	230.03
P8	10.14	10.75	13.3	11.43	9.25	9.51	7.81
EMA	68.37	73.26	76.4	72.63	81.19	84.18	90.15
IMF	3.86	3.57	3.82	3.08	3.15	2.6	2.47
Predicted means for carcass quality traits							
HCWt	187.73	195.52	226.4	214.94	227.28	224.01	231.58
P8	11.09	11.76	14.55	12.5	10.12	10.4	8.55
EMA	69	73.94	77.11	73.31	81.94	84.97	90.98
IMF	4.21	3.9	4.17	3.36	3.44	2.84	2.69
Lower prediction interval for carcass quality traits							
HCWt	147.54	153.7	177.92	168.87	178.64	176.09	182.03
P8	4.28	4.54	5.61	4.82	3.91	4.02	3.3
EMA	51.83	55.54	57.91	55.03	61.53	63.82	68.33
IMF	1.65	1.53	1.63	1.32	1.35	1.11	1.06
Upper prediction interval for carcass quality traits							
HCWt	235.62	245.35	284.18	269.84	285.23	281.11	290.61
P8	23.89	25.32	31.34	26.96	21.78	22.4	18.4
EMA	90.12	96.58	100.73	95.8	107.04	110.98	118.85
IMF	8.98	8.31	8.9	7.18	7.34	6.05	5.74
Lower confidence interval for carcass quality traits							
HCWt	180.01	187.74	216.94	205.69	218.06	215.05	222.29
P8	8.78	9.36	11.49	9.81	8.03	8.27	6.8
EMA	64.92	69.57	72.47	68.77	77	79.91	85.53
IMF	3.35	3.11	3.31	2.65	2.73	2.26	2.14
Upper confidence interval for carcass quality traits							
HCWt	193.12	200.86	233.06	221.54	233.67	230.18	237.98
P8	11.65	12.29	15.31	13.23	10.6	10.88	8.94
EMA	71.94	77.1	80.49	76.66	85.54	88.63	94.94
IMF	4.43	4.09	4.4	3.57	3.62	2.98	2.83
Median body weights (kg)							
Birth	32.29	34.72	36.05	38.88	39.3	39.67	39.67
250 days	224.58	225.48	247	245.28	249.5	250.03	250.85
420 days	306.54	303.85	340.7	335.24	344.35	338.47	344.34
500 days	327.96	325.26	366.41	359.94	372.44	363.58	370.6

Belgian Blue, Limousin, South Devon, Angus and Hereford had heavier HCWt and EMA than those of Wagyu and Jersey. Mean of carcass P8 fat was highest for Angus and lowest for Belgian Blue. Carcasses of heifers from Belgian Blue, Limousin and South Devon had less marbling (lower IMF than those of Angus, Jersey, and Wagyu). The same pattern was observed for the domestic and export market values (Table 1). Prediction intervals (0.95%) were wider than the corresponding confidence intervals. Generally, predicted median carcass quality traits of heifers and steers in this study revealed that differences existed between breeds for all traits but the ranking of the breeds within each sex were the same. With respect to breed comparisons, all schemes followed the same pattern of quantity and fat traits for both heifers and steers (Table 1).

Overall, the median and mean values for carcass quality traits were similar. This occurred because as given in, the mean of body weight was E(Body Weight) = $\exp(\mu + \sigma^2 / 2)$ and the median was $\exp(\mu)$. Because the standard error (σ) of estimation based on the log transformation is so small then the `` $\sigma^2 / 2$" term becomes negligible and can be ignored.

Wide prediction intervals were detected for carcass traits, perhaps because the permanent environmental variance for growth and environmental variance (permanent and temporary environmentl) for carcass traits especially fat traits were significant. In the case of fat traits it may be occurred due to large permanent environmental variances and very small covariances between carcass fat traits and body weights.

The issue of error associated with the predictions obtained from the model has three main sources. One source is the stochastic character of the estimated model coefficients, which can be reduced only by gathering more growth data that contains more variation especially during the pre-weaning period. Another source of errors is in the not being estimated some effects of the variables of the models. Since the current model involves a cubic regression model, further research may necessary to develop other methods to overcome this issue.

Implications

The potential of the present model lies in its simplicity to provide a tool by which the producer can assess the impact of possible changes in future management decisions. This approach potentially is very useful if data structure issues well addressed. Still, some topics remain unsolved and need further research.

Therefore, the following activities are proposed; fitting management group nested within sex, applying independent data sets, applying more growth measures along with live weights such as body measurements especially height and P8 fat scan and applying functions other than polynomial, such as piecewise linear regression models and spline functions.

References

Hoch, T., and J. Agabriel. 2004. A mechanistic dynamic model to estimate beef cattle growth and body composition: 1. Model description. Agricultural Systems 81: 1-15.

Keele, J. W., C. B. Williams, and G. L. Bennett. 1992. A computer model to predict the effects of level of nutrition on composition of empty body gain in beef cattle: I. Theory and development. Journal of Animal Science. 70: 841-857.

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Williams, C. B., and T. G. Jenkins. 1998. A computer model to predict composition of empty body weight changes in cattle at all stages of maturity. Journal of Animal Science. 76: 980-987.