ESTIMATES OF GENETIC PARAMETERS FOR SEASONAL WEIGHT CHANGES OF BEEF COWS

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SUMMARY

Genetic parameters were estimated for seasonal body weight changes of cows and weaning weight of their calves in two beef herds run at pasture in a Mediterranean climate. Heritability estimates for weight changes were low. Cows predisposed to lose more weight were also likely to gain more weight, and larger cows had greater genetic potential for weight changes. Low to moderate genetic and permanent environmental correlations indicated that cows with greater seasonal weight changes weaned heavier calves, due in part to the genetic association between weaning weight and cows' mature body weight. Results indicate that in this environment scope to select for heavy weaning weight without penalty to cow body weight during periods of seasonal feed scarcity is limited.

INTRODUCTION

Pasture based livestock production in Australia is affected by extreme seasonal variation which results in an annual pattern of weight gains and losses, depending on feed availability. Resource allocation theory posits that an ability to wean a heavy calf with little penalty to her own body weight should provide a cow with 'robustness' to environmental challenges. In spite of increasing interest in robust cows, few studies reporting genetic parameters for body weight changes are available. We examine patterns of variation for seasonal weight changes of beef cows and the relation to growth of their calves using data from a selection experiment in Western Australia.

MATERIAL AND METHODS

Data originated from the Wokalup selection experiment which comprised two herds of approximately 300 cows, Polled Herefords (HEF) and a synthetic breed, the so-called Wokalups (WOK); details are given by Meyer *et al.* (1993). Except during calving, all animals were weighted on a monthly basis. Production was entirely pasture based and governed by a Mediterranean climate with winter rains and summer droughts, i.e. feed growth in winter and spring and subsequent dearth in summer and autumn. Calving took place mainly in April and May and calves were weaned, depending on the season, in late November or December. This resulted in strong seasonal variation in body weight, with cows usually at their top weight in January and lowest weight in June.

Analyses. Traits considered were cow body weights in January (JAN) and June (JUN), weight changes from January to June (LOSS) and June to the following January (GAIN) and calf weaning weight (WW), disregarding observations for cows more than 8 years old and WW records for calves not raised by their genetic dam. Characteristics of the data are summarised in Table 1.

Data were analysed fitting a random regression (RR) model, treating WW as a characteristic of the cow. Fixed effects comprised a quadratic regression on age of cow (in years) and contemporary groups, defined as year-paddock classes for the cow traits and year-paddock-sex of calf classes for WW. Other effects for cow traits included month of calving, assigning a separate code (0) if a corresponding calf record was not found. For WW, birth type (single or twin) as well as a within sex linear regression on age at weaning, were fitted. Random effects were additive genetic (G) and permanent environmental (PE) effects of the cow, modelling changes in variation through a RR on Legendre polynomials of age.

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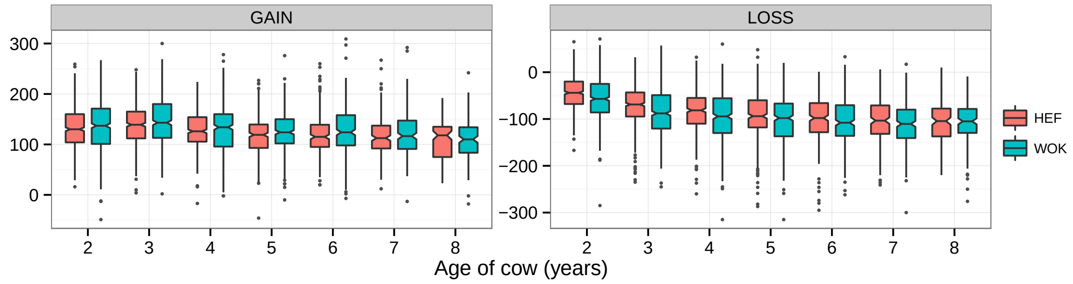

Figure 1. Distribution of cow weight changes (kg).

For WW, the random effect of the calf's sire was included in addition (intercept only). Estimates of covariance components were obtained via restricted maximum likelihood (REML) using WOMBAT (Meyer 2007) with a sampling approach (Meyer and Houle 2013) to approximate standard errors.

Numerous univariate RR analyses were carried out for each trait, considering different orders of polynomial fit (up to quartic), as well as reduced rank estimates of the covariance matrices among RR coefficients, fitting separate measurement error variances for each year of age. The most parsimonious model was then selected based on the REML form of the Bayesian information criterion (BIC), and additional analyses decreased the number of error variances as far as possible without increasing BIC. The final model fitted 2 error variances (2, 3-8 years) for LOSS and JUN and a single error variance otherwise (see Table 1). Bi- and trivariate RR analyses were performed fitting the best model thus identified for each trait, again reducing rank of fit if eigenvalues close to zero were encountered.

RESULTS AND DISCUSSION

As illustrated in Figure 1, there was substantial variation in weight changes between cows. Cows continued to grow till 4 or 5 years of age and body weight changes depended on cow size, resulting in lower LOSS and somewhat higher GAIN at younger ages. Stringent model selection resulted in a single coefficient to be fitted for genetic effects for all traits, i.e. genetic covariances were considered constant for all ages. As found previously (Meyer 1999), quadratic or cubic polynomials were required to model changes in variation with age for permanent environmental effects on individual weights. Considering weight changes, however, these higher order effects mostly cancelled out, so that a simple repeatability model appeared appropriate for GAIN in both breeds. For LOSS, differences were most pronounced for heifers and required separate measurement error variances for heifers and older cows (see Table 1).

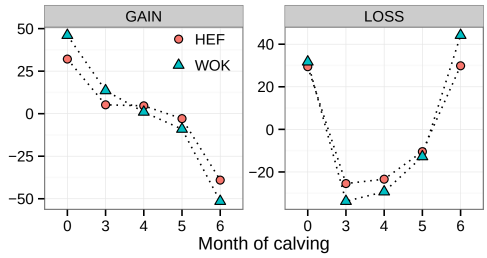

Figure 2. Month of calving effects (kg).

Table 1. Characteristics of data and univariate random regression models fitted

Trait	Hereford								Wokalup							
	n^a	nc^b	$\bar{x}^c$	sd^d	p^e	G[f]	PE[f]	R[g]	n	nc	$\bar{x}$	sd	p	G	PE	R
JUN	2679	729	436	82	12	1	4/3	2	2889	808	463	85	9	1	3/3	2
JAN	2490	692	559	78	7	1	3/2	1	2625	722	592	84	5	1	3/1	1
GAIN	2398	663	128	41	3	1	1	1	2468	702	132	47	3	1	1	1
LOSS	2504	715	-78	48	6	1	3/1	2	2661	774	-89	53	4	1	1	2
WW	1985	631	244	44	4	1	1	1	2203	777	269	45	4	1	1	1

[a] No. of records [b] No. of cows [c] Mean [d] Standard deviation [e] No. of parameters [f] Order of fit/Rank fitted: G genetic, PE permanent environmental [g] No. of residual classes

Table 2. Estimates of correlations from selected bivariate analyses

Traits	HEF				WOK			
	JUN GAIN	JAN LOSS	JUN WW	JAN WW	JUN GAIN	JAN LOSS	JUN WW	JAN WW
Genetic	0.88	-0.86	0.80	0.58	0.57	-0.69	0.91	0.89
Permanent environment[a]	0.46	-0.71	-0.75	-0.65	0.70	-0.94	0.16	-0.43
Phenotypic[a]	-0.13	-0.16	-0.01	-0.01	-0.13	-0.09	0.25	0.24

[a] Correlation for cows at 4 years of age

With calving spread over about three months, month of calving had a strong effect, similar for both breeds, on LOSS and GAIN. Figure 2 gives estimates for their effects, scaled to sum to zero. As expected, cows without a calf recorded (month 0) had substantially larger gains and lost less weight.

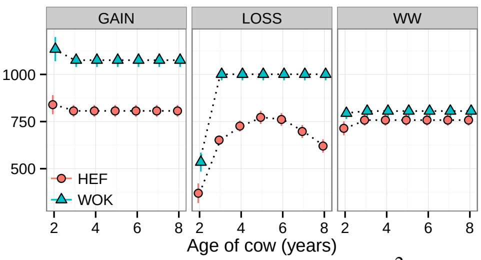

Figure 3. Phenotypic variances (kg^2).

Estimates of phenotypic variances and corresponding variance ratios from trivariate analyses are summarized in Figure 3 and Figure 4, respectively, with vertical bars showing the range of plus or minus one standard deviation. Genetic correlations between cow weights at different ages are generally found to be high. Hence, not surprisingly, heritability estimates for weight changes were low. Similarly, Rose *et al.* (2013) also obtained low estimates for seasonal body weight changes of Merino ewes in Western Australia. Analogous arguments held for PE effects of cows, and corresponding repeatabilities were thus also low, ranging from 15 to 17%. Fitting a quadratic regression for PE effects for LOSS in HEF resulted in a corresponding shape for estimates of the pertaining variances which may well reflect so-called 'end-of-range' problems often encountered in RR analyses. Treating WW as trait of the cow, variation between animals reflects a cow's potential for growth transmitted to the calf as well as her maternal effects. Estimates of variance ratios were consistent with results from previous analyses of WW as trait of the calf (Meyer *et al.* 1993), which identified maternal effects for HEF to be twice as important as for WOK.

Corresponding estimates of correlations are summarised in Figure 5 and selected results from bivariate analyses are given in Table 2. Genetic (r_G) and permanent environmental (r_{PE}) correlations between GAIN and LOSS were essentially unity, i.e. cows pre-disposed to lose more weight are also likely to gain more subsequently. However, with most variation due to environmental effects, corresponding phenotypic (r_P) correlations were weak. Estimates of r_G between individual weights and weight changes ranged from 0.7 to unity (absolute value; Table 2), emphasizing that genetically larger cows had the genetic potential for larger weight changes.

While phenotypic associations between seasonal changes and WW lacked strength, there were low to moderate genetic and permanent environmental correlations indicating that cows with more seasonal weight changes weaned larger calves. Of course, this was largely explicable by the genetic association between potential for growth of the cow and her calf. Correlations between GAIN and WW were somewhat weaker for HEF than for WOK. While differences were well within the range of sampling variation, this may reflect some dissimilarity in maternal capability, especially milk production. WOK are a synthetic breed comprising 25% Friesians, so that milk production is not considered a limiting factor. In contrast, estimates of maternal PE effects on WW in Hereford are consistently much higher, around the 20% mark, than in most other breeds which anecdotally is often attributed to poor milk production or short lactations.

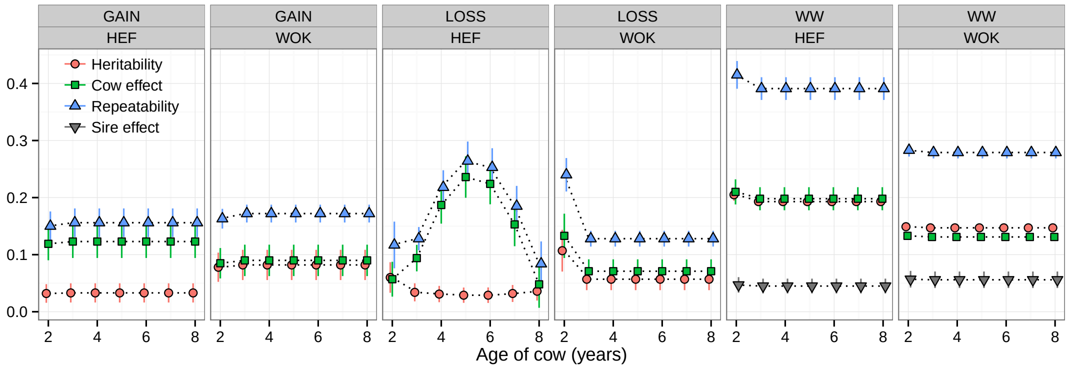

Figure 4. Estimates of variance ratios from trivariate analyses.

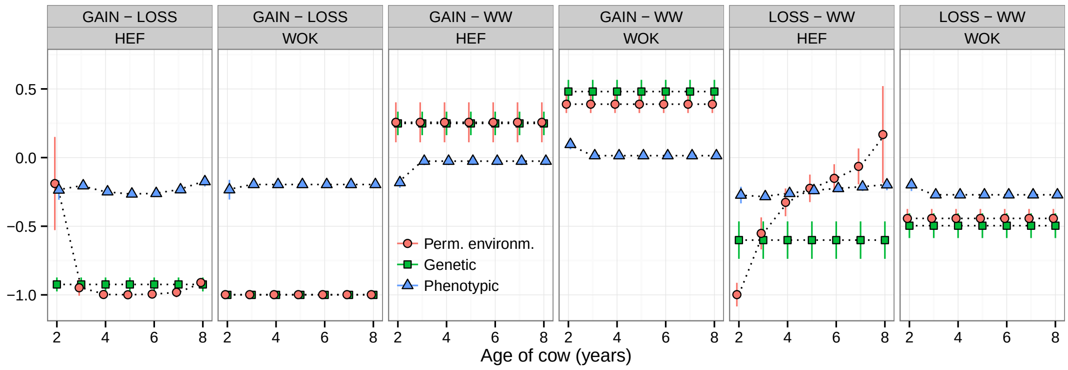

Figure 5. Estimates of correlations from trivariate analyses.

CONCLUSIONS

Beef cows in pasture based production systems are likely to show strong seasonal fluctuations in body weight, with substantial variation between animals. However, most appears to be due to environmental effects, with low heritabilities and repeatabilities for weight changes. Estimates of genetic correlations suggest that larger cows are likely to lose and subsequently gain more weight. Selecting for robustness relies on proximate measures such as body weight change to predict through genetic parameters the capacity of the animal to achieve production goals while maintaining resilience to environmental challenges and its ability to express functional traits. Current results suggest there may be limited scope to enhance robustness by maintaining body weight reserves of the cow while selecting for calf weaning weights in a pasture based Mediterranean production environment.

ACKNOWLEDGEMENTS

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