

MODELLING PHENOTYPIC VARIATION IN MONTHLY WEIGHTS OF AUSTRALIAN BEEF COWS USING A RANDOM REGRESSION MODEL

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SUMMARY

Weights of cows in the Wokalup selection experiment, recorded on a monthly basis, were analysed using a random regression model. Records from 19 to 84 months of age were considered. Analyses fitted a phenotypic animal effect only, ie. did not attempt to separate genetic and permanent environmental effects due to the animal, and ignored relationships between animals. Curves fitted included orthogonal (Legendre) polynomials of age, up to an order of fit of 20, segmented quadratic polynomials and Fourier series. Data were characterised by cyclic, seasonal variation not only in means but also in variances which was not removed by transformation to logarithmic scale. A large number of parameters was required to model this variation in variances adequately.

Keywords: Random regression, growth curve, mature weights, beef cattle

INTRODUCTION

Recently, random regression (RR) models and covariance functions have been advocated for the analysis of traits with 'repeated' records per animal, especially traits which change gradually and continually over time. In particular, analysis of growth data has been considered a prime area of application. Records for weights of beef cows from the Wokalup selection experiment have earlier been analysed using this approach (Meyer 1997 and 1999). However, analyses considered January weights only, which typically represented the top weights within the year. The experimental protocol comprised monthly weighing of cows except during the calving season. This paper extends the RR analysis to include records throughout the year. As a first step to defining the correct model for a subsequent genetic analysis, phenotypic animal effects only are considered.

MATERIAL AND METHODS

Data. Data consisted of weights of cows recorded in the Wokalup selection experiment, carried out at the Wokalup research station in the South of Western Australia. The experiment comprised two herds of about 300 cows, a purebred Polled Hereford (PH) herd and a herd of a four-breed synthetic formed by mating Charolais x Brahman bulls to Friesian x Angus or Friesian x Hereford cows, the so-called 'Wokalups' (WOK), with selection for improved preweaning growth (Meyer *et al.* 1993). Management of the herds was characterised by short (2 months) mating periods and correspondingly short calving seasons with the bulk of calves born in April and May, which resulted in partial confounding between ages and months of weighing. Throughout the experiment all animals were weighed on a monthly basis, except during calving, yielding, after basic edits, a total of 87,516 weights taken between 1977 and 1990. Records considered were weights of cows taken between 19 and 84 months of age (inclusive). Earlier and later records were excluded to minimise the influence of maternal effects and problems associated with small numbers per age and subclass, respectively. Similarly, small numbers of weights taken in April and May were ignored. This yielded 27,728

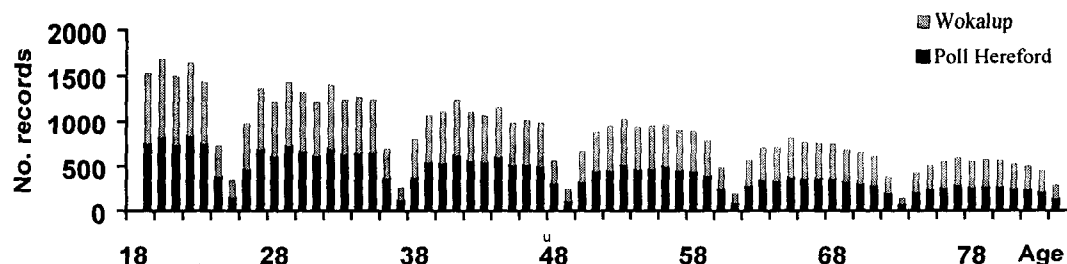


Figure 1 : Numbers of records per age (months).

records for 922 PH cows and 29,033 records for 1020 WOK cows with weights ranging from 193 to 836 kg and 226 to 946 kg, respectively, and a maximum of 62 records per cow.

Analyses. Data were analysed fitting a RR model with age at weighing as the independent covariable. For simplicity, 'phenotypic' animal effects only, comprising animals' genetic and permanent environmental effects, were fitted and relationships between animals were ignored. Contemporary groups (CG), defined as paddock-year-week of weighing subclasses, were fitted as fixed effects and population age trends were modelled by a fixed regression on orthogonal polynomials of age at weighing. With partial confounding of CG and age, a cubic regression sufficed. Additional, univariate analyses fitting a standard repeatability model, fitting both animals additive genetic and permanent environmental effects (random), were carried out to assess differences in variation between months. These considered records in a single month only and fitted separate CG for each year of age and a cubic regression on age. A range of RR models to represent (co)variation across ages was investigated. These included RR on orthogonal (Legendre) polynomials (OP) of age up to an order of fit of 20, RR on segmented, quadratic polynomials (Fuller 1969), and RR on simple Fourier series approximations. Temporary environmental effects were considered to be independently distributed but have heterogeneous 'measurement error' variances (σ_e^2). Alternatives considered fitted σ_e^2 grouped according to (half-) years of age, individual σ_e^2 for each of the 66 ages in the data, and attempted to model fluctuations in σ_e^2 by a polynomial regression on age up to an order of fit of 17. Some analyses transformed records to logarithmic scale to eliminate scale effects. Covariances of RR coefficients, phenotypic covariance functions (P) and

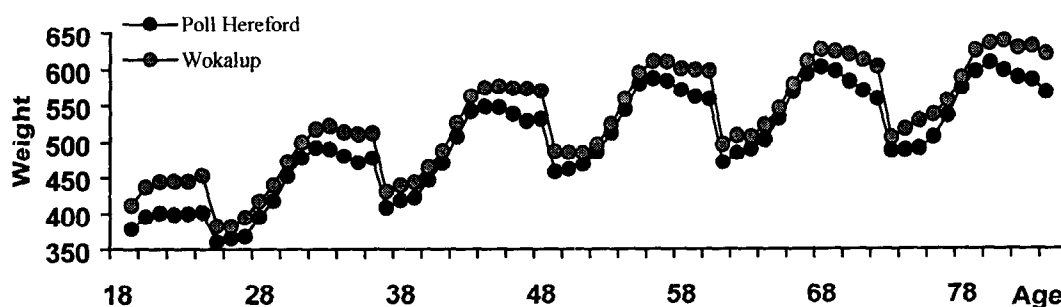


Figure 2 : Mean weights (kg) for ages (months).

σ_e^2 were estimated by restricted maximum likelihood using program DXMRR (Meyer 1998). Up to 276 parameters were estimated simultaneously. Covariance matrices for the ages in the data were computed from estimates of P .

RESULTS AND DISCUSSION

Numbers of records for each age are given in Figure 1. Corresponding means are exhibited in Figure 2. As shown in Table 1, there was considerable monthly variation in weights of cows, the climate at the Wokalup research station being Mediterranean with spring rains followed by almost complete drought from November to April and winter dearth, resulting in lowest weights during winter (June and July), accompanied by lowest phenotypic variances (σ_P^2). Coefficients of variation were highest in winter and lowest in January (ranging from 10.4 % to 9.1 % for PH and 11.1 % to 9.7 % for WOK), indicating that seasonal differences in σ_P^2 could only partially be attributed to scale effects.

Orthogonal polynomials. RR on OPs of age (of animal) were fitted considering orders of fit (k) from 7 to 20 and estimating between 11, 15 or 66 measurement error variances. Likelihoods increased consistently and significantly with k . For example, increasing k from 19 to 20 for PH, added 20 parameters while augmenting log L by 289.4. Values of $k > 20$ were not examined due to computational requirements. For low orders of fit ($k < 10$), phenotypic variances for later ages (> 70 months) were dramatically overestimated. From $k = 12$ onwards, there was little difference in the average trend in estimates of phenotypic standard deviations (SD). However, with rising k , plots of SDs became more and more 'wavy', ie. RR modelled seasonal differences in variation more explicitly. Transforming data to logarithmic scale did not reduce the wave pattern. Estimates of SD for animal and temporary environmental effects for $k = 20$ and a separate σ_e^2 for each age are shown in Figures 3 and 4, respectively. Figure 3 clearly exhibits seasonal variation in SD, with a cycle of about 12 months. Estimated SD and their fluctuations were larger for WOK than PH. Estimates of σ_e^2 were similar for both breeds and, again, showed a cyclic pattern.

Table 1. Numbers of records (N), means and estimates⁴ from univariate analyses for months

	Polled Hereford						Wokalup					
	N	Mean	σ_P^2	h^2	p^2	t	N	Mean	σ_P^2	h^2	p^2	t
Jan	3473	512.3	2337	0.38	0.22	0.60	3563	546.6	3077	0.38	0.17	0.55
Feb	3072	502.5	2362	0.26	0.30	0.57	3157	546.7	3263	0.40	0.16	0.55
Mar	3983	490.0	2212	0.28	0.29	0.57	4234	536.5	3087	0.35	0.22	0.57
Jun	2389	424.4	2095	0.27	0.30	0.57	2623	448.4	2524	0.39	0.21	0.60
Jul	2155	444.6	2091	0.30	0.37	0.67	2191	468.0	2660	0.46	0.23	0.68
Aug	2456	457.7	2331	0.27	0.39	0.66	2589	475.9	2793	0.39	0.26	0.65
Sep	2486	477.2	2653	0.31	0.27	0.58	2802	489.9	3084	0.40	0.22	0.62
Oct	2251	514.4	2430	0.33	0.37	0.69	2259	538.7	3291	0.40	0.30	0.70
Nov	3089	519.6	2289	0.37	0.28	0.65	3029	546.0	2986	0.42	0.21	0.63
Dec	2374	507.2	2144	0.41	0.19	0.60	2586	535.7	2922	0.40	0.19	0.59

⁴ σ_P^2 : Phenotypic variance, h^2 : heritability, p^2 : permanent environmental effect, t : repeatability