ESTIMATES OF GENETIC PARAMETERS FOR CANNON BONE LENGTH IN BEEF CATTLE

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SUMMARY

Estimates of genetic parameters for cannon bone length at birth and hip height at weaning and their correlations with growth traits were obtained for the two herds in the Wokalup selection experiment. Wokalups were heavier, had longer cannon bones and were taller at weaning than Polled Herefords, and exhibited more genetic and phenotypic variation. There were small genetic and permanent environmental effects, mainly attributable to maternal effects on weight at recording. Genetic correlations with growth traits were moderate to high, on the whole higher for Wokalups than Polled Herefords, and of similar magnitude to those between weights.

INTRODUCTION

There has always been interest in the early prediction of rate of maturity and size of animals. With bones having a high priority for nutrients during development, thus being less prone to suffer under low planes of nutrition than other tissues, and length of bone being an early maturing criterion, Hammond (1940) considered cannon bone length relative to body size as an indicator of an animal's approach to maturity and its inherent productive ability. Furthermore, he observed that bones of sheep breeds improved for meat production were shorter and relatively thicker than in unimproved breeds.

This paper presents genetic parameters for cannon bone length and hip height of calves and examines their relationship with weight at various ages.

MATERIAL AND METHODS

Data originated from the selection experiment conducted at Wokalup in the South West of Western Australia beginning in 1972, selecting since 1978 for increased pre-weaning growth rate in two herds of about 300 cows each. One herd comprised straightbred Polled Herefords, the other a synthetic breed formed by mating Charolais × Brahman bulls with Friesian × Angus or Hereford cows, 'Wokalups' for short. Further details of the experiment, management and environmental condition are given by Meyer *et al.* (1993).

Traits considered were cannon bone length (CB), measured at birth, and hip height (HH), recorded at weaning, and their relation with birth weight (BW), weaning weight (WW) final or 600-day weight (FW). While weight records were available from 1973 until 1990 (inclusively), CB recording did not begin until 1981 and HH was only measured from 1986 onwards, yielding a total of 3907 and 1564 records, respectively. Characteristics of the data structure are summarised in Table 1.

Estimates of (co)variance components and genetic parameters were obtained by Restricted Maximum Likelihood fitting an animal model and utilising all pedigree information available. Calculations were carried out using DfReml Version 2.1 (Meyer, 1992). Models of analyses were as used previously in the analysis of growth traits (see Meyer *et al.*, 1993), i.e. fitting birth type (single vs. twin), sex at weighing, year-paddock and year-month of weighing subclasses as fixed effects, and fitting age of dam and age at weighing (for HH) as a linear and quadratic covariable each. Further analyses included weight at recording (BW and WW for CB and HH, respectively)

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	Hereford					Wokalup				
	CB	HH	BW[a]	WW[a]	FW[a]	CB	HH	BW[a]	WW[a]	FW[a]
No. records	1907	757	3414	3088	1114	1972	796	3769	3191	1242
No. animals[b]	2462	1415	3783	3421	1415	2633	1574	4518	3857	1638
No. dams[c]	618	361	1033	956	600	644	396	1473	1201	716
$\bar{x}^d$	178.2	109.5	31.5	227.6	409.8	193.7	116.4	36.0	257.7	440.2
sd	9.3	8.6	5.3	51.5	62.3	11.9	6.1	6.3	52.9	77.6

[a] from Meyer *et al.* (1993)
[b] in the analysis, i.e. including parents
[c] with progeny in the data
[d] Raw mean ($\bar{x}$) and standard deviation (*sd*)

Table 1: Characteristics of the data structure

Analyses for CB and HH considered up to four different models to evaluate the importance of maternal effects. Following the notation of previous growth traits analyses (Meyer *et al.*, 1993), Model 1 (M1) was a simple animal model fitting animals' direct additive genetic effects as the only random effects. Model 2 (M2) allowed for permanent environmental effects of the dams in addition, while Model 3 (M3) fitted maternal genetic effects. Model 5 (M5) finally included both genetic and permanent environmental effects. In bivariate analyses together with growth traits, M5 was fitted for BW and WW and M3 for FW. As direct-maternal genetic covariances had been found to be unimportant for growth traits (Meyer *et al.*, 1993), direct and maternal genetic effects were considered uncorrelated throughout.

Estimates from individual analyses and previous analyses of growth traits (Meyer *et al.*, 1993) were combined to form pooled correlation and covariance matrices, 'bending' (Hayes and Hill, 1981) them if necessary to ensure estimates within the parameter space.

RESULTS AND DISCUSSION

Estimates from univariate analyses of CB under all four models are summarised in Table 2. Wokalups were bigger than Herefords with longer cannon bones (see Table 1) and showed more phenotypic variation (σ^2_P), and, as found previously for growth traits (Meyer *et al.*, 1993), direct heritability (h^2) estimates were higher and maternal effects were less important. As (log) likelihood (log $\mathcal{L}$) values show, CB was subject to significant maternal effects in both breeds, permanent environmental maternal effects (c^2) being about twice as high as maternal heritabilities (m^2).

	Hereford				Wokalup			
	M1	M2	M3	M5	M1	M2	M3	M5
σ^2_P	71.6	70.7	71.3	70.6	124.4	126.1	126.4	126.5
h^2	0.39	0.31	0.30	0.29	0.46	0.44	0.41	0.42
m^2			0.09	0.04			0.06	0.03
c^2		0.09		0.06		0.07		0.05
log $\mathcal{L}$	-9.22	-0.71	-1.84	0	-4.18	-0.47	-1.36	0
	Fitting BW as a covariable							
σ^2_P	47.8	47.7			71.9	71.7		
h^2	0.21	0.20			0.28	0.26		
c^2		0.03				0.03		
log $\mathcal{L}$	-0.12	0			-0.98	0		

Table 2: Estimates for Cannon Bone length

Corresponding literature results varied. Atkins and Thompson (1986a) reported a h^2 of 0.33 in sheep for CB at 8 weeks corrected for body weight. Wilson *et al.* (1977) found a h^2 of 0.48 for length of metacarpal bone in cattle slaughtered at fixed weight, while corresponding estimates for length of rear and fore cannon in live animals were only 0.08 and 0.11, respectively (Wilson *et al.*, 1976).

Fitting BW as a covariable reduced estimates of phenotypic variances, h^2 and maternal effects markedly, i.e. part of the variation in CB could be explained through differences in BW. Similarly, maternal effects on CB could be explained almost entirely through maternal effects on BW. “Residual” h^2, however, were more than 20%, i.e there was considerable genetic variation in CB independent of BW. Accounting for BW, only a small, non-significant permanent environmental maternal effect on CB of less than 3% remained.

Estimates for HH are given in Table 3. It was found to be highly heritable and little influenced by maternal effects. Neville *et al.* (1978) gave h^2 estimates for HH in two herds of cattle of 0.54 and 0.75. Gilbert *et al.* (1993) reported h^2 values of 0.43 and 0.57 for HH of Angus and Hereford cattle measured at weaning and approximately one year of age, respectively. Again, variances and h^2 were higher in Wokalups than in Herefords, with a small, permanent environmental maternal effect on HH for the latter. As for CB, weight (WW as covariable) explained considerable phenotypic and some genetic variation in HH, and accounted for maternal effects.

	Heref.		Wokal.	
	M1	M2	M1	M2
σ^2_P	11.3	11.3	17.9	18.0
h^2	0.38	0.36	0.54	0.53
c^2		0.04		0.00
log $\mathcal{L}$	-0.47	0	-0.00	0
Fitting WW as a cov.				
σ^2_P	6.1	6.2	9.1	
h^2	0.39	0.38	0.42	
c^2		0.01		
log $\mathcal{L}$	-0.04	0		

Table 3: Estimates for hip height

Trait 1	CB	CB	CB	CB	HH	HH	HH
Trait 2	HH	BW	WW	FW	BW	WW	FW
	Hereford						
No. anim.s	2369	3783	3447	2704	3783	3426	1921
- tr. 1 only	1151	0	116	1293	0	0	508
- tr. 2 only	1	1507	1297	500	2657	2331	865
- both tr.s	756	1907	1791	614	757	757	249
	Wokalup						
No. anim.s	2637	4518	3999	2992	4518	3857	2175
- tr. 1 only	1180	0	142	1343	0	0	528
- tr. 2 only	4	1797	1361	613	2973	2395	974
- both tr.s	792	1792	1830	629	796	796	268

Table 4: No.s in bivariate analyses

Numbers of animals in each bivariate analysis (including parents without records) and for each combination of traits recorded are given in Table 4. Bivariate analyses were carried out fitting models M1, M2 and M5 in turn for CB and HH. Inspection of log likelihood values (not shown) then suggested M5 and M2 to fit best overall for CB for Herefords and Wokalups, respectively, while M2 was sufficient to explain the variation in HH for both breeds.

Pooled correlation matrices for both breeds are given in Table 5. Estimates of phenotypic correlations between CB and HH and weights were moderate to low and consistent with the reduction in variance observed when fitting weight as a covariable (see Tables 2 and 3). As well as heritabilities, genetic correlation estimates were higher in Wokalups than Polled Herefords, correlations between CB and HH and weights being of similar magnitude than correlations amongst weights. Estimates were comparable to literature values, Atkins and Thompson (1986) reported estimates of genetic and phenotypic correlations between CB and body weight in sheep, both measured at 8 weeks of age, of 0.55 and 0.73, respectively.

		Hereford					Wokalup				
		CB	HH	BW	WW	FW	CB	HH	BW	WW	FW
A[a]	CB	0.29					0.44				
	HH	0.60	0.36				0.85	0.53			
	BW	0.76	0.53	0.43			0.82	0.70	0.51		
	WW	0.74	0.75	0.66	0.20		0.70	0.75	0.74	0.29	
	FW	0.51	0.42	0.63	0.81	0.38	0.73	0.79	0.71	0.98	0.43
M[b]	CB	0.05									
	BW	0.47		0.10					0.06		
	WW	0.19		0.28	0.16				0.74	0.09	
	FW	0.69		0.40	0.84	0.15			0.55	0.97	0.06
C[c]	CB	0.07					0.07				
	HH	0.61	0.05				0.47	0.01			
	BW	0.83	0.72	0.11			0.90	0.74	0.04		
	WW	0.40	0.09	0.72	0.15		0.40	0.67	0.36	0.08	
P[d]	CB	70.6					126.1				
	HH	0.43	11.3				0.56	18.0			
	BW	0.57	0.46	17.7			0.65	0.54	28.3		
	WW	0.30	0.52	0.49	754.3		0.43	0.66	0.54	802.2	
	FW	0.32	0.44	0.36	0.64	1185.2	0.40	0.50	0.50	0.75	1787.9

[a]Direct additive genetic effects : heritabilities on, correlations below the diagonal.
[b]Maternal additive genetic effects: heritabilities on, correlations below the diagonal.
[c]Maternal permanent environmental effects : ”c-squared” effects on, correlations below the diagonal.
[d]Phenotypic effects : variances on, correlations below the diagonal.

Table 5: Pooled correlation matrices

CONCLUSIONS

With moderate to high heritabilities, genetic correlations with weight at measurement of about 0.8, and correlations with FW of similar magnitude than those with the corresponding weights, early skeletal measurements such as CB and HH could provide useful additional information to predict weights of animals at later ages, such as FW in this study, or mature size.

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