Estimates Of Genetic Parameters And Direct And Maternal Genetic Relationships Of Body Measurements At Early Growth Stage In Japanese Black Cattle

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Introduction

In Japan, the production of Japanese Black cattle is competitive against imported beef products only because of its meat quality. Japanese Black cattle, the most common breed among domestic beef breeds in Japan, has recently attracted considerable attention from scientists in the United States (Harris et al., 1995), Canada (Kazala et al., 1999) and Australia (Yang et al., 1998). Estimation of direct and maternal genetic parameters is a prerequisite for implementing sound breeding programs aimed at improving performance traits. In this study, we estimated the genetic parameters of direct and maternal genetic effects on body measurement traits at 0 month (0-mo) and 4 months (4-mo) of age, and investigated the direct and maternal genetic correlations among the traits in a herd of Japanese Black cattle.

Materials and methods

Data management: Body measurements of 889 calves at an early growth stage are recorded monthly at Tsudaka farm of Okayama University. To estimate genetic parameters, a pedigree file of a total of 1648 animals was constructed**,** and the measurements covered the following traits: wither height (WH), hip height (HH), body length (BL), chest depth (CD), chest width (CW), thurl width (TW), heart girth (HG) and body weight (BW).

Statistical analyses: The GLM procedure of R-program (Fox, 2006) was used in the development of analytical models for traits in the study. Variance components for body measurement traits were estimated according to the animal model by VCE-6 (Groeneveld et al., 2008). The statistical model used in the analysis was**:** $\mathbf{y=Xb+Zu+Wm+e}$**;** where, $\mathbf{y}$ is the vector of observations, $\mathbf{b}$ the vector of fixed effects, $\mathbf{u}$ the vector of additive direct genetic effect and $\mathbf{m}$ the vector of maternal genetic effect. The fixed effects in $\mathbf{b}$ were sex, birth year, birth season, linear and quadratic regression coefficients of the age of calves and the parity of dams. $\mathbf{X}$**,** $\mathbf{Z}$ and $\mathbf{W}$ were incident matrices related to $\mathbf{b}$, $\mathbf{u}$ and $\mathbf{m}$, respectively. The permanent environmental effect was excluded from the model because the estimated values were very low.

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Results and discussion

The basic statistics and heritability estimates using the univariate model and ignoring maternal effects **(**Table 1**)** show that the heritabilities for WH and HH were high at both 0-mo and 4-mo; the heritability estimates for the rest of the traits ranged between 0.27±0.07 and 0.55±0.07 at 0-mo and between 0.28±0.06 and 0.47±0.08 at 4-mo.

Table 1: Basic statistics of body measurements at 0 and 4 months of age

Traits[‡]	WH	HH	BL	CD	CW	TW	HG
0 month							
Frequency	790	790	790	790	790	790	790
CV	0.05	0.06	0.08	0.08	0.14	0.09	0.08
Mean±SD	71.73±3.81	76.00±4.22	63.94±5.37	28.65±2.33	16.20±2.26	19.91±1.70	78.22±5.89
h^2±S.E	0.62±0.08	0.65±0.07	0.31±0.07	0.52±0.09	0.27±0.07	0.42±0.08	0.55±0.07
4 months							
Frequency	878	878	878	878	878	878	878
CV	0.05	0.04	0.06	0.06	0.12	0.07	0.06
Mean±SD	95.38±4.41	98.33±4.39	97.74±5.99	44.38±2.74	27.06±3.26	29.75±1.94	118.16±7.36
h^2±S.E	0.54±0.07	0.51±0.10	0.33±0.08	0.44±0.08	0.28±0.06	0.47±0.08	0.39±0.08

[‡]WH, wither height; HH, hip height; BL, body length; CD, chest depth; CW, chest width; TW, Thurl width; HG, heart girth; SD, standard deviation.

Table 2: Variance components, correlation between direct and maternal genetic effects and heritabilities (±SE) for body measurements at 0 and 4 months of age

Para-meters	WH	HH	BL	CD	CW	TW	HG
0 month							
σ^2_a	3.50	6.63	2.54	1.68	0.92	0.55	4.64
σ^2_m	1.40	2.24	1.13	0.70	0.87	0.14	4.79
σ^2_p	8.10	14.81	15.01	4.33	3.68	1.74	17.72
r_{am}	-0.06±0.26	-0.19±0.31	-0.14±0.62	-0.86±0.13	-0.45±0.29	0.10±0.60	-0.17±0.38
h^2_a	0.43±0.12	0.45±0.12	0.17±0.09	0.39±0.13	0.25±0.14	0.32±0.10	0.26±0.13
h^2_m	0.16±0.06	0.15±0.06	0.08±0.08	0.16±0.08	0.24±0.08	0.08±0.07	0.27±0.08
4monts							
σ^2_a	3.51	5.40	3.91	1.97	3.51	0.96	4.18
σ^2_m	3.84	2.58	5.49	0.98	3.84	0.63	8.75
σ^2_p	14.83	16.79	26.51	5.98	14.83	3.08	28.20
r_{am}	0.11±0.30	0.34±0.36	0.02±0.43	-0.38±0.33	0.11±0.30	0.01±0.27	-0.24±0.35
h^2_a	0.24±0.09	0.32±0.09	0.15±0.07	0.33±0.13	0.24±0.09	0.31±0.10	0.15±0.14
h^2_m	0.26±0.06	0.15±0.04	0.21±0.06	0.13±0.06	0.26±0.06	0.20±0.05	0.31±0.07

σ^2_a, additive genetic variance; σ^2_m, maternal genetic variance; σ^2_p, phenotypic genetic variance; r_{am}, correlation between direct and maternal genetic effects; h^2_a, direct heritability; h^2_m, maternal heritability; WH, wither height ; HH, hip height; BL, body length; CD, chest depth; CW, chest width; TW, Thurl width; HG, heart girth.

The estimated heritabilities for WH at 0-mo and 4-mo were higher than 0.45 reported by Baco et al. (1998) and Mukai et al. (1993), respectively. Also, those for CD and HG were higher than the 0.44 and 0.42**,** respectively, estimated by Oyama et al. (1996)**.** These differences may be due to differences in the residual term in the model**,** especially that calves in the present study were raised under a comparatively more uniform environment.

Variance components, direct and maternal heritabilities using bivariate analysis for the traits **(**Table 2**)** show that at 0-mo the correlation between direct and maternal genetic effects (r_{am}) for CD (-0.86±0.13) was highly negative. The estimated direct heritabilities were higher than the maternal heritabilities for WH, HH, CD and TW, whereas the maternal heritabilities were higher than the direct heritabilities for BW. The direct and maternal heritabilities were similarly estimated for BL, CW and HG. At 4-mo the estimated direct heritabilities were higher than the maternal heritabilities for HH, CD and TW, whereas the maternal heritabilities were higher than the direct heritabilities for BL, HG and BW. The direct and maternal heritabilities were similarly estimated for WH and CW.

The direct genetic correlations among different body traits measured at 0-mo and at 4-mo **(**Table 3**)** were all positive and generally high, suggesting that selection of one trait leads to indirect genetic changes in other traits. Our estimates are in agreement with published results (Lima et al., 1989; Varade and Ali, 2001). Lima et al. (1989) have reported that taller animals tend to be heavier in Nellore cattle. Varade and Ali (2001) have also reported that traits of body size of cattle are positively correlated one another. Our study suggests that high genetic correlations between body size and body weight of animals is a useful selection aid because indirect selection by body weight could be made at both 0-mo and 4-mo. The estimated genetic correlations between HG and CW, and between HH and WH at 0-mo were above 0.95, indicating that each pair of these traits can be regarded as one trait. High genetic relationships of WH with other body measurements were found at 0-mo. In the present study the direct genetic correlations between WH and CD were 0.81 and 0.91 at 0-mo and 4-mo, respectively**,** and higher than the 0.61 and 0.68 reported by Mukai et al. (1993) and Baco et al. (1998), respectively. These differences may be due to smaller residual components because calves in the present study were raised under a more uniform environment than the data sets of a multi-herd population.

Table 3: Direct genetic correlations (±SE) among different body measurements at 0 month (above the diagonal) and 4 months (below the diagonal) of age

Traits‡	WH	HH	BL	CD	CW	TW	HG
WH	-	0.98±0.01	0.80±0.08	0.81±0.07	0.63±0.13	0.89±0.05	0.80±0.06
HH	0.95±0.02	-	0.89±0.06	0.85±0.06	0.60±0.12	0.91±0.04	0.80±0.06
BL	0.77±0.08	0.82±0.08	-	0.72±0.12	0.61±0.16	0.82±0.09	0.79±0.09
CD	0.91±0.05	0.78±0.08	0.71±0.09	-	0.59±0.13	0.79±0.07	0.85±0.05
CW	0.65±0.13	0.75±0.15	0.66±0.15	0.57±0.14	-	0.71±0.13	0.96±0.08
TW	0.72±0.09	0.80±0.06	0.81±0.06	0.59±0.10	0.69±0.14	-	0.83±0.06
HG	0.75±0.07	0.76±0.08	0.74±0.09	0.78±0.07	0.72±0.12	0.80±0.07	-

‡ WH, wither height; HH, hip height; BL, body length; CD, chest depth; CW, chest width; TW, Thurl width; HG, heart girth.

The maternal genetic correlations among different traits (Table 4) show that at 0-mo the correlation between HH and CD was negative and high, while at 4-mo it was positive and low, indicating that the maternal effect influenced the traits differently at birth. The large standard error associated with the estimates indicated inaccurate estimation of the genetic relationships. The low maternal genetic correlations among traits indicated that the maternal effect is more independent among the traits at 4-mo, whereas some high correlations were practically less important because of large standard errors. To our knowledge there are no published studies on maternal genetic correlations among different body measurements for comparison with the results of the present study. Nonetheless, the low genetic correlation between direct genetic effect and maternal genetic effect suggests that the maternal effect should be taken into account in a genetic evaluation system.

Table 4: Maternal genetic correlations (±SE) among different body measurements at 0 month (above the diagonal) and 4 months (below the diagonal) of age

Traits	WH	HH	BL	CD	CW	TW	HG
WH	-	-0.14±0.34	-0.13±0.59	-0.32±0.29	-0.30±0.34	-0.32±0.20	-0.25±0.24
HH	0.14±0.31	-	-0.27±0.38	-0.65±0.28	-0.16±0.35	0.02±0.42	-0.40±0.28
BL	0.31±0.44	0.64±0.37	-	-0.63±0.27	-0.46±0.26	-0.01±0.46	-0.13±0.37
CD	0.12±0.38	0.23±0.39	-0.09±0.31	-	-0.14±0.30	-0.18±0.30	-0.23±0.26
CW	0.71±0.77	-0.14±0.63	-0.26±0.42	-0.05±0.71	-	-0.20±0.29	-0.20±0.33
TW	0.12±0.24	0.09±0.25	0.08±0.25	0.08±0.20	0.05±0.25	-	-0.26±0.20
HG	0.07±0.44	-0.21±0.34	-0.28±0.25	-0.09±0.30	-0.10±0.83	-0.42±0.24	-

‡ WH, wither height; HH, hip height; BL, body length; CD, chest depth; CW, chest width; TW, Thurl width; HG, heart girth**.**

Conclusion

Moderate to high heritability for body measurements demonstrated that the presence of a large genetic variability could lead to further improvement in the overall body size of this breed. Direct genetic correlations among the traits were highly positive at 0-mo and at 4-mo, suggesting that the highly correlated traits can be improved as a unit. Maternal effects need to be included in a genetic evaluation because they are relatively independent with direct genetic effect on the traits of body measurement.

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