Estimation of additive and maternal genetic parameters for some growth and carcass traits of Japanese Black calves using a multi-trait animal model

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INTRODUCTION

In Japan, Production of domestic Japanese beef is competitive with imported meat only because of its outstanding quality. Hence, the main breeding program is aimed for improving meat quality to compete with imported beef. Estimations of genetic and maternal genetic parameters are prerequisite for implementing sound breeding programs for improving growth and carcass traits.

OBJECTIVE

The objective of this study was to estimate additive genetic and maternal genetic parameters for some growth and carcass traits of Japanese Black calves, using a multi-trait animal model.

MATERIALS AND METHODS

Data analyzed were records of Japanese Black calves fattened during the period from 1997 to 2002 in a herd located in Shiroshi city, Miyagi prefecture, Japan. Records with implausible data were excluded. After editing, the total number of calves was 1170, offspring of 33 sires and 255 dams. Total number of animals in pedigree including animals with records was 1458. All animals had known sire and dam identifications. Dams were purchased from 5 prefectures, and thus they have different genetic origin. Growth and carcass traits considered in this study were initial body weight at the start of the feedlot period (BWS, kg), final body weight at the end of the feedlot period (BWF, kg), average daily gain during the feedlot period (ADG, kg/day), rib thickness (RT, cm), beef marbling score (BMS, unit), subcutaneous fat thickness (SFT, mm), yield estimate (YE, %) and rib eye area (REA, cm^2). Table (1) shows the number of records, unadjusted means, standard deviations and extreme values per trait.

A multi-trait animal model was considered. The model included parity, prefecture and sex of calf as fixed effects and additive genetic and maternal genetic as random effects. A linear regression of calf age at the start of the fattening period (mo) was included in the model fitted to BWS, whereas linear regressions of calf age at the end of the fattening period (mo) and period of fattening (days) were included in the model fitted to BWF and CW.

The multiple trait animal model analyses were conducted using the 5.1.2 version of VCE program. The direct by maternal genetic covariance was constrained to zero. A minimum of three cold restarts was used to ensure convergence to the same solution.

RESULTS AND DISCUSSION

Direct heritability estimates and genetic and phenotypic correlations for the studied traits are in Table (2).

The estimates of direct h^2 were comparatively high, except those of SFT and BMS.

The highest genetic correlation was 0.99 between BWF and CW. Genetic correlations between BWF and ADG, between CW and ADG, between YE and REA and between RT and ADG were also high, accounting for 0.93, 0.92, 0.93 and 0.82, respectively.

Genetic correlations were all positive, except those between BWS and each of SFT and YE.

Phenotypic correlations were generally lower than the corresponding genetic correlations, except those between BWS and each of BWF, CW, ADG, REA and RT, and between RT and ADG. The highest value was 0.96 between CW and BWF, followed by that between RT and ADG (0.91). The phenotypic correlations were all positive except those between BWS and each of SFT and YE, and those between SFT and each of REA, YE and BMS, accounting for -0.09, -0.04, -0.05, -0.41 and -0.21, respectively. Phenotypic and genetic correlations between BMS and YE were equal (0.26).

The highly heritability estimates may indicate that a large genetic variability still remains in the Japanese Black population, suggesting great opportunity for improving growth and carcass characteristics of the breed.

Maternal heritability and maternal genetic correlations are presented in Table (3).

The estimates of maternal hertiability ranged between 0.08 for BWS, CW and ADG to 0.003 for BMS. The low estimate of BMS indicates that maternal effect is relatively unimportant for this trait.

Maternal genetic correlation between BWS and CW, between REA and each of ADG and RT and between SFT and BMS were relatively high accounting for 0.89, 0.87, 0.86 and 0.82, respectively. The lowest maternal genetic correlation was between BWS and ADG (0.003).

CONCLUSION

Single trait selection should be avoided, and balanced multiple trait selection should be used instead.

Using multiple trait selection would lead to small but positive gains in carcass traits. The difficulty lies in achieving the optimum balance of traits.

Effectiveness of simultaneous selection of some multiple trait combinations could be slowed by antagonistic genetic correlations.

Most of the traits are influenced by maternal genetic effects and could be used as indicators of maternal ability.

Selection programs incorporating maternal effects will contribute to the improvement process not only in post-weaning growth, but also in carcass quantity.

Selection index combining information on growth and carcass traits of calves and maternal traits of dams is recommended for maximizing genetic gain.

Table (1): Means, standard deviations (SD), coefficients of variation (CV) and extreme values (Min-Max) for body weight at the start of the fattening period (BWS), final body weight after fattening at the end of fattening period (BWF), carcass weight (CW), body weight gain during the fattening period (ADG), rib eye area (REA), rib thickness (RT), subcutaneous backfat thickness (SFT), yield estimate (YE) and beef marbling score (BMS) for the Japanese Black calves.

Trait	Number of records	Mean±SD	CV (%)	Min-Max
BWS (kg)	1170	265.04±27.92	11	171-369
BWF (kg)	1170	645.15±90.28	14	416-872
CW (kg)	1170	393.56±55.07	14	254-532
ADG (kg/d)	1170	0.582±0.12	21	0.21-1.03
REA (cm^2)	1170	52.95±7.26	14	34-75
RT (cm)	1170	7.52±0.95	13	5.30-10.30
SFT (mm)	1170	2.49±0.78	31	0.80-6.50
YE (%)	1170	74.16±1.22	2	70.70-77.60
BMS[a] (unit)	1170	7.12±2.22	31	3.00-12.00
Age[1] (mo)	1170	11.04±0.75	7	8.70-14.40
Age[2] (mo)	1170	32.77±2.19	7	26.30-40.10
Period[b] (days)	1170	660.67±63.78	10	462-882

[a]Scored on scale of 1 to 12

Age[1] is the age of calves at the beginning of fattening period

Age[2] is the age of calves at the end of the fattening period

[b]Period is the fattening period in days

Table (2): Heritability (on diagonal) additive genetic (above diagonal) and phenotypic (below diagonal) correlations between body weight at the start of the fattening period (BWS), final body weight after fattening at the end of fattening period (BWF), carcass weight (CW), body weight gain during the fattening period (ADG), rib eye area (REA), rib thickness (RT), subcutaneous backfat thickness (SFT), yield estimate (YE) and beef marbling score (BMS) for the Japanese Black calves.

Trait	BWS	BWF	CW	ADG	REA	RT	SFT	YE	BMS
BWS	**0.55±0.08**	0.44±0.06	0.44±0.06	0.09±0.04	0.15±0.06	0.03±0.10	-0.49±0.05	-0.14±0.06	0.04±0.04
BWF	0.52	**0.69±0.02**	0.99±0.02	0.93±0.03	0.61±0.04	0.72±0.04	0.23±0.09	0.36±0.05	0.17±0.06
CW	0.54	0.96	**0.78±0.04**	0.92±0.03	0.60±0.04	0.72±0.04	0.23±0.08	0.35±0.05	0.17±0.06
ADG	0.20	0.82	0.82	**0.46±0.04**	0.60±0.02	0.82±0.02	0.48±0.07	0.44±0.05	0.17±0.05
REA	0.17	0.44	0.47	0.73	**0.44±0.02**	0.74±0.03	0.32±0.06	0.93±0.07	0.25±0.07
RT	0.10	0.53	0.57	0.91	0.64	**0.50±0.03**	0.47±0.07	0.66±0.06	0.26±0.05
SFT	-0.09	0.09	0.08	0.28	-0.05	0.01	**0.07±0.01**	0.48±0.11	0.14±0.08
YE	-0.04	0.27	0.27	0.37	0.79	0.54	-0.41	**0.50±0.01**	0.26±0.06
BMS	0.02	0.07	0.01	0.13	0.20	0.18	-0.21	0.26	**0.16±0.01**

±standard error

Table (3): Maternal heritability (on diagonal) and maternal genetic correlation (above diagonal) between body weight at the start of the fattening period (BWS), final body weight after fattening at the end of fattening period (BWF), carcass weight (CW), body weight gain during the fattening period (ADG), rib eye area (REA), rib thickness (RT), subcutaneous backfat thickness (SFT), yield estimate (YE) and beef marbling score (BMS) for the Japanese Black calves.

Trait	BWS	BWF	CW	ADG	REA	RT	SFT	YE	BMS
BWS	**0.08**	0.42	0.89	0.003	0.40	0.22	0.14	0.20	0.41
BWF		**0.04**	0.74	0.31	0.45	0.34	0.24	0.28	0.34
CW			**0.08**	0.31	0.63	0.42	0.26	0.30	0.51
ADG				**0.08**	0.87	0.67	0.43	0.35	0.60
REA					**0.03**	0.86	0.49	0.48	0.70
RT						**0.04**	0.49	0.51	0.65
SFT							**0.06**	0.61	0.82
YE								**0.02**	0.62
BMS									**0.003**