Genetic Analysis of Direct and Maternal Effects for Calf Market and Carcass Weights in Japanese Black Cattle

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ABSTRACT : To evaluate direct and maternal effects on calf market weight (CMW) and carcass weight (CW) in Japanese Black cattle under an animal model, genetic parameters were estimated using 51,320 records of CMW and 11,944 records of CW, respectively. Direct and maternal heritabilities, and direct-maternal genetic correlation were estimated to be 0.22, 0.06 and 0.27 for CMW, and 0.23, 0.12 and -0.40 for CW, respectively. Correlation coefficient between maternal breeding values for CMW and CW was 0.521 for 157 sires appeared in both CMW and CW data sets. These results suggest that the maternal genetic effect on pre-weaning growth carries over to carcass weight. Maternal breeding values for both calf market weight and carcass weight could be used as the indicator traits of maternal ability in Japanese Black cattle. (*Asian-Aus. J. Anim. Sci. 1999. Vol. 12, No. 6 : 843-845*)

Key Words : Maternal Genetic Effects, Calf Growth, Carcass Weight, Beef Cattle, Japanese Black Cattle

INTRODUCTION

Since pre-weaning growth of beef cattle is strongly influenced by maternal effects of their dams (Marston et al., 1992), the improvement of maternal effects will significantly contribute to the increase in the efficiency of calf production. It has been shown that the maternal effect of beef cattle is mainly determined by milk yield (Meyer, 1992). Shimada et al. (1988) reported that the milk yield of cows in Japanese Black cattle explains more than 80% of variance in calf daily gain from birth to 8 weeks. However, due to the high cost, it is quite difficult to measure birth and 8-week weights in field. Calf weight in market may be used as an alternative trait for evaluation of the maternal effect. Because the weights are recorded in calf market routinely, it requires little additional cost to collect the records. Many genetic parameters of calf weaning weight around 200 days of age have been reported (Lee et al., 1997; Meyer, 1992; Waldron et al., 1993), and the estimate of breeding value for the maternal effect was found to be a good indicator for the performance of dam's milk yield (Diaz et al., 1992; Mallincakrodt et al., 1993; Marston et al., 1992; Meyer et al., 1994; Shimada et al., 1996).

In beef production with crossbreeding, maternal effects have been reported to have significant influence on carcass traits (Gregory et al., 1978; Peacock et al., 1982; Koch et al., 1983; Neville et al., 1984). In pure breeds of beef cattle, the 'carry-over' effect of maternal influences till pre-weaning growth on post-weaning growth has been considered to be less important (Meyer, 1992), Shimada et al. (1988) showed, however, that milk yields per day of Japanese Black cows were varied from 2.1 to 6.6 kg at first parity and from 4.5 to 8.0 kg at second parity. This large difference of milking abilities among dams may have some influence on carcass traits of progeny, especially on the carcass quantity.

In the present study, the authors analyzed direct and maternal genetic effects for calf market weight in Japanese Black cattle, to evaluate the utility as an indicator trait of maternal effect. The similar analysis was also carried out for carcass weight, and the genetic relationship of maternal effects between calf market and carcass weights was estimated.

MATERIALS AND METHODS

The data used in the analysis of calf market weight (CMW) are the records of 51,320 Japanese Black calves obtained at Shimane Central Market between October, 1988 and March, 1997. The average (standard deviation) age of calf was 251.9 (19.9) days. For carcass weight (CW), the records of 11,944 steers born in Shimane prefecture and slaughtered between April, 1988 and March, 1997 were collected from the carcass markets and used for the analysis. The average (standard deviation) slaughter age of the steers was 28.3 (2.2) months.

Estimates of variance components were obtained by REML using the MTDFREML programs coded by Boldman et al. (1993). Mathematical model fitted to CMW data included the agricultural cooperative, calf sex, market year, market season, age of dam as the fixed effects and both linear and quadratic partial

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regressions on market age of calf. For CW, the model included the effects of slaughter year, carcass market place and feeding place. Linear and quadratic regressions on slaughter age and linear regression on inbreeding coefficient were also considered. In both traits, random effects considered were direct additive genetic effect, maternal additive genetic effect, permanent environmental effect of dam, covariance between direct and maternal genetic effects and residual error. Heritability estimates and the genetic correlation between additive direct and maternal effect and permanent maternal environmental variance as a proportion of the phenotypic variance were calculated from the (co)variances components. The convergence criterion was 1×10^{-10} for each analysis. The pedigree of animals was traced back to the ancestors born in 1955. To clarify the genetic relationship between maternal effects for CMW and CW, the correlation coefficient between maternal breeding values for CMW and CW was calculated for 157 sires, which appeared in both CMW and CW data sets.

RESULTS AND DISCUSSION

Table 1 gives the estimates of variance, covariance and genetic parameters for CMW and CW. The direct and maternal heritabilities for CMW (0.22 and 0.06, respectively) were lower than the estimates for weaning weight at 180 days of age (0.29 and 0.34, respectively) reported by Shimada et al. (1996), who used the records collected in a Japanese Black herd managed for an experimental purpose. Meyer (1992) presented extensive lists of literature estimates of direct and maternal effects parameters for weight traits in beef cattle. According to the lists, the estimates of direct heritability for weaning weight ranged from 0.10 to 0.66 with a mean of 0.25 (21 values), and the maternal heritabilities ranged from 0.07 to 0.52 with a mean of 0.20 (18 values). The estimates of direct and maternal heritabilities in the present study were lower than the means of literature estimates. Maternal heritability for CW was estimated to be 0.12, being larger than those for the other carcass traits (ranging from 0.01 for yield estimate to 0.03 for marbling score and rib thickness) reported by Shimada et al. (1998). Waldron et al. (1993) found that the maternal effects for weight traits in one Hereford and two Angus experimental herds progressively decreased in importance with time after weaning. The lists of literature estimates of Meyer (1992) also show that estimates of maternal heritabilities for post weaning gain and final weight are generally low (0.01-0.09). The maternal heritability for CW estimated in this study tended to be higher than these estimates. The large variation in milking ability of cows in Japanese Black cattle (Shimada et al., 1988) may be a possible reason of the high maternal heritability for CW. The genetic correlation between direct and maternal effects was positive (0.27) for CMW, and negative (-0.40) for CW. From the list of literature estimates made by Meyer (1992), the genetic correlation for weaning weight ranged from -0.72 to 0.25 with a mean of -0.16 (14 values), and for post weaning gain and final weight ranged from -0.28 to 0.24 with a mean of -0.01 (4 values). The genetic correlations for weight traits estimated by Waldron et al. (1993) were variable in the Hereford herd, ranging from -0.35 for weaning weight to 0.97 for yearling weight, but all genetic correlation estimated in the two Angus herds were positive, and the averages over the two herds ranged from 0.03 for weaning weight to 0.20 for birth weight. The various estimates of genetic correlation between direct and maternal effects for pre-weaning growth and weight traits have been also reported in Japanese Black cattle: The consistent negative genetic correlations for weights of various pre-weaning stage were estimated in an experimental herd by Shimada et al. (1995). In contrast, Yokoi et al. (1997) reported the positive genetic correlations for pre-weaning growth traits in a different experimental herd.

The difference of estimated genetic parameters among herds in Japanese Black cattle may be a reflection of the genetic history of breed. Before the breed establishment of Japanese Black cattle (1944), the native cattle in Japan were crossbred with various breeds, such as Shorthorn, Simmental and Brown Swiss. The breeds used in the crossbreeding and the degree of cross were varied among prefectural populations. Even after the establishment of breed, most of the breeding projects have been carried out separately within each prefectural population, though there have been some amount of gene flow, usually through males, among prefectural populations. From pedigree analysis, Nomura and Sasaki (1988) have

Table 1. Variance components and genetic parameters for calf market weight and carcass weight

Traits	h_a^2	h_m^2	r_{am}	C	σ_a^2	σ_m^2	σ_{am}	σ_c^2	σ_e^2
Calf market weight	0.22	0.06	0.27	0.07	104.0	26.5	14.1	34.2	288.4
Carcass weight	0.23	0.12	-0.40	0.05	462.5	241.0	-132.2	109.1	1355.2

h_a^2: direct heritability, h_m^2: maternal heritability, r_{am}: direct-maternal genetic correlation, C: σ_c^2/phenotypic variance, σ_a^2: direct additive genetic variance, σ_m^2: maternal additive genetic variance, σ_{am}: genetic covariance of maternal and direct, σ_c^2: permanent maternal environmental variance, σ_e^2: residual environmental variance.

revealed that the breeding history has a great influence on the genetic structure and the breed is genetically divided into several local sub-populations, each with different genetic backgrounds.

Although the 'carry-over' effect of maternal influences till pre-weaning growth on post-weaning growth has been considered to be less important in pure breeds of beef cattle (Meyer, 1992), a tangible genetic variation of maternal effect on CW was estimated in the present study (table 1). To evaluate the genetic similarity between maternal effects for CWM and CW, relationship between maternal breeding values for CMW and CW was examined for the 157 sires which appeared in both CMW and CW data sets. A statistically significant ($p<0.01$) correlation coefficient (0.521) was estimated. This simple correlation may not be considered as the genetic correlations, since the differences among the prediction error variances of breeding values are not taken into account. To obtain the genetic correlation, the simple correlation between estimated breeding values should be adjusted in terms of the reliabilities of the estimated breeding values (Hodel et al., 1995). However, the significant correlation between maternal breeding values suggests that the maternal genetic effect on weight of weaning stage carries over to the carcass weight.

In the breeding of Japanese Black cattle, the genetic evaluation project of meat quality with BLUP (best linear unbiased prediction) methodology was initiated in nine prefectural populations in 1991, and now the project covers all of the main prefectural populations. However, since the liberalization of beef import restrictions in 1991, reducing the cost of calf production has become an important problem in Japanese beef industry in order to compete with imported beef of a lower price. The establishment of genetic improvement system of maternal ability is now an urgent task in the breeding of Japanese Black cattle.

The present study shows that both calf market and carcass weights of Japanese Black cattle are influenced by maternal genetic effects and could be used as indicator traits of maternal ability. In Japanese Black cattle, selection programs incorporating maternal effects will contribute to the improvement not only in pre-weaning growth but also in carcass quantity.

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