GENETIC PARAMETERS OF FIELD REPRODUCTIVE AND CARCASS TRAITS IN JAPANESE BLACK CATTLE

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INTRODUCTION

Approximately 44% of Japanese domestic beef are produced by 4 native beef breeds, Wagyu, and Japanese Black accounts for more than 90% of Wagyu. Genetic evaluation of carcass traits in Japanese Black has been undertaken since 1991 and currently 890,000 breeding stock are evaluated using 680,000 carcass records. Although carcass characteristics will undoubtedly remain as primary breeding objectives, the need to improve reproductive performance is also increasing because it directly affects herd productive efficiency. The genetic correlations are essential information to discuss correlated responses in reproductive traits through selection for carcass traits and to improve both abilities. Although such estimates in beef cattle have been available from some studies (*e.g.* MacNeil *et al.*, 1984 ; Splan *et al.*, 1998 ; Mialon *et al.*, 2001), few have reported the estimates using field data. The objective of this study is to estimate genetic relationships between field reproductive performances in female and carcass traits of Japanese Black and to investigate the potential for simultaneous genetic improvement in both abilities.

MATERIAL AND METHODS

Data preparation. Calving records were obtained from Hyogo and Shimane prefectures. The raw data contained 65,275 and 59,553 records, which covered February 1990 to May 2001, of 17,303 and 15,612 breeding cows in Hyogo and Shimane, respectively. The cows, which have been used as ET donors or recipients, were excluded firstly. Then age at first calving (AFC, months), gestation length (GL, days), days open (DO, days) and calving interval (CI, days) were calculated. In the present study DO, which was greater than 364 days or less than 21 days, was eliminated. The GL from twins, abortion or stillbirth and GL, which was less than 241 days, was eliminated. The i-th CI of a cow was eliminated if any of i-th DO or $(i+1)$-th GL was not a valid record. If a cow had valid first GL and her AFC fell between mean ± 3 s.d., then her AFC was treated as a valid record. After data editing, 13,957 and 10,542 records were available for AFC of Hyogo and Shimane, respectively. In other traits 41,614 to 63,034 records from 12,102 to 15,546 cows of Hyogo and 30,939 to 54,012 records from 9,068 to 13,391 cows of Shimane were available for analyses.

Offspring, half- and full-sibs, which were fattened in Hyogo or Shimane, of cows in raw reproductive data were sampled as raw carcass records. There were 18,985 and 9,550 records for Hyogo and Shimane, respectively. Among them, 16,565 and 7,171 records, which fell between mean ± 3 s.d. in age at slaughter, were used for Hyogo and Shimane, respectively.

Traits analyzed were carcass weight (CW, kg), *longissimus* muscle area (LMA, cm^2), rib thickness (RT, cm), subcutaneous fat thickness (SFT, cm), yield estimate (YE, %) and beef marbling score (BMS, unit) measured by certified graders. All carcass traits except for CW were evaluated at the section between 6th and 7th ribs. The details of the traits were described by Mukai *et al.* (1995). All data edits were done for each prefecture separately.

Analytical procedure. (Co)variance components were estimated from pairwise analyses of two-trait animal models with restricted maximum likelihood methodology. Repeatability models were used to analize GL, DO and CI. The models for reproductive traits included year of calving, month of calving, sex of calf and body condition score (AFC only) as fixed effects, age at calving (except for AFC), inbreeding coefficient of cow and of calf (except for DO) as covariates, and breeding farm (except for GL), additive genetic, permanent environment (except for AFC) and residuals as random effects. The model for carcass traits included slaughter year, sex and carcass market as fixed effects, age at slaughter and inbreeding coefficient as covariates, and fattening farm, additive genetic and residuals as random effects. Genetic base years for the evaluation were all set in 1965. Genetic trends were estimated as linear regressions of average predicted breeding values of cows with records for reproductive traits and of cows with slaughtered progeny for carcass traits, on birth year.

Table 1. Summary statistics, heritability (h^2) and repeatability (*r*) estimates of reproductive and carcass traits

	Hyogo				Shimane			
Traits	Mean	s.d.	h^2	*r*	Mean	s.d.	h^2	*r*
AFC	25.0	2.87	0.099		25.2	2.83	0.269	
GL	289	4.88	0.451	0.451	289	5.18	0.347	0.347
DO	108	62.9	0.033	0.067	116	67.4	0.032	0.090
CI	397	63.0	0.034	0.074	406	67.5	0.034	0.094
CW	381	41.2	0.337		435	47.8	0.389	
LMA	49.7	6.94	0.457		51.7	7.31	0.417	
RT	6.8	0.76	0.334		7.1	0.79	0.322	
SFT	2.1	0.65	0.439		2.7	0.86	0.410	
YE	73.7	1.11	0.510		73.0	1.31	0.534	
BMS	1.84	0.783	0.531		1.32	0.691	0.591	

RESULTS AND DISCUSSION

Summary statistics, heritability (h^2) and repeatability estimates are shown in Table 1. The estimates for reproductive traits are the averages of pairwise analyses with carcass traits, and vice versa. However an analysis between DO and RT in Shimane is not included because it did not converge. The h^2 of AFC are estimated at 0.099 for Hyogo and 0.269 for Shimane. In the literature a substantial variation is found for h^2 of AFC such as 0.04 (Oyama *et al.*, 1996) and 0.38 (Ojango and Pollott, 2001). It indicates that a large difference in genetic variation between breeds exits for AFC. Moderate h^2 are obtained for GL (0.451 and 0.347 for Hyogo and Shimane, respectively) and are similar to literature estimates (*e.g.* MacNeil *et al.*, 1984 ;

McGuirk *et al.*, 1999). It is unrealistic for GL to become one of the breeding objectives. Thus an attention should be paid for the correlated response in GL through selection for other traits because animals are considered to have the optimum GL as McGuirk *et al.* (1999) mentioned. The h^2 of CI and DO are similar and very low. The literature values for CI are also low (*e.g.* Oyama *et al.*, 1996 ; Frazier *et al.*, 1999 ; Ojango and Pollott, 2001). In the present study, breeding farm and residual effects acount for approximately 10% and 80% of phenotypic variances in CI, respectively, and except for AFC the estimated variance components of reproductive traits in Hyogo are similar to those in Shimane (data not shown). Carcass traits are found to be moderately to highly heritable as often reported (*e.g.* see Koots *et al.* (1994) or Marshall (1994) for review).

Table 2. Estimates of genetic correlations between reproductive and carcass traits

	Hyogo				Shimane			
Traits	AFC	GL	DO	CI	AFC	GL	DO	CI
CW	-0.170	0.120	-0.045	-0.121	-0.391	0.122	0.031	0.124
LMA	-0.125	0.100	0.060	0.040	-0.293	0.085	0.249	0.273
RT	-0.064	0.068	-0.217	-0.259	-0.016	0.073	n.a.[A]	-0.336
SFT	0.002	0.027	-0.249	-0.240	-0.100	0.172	-0.302	-0.211
YE	-0.055	0.045	0.105	0.091	0.036	-0.056	0.229	0.173
BMS	-0.280	0.025	-0.067	-0.012	-0.210	0.019	0.270	0.274

[A] Not available due to convergence problem.

The genetic correlations between reproductive and carcass traits of Hyogo and Shimane are presented in Table 2. Negative estimates show favorable relationships except for SFT. The estimates between GL and carcass traits are generally low and considerable correlated response will not occur in GL through selection for carcass traits. Small but unfavorable estimates are obtained between AFC and SFT or YE of Shimane. Except for these 2 estimates AFC correlated favorably with carcass traits. MacNeil *et al.* (1984) also reported low correlations between GL and CW, fat trim or retail product. In contrast, they showed unfavorable estimates between age at puberty and above 3 carcass traits and Splan *et al.* (1998) obtained low correlations ranged from –0.04 to 0.06 for age at puberty and CW, LMA, fat thickness, retail product or BMS. Oyama *et al.* (1996) estimated genetic correlations between AFC and carcass traits for Japanese Black in Hiroshima prefecture. The discrepancies between their and the present studies are only observed where weak relationship exists. Selection for CW, RT, BMS in Hyogo or RT in Shimane is expected to improve DO and CI, and selection for other carcass traits tends to extend DO and CI. Between interval from calving to first positive progesterone test and fat content, a small but negative estimate is also reported by Mialon *et al.* (2001). With CI, Oyama *et al.* (1996) estimated desirable correlations in CW, LMA and RT, which relate to meat quantity, and undesirable correlations in SFT and BMS, which relate to fat deposition. Generally the relationships found in the present study are low. If genetic correlation, which is less than 0.1 in magnitude, could be regarded as no relationship exists between the traits, unfavorable relationships are found between CW or LMA and GL, SFT and DO or CI, and YE and DO in Hyogo. More estimates are undesirable in Shimane and the estimates between CW and GL or CI, LMA and DO or CI, SFT and AFC, DO or CI, YE and DO or CI, and BMS and DO or CI are found to be unfavorable.

Genetic trends of -0.08 months/year ($P < 0.001$) are observed in AFC in both prefectures. It might be explained partly by significant positive trends in CW, LMA, YE, BMS in Hyogo, LMA, YE and BMS in Shimane. The other regressions of reproductive traits except for GL in Shimane, which is -0.08 days/year ($P < 0.01$), are found to be non-significant.

CONCLUSION

The h^2 of Japanese Black estimated herein agreed with literature values and the differences between prefectures were small. Genetic correlations were generally low and similar between prefectures. However some important traits such as CW and BMS did not show consistency between prefectures. It indicates that they should be estimated for each prefecture to discuss correlated responses in detail. In addition, it seems that some carcass traits correlate unfavorably with reproductive traits. The results suggest the need to include reproductive traits in breeding programs of Japanese Black.

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