Genetic and Environmental Effects on Carcass Traits of Japanese Brown Cattle

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ABSTRACT : Studies on the genetic and environmental effects on *M.longissimus thoracis* area (MLTA), fat thickness (SFT), rib thickness (RT) and marbling score (MS) were conducted on 21,086 steers and 7,151 heifers of Japanese Brown breed. All carcass traits were affected significantly ($p<0.01$) by sire, sex and initial year effects. Both of the MLTA and MS of steers were greater than heifers. Their differences were 1.4 cm^2 for MLTA and 0.05 for MS, respectively. Cattle started for fattening in winter tend to have higher of MLTA and MS and thicker of SFT and RT than those in other seasons. MLTA increase from 1987 to 1989 (about 1.9 cm^2) and decrease until 1994 (about 2.4 cm^2) and then increase again up to 1995 (about 1.5 cm^2). MS were nearly equal from 1987 to 1991 (about "1") and then decrease up to 1995 (about "1"). Heritability estimates of MLTA, RT, SFT and MS were ranged from 0.22 to 0.36. Genetic and phenotypic correlations of MLTA, RT, SFT and MS were positive and ranged from 0.05 to 0.62 and from 0.03 to 0.32 except SFT with MLTA was negative (-0.14 and -0.03). (***Asian-Aus. J. Anim. Sci. 2000. Vol. 13, No. 1 : 1-5***)

Key Words : Japanese Brown Cattle, Carcass Traits, Genetic Parameters

INTRODUCTION

Production of domestic Japanese beef cattle is competitive only because of its outstanding in meat quality. In Japan, meat quality is determined primally by degree of marbling which is the most important trait for carcass evaluation. Therefore the main breeding objectives of Japanese Beef Cattle production is improving and keeping the meat quality and quantity.

Japanese Brown cattle has lower meat quality but higher growth rate and better on feed efficiency than Japanese Black cattle, the main beef bred in Japan (Namikawa, 1992). Breeding program for improving meat quality and quantity of Japanese Brown cattle were done by selections and evaluation systems for obtaining superior breeding stock. Establishment of recording systems under field conditions and accurate genetic parameter estimates using these records will be valuable in efficient and successful breeding program.

The purposes of this study were examining basically the genetic parameters of MLTA, SFT, RT and MS and to clarify some effects such as sire, sex, initial year and initial season of fattening period on these carcass traits of Japanese Brown cattle.

MATERIALS AND METHODS

Experimental animals

Fields records of carcass traits were obtained from 21,086 steers and 7,151 heifers of Japanese Brown cattle (represented by 121 sires) from 1987 to 1995 at Kumamoto prefecture. Those cattle were fattened with water and fed with concentrate and roughage *ad libitum*. Feeding was given in a form of concentrate feeds with total digestible nutrients (TDN) of 73.0% and digestible crude protein (DCP) of 10.0%. Before slaughtering, the animals were stayed overnight at slaughter place without feed an water. Measurements were done between the 6^{th} and 7^{th} ribs on the left side of carcass 24 hours after slaughter to obtain carcass traits of MLTA, SFT, RT and MS. Average age and body weight of cattle at starting of fattening were 9.9 ± 1.1 month of age and 302.0 ± 29.7 kg while average period of fattening were 14.5 ± 1.3 month.

Statistical method

Data was analyzed using LSMLMW Program of Harvey (1990). The mathematical model used in this analysis was :

$$Y_{ijklm} = \mu + s_i + X_j + Y_k + S_l + (YS)_{kl} + (XY)_{jk} + (XS)_{jl} + a(A_{ijkl} - \overline{A}) + b(U_{ijkl} - \overline{U}) + c(E_{ijkl} - \overline{E}) + e_{ijklm}$$

where, Y_{ijklm} are observation ijklm for the traits; μ are the overall mean; s_i are the random effects of i^{th} sire (1,..., 121); X_j are the fixed effects of j^{th} sex (1, 2); Y_k are the fixed effects of k^{th} initial year of fattening (1,..., 9); S_l are the fixed effects of l^{th} initial season of fattening (1=Dec~Feb, 2=March~May, 3=June~Aug and 4=Sep~Nov); $(YS)_{kl}$ are the interaction effects of initial year with initial season of fattening; $(XY)_{jk}$ are the interaction effects of sex with initial year of fattening; $(XS)_{jl}$ are the interaction effects of sex with initial season of fattening; a, b, c

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are linear regression coefficients; A_{ijkl}, U_{ijkl}, E_{ijkl} are initial age, initial weight and fattening period; and e_{ijklm} are random errors.

Duncan's New Multiple Range Test was used to test the differences within least squares means of carcass traits (Duncan, 1955).

RESULTS AND DISCUSSION

Descriptive statistics for each traits is presented in table 1. Means and standard deviations were 48.7±5.9 cm^2 for MLTA, 69.7±7.4 mm for RT, 25.7±8.5 mm for SFT and 0.86±0.46 for MS while those for final weight, carcass weight and daily gain were 669.7± 66.2 kg, 432.6±50.1 kg and 0.84±0.15 kg/day. In concern with those results, Oyama et al. (1995) reported that carcass measurements of Japanese Black fattening cattle were 48.4±6.1 cm^2, 73.0±7.8 mm, 31.0±8.6 mm and 1.75±0.7 for MLTA, RT, SFT and MS. Rahim (1998) showed that MLTA, RT, SFT and MS of Japanese Brown cattle 47.2±6.2 cm^2, 68.1± 8.1 mm, 20.8±6.8 mm in Kochi prefecture and 48.8 ±5.9 cm^2, 69.8±7.5 mm, 24.9±7.8 mm and 0.91± 0.48 in Kumamoto prefecture.

Table 1. Basic statistics and coefficients of variation of carcass traits of Japanese Brown cattle

Traits[a]	Mean±SD	Coefficient of variation
MLTA	48.7 ±6.0	12.3%
RT	69.7 ±7.4	10.6%
SFT	25.6 ±8.5	33.0%
MS	0.86±0.46	53.5%

(n = 28,237).

[a] MLTA: *M. longissimus thoracis* area (cm^2); RT: Rib thickness (mm) SFT: Subcutaneous fat thickness (mm); MS: Marbling score.

There are small differences of MLTA between both of breeds but Japanese Brown cattle have thinner RT and SFT and lower MS than Japanese Black cattle. These differences may depend on not only breed but also on period of fattening which Japanese Brown cattle was six month shorter than Japanese Black. Coefficient of variation of MS was the biggest (53.5%) comparing with MLTA (12.3%), RT (10.6%) and SFT (33.0%). Range of MS of Japanese Brown cattle were narrower (about "0" to "1") than Japanese Black (about "0" to "5").

Genetic effects on carcass traits of Japanese Brown cattle

The results of least squares analysis of variances for carcass traits are shown in table 2. Sire and sex effects were significant ($p<0.01$) for all carcass traits. Least squares means of carcass traits of steers were bigger of MLTA, higher of MS and thicker of RT than heifers. It was indicated that body weight and proportion of fat intramuscular of steers were heavier and higher than heifers while heifers were thicker of fat subcutaneous. These results can be used as information for select the Japanese Brown sire based on MLTA and MS.

The heritability, genetic and phenotypic correlations on carcass traits of Japanese Brown cattle are shown in table 3. MLTA had the highest heritability (0.36) comparing with SFT (0.33), MS (0.32) and RT (0.22), respectively. Present heritability estimates of MLTA were in the range of previous reports for Japanese Black steers (0.32) by Fukuhara et al. (1989) and (0.54) by Oyama et al. (1996) and for Japanese Brown steers (0.38) by Hirooka et al. (1996). The differences of heritability may depend on source of data and statistical analysis on calculation. Present heritability estimates of MS were under than those

Table 2. Analysis of variance for carcass traits of Japanese Brown cattle

Source of variance	df	Mean squares			
		MLTA	RT	SFT	MS
Sire	120	698.7**	663.1**	1,270.1**	3.63**
Sex (X)	1	2,871.5**	1,053.8**	13,735.3**	3.45**
Season (S)	3	433.3**	2,501.0**	242.1**	0.46
Year (Y)	8	718.7**	1,040.3**	2,211.8**	20.40**
(S)*(Y)	24	125.5**	205.4**	246.3**	0.59**
(X)*(Y)	8	58.3**	174.6**	221.5**	0.36
(X)*(S)	3	45.7**	94.7	581.4**	0.82**
Linear regression :					
Initial Age	1	57.7	1,826.8**	1,166.0**	5.55**
Initial Weight	1	7,404.8**	25,588.9**	17,427.7**	1.79**
Fattening Period	1	1,142.7**	10,013.9**	4,038.2**	6.30**
Remainder	28,066	31.7	49.3	62.7	0.19

Abbreviations of carcass traits are same as table 1; *p<0.05; **p<0.01.

have been reported for Japanese Brown steers (0.40) by Hirooka et al. (1996).

Table 3. Genetic parameters of carcass traits of Japanese Brown cattle

Traits[a]	MLTA	RT	SFT	MS
MLTA	0.36	0.55	-0.14	0.38
RT	0.27	0.22	0.17	0.62
SFT	-0.03	0.32	0.33	0.05
MS	0.21	0.28	0.03	0.32

[a] Abbreviation of carcass traits are same as table 1. Genetic and phenotypic correlation are above and below diagonal.

Genetic correlations of all carcass traits were positive and ranged from 0.05 to 0.62 except correlation of MLTA with SFT was negative (-0.14). Yang et al. (1985) also reported a negative correlation between MS with SFT of Japanese Black cattle (-0.10) while Wilson et al. (1993) reported by Angus field data (-0.13). Low genetic correlation were found between SFT with RT (0.17) and SFT with MS (0.05). The results of low and negative genetic correlation between MLTA and SFT could be used as information to farmers and breeders to produce beef cattle with more higher quality without increasing of subcutaneous. Genetic correlations between MLTA and MS (0.38) were higher than those reported by Hirooka et al. (1996) for Japanese Brown steer (0.12) but lower than those reported by Harada (1996) for Japanese Brown cow (0.73).

Phenotypic correlations of all carcass traits were positive and ranged from 0.03 to 0.32 except MLTA with SFT was negative correlation (-0.03). Moderate phenotypic correlations were found between RT with MLTA (0.27), RT with SFT (0.32) and RT with MS (0.28) while low phenotypic correlation was found between MS with SFT (0.03). These results were informative as information for selecting superior breeding sire or dam for making better meat quality and quantity of next generation. Pedigree selection and improving handling cattle's management may increase the correlation between main carcass traits (MLTA and MS).

Environmental effects on carcass traits of Japanese Brown cattle

Season and year effects were significant ($p<0.01$) for all carcass traits except season effects for MS. Least squares means of carcass traits of Japanese Brown cattle by season are shown in figure 1 and 2. Environmental alteration, such as differences of grazing places, were influencing variances of least squares means of carcass traits. There are some group of cattle at some place have to move from hill to valley and stay in paddock along winter and then coming back to hill and staying there along spring, summer and autumn. Those cattle need more energy for movement in ranch and also differences of environment will influencing the quality and quantity of feed stuff, especially quality of grass. Those situation should influencing of carcass growth. Cattle were fattened from winter tended to have the biggest MLTA (49.1 cm^2), the thickest RT (70.3 mm) and SFT (26.6 mm) and the highest MS (0.89) than those were fattened from other seasons. It indicated that cattle were fattened from winter will showing better carcass quality with big size of MLTA and more marbled of meat. Nevertheless, cattle started for fattening in winter or autumn tended to have nearly similar size of MLTA (49.1 cm^2 and 48.9 cm^2) while those for summer and autumn tended to have similar MS (0.86).

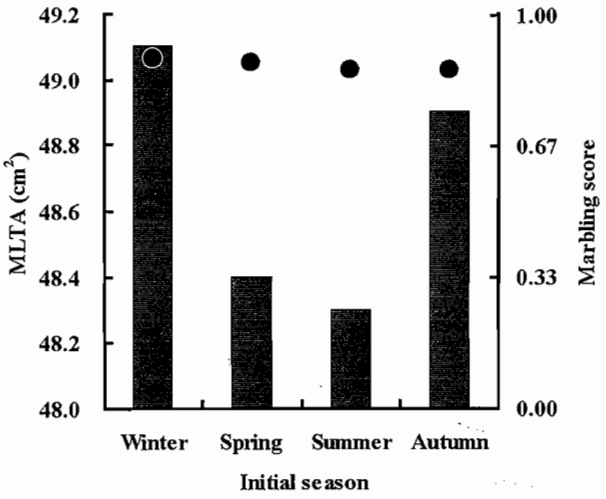

Figure 1. Pattern of MLTA and MS of Japanese Brown cattle, by season (▩ MLTA ◍ MS)

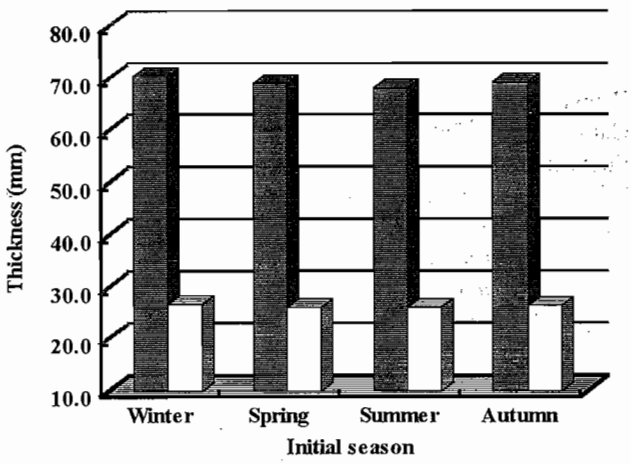

Figure 2. Pattern of RT and SFT of Japanese Brown cattle, by season (▩ RT □ SFT)

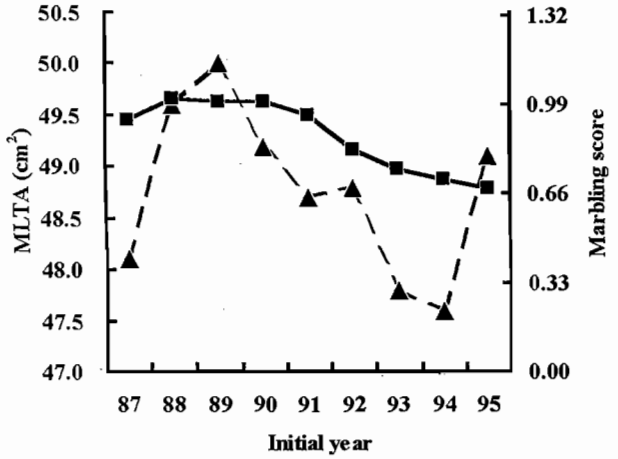

Figure 3. Pattern of MLTA and MS of Japanese Brown cattle, by year (--▲-- MLTA —■— MS)

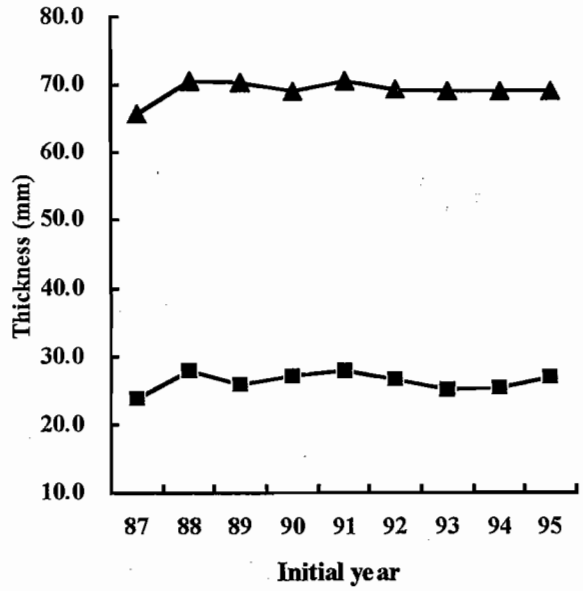

Figure 4. Pattern of RT and SFT of Japanese Brown cattle, by year (—▲— RT —■— SFT)

Least squares means of carcass traits of Japanese Brown cattle by year are shown in figure 3 and 4. Cattle were fattened in 1988 tended to have the thickest RT (70.6 mm) and SFT (28.0 mm), the highest MS (1.01) while cattle were fattened in 1989 tended to have the biggest MLTA (50.0 cm^2). MLTA were increased from 1987 to 1989 (about 1.9 cm^2) and decreased up to 1994 (about 2.4 cm^2) and increased to 1995 (about 1.5 cm^2). Variation of MLTA were big all the year and it indicated that environmental effect at that time were really influencing growth size of MLTA. Range of MS were not big (about "1" to "1"), although MS decreased after reach the highest value in 1988. Range of RT were 65.7 mm to 70.6 mm and range of SFT were 23.9 mm to 28.0 mm while the highest increasing were shown in 1987 to 1988 for both of traits.

The interaction effects of year with season were significant ($p<0.01$) for all carcass traits but interactions effects of year with sex were significant ($p<0.01$) for RT and SFT while interactions effects of season with sex were significant ($p<0.01$) only for SFT. The highest means were shown by interactions of sex with year in winter in 1988 for MLTA (50.6 cm^2) and RT (71.6 mm) and by interactions of season with year in spring in 1988 for SFT (29.6 mm) and MS (1.05).

Linear regression of RT, SFT and MS were positive and significant ($p<0.01$) affected by initial weight and period of fattening. Linear regression of MS was positive and significantly ($p<0.01$) affected by initial age while those for RT and SFT were negative and significant ($p<0.01$). However linear regression of MLTA were negative and non significant affected by initial age. It indicated that more heavier of initial weight and more longer of fattening period tended to increase of size of MLTA, thickness of SFT and RT and value of MS. More older of initial age of cattle tended to decrease of MLTA, RT and SFT while those for MS was increasing.

In conclusion, it is better for breeder to use the cattle which have heavy of initial weight and start of fattening period in winter for getting best carcass quality and quantity (in term of bigger of MLTA, thicker of SFT and highest of MS).

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