Estimation of Genetic and Environmental Parameters of Carcass Traits in Hanwoo (Korean Native Cattle) Populations

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ABSTRACT : Genetic parameters of carcass weight (CWT), dressing percent (DP), cook loss (CL), eye muscle area (EMA), back fat thickness (BFT), and meat tenderness in terms of mastication (MAS), shear force (SFR) and penetration (PEN) in Korean native cattle were estimated in this study. Effects of sire, location and their interaction on these traits were also evaluated. Sire effects were found to be significant on all the traits studied except for PEN. The CWT and DP were also significantly affected both by location ($p < 0.01$) and by interaction effect between sire×location ($p < 0.05$). The EMA was significantly ($p < 0.05$) affected by location but not by interaction effect between sire×location. All the traits were positively correlated (r_g and r_p) with each other except between CL and meat tenderness (negatively correlated). Moderate to high genetic correlations between CWT and other important traits were obtained; indicating that selection for CWT would lead to improve carcass quality. Heritability estimates were 0.64, 0.52, 0.37, 0.25, 0.19 and 0.18 for MAS, SFR, CWT, PEN, DP and EMA, respectively. *(Asian-Aust. J. Anim. Sci. 2002. Vol 15, No. 11 : 1523-1526)*

INTRODUCTION

In Hanwoo, the main beef cattle of Korea, individual bulls have genetic influences in the population because large numbers of progeny are produced by artificial insemination. In most situations, the breeding beef bulls are evaluated based on their own yearling weight and growth rate. The estimation of genetic parameters in body weights of Hanwoo were made by some researchers (Shin and Park, 1990; Son et al., 1997). Growth and live weight are correlated with carcass traits but the correlation may not be strong enough to improve Hanwoo. In addition, using the results of progeny test leads to improved reliability to individual evaluation of bull. Carcass quality evaluated at slaughterhouses predicts beef producing ability better than growth or live weight. Despite the endeavor to improve Hanwoo, information on the effects of genetic and environment on the merit of carcass is limited.

Carcass traits of cattle have been studied considerably, and most of the traits have been found to be of high or moderate heritability (Robinson et al., 1990; Arnold et al., 1991; Gregory et al., 1994; Wheeler et al., 1996). However, the results cannot be easily generalized into Hanwoo population, because most of the studies have involved European beef breeds, which are only of marginal importance in Korea. The aim of this study was to investigate the sire, location and interaction between sire and location factors affecting carcass traits in Hanwoo steers and to estimate heritability, genetic and phenotypic correlations between different carcass traits.

MATERIALS AND METHODS

This experiment was undertaken at the laboratory of Animal Resources and Biotechnology, Chonbuk National University, Korea. A total of 161 progeny aged between 657-753 days (average 717 days) belonging to 23 sire groups were used in this study. The progeny were reared in two locations i.e. Namwon (NWN) located 800 m above sea level and Taekwanryung (TKG) which is 500 m above sea level. Meat samples were collected from 13th-14th ribs of the steers within 24 h of slaughter and evaluated by mechanical and physical means. The traits studied were carcass weight (CWT), dressing percent (DP), eye muscle area (EMA), back fat thickness (BFT), cook loss (CL) and meat tenderness in terms of mastication (MAS), shear force (SFR) and penetration (PEN). Meat tenderness was estimated using Fudoh Rheo Meter within 32-36 h postmortem. The CWT were obtained by weighing the weight of slaughtered steers after the removal of the lungs, heart, liver, intestines and ancillary organs or mesenteries, bladder, reproductive organs and blood. The DP was calculated based on live weight at slaughter and BFT was measured at the 12th and 13th vertebra. Five pairs of isolated tracings of the muscle *longissimus dorsi* or 'eye muscle' were made on a transparent acetate sheet to determine the cross section area of the muscle. Each acetate paper was xeroxed onto a plain white paper of known area and weight. The demarcated areas on to a white paper for eye muscle were cut out and weighed and from the area-

weight relationship the eye muscle area was determined by simple calculation. The CL was calculated from the weight differences between before and after boiling the samples at 65°C for 30 min.

Statistical analysis

(Co)variance components for CWT, DP, CL, EMA, MAS, SFR, PEN and BFT were analyzed by least squares techniques of the GLM procedures using SAS statistical package (SAS, 1991). In the model, all effects were considered as fixed effects except for error effects. The statistical model used for the analysis of carcass traits was as follows:

$$Y_{ijk}=\mu+S_i+L_j+(S\times L)_{ij}+e_{ijk}$$

Where,

Y_{ijk}=individual record
μ=mean
S_i=effect of sire (i=1-23)
L_j=effect of location (j=1-2)
$(S\times L)_{ij}$=interaction effect between sire and location
e_{ijk}=residual error

Duncans Multiple Range Test (DMRT) was performed to separate means of significant difference among themselves. Values of h^2 and correlations (r_g and r_p) were estimated based on paternal half sib analysis method (Becker, 1985) involving 23 sire groups.

RESULTS AND DISCUSSION

Effects of sire

Effects of sire on CWT, DP, CL, EMA, muscle hardness and BFT in Hanwoo steers are presented in Table 1. The effects of individual sire were found to be significant on all these traits except PEN. The highest CWT (343.75 kg), DP (58.53%) and EMA (88.67 cm²) were observed in the progeny from sire 528, sire 535 and sire 533, respectively. The lowest (5.30%) and highest (8.74%) CL were observed in the progeny of to sire 543 and sire 523, respectively. The highest MAS (60.83 g/cm²) and SFR (5,197 g/cm²) were observed in the progeny produced from sires 531 and sire 528, respectively. Sire 528 and sire 539 performed highest (1.15 cm) and lowest (0.64 cm) BFT production, respectively. These results are in agreement with Xie et al. (1996), who analyzed the carcass data of the progeny derived from four Wagyu bulls and two Angus bulls mated with Angus-Hereford cows and reported that sire had a

Table 1. Least-squares mean of carcass traits in progeny of different sires of Hanwoo cattle

Sire	Traits							
	CWT (kg)	DP	CL (%)	EMA (cm²)	MAS (g/cm²)	SFR (g/cm²)	PEN (g/cm²)	BFT (cm)
441 (4)	273.25[c]	55.75[b]	6.60[ab]	74.25[b]	58.89[b]	3,250[ab]	4,814	0.67[b]
513 (10)	299.00[abc]	57.59[ab]	5.67[ab]	76.70[ab]	60.26[a]	3,992[ab]	5,235	0.82[ab]
514 (7)	326.57[ab]	57.69[ab]	7.93[ab]	83.86[ab]	45.99[ab]	2,777[ab]	5,857	0.83[ab]
515 (3)	294.67[bc]	57.00[ab]	7.96[ab]	76.67[ab]	52.18[ab]	4,246[ab]	6,540	0.60[ab]
516 (6)	332.83[ab]	58.07[ab]	7.15[ab]	86.17[ab]	30.78[ab]	4,005[ab]	5,388	0.83[ab]
517 (6)	321.50[ab]	56.65[ab]	6.42[ab]	82.83[ab]	42.29[ab]	3,627[ab]	6,341	0.82[ab]
519 (7)	299.86[abc]	57.17[ab]	6.57[ab]	77.43[ab]	28.94[ab]	3,594[ab]	4,494	0.88[ab]
522 (9)	321.22[ab]	56.48[ab]	7.89[ab]	84.89[ab]	50.53[ab]	3,457[ab]	6,583	0.99[ab]
523 (4)	322.50[ab]	57.60[ab]	8.74[b]	77.50[ab]	43.17[ab]	2,623[b]	4,106	0.80[b]
524 (6)	326.17[ab]	58.23[a]	6.80[ab]	81.50[ab]	18.13[b]	3,991[ab]	6,362	0.78[ab]
525 (9)	303.44[abc]	56.52[ab]	5.36[a]	79.33[ab]	36.73[ab]	3,831[ab]	4,678	0.76[ab]
526 (9)	306.56[abc]	56.66[ab]	6.69[ab]	78.89[ab]	40.39[ab]	4,093[ab]	5,917	0.90[ab]
528 (4)	343.75[a]	57.98[ab]	5.84[ab]	84.25[ab]	54.35[ab]	5,197[a]	6,056	1.15[a]
529 (11)	303.36[abc]	57.28[ab]	5.87[ab]	82.46[ab]	49.18[ab]	3,416[ab]	5,085	0.68[ab]
530 (8)	328.38[ab]	57.61[ab]	7.86[ab]	87.25[a]	35.16[ab]	3,686[ab]	5,695	0.91[ab]
531 (9)	307.00[abc]	57.33[ab]	7.85[ab]	81.11[ab]	60.83[a]	4,506[ab]	4,873	0.73[ab]
533 (3)	336.67[ab]	58.47[a]	7.15[ab]	88.67[a]	60.17[a]	4,495[ab]	6,608	1.00[ab]
535 (4)	338.25[ab]	58.53[a]	6.42[ab]	82.00[ab]	59.03[a]	3,383[ab]	4,006	1.14[a]
539 (9)	310.56[abc]	56.79[ab]	6.57[ab]	78.78[ab]	46.07[ab]	3,410[ab]	6,623	0.64[b]
540 (8)	333.50[ab]	58.05[ab]	7.89[ab]	88.00[a]	23.39[b]	3,402[ab]	4,879	0.89[ab]
541 (13)	314.31[abc]	57.43[ab]	8.71[b]	81.00[ab]	32.80[ab]	5,010[a]	4,442	0.85[ab]
542 (6)	304.33[abc]	58.33[a]	6.80[ab]	78.17[ab]	33.34[ab]	4,602[ab]	4,091	0.95[ab]
543 (6)	326.33[ab]	57.57[ab]	5.30[a]	84.17[ab]	53.80[a]	3,127[ab]	4,574	0.90[ab]
p-value	0.004	0.032	0.041	0.028	0.015	0.017	0.062	0.033

CWT=Carcass weight; DP=Dressing percentage; CL=Cook loss; EMA=Eye muscle area; MAS=Mastication; SFR=Shear force; PEN=Penetration; BFT=Back fat thickness.
Figures in the parentheses indicate the number of progeny for each sire.
Means with different superscript (s) in the same column differ significantly.

significant (p<0.05) effect on EMA and BFT in progeny. However, Hoving-Bolink et al. (1999) stated that sire had an influence on intra-muscular fat in beef. These genetic differences among sires could be utilized by selective breeding to produce beef cattle with greater genetic ability to carcass quality and quantity.

Effects of location

Effects of location on carcass traits in Hanwoo steers are presented in Table 2. Table 2 showed that among the traits, location had a significant effect on CWT (p<0.01), DP (p<0.01) and EMA ((p<0.05). The progeny reared in NWN area, irrespective of sire, produced more CWT, DP and EMA (329.71 kg, 57.66 % and 82.95 cm^2, respectively) than those in TKG area (307.66 kg, 55.96 % and 80.76 cm^2, respectively). Hence, management seems to have a key role in the production of animals of heavier carcass as well as higher meat content. The CL, BFT and muscle hardness were not affected significantly by location in this study. Hoving-Bolink et al. (1999) concluded that different environmental systems result in minor differences in meat quality in beef breeds.

Interaction effects of sire×location

The interaction effects of sire and location on carcass traits are presented in Table 3. The CWT and DP were significantly (p<0.05) affected by the interaction effects, whereas the other traits were not affected by interaction between sire and location. It seems that environmental variation in CWT and DP exists among different sires. A similar conclusion was made by Parkkonen et al. (2000), who showed that carcass quality of Finnish Ayrshire and Holstein-Friesian was significantly affected by genotype and environment interaction.

Genetic parameters

Table 4 shows the estimates of genetic parameter for different carcass traits. That CL is negatively correlated (r_g and r_p) with MAS, SFR and PEN may be because harder muscle contains less water. The correlations between all other traits were positive. CWT was highly and positively correlated with EMA (0.82 and 0.52 for r_g and r_p, respectively), indicating that a greater EMA is associated with a higher production of CWT. There is a wide range in published estimates for r_g between CWT and EMA. Koch et

Table 2. Effects of location on carcass traits in Hanwoo cattle

Location	Traits							
	CWT (kg)	DP	CL (%)	EMA (cm^2)	MAS (g/cm^2)	SFR (g/cm^2)	PEN (g/cm^2)	BFT (cm)
NWN (96)	329.71[a]	57.66[a]	6.60	82.95[a]	47.66	3788.42	6123.04	0.86
TKG (65)	307.66[b]	55.96[b]	6.42	80.76[b]	39.31	3938.95	6618.33	0.80
MS	5624.73	18.77	5.16	186.47	2605.71	761274	6350465	0.19
p-value	0.007	0.005	0.654	0.012	0.423	0.453	0.211	0.151

CWT=Carcass weight; DP=Dressing percentage; CL=Cook loss; EMA=Eye muscle area; MAS=Mastication; SFR=Shear force; PEN=Penetration; BFT=Back fat thickness; NWN=Namwon area; TKG=Taekwanryung area.
Figures in the parentheses indicate the number of observations for each location.
Means with different superscript in the same column differ significantly.

Table 3. Interaction effects of bull×location on carcass traits in Hanwoo cattle

Effects	Traits							
	CWT (kg)	DP	CL (%)	EMA (cm^2)	MAS (g/cm^2)	SFR (g/cm^2)	PEN (g/cm^2)	BFT (cm)
MS	653.31	2.73	6.36	57.18	609	1771695	4132163	0.14
p-value	0.018	0.025	0.358	0.648	0.480	0.201	0.430	0.082

MS=Mean square; CWT=Carcass weight; DP=Dressing percentage; CL=Cook loss; EMA=Eye muscle area; MAS=Mastication; SFR=Shear force; PEN=Penetration; BFT=Back fat thickness.

Table 4. Heritabilities (± SE), phenotypic and genetic correlations of carcass traits in Hanwoo cattle

Traits	CWT	DP	CL	EMA	MAS	SFR	PNT	BFT
CWT	0.37±0.02	0.62±0.03	0.38±0.05	0.82±0.07	0.58±0.03	0.18±0.02	0.32±0.03	0.42±0.05
DP	0.21±0.02	0.19±0.01	0.35±0.02	0.68±0.06	0.59±0.02	0.48±0.03	0.54±0.04	0.52±0.05
CL	0.11±0.01	0.12±0.01	0.05±0.02	0.32±0.02	-0.43±0.01	-0.73±0.06	-0.52±0.01	0.11±0.03
EMA	0.52±0.06	0.38±0.04	0.15±0.02	0.18±0.01	0.37±0.01	0.22±0.02	0.61±0.03	0.38±0.02
MAS	0.24±0.03	0.18±0.02	-0.11±0.01	0.12±0.01	0.64±0.01	0.23±0.03	0.52±0.03	0.72±0.04
SFR	0.05±0.01	0.19±0.01	-0.28±0.01	0.06±0.01	0.07±0.01	0.52±0.03	0.11±0.01	0.14±0.01
PNT	0.17±0.01	0.19±0.01	-0.14±0.01	0.28±0.02	0.11±0.01	0.05±0.01	0.25±0.03	0.35±0.03
BFT	0.15±0.02	0.34±0.02	0.04±0.01	0.11±0.01	0.39±0.04	0.05±0.01	0.12±0.01	0.07±0.02

Heritabilities on the diagonal, and phenotypic and genetic correlations below and above the diagonal, respectively.
CWT=Carcass weight; DP=Dressing percentage; CL=Cook loss; EMA=Eye muscle area; MAS=Mastication; SFR=Shear force; PEN=Penetration; BFT=Back fat thickness.

al. (1982) reported r_g of 0.44 between cold carcass weight and EMA; Cundiff et al. (1971) reported 0.66 between hot carcass weight and EMA. The phenotypic correlations were lower than the genetic correlations in the present study but they were in the same direction. The correlations of CWT with DP, EMA, PEN and BFT are favorable for work towards the breeding goal of improvement of carcass traits. Estimated heritabilities especially for MAS (0.64), SFR (0.52) and CWT (0.37) were relatively high (Table 4). This indicates that in Hanwoo cattle a large genetic variability still remains which may be used for the improvement of carcass characteristics. In Hereford and some other beef breeds, h^2 of carcass traits were found to be moderate (Lamb et al., 1990; Arnold et al., 1991; Gregory et al., 1994; Wheeler et al., 1996), which partially supports the present findings. Kenttamies (1983) estimated heritabilities for CWT in Finnish Ayrshire bulls as 0.23 and Friesian bulls as 0.61. Heritability estimates for DP and EMA in the present study are in agreement with those reported by Lee et al. (2000).

CONCLUSION

Significant variation between the progeny performances of individual sire groups in several carcass traits-CWT, DP, CL, EMA, BFT, MAS, SFR-indicates the scope for sire selection to improve meat potential of Korean native cattle. However, there are variations in carcass quality due to both genetic and environmental effects. As Hanwoo provides the most of the beef in Korea, main concern should be on improving management in beef production. Positive genetic correlations between CWT and other important carcass traits suggest sire selection for CWT does also lead to an increase in EMA, DP and BFT.

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