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Estimation of Genetic Parameters for Economic Traits of Hanwoo Cows Using Ultrasound

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ABSTRACT

This experiment was conducted to estimate the genetic parameters and breeding values of the economic traits measured from the cows (aged 15 months or older) using ultrasound and to use them as the information for the selection of stock animals at the farm level. The means and standard deviations of longissimus muscle area, backfat thickness and marbling score were 54.11 cm^2 ± 9.06, 3.57 mm ± 2.45 and 2.65 ± 2.88, respectively. While the linear regression coefficients of longissimus muscle area, backfat thickness and marbling score for age (in months) were all positive (0.3532, 0.0868 and 0.0833), the quadratic regression coefficients of them for age (in months) were all negative (−0.0023, −0.0005 and −0.0006), and as the body condition score increased longissimus muscle area, backfat thickness and marbling score increased collectively. The heritability estimates for the longissimus muscle area, backfat thickness and marbling score were 0.39, 0.48 and 0.13, respectively and the estimated annual genetic gains for the longissimus muscle area, backfat thickness and marbling score were 0.00334 cm^2, −0.0073 mm and 0.0043 score, respectively, which were not significantly different from zero.
(**Key words :** Longissimus muscle area, Backfat thickness, Marbling score, Heritability, Genetic gains)

INTRODUCTION

The genetic improvement of Korean native cattle (Hanwoo) is mainly due to the implementation of selective breeding of genetically superior bulls. In recent years, however, genetic improvement using superior cows is the focus of academia as well as large-scale farms and producer groups. As a way for that, diagnostic technique using ultrasound, measuring meat quality from live cows, is mostly used. Information on major economic traits of cattle including meat yield and quality has been obtained after being slaughtered. However, it is desirable to predict carcass characteristics of cattle using ultrasound for the selection of superior cows to be utilized as dams.

Generally, ultrasound has the frequency above the auditory limit of humans (20 Hz ~ 20 KHz) and has short wavelength. It is also highly directive, forming a plane wave unlike audible sound. Especially, when the scanning frequency becomes above 1 MHz the wave moves in a linear manner (Krautkramer et al., 1969). In early 1950s, Ludwig (1950) and Howry & Bliss (1952) directed ultrasound waves into the tissues of cattle, pigs and humansin an attempt to measure the propagation velocity and to understand the internal tissue structures. Since these experiments, measurement of economic traits from live animals using ultrasound has been under active progress.

In Korea, research projects on the live animal evaluation using ultrasound are rapidly growing to increase utility of ultrasound and predictability of the measurements (Kim et al., 2003; Bang, 1997; Yoon et al., 1997; Song et al., 2002).

This experiment was conducted to estimate the genetic parameters and breeding values of the economic traits using the ultrasonic measurements for the selection of Hanwoo cows at the farm level for breeding purposes.

MATERIALS AND METHODS

1. Description of the data

From the 242 farms in 14 different areas of Gyeonggi-do, a total of 6,726 ultrasonic data were collected from the cows (aged 15 months or older) by 9 persons. Of the 6,726 data collected, data from 87 non-registered cows (1.3%) and the data from 10 cows that had smaller than 25 of longissimus

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muscle area and more than 45 mm of backfat thickness were excluded, and finally, data from 6,629 heads of Hanwoo cows were analyzed. Of the total cows, 1,433 heads (21.6%) were non-pedigreed, 2,337 heads (35.3%) were pedigreed, and 2,859 heads (21.6%) were pedigreed & superior cows.

Body condition scores were recorded and using ultrasound, the cross-sectional area between the 13th thoracic and first lumbar vertebra was measured in real time. Measured iconic data were stored in PC and they were deciphered using iconic reading program (Image-Pro Express, Media Cybernetics, USA).

Longissimus muscle area represents a cross-sectional area of the longissimus muscle, which is the area under the connected curve lines of reflected waves occurring at border lines among different tissues. Backfat thickness represents the subcutaneous fat thickness over longissimus muscle area (measured at the 2/3 point of it) and marbling score was scaled from 1 to 22 by the subjective decision of one expert. On the other hand, there is no significant effect on traits among the measurers.

2. Statistical model

The statistical animal model used was as follows:

$$y_{ijkl} = \mu + rys_i + bcs_j + \beta_1 age_{ijkl} + \beta_2 age^2_{ijkl} + a_k + e_{ijkl}$$

Where, y_{ijkl} = observations of longissimus muscle area, backfat thickness and marbling score (6,629 records), μ = overall mean, rys_i = fixed effect of the i^{th} region-birth year-measured season (i = 1, 2, ⋯, 441), bcs_j = fixed effect of the j^{th} body condition score (j =1, 2, ⋯, 9), β_1, β_2 = linear and quadratic regression coefficients for month of age, age_{ijkl} = age in months, a_k = additive genetic effect of the k^{th} animal (i = 1, 2, ⋯, 10,246), e_{ijkl} = random residual error, $Var(a) = A \otimes \sigma^2_a$ and $Var(e) = I \otimes \sigma^2_e$. Where A = numerator relationship matrix and I = identity matrix. Estimates of genetic parameters and breeding values for the aforementioned traits were calculated using a Multiple Traits Restricted Maximum Likelihood (MTCAFS; Mitztal, 1992) and PEST program (Groeneveld, 1990), respectively.

RESULTS AND DISCUSSION

1. Effect of age and body condition score

The body condition scores and characteristics of ultrasonic measurements by age are shown in Table 1. As the age of cows increased, the longissimus muscle area increased up to 78 months of age, but it decreased gradually after that age (Fig. 1). A similar trend was noted for backfat thickness and marbling score. The means and standard deviations of longissimus muscle area, backfat thickness and marbling score were 54.11 cm^2 ± 9.06, 3.57 mm ± 2.45 and 2.65 ± 2.88, respectively. The linear regression coefficients of longissimus muscle area, backfat thickness and marbling score for age

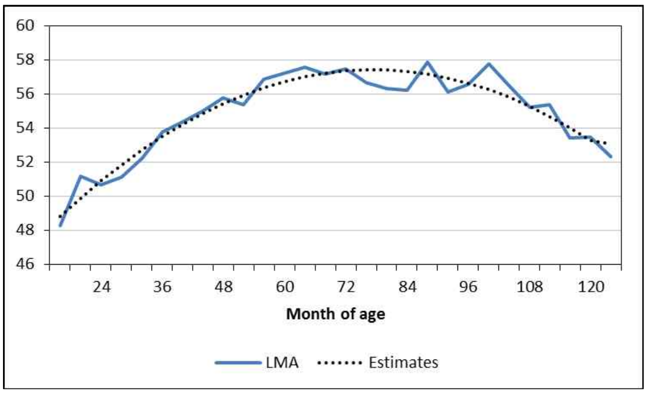

Fig. 1. Relationship between longissimus muscle area (LMA, cm^2) and month of age.

Table 1. Number of cows (%), means and standard deviations for traits by month of age

Month of age	No. of cows	BCS[1] (score)	LMA[2] (cm^2)	BF[3] (cm)	MS[4] (score)
~24	735 (11.1)	4.43 ± 1.03	50.77 ± 7.24	2.74 ± 1.44	1.73 ± 1.74
36	1,916 (28.9)	4.61 ± 1.19	51.98 ± 8.65	2.98 ± 1.89	2.13 ± 2.39
48	1,533 (23.1)	4.98 ± 1.29	54.80 ± 9.27	3.65 ± 2.38	3.06 ± 3.21
60	956 (14.4)	5.12 ± 1.27	56.25 ± 8.53	3.87 ± 2.54	3.01 ± 2.94
72	563 (8.5)	5.15 ± 1.28	57.42 ± 8.96	4.41 ± 2.89	3.26 ± 3.31
72 <	926 (14.0)	5.11 ± 1.34	55.78 ± 9.58	4.49 ± 3.22	3.03 ± 3.22
Overall	6,629 (100)	4.86 ± 1.26	54.11 ± 9.06	3.57 ± 2.45	2.65 ± 2.88

[1] Body condition score, [2] longissimus muscle area, [3] backfat thickness, [4] marbling score

Table 2. Simple regression coefficients (b), standard error (SE) and coefficient of determination (r^2) of traits for month of age

Traits	Linear (b_1)	Quadratic (b_2)	r^2
Longissimus muscle area	0.3532 ± 0.0208	−0.0023 ± 0.0001	0.93
Backfat thickness	0.0868 ± 0.0083	−0.0005 ± 0.0001	0.86
Marbling score	0.0833 ± 0.0097	−0.0006 ± 0.0001	0.75

All values were significantly different from zero ($p < 0.001$).

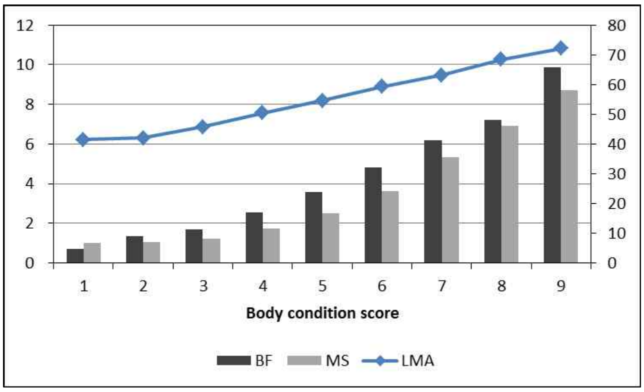

Fig. 2. Trends on backfat thickness (BF), marbling score (MS) and longissimus muscle area (LMA) by body condition score.

were all positive and 0.3532 cm^2, 0.0868 mm and 0.0833, respectively and those of quadratic regression coefficients were all negative and −0.0023 cm^2, −0.0005 mm and −0.0006, respectively (Table 2).

Also, as the body condition score increased, longissimus muscle area, backfat thickness and marbling score increased collectively (Fig. 2), which coincides with the results reported by Lee et al. (2008).

2. Generation interval

The estimates of generation interval of Hanwoo cows in Gyeonggi-do area are shown in Table 3. Generation interval is the average time period between the birth of parents and the birth of their offspring. The estimates of average generation interval from sire to cow and from dam to cow were 7.71 and 4.08 years, respectively, and the average from parent to offspring were 5.63 years.

3. Heritability

The heritability estimates for longissimus muscle area, backfat thickness and marbling score were 0.39, 0.48 and 0.13, respectively (Table 4). Moon et al. (2007) reported that the heritability estimates for longissimus muscle area, backfat thickness and marbling score from carcass data were 0.12, 0.13 and 0.47, respectively, which were slightly different from our results. The heritability estimates for longissimus muscle area, backfat thickness and marbling score were 0.33, 0.51 & 0.31 as reported by Park & Park (2002), or 0.27, 0.35 & 0.48 reported by Yoon et al.(2002), respectively, and the estimates for longissimus muscle area and backfat thickness reported earlier are in accordance with the heritability estimates from this experiment, but heritability estimates for marbling score were lower than those of previous studies.

The genetic and phenotypic correlation coefficients between longissimus muscle area and backfat thickness were 0.50 and 0.44, respectively, and the genetic and phenotypic correlation coefficients between longissimus muscle area and marbling score were 0.58 and 0.42, respectively. The genetic and phenotypic correlation coefficients between backfat thickness

Table 3. Generation intervals of Gyeonggi-do Hanwoo cows

Pathway	No. of pairs	Generation interval (year)			
		Mean ±SD[1)]	Skewness	Median	Mode
Sire → cow (L_{SC})	3,866	7.71 ± 1.21	−0.52	7.78	7.12
Dam → cow (L_{DC})	5,204	4.08 ± 2.18	1.47	3.60	2.93
Parent → offspring (L_{PO})	9,070	5.63 ± 2.56	0.08	6.03	2.93

[1)] Standard deviation.

Table 4. Genetic (residual) variance components, genetic and phenotypic parameters among longissimus muscle area (LMA), backfat thickness (BF) and marbling score (MS)

Traits	Variance-covariance components			Parameters		
	LMA	BF	MS	LMA	BF	MS
LMA	18.04 (28.10)	2.83	2.18	0.39	0.50	0.58
BF	2.91	1.80 (1.94)	0.15	0.44	0.48	0.12
MS	4.91	1.21	0.78 (5.31)	0.42	0.28	0.13

diagonal : genetic variance (residual) & heritability, above : genetic covariance and correlation,
below : residual covariance and phenotypic correlation.

and marbling score were 0.12 and 0.28, respectively, which are relatively lower than expected.

4. Genetic gains

The genetic gains were estimated using the breeding value estimates for the longissimus muscle area, backfat thickness and marbling score according to the year of birth. The estimates of genetic gains for the longissimus muscle area, backfat thickness and marbling score were 0.00334 cm^2, −0.0073 mm and 0.0043, respectively (Table 5), which were not different from zero. The changes in genetic gain estimates for these traits according to birth year are illustrated in Fig. 3.

Table 5. Genetic trends on traits by year of birth

Traits	Linear	r^2
Longissimus muscle area	0.0334 ± 0.0204	0.23
Backfat thickness	−0.0076 ± 0.0098	0.06
Marbling score	0.0043 ± 0.0042	0.11

All values were not significantly different from zero ($p > 0.05$).

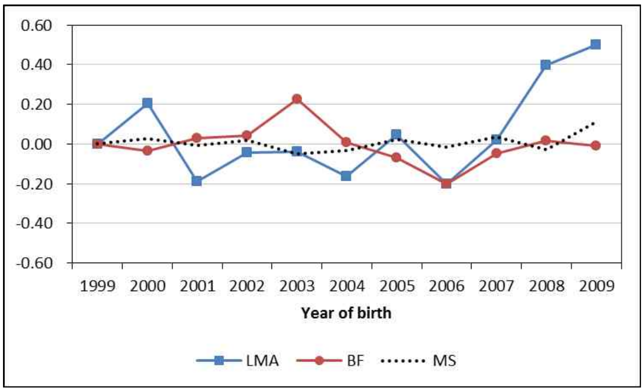

Fig. 3. Genetic trends on longissimus muscle area (LMA), Backfat thickness (BF) and Marbling score (MS) by year of birth.

CONCLUSIONS

The selection of superior cows is very important from the point of farmer's income and Hanwoo improvement. For the accurate evaluation of genetic performance, however, collection of correct data is very important. Therefore, standardized measurement techniques must be developed to increase the accuracy of ultrasonic measurements along with the development of advanced photographing and deciphering techniques. When these conditions are met, the accuracy of genetic parameter estimation and selection for the evaluation of genetic performance will be increased and the genetic performance of cows will be continuously improved.

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