Estimates of Parameters for Genetic Relationship between Reproductive Performances and Body Condition Score of Hanwoo Cows

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ABSTRACT : This study was conducted to estimate phenotypic and genetic parameters of body condition score (BCS) and reproductive traits in Hanwoo cows. DFREML procedures were applied to obtain variance-covariance components and heritability estimates with single or two-trait models. Estimates of phenotypic correlations of BCS at service with BCS at calving was 0.16 and 0.26 with calving interval, 0.08 with gestation length, and 0.06 with number of services per conception, respectively. Estimates of phenotypic correlation of BCS at calving was 0.10 with calving interval, 0.13 with gestation length, and 0.10 with number of services per conception, respectively. Estimates of phenotypic correlation were low and negative, -0.11 between calving interval and gestation length and -0.13 between gestation length and number of services per conception. Estimates of direct genetic correlation were -0.06, between BCS at service and BCS at calving, 0.37 between BCS at service and BCS at weaning, and -0.18 between BCS at calving and BCS at weaning. Estimates of direct genetic correlation of days from calving to the 1st service were 0.17 with number of services per conception and -0.21 with BCS at service. Estimates of direct genetic correlation for BCS at calving were -0.02 with number of services per conception and -0.08 with BCS at service. Estimates of direct genetic correlation for BCS at weaning were 0.02 with number of services per conception and -0.07 with BCS at service. Estimates of direct heritability from single trait analyses were 0.13 for BCS at service, 0.20 for BCS at calving, 0.02 for BCS at weaning, and 0.20 for number of service per conception, respectively. Estimates of direct heritability were 0.20 for birth weight and 0.10 for weaning weight. ***(Asian-Aust. J. Anim. Sci. 2005. Vol 18, No. 7 : 909-914)***

Key Words : Body Condition Score, Genetic Correlation, Heritability, Hanwoo

INTRODUCTION

Body condition of cows around calving season is closely related with efficiency of cows' reproduction such as recurrence of heat, milking, days open, calving interval, and nursing calves up to weaning (Herd and Sprott, 1986). Poor body conditioned cows had prolonged days to heat after calving with longer days open. Over-conditioned cows, on the other hand, required more times of services for conception and obese cows often failed maintaining normal reproductive cycle (Rasby and Gosey, 1998). Body condition of immature heifers is especially important for their normal body growth and for their successful reproduction in the future as well as stayability in breeding herd. Female reproductive traits such as age at first service, age at first calving, calving interval, number of services per conception or days from calving to first service are lowly heritable and, hence, are affected greatly by environments. Therefore, it is important to adjust variables for identifiable environmental effects and to choose optimal statistical model for correct evaluation of animals' genetic potential (Northcutt and Wilson, 1993). Genetic analyses of BCS had rarely been done in the literature.

On of the best way to measure meat quality in live animal night be ultrasound scans and ultrasound EPD, if breeder concerned costly and timely to improve meat quality in Korean beef cattle (Lee and Kim, 2004).

Arango et al. (2002) suggested that body condition score might be useful for evaluating cow weight at constant fatness. And Selection would be effective either weight or height and selection for weight would be expected to affect body condition score.

The objective of this study was to estimate genetic parameters of and between days from calving to first service, number of services per conception, calves' birth and weaning weights and BCS of cows and heifers at services, at calving or at weaning which might vary with reproductive and physiological status, season and nutrition.

We expect that results from this study would be directly applied for better reproductive and feeding management of cows and heifers.

MATERIALS AND METHODS

Animals

Body condition scores (BCS) of cows and heifers on reproduction from 1999 to 2000 at two stations (Namwon and Daekwanryong branches) of National Livestock Research Institute, Korea and three private breeding farms were observed. Their records on growth and reproduction were collected from each farm. Data structure and number of animals observed are summarized in Table 1 by the year of observations and farms and in Table 2 by parity.

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Table 1. Number of animals by the year of observations and farms

Traits	Year	Farms[a]					Total
		A	B	C	D	E	
BCS at service	1999	30	-	98	68	23	219
	2000	15	-	86	44	19	164
	Sub-total	45	-	184	112	42	383
BCS at calving	1999	35	37	91	63	39	265
	2000	27	36	83	55	37	238
	Sub-total	62	73	174	118	76	503
Days from calving to 1st service	1999	37	26	38	20	40	161
	2000	24	14	26	12	37	113
	Sub-total	61	40	64	32	77	274
No. of services per conception	1999	75	86	64	78	82	385
	2000	52	61	52	57	67	289
	Sub-total	127	147	116	135	149	674
BCS at weaning	1999	31	46	82	52	29	240
	2000	42	66	76	47	32	263
	Sub-total	73	112	158	99	61	503
Birth weight	1999	38	89	82	109	41	359
	2000	39	92	77	120	37	365
	Sub-total	77	181	159	229	78	724
Weaning weight	1999	36	67	45	-	-	148
	2000	30	57	39	-	-	125
	Sub-total	66	124	83	-	-	273
Total		511	677	938	725	483	3,334

[a] Individual farms.

Table 2. Number of animals by parity

Parity	Traits						
	BCS at service	BCS at calving	BCS at weaning	Days from calving to 1st service	No. of services per conception	Birth weight	Weaning weight
≤1	182	208	177	145	294	287	77
2	82	104	113	46	147	139	48
3	81	94	110	26	118	162	72
4	34	65	57	37	81	84	39
≥5	4	32	36	20	34	52	37
Total	383	503	503	274	674	724	273

Body condition scores were observed according to the standards suggested by Beef Improvement Federation, USA. (BIF. 1996; Whitman, 1975) 1 (severely emaciated) through 9 (very obese). Cows and heifers were evaluated three times each month during test years (1st. 15th. and 25th day) by one observer. Animals covered with thick and long hairs especially in cold winter days were palpated to ensure correct scoring.

Statistical analyses

Series of mixed animal models were applied with MTDFREML package of derivative free REML procedure (Boldmann et al., 1995) to estimate genetic variances-covariances (of and) between traits. Global maximum likelihood estimates were iteratively estimated using estimates from previous run as priors with each run to go within the variation range to be less than 10^{-6}.

Four separate animal models were applied in this study. Three fixed effects of parity of dams, year-season of calf births, and farms borne were fit to the models for female reproduction. Four fixed effects of parity, year-season of birth, farms born, and sexes were fit to the models for calf growth traits. Weaning weights (WW) of calves borne from cows observed were linearly adjusted to 90 days from birth.

Model 1: $y = X\beta+Za+e$

Model 1 included additive genetic variance and residual effects.

Model 2: $y = X\beta+Za+Wp+e$

Model 2 was based on Model 1 but included maternal environmental effects.

Model 3: $y = X\beta+Z_1a+Z_2m+Wp+e$

Table 3. Parameters estimated with five models

Model	Parameters[a]				
	σ^2_a	σ^2_m	σ^2_p	σ^2_e	Covariate
1	V			V	
2	V		V	V	
3	V	V	V	V	
4	V	V		V	
5	V	V		V	V

[a] σ^2_a= Additive genetic variance, σ^2_m= maternal genetic variance, σ^2_p = variance of residual environmental effects, and σ^2_e = variance of permanent environmental effects.

Model 3 was based Model 2 but included maternal effects.

Model 4: $y = X\beta+Z_1a+Z_2m+e$

Model 4 was used for additive genetic effects and maternal effects.

Model 5: $y = X\beta+Z_1a+Z_2m+e$

Model 5 was used to analyze the traits such as birth weight and weaning weight of calves with body condition of dams at delivery and at weaning as a linear covariate, respectively.

where, y = $N\times1$ vector of observations,

β = vector of fixed effects (parity, year-season, farm, and sex),

a = vector of random additive genetic effects,

m = vector of random maternal genetic effects,

e = vector of random environmental effects,

p = vector of random permanent environmental effect, and

X, Z and W = incidence matrix relating observation vector (y) to β, a, p, m

Data structures by the year of observations and by parity are shown in Table 1 and 2. Parameters estimated from each model are summarized in Table 3.

Model 1 for each trait was again used for bi-variate model to derive genetic and environmental variance-covariance components.

RESULTS AND DISCUSSION

Averages and standard deviations of BCS's (at service, at calving, and at weaning), days from delivery to first insemination, number of insemination per conception, birth weight, and weaning weight of calves are summarized in Table 4.

Table 5. Estimates of variance components and genetic parameters for different BCS in the model 1

Parameters	Traits		
	BCS at service	BCS at calving	BCS at weaning
σ^2_a	0.23	0.35	0.03
σ^2_e	1.48	1.37	2.12
h^2	0.13	0.20	0.02

σ^2_a= Additive genetic variance, σ^2_e= variance of residual error, and h^2 = heritability.

Table 6. Estimates of variance components and genetic parameters for day from calving to 1st service

Parameters[a]	Models			
	1	2	3	4
σ^2_a	1004.06	989.56	998.99	1,008.92
σ^2_m	-	-	50.66	185.46
σ_{am}	-	-	-50.65	-185.45
σ^2_p	-	19.57	0.01	-
σ^2_e	0.01	0.01	0.01	0.01
h^2_a	1.00	0.98	1.00	1.00
h^2_m	-	-	0.05	0.18
r_{am}	-	-	-0.23	-0.43
p^2	-	0.02	0.00	-

[a] σ^2_a = additive genetic variance, σ^2_m = maternal genetic variance, σ_{am} = covariance between direct and maternal effects, σ^2_e= residual error, σ^2_p = variance of permanent environmental effects, h^2_a = direct heritability, h^2_m = maternal heritability, r_{am} = genetic correlation between direct and maternal effects, and p^2= fraction of variance due to permanent environmental effects.

Univariate analyses

Genetic parameters of BCS are shown in Table 5. Heritability of BCS at service was eastimated to be 0.13, which was somewhat lower than that at calving (0.20). Shanks et al. (1997) reported that the heritability estimate of BCS was 0.02 for American that was much far lower than that from Hanwoo. There seems to present more of environmental variation than genetic variation for BCS. Arango et al. (2002) obtained estimates of heritability for body condition score of 0.16 for Angus and Hereford reciprocal crossbred.

Heritability estimate of BCS at weaning was lower than that at calving, which might be due to missing observations

Table 4. Summary statistics for different BCS and reproductive traits

Traits	No. of animals	Mean	SD	Min.	Max.	Normality (W)
BCS at service	383	4.55	1.30	1	9	0.95
BCS at calving	503	5.42	1.63	1	9	0.96
BCS at weaning	503	4.55	1.73	1	9	0.85
Days from calving to 1st service	274	66.20	12.9	42	89	0.89
No. of services per conception	674	1.78	1.04	1	8	0.69
Birth weight (kg)	724	25.40	4.04	10	40	0.98
Weaning weight (kg)	273	76.00	11.7	40	105	0.99

Table 7. Estimates of variance components and genetic parameters for number of services per conception

Parameters[a]	Models			
	1	2	3	4
σ^2_a	0.08	0.07	0.12	0.21
σ^2_m	-	-	0.04	0.18
σ_{am}	-	-	-0.07	-0.20
σ^2_p	-	0.00	0.00	-
σ^2_e	1.00	1.01	0.99	1.09
h^2_a	0.07	0.07	0.11	0.20
h^2_m	-	-	0.04	0.17
r_{am}	-	-	-1.00	-1.00
p^2	-	0.00	0.00	-

[a] σ^2_a = Additive genetic variance, σ^2_m = maternal genetic variance, σ_{am} = covariance between direct and maternal effects, σ^2_e= residual error, σ^2_p = variance of permanent environmental effects, h^2a = direct heritability, h^2_m = maternal heritability, r_{am} = genetic correlation between direct and maternal effects, and p^2= fraction of variance due to permanent environmental effects.

Table 8. Estimates of variance components and genetic parameters for birth weight of calves (kg)

Parameters [a]	Models				
	1	2	3	4	5
σ^2_a	4.63	4.59	2.21	2.37	2.28
σ^2_m	-	-	0.48	1.04	0.43
σ_{am}	-	-	1.03	0.25	0.99
σ^2_p	-	0.0007	0.00004	-	-
σ^2_e	7.80	7.85	8.25	8.32	8.30
h^2_a	0.37	0.37	0.18	0.20	0.19
h^2_m	-	-	0.04	0.09	0.04
r_{am}	-	-	1.00	0.16	1.00
p^2	-	0.00006	0.00004	-	-

[a] σ^2_a = Additive genetic variance, σ^2_m = maternal genetic variance, σ_{am} = covariance between direct and maternal effects, σ^2_e= residual error, σ^2_p = variance of permanent environmental effects, h^2_a = direct heritability, h^2_m = maternal heritability, r_{am} = genetic correlation between direct and maternal effects, and p^2= fraction of variance due to permanent environmental effects.

at weaning and other unknown environmental conditions. Genetic components were estimated from Model 1 only out of 4 models run which also might be due to small data size. Therefore, the estimates appeared on Table 5 only came from Model 1.

Genetic components in dams' reproductive performances were estimated with four analytical models except Model 5 and three fixed effects-parity, year-season, and farm were considered in the models. And the results from univariate analyses for days from calving to first service are summarized in Table 6.

Heritability estimates of days from calving to first service were all out of parameter space (0.98 from Model 1 and 1.0 from Models 1, 3 and 4). Therefore this was excluded in the bivariate analyses. Maternal heritability of this trait was estimated as 0.05 from Model 3 and 0.18 from Model 4, which suggest significant maternal effects on

Table 9. Estimates of variance components and genetic parameters for weaning weight (kg) of calves

Parameters[a]	Models				
	1	2	3	4	5
σ^2_a	8.25	7.98	6.80	8.62	6.88
σ^2_m	-	-	5.79	23.97	22.51
σ_{am}	-	-	-6.28	-14.37	-12.44
σ^2_p	-	0.06	17.60	-	-
σ^2_e	81.80	81.95	65.50	71.88	73.11
h^2_a	0.09	0.09	0.08	0.10	0.08
h^2_m	-	-	0.06	0.27	0.25
r_{am}	-	-	-1.00	-1.00	-1.00
p^2	-	0.007	0.20	-	-

[a] σ^2_a = Additive genetic variance, σ^2_m = maternal genetic variance, σ_{am} = covariance between direct and maternal effects, σ^2_e= residual error, σ^2_p = variance of permanent environmental effects, h^2_a = direct heritability, h^2_m = maternal heritability, r_{am} = genetic correlation between direct and maternal effects, and p^2 = fraction of variance due to permanent environmental effects.

reproductive performances.

Genetic parameter estimates of number of services per conception are shown in Table 7. Heritability estimates of this trait were 0.07 from Models 1 and 2 but somewhat higher (0.11) from Model 3 with maternal effect. Its estimate became even larger to be 0.20 in Model 5 where permanent environment was put into model with maternal genetic effect.

Genetic parameters regarding birth weight and weaning weight of calves were estimated through 5 models. The last model (Model 5) was applied to see the effect of dams' body condition on calves' growth. And the results are summarized in Table 8. Heritability estimate of calf birth weight from the simplest Model 1 was 0.37, which was higher than estimates in Hanwoo population reported by Lee et al. (1985) 0.12 for birth weight and 0.31 for weaning weight or by Shin et al. (1990) 0.15 for birth weight and 0.20 for weaning weight. Model 1 estimated similar heritability for birth weight even with very low variance due to permanent environmental effect in the model. In Model 3 that included maternal genetic effects in addition to Model 2, heritability estimate of birth weight was somewhat lower to be 0.18. This was similar to the estimate from model 4 (0.20) in which additive genetic effects and maternal effect without permanent environment effect was fit. From Model 4, maternal heritability was estimated as 0.09. Maternal heritability was estimated as 0.04 from Model 3, which was lower than its estimate from Model 4 (0.09) without permanent environmental effect. Model 5 was the same model as Model 4 except that it included dam's BCS as a linear covariate. Heritability estimates of direct or maternal genetic effect were similar to those from Model 3 (Table 8). This implies that dam's body condition during pregnancy or near calving takes effect as permanent environments for calf's birth weight.

Table 10. Estimates of genetic correlation between traits

	BCS at services	BCS at calving	BCS at weaning	1st service after calving	No. of service per conception
BCS at services	0.07	-0.26	0.37	0.17	-0.21
BCS at calving	1.00	0.39	-0.18	-0.02	-0.18
BCS at weaning	-0.29	1.00	0.44	0.02	-0.17
Days from calving to 1st service	-1.00	-0.43	-0.09	0.39	-0.11
No. of services per conception (times)	0.45	1.00	1.00	-0.48	0.20

Diagonal:Heritability, upper diagonal:genetic correlation, and lower diagonal:environmental correlation.

Table 11. Estimates of genetic and environmental covariance between traits

	BCS at services	BCS at calving	BCS at weaning	Days from calving to 1st service	No. of service per conception
BCS at services		-0.30	0.40	0.83	-0.12
BCS at calving	0.54		-0.17	-1.06	-0.17
BCS at weaning	-0.12	1.29		1.82	-0.18
Days from calving to 1st service	-28.94	-10.82	-3.14		-0.44
No. of services per conception (times)	0.07	1.28	-11.75	-11.75	

Upper diagonal:genetic covariance and lower diagonal:environmental covariance.

Table 12. Estimates of genetic correlation between birth weight (BW) and weaning weight (WW) of the calves

	BW	WW
BW	0.18	0.70
WW	0.18	0.11

Diagonal:heritability, upper diagonal:genetic correlation between two traits, lower diagonal:environmental correlation.

Variance component and heritability estimates of weaning weight from the same models as used for birth weight are shown in Table 9. Heritability estimates for weaning weight were low from 0.08 to 0.10 from 5 models.

Yang et al. (2004) reported heritability of the body weight at 3 months of age was 0.31 in Chinese Simmental cattle.

But the maternal heritability estimates from Models 4 and 5 were high (0.27 and 0.25) to consider them as significant source of variation compared to the maternal heritability estimate from Model 3 (0.06). This implies that, for preweaning growth of calves, permanent environment other than maternal genetic effect play significant roles and that mother's body condition till weaning means something environmentally affecting mothering ability in harmony with genetic ability of the growth of calves.

Bivariate analyses

Heritability estimates from bivariate analyses (Table 10) were somewhat higher than those from univariate analyses (Table 5) except for BCS at services. Heritability estimates of BCS at calving, BCS at weaning, days from calving to first service, and number of services per conception were low to moderate.

Bivariate analyses were made with only direct genetic effect without maternal or permanent environmental effect as in Model 1. The results from analyses, genetic and environmental covariances and correlation coefficients are shown in Table 10 and 11. Negative genetic correlations were found between BCS at service and BCS at calving and between BCS at service and number of services per conception. However, BCS at weaning is positive genetically correlated with days from calving to first service. Another negative genetic correlations were found between BCS at calving and BCS at weaning and between BCS at calving and number of services per conception. Genetic correlation between BCS at calving and days from calving to first service was negative but near the zero.

Genetic correlation between number of services per conception and BCS at weaning and between number of services per conception and days from calving to first service were both low and negative.

Heritability estimates for birth weight and weaning weight of calves from bivariate analyses were low and similar to those from univariate analyses (Table 12). Genetic correlation between these two traits was 0.70, which was higher than the estimate by Choi et al. (2000) with Hanwoo population using only data from male progeny. Nelsen and Kress (1979) reported that the genetic correlation estimate between birth weight and weaning weight of Angus cattle was 0.53. Environmental correlation between theses two traits in our study Hanwoo population was estimated to be low and positive.

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