ESTIMATION OF GENETIC RELATIONSHIPS AMONG GROWTH CURVE PARAMETERS OF HANWOO (KOREAN BROWN CATTLE)

Y.M. Cho[1], H.B. Yoon[2], B.S. Ahn[1] and Y.I. Park[2]

[1] National Livestock Research Institute, R.D.A., Cheonan, 330-801, Korea
[2] Dept. of Animal Science & Technology, Seoul National University, Suwon, 441-744, Korea

INTRODUCTION

Increased interest among animal scientists and producers in life-time weight-age relationships has been stimulated by the recognition of the economic importance of rate of maturing, rate of gain, mature size and related characters. But, a series of weight measured during the lifespan of individual is difficult to interpret. The use of mathematical growth models provides a good way of condensing the information contained in such data into a few parameters with biological meaning. In Korea, for several decades, the efforts to improve the productivity of Hanwoo (Korean cattle) have been dedicated at nationwide level. Hence, the information on growth characteristics of Hanwoo seems to be critical source on decision of breeding scheme of Hanwoo. The Purpose of this study was to estimate the relationships among growth curve parameters of Hanwoo, using the Gompertz model and the Richards model.

MATERIALS AND METHODS

The data used were weight-age data from 1,133 heads of Hanwoo bulls calved from 1990 to 1996 and raised in the Hanwoo Improvement Center, Korea. To establish the characteristics for the growth of Hanwoo, Gompertz model (Winsor, 1932) and Richards model (Richards, 1959) were fitted to individual weight-age data of Hanwoo. The models and relevant statistics are described in Table 1. Parameter estimates for weight-age data were obtained using DUD (Doesn't Use Derivative) method with PROC NLIN in SAS package program for non-linear models. Estimated parameters from two models were analyzed by general linear model that includes the fixed effects of year-season of birth and age of dam, and difference between mature weight and slaughter weight as a covariate (SAS, 1990). Heritabilities and genetic correlations were estimated with multiple trait animal model using the MTDFREML program (Boldman *et al*., 1995).

Table 1. Model equations for estimation of growth curve parameters and derived traits[A]

Model	Equation	Mature weight	Maturing rate	Growth rate
Gompertz	$Ae^{-Be^{-Kt}}$	A	K	$KBW_t e^{-Kt}$
Richards	$A\left(1-Be^{-Kt}\right)^M$	A	K	$MKW_t\left[Be^{-Kt}/\left(1-Be^{-Kt}\right)\right]$

[A] W_t is weight at age t; A, B, K and M are fitted parameters.

RESULTS AND DISCUSSION

Growth curve parameters. For the growth curve parameters fitted on individual weight-age data using Gompertz model, the mean estimates of A, B and K were 767.16±3.56, 3.4074±0.0116 and 0.1083±0.0006 respectively, and mean estimates of body weight, age in month and gain rate at inflection were 282.22±1.31kg, 11.59±0.06month and 29.94±0.12kg/month respectively. For Richards model, the mean estimates of A, B, K and M were 793.65±3.21, 0.2858±0.0059, 0.0974±0.0005 and 15.219±0.305 respectively, and mean estimates of body weight, age in month and gain rate at inflection were 272.68±1.03kg, 11.20±0.05month and 29.66±0.098kg/month respectively.

Analysis of variance. The analysis of variance of growth curve parameters estimated from two models is presented in Table 2. The effects of year-season of birth and age of dam were significant for the growth curve parameters estimated from Gompertz model (p<.01), however the effects of age of dam for K were insignificant (p>.05). Covariates as difference between mature weight and slaughter weight were significant for all parameters from Gompertz model (p<.05). The effects of year-season of birth were significant for all parameters estimated from Richards model (p<.01), but the effects of age of dam were insignificant for all parameters (p>.05), of which results are similar with those of DeNise *et al.* (1985). Covariates were significant for all parameters from Richards model (p<.05), except for M (p>.05). Results of analysis of variance indicate that year-season of birth and age of dam as fixed effect and difference between mature weight and slaughter weight as covariate should be considered to estimate the genetic parameters for growth curve parameters of Hanwoo.

Table 2. Analysis of variance of growth curve parameters[A] using Gompertz model and Richards model for the data studied

Model		Year-season [B]	Age of dam [C]	Covariate [D]	Residual
	df	12	5	1	1114
Gompertz	A	91,784.09**	9,295.42**	9,100,782.12**	1,977.77
	B	4.9918**	1.3137**	0.3744*	0.0946
	K	0.0073485**	0.0001417NS	0.1605426**	0.0000805
Richards	A	127,956.00**	3,794.24NS	3,100,399.58**	6,917.04
	B	0.9861**	0.0258NS	0.1876*	0.0282
	K	0.00522**	0.00016NS	0.02145**	0.00019
	M	1,276.502**	144.828NS	38.481NS	90.815

[A] A and K are mature weight and maturing rate respectively, and B and M are controlling paratemer with respect to growth rate and inflection point respectively in Richards model;
[B] Year-season of birth is ranged from spring-1990 to spring-1996 and each year is divided into two terms as spring and fall;
[C] Age of dam classifications (less than 3, 3, 4, 5~9, 10~11 and more than 11year olds);
[D] Covariate is difference between mature weight and slaughter weight;
**: p<.01, *: p<.05, NS: Not significant at 0.05 level of significance.

Heritabilities, phenotypic and genetic correlations. The heritability estimates of growth curve parameters are presented in Table 3. The heritability of A parameter estimated from Gompertz model, 0.21 was not higher than those of conventional body weight, and was not similar with estimate from Richards model. The estimated heritabilities of A, B, K and M for Richards model ranged from 0.02 to 0.09, were very low. Estimates of heritability of growth curve parameters from Richards model reported by DeNise *et al*. (1985) ranged from 0.21 to 0.44 were higher than the results of this study.

Table 3. Genetic variance, environmental variance and heritability of growth curve parameters fitted for body weight of Hanwoo

Model	Gompertz			Richards			
Parameter	A	B	K	A	B	K	M
σ_a^2	499.08	0.1808	0.0000029	864.31	5.204	0.08721	255.97
σ_e^2	1854.86	0.7695	0.000085	8861.58	278.669	1.99213	8833.17
h^2	.21	.19	.03	.09	.02	.04	.03

The phenotypic correlation among growth curve parameters and derived statistics are presented in Table 4. For the estimates from Gompertz model, the phenotypic correlations of K with gain rate at inflection, mature weight, A and age in month at inflection were 0.20, -0.69 and -0.84 but mature weight, A was positively correlated to the age in month at inflection, indicating that late maturing bulls with lower K had longer maturing period with increasing gain rate and reached point of inflection later than early maturing bulls with higher K, and grew to larger mature weight. Similar relationships were shown among parameters and derived statistics in Richards model.

Table 4. Phenotypic correlations among growth curve parameters and derived statistics from Hanwoo male data [A]

	Compertz model			
	B	K	t_I	$\partial W/\partial t_I$
A	.10	-.69	.79	.20
B		.35	.16	.59
K			-.84	.55
t_I				-.27

	Richards model					
	B	K	t_I	M	W_I	$\partial W/\partial t_I$
A	.43	-.63	.43	-.29	.79	.35
B		-.81	-.18	-.66	-.15	-.36
K			-.22	.90	-.15	.46
t_I				.16	.62	.06
M					.06	.20
W_I						.64

[A] A, B, K and M are fitted parameters; t_I is age at point of inflection; W_I is weight at inflection; $\partial W/\partial t_I$ is rate of gain at inflection.

Table 5. The genetic and phenotypic correlations among growth curve parameters from Gompertz model and those from Richards model [A]

	GA	GB	GK	RA	RB	RK	RM
GA		.16	-.21	.98	.01	.18	-.19
GB	.10		.28	-.27	-.99	N/A	N/A
GK	-.69	.35		-.01	-.70	.99	N/A
RA	.70	.01	-.39		.48	-.95	-.89
RB	.02	-.52	-.26	.43		.94	-.99
RK	-.30	.48	.55	-.63	-.81		.05
RM	-.01	.37	.13	-.29	-.66	.53	

[A] GA, Gb, GK: growth curve parameters in Gompertz model with respect to A , B and K ;
RA, RB, RK RM: growth curve parameters in Richards model with respect to A , B , K and M

The genetic and phenotypic correlations among growth curve parameters from Gompertz model and those from Richards model are presented in Table 5. For Gompertz model, the genetic correlation of A with K was -0.21 and B with A and K were 0.16 and 0.28, respectively. For Richards model, the genetic correlations of A with B , K and M were 0.48, -0.95 and -0.89, respectively, and B with K and M were -0.94 and -0.99, respectively, and the genetic correlation between K and M was 0.05. The phenotypic correlations of A in Gompertz model with A , B , K and M in Richards model were 0.70, 0.02, -0.30 and -0.01, respectively, and the genetic correlations were 0.98, 0.01, 0.18 and -0.19, respectively. The phenotypic correlations of K in Gompertz model with A , B and K in Richards model were -0.39, -0.26, 0.55 and 0.13, respectively, and the genetic correlations were -0.01, -0.70 and 0.99, respectively.

REFERENCES

Boldman, K. G., Kriese, L. A., Van Vleck, L. D., Van Tassell, C. P. And Kachman, S. D. (1995) " A Manual for use of MTDFREML ". USDA, ARS. USA.

Brown, J. E., Fitzhugh, H. A., and Cartwright, T. C. (1976) *J. Anim. Sci.* **42** : 810-818.

DeNise, R. S. K. and Brinks, J. S. (1985) *J. Anim. Sci.* **61** : 1431-1440.

SAS (1990). " SAS/STAT User's guide vol. 2 ". SAS institute Inc., Cary, NC. USA.

Richards, F. J. (1959) *J. Exp. Bot.* **10** : 290.

Winsor, C. R. (1932) *Proc. Natl. Acad. Sci.* **18** : 1.