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Estimation of Inbreeding Levels and Its Effect on Growth Performances of Calves in Hanwoo and Chikso (Korea Brindle) Cattle Population

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ABSTRACT

The objective of this study was to compare the effects of the levels of inbreeding on body weight traits between two breed populations, Hanwoo and Korea Brindle cattle. Birth weight (BW), weaning weight (WW), body weight at 6 months of age (W6) and yearling weight (YW). Records of 1,745 calves (1,513 from Hanwoo, and 232 from Korea Brindle calves) were collected from Livestock Research Institutes in Kangwon, Gyeongbuk and Chungbuk provinces. The least squares means (LSM) and their standard errors for BW, WW, W6 and YW were 25.4±0.1 kg, 81.0±1.8 kg, 146.1±3.7 kg and 291.5±2.4 kg, respectively in Hanwoo calves and 22.6±0.3 kg, 79.9±2.3 kg, 137.6±4.6 kg and 249.3±6.6 kg, respectively in Korea Brindle calves. Pedigree data showed that 14.8% (316 out of 2131) of Hanwoo was inbred and the average inbreeding coefficient was 0.0209 (2.09%). Inbreeding coefficients of ten calves out of 316 total inbred Hanwoo calves were 12.5% or higher, whereas those of the other 306 calves were less than 12.5%. In both breeds, calves were divided into three groups of inbreeding classes - highly inbred group($F \geq 0.125$), lowly to medially inbred group($0 < F < 0.125$) and no inbred group($F=0$). In Korea Brindle calf populations, 12.2% of the calves observed (57 out of 467 calves) were inbred and the average inbreeding coefficient was 0.1367(13.67%). Forty four calves out of 57 inbred Korea Brindle calves had inbreeding coefficients of 12.5% or higher and the other 13 calves had less than 12.5% of inbreeding coefficients. Average inbreeding coefficient and the number of calves with greater than 12.5% inbreeding coefficient were higher in Korea Brindle calf groups than in Hanwoo calf groups. On the average, body weight growth of Korea Brindle calves was slower than that of Hanwoo calves. This would be due to very small breeding population structure of Korea Brindle cattle as compared to Hanwoo cattle, which would lead to rapid increase in inbreeding coefficients in the population. In conclusion, our study suggests that planned mating system is needed to control inbreeding in Korea Brindle population.

(Key words : Growth performance, Inbreeding, Hanwoo, Korea brindle cattle)

INTRODUCTION

Beef cattle population in Korea can be categorized into three breeds - Hanwoo, Chikso(Korea Brindle) and Heugwoo(Korea Black). Of these three breeds, Hanwoo cattle have been under national breeding program for a long time since early 1980's. Hanwoo cattle are mostly registered in a herd book of Korea Animal Improvement Associaiton which manages pedigree information and type scores. Performances of bulls born in the country are tested and the semen of proven bulls are distributed to commercial breeders for AI operations. Therefore the size of Hanwoo population is steadily increasing. However, Chikso and Heugwoo population is in danger due to neglect of national genetic improvement (personal communication). Recent research works on these breeds focus mostly on phylogenetic studies about coat color expression patterns (Lee *et al.*, 2002). Problems we face in these breeds with small population

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size are rapid increase in inbreeding and some findings of depressed growth rate presumably due to inbreeding. Inbreeding results in increase in the frequency of homozygotes which have deleterious effects on growth rate, milking performances or on reproduction efficiency such as litter size in pigs (Weigel, 2001; Pollak and Ufford, 1978; Cassel *et al.*, 2003). In Hawoo, there was a report that inbreeding affected body weights at birth or at weaning in negative way (Park *et al.*, 1969). Another researchers in their studies on Hanwoo population involved in national breeding program calculated average inbreeding coefficients (Hwang *et al.*, 2009) and effective population size as a result of increase in inbreeding (Dang *et al.*, 2010).

The objective of this study was to compare the growth performances of Hanwoo and Chikso (Korea Brindle) cattle raised under the same environments at three institutes with regards to the levels of inbreeding.

MATERIALS AND METHODS

Animals and Data

Records of birth weight (BW), weaning weight (WW), body weight at 6 months of age (W6) and yearling weight (YW) from 1,745 calves (1,513 Hanwoo and 232 Korea Brindle) were collected from Livestock Research Institutes in Kangwon, Gyeongbuk and Chungbuk provinces.

Statistical Analyses

Inbreeding coefficients(F) were calculated from pedigree information by a program developed by Kim *et al.* (2006), who used the algorithm of Meuwissen and Luo (1992). Effects of the inbreeding levels on growth performances were estimated with the following multivariate generalized linear models. Least squares estimation of the effects were solved using GLM procedure of SAS 9.0.

$$y_{ijkl} = \mu + YR_i + S_j + P_k + I_l + e_{ijkl}$$

Here, y is an observation of the growth performance traits(BW, WW, W6, YW), μ is the overall mean, YR_i is the effect of year of birth, S_j is the effect of sex(1=female, 2=male) of the calves, P_k is the effect of herd location, I_l is the effect of inbreeding level classes(High : $F \geq 0.125$, Low : $0<F<0.125$, and Not Inbred : $F=0$) and e_{ijkl} is a random residual.

RESULTS AND DISCUSSION

Table 2 shows least squares mean(LSM) for birth weight(BW), weaning weight(WW), body weight at 6 age (W6) and Yearling weight(YW) in different Hanwoo breeds. The least squares means (LSM) and their standard errors for BW, WW, W6 and YW were 25.4±0.1 kg, 81.0±1.8 kg, 146.1±3.7 kg and 291.5±2.4 kg, respectively in Hanwoo calves and 22.6±0.3 kg, 79.9±2.3 kg, 137.6± 4.6 kg and 249.3±6.6 kg, respectively in Korea Brindle calves. The least squares means (LSM) of BW, WW, W6 and YW of Hanwoo calves were heavier than those of Korea Brindle calves. Differences in LSM's of YW were significant.

Table 2. Least squares means(LSM) of birth weight(BW), weaning weight(WW), body weight at 6 months of age(W6) and yearling weight(YW)

Trait	Hanwoo		Korea Brindle	
	N	LSM±SE	N	LSM±SE
BW	1,403	25.4±0.1	195	22.6±0.3
WW	618	81.0±1.8	102	79.9±2.3
W6	534	146.1±3.7	95	137.6±4.6
YW	432	291.5±2.4	54	249.3±6.6

Table 1. Summary statistics for birth weight(BW), weaning weight(WW), body weight at 6 age(W6) and Yearling weight(YW) in different Hanwoo breeds

Trait	Breed	No.	Mean	SD	Min	Max
BW	Hanwoo	1,403	25.9	3.6	12.0	41.0
	Korea Brindle	195	24.1	3.4	15.0	34.0
WW	Hanwoo	618	79.4	14.9	22.8	123.0
	Korea Brindle	102	79.2	13.7	43.2	109.8
W6	Hanwoo	534	143.6	31.8	62.3	244.6
	Korea Brindle	95	132.5	29.4	72.6	196.2
YW	Hanwoo	432	295.4	72.6	152.7	525.3
	Korea Brindle	54	240.7	52.0	141.5	371.2

Ki *et al.*(2007) estimate the genetic parameters with weight traits of the steers and bulls in the Hanwoo population. The data used were weights and weight gain of performance and progeny test from 6,024 heads of Hanwoo. Means and standard deviations of body weights at 6 and 12 months of age from the data of performance test were 181.72±30.22 kg, 351.48±40.24 kg, respectively. Means and standard deviations of body weights at 6, 12, and 24 month of age from the data of progeny test were 169.18±32.82 kg, 229.37±44.57 kg, 570.45 ±64.36 kg, respectively. Choi *et al.* (2007) estimate the genetic characteristics of body weight for Hanwoo. The means for the weights were 25.60, 79.31, 98.91, 145.40, 283.26, 392.32, 545.65 kg at birth, 3, 4, 6, 12, 18, 24 month, respectively. These averages were far less than those in the report of Ki *et al.* (2007) who estimated average body weights of steers on progeny tests but were similar to the estimates by Choi *et al.* (2007).

Table 3 shows average inbreeding coefficient and proportion (in parentheses) by breeds. Pedigree data showed that 14.8% (316 out of 2,131) of Hanwoo was inbred and the average inbreeding coefficient was 0.0209 (2.09 %). Inbreeding coefficients of ten (0.5%) calves out of 316 total inbred Hanwoo calves were 12.5% or higher, whereas those of the other 306 (14.4%) calves were less than 12.5%. In Korea Brindle calf populations, 12.2% of the calves observed (57 out of 467 calves) were inbred and the average inbreeding coefficient was 0.1367 (13.67 %). Forty four (9.4%) calves out of 57 inbred Korea Brindle calves had inbreeding coefficients of 12.5% or higher and the other 13(2.8%) calves had less than 12.5 % of inbreeding coefficients. In our study population, the proportion of inbred animals with over zero inbreeding coefficients was higher in Hanwoo than in Korea Brindle calf. But the average inbreeding coefficient or the average of cattle with over 12.5% inbreeding coefficients were higher in Chikso cattle compared to Hanwoo cattle. There were a few reports on inbreeding coefficients in Hanwoo population on a national basis. Lee *et al.*(1992) calculated national average inbreeding coefficient of Hanwoo cattle as 0.17% based on pedigree information of the registered cattle. Later Hwang *et al.*(2009) calculated national average inbreeding coefficients of registered Hanwoo cattle by birth years and found increasing trend of inbreeding from 0% in 1995 to 0.3% in 2007. The average inbreeding coefficient observed in our Hanwoo population was near the national average but that observed in Korea Brindle populations was higher than national average of Hanwoo. Garrido *et al.* (2008) with Brangus and Angus populations reported that the average inbreeding coefficient was 0.5%. Parland *et al.* (2007) reported that the average inbreeding coefficients of cattle born in 2004 were 2.19% in Hereford population, 1.49% in Holstein-Friesian population, 1.35% in Simmental population, 1.31% in Angus population, 0.57% in Limousin population, and 0.54% in Charolais population. Inbreeding coefficient estimates in our study population showed similar estimate in Hanwoo cattle while that in Chikso cattle was higher as compared to their estimates.

Table 4, Fig. 1 shows trend of averaged inbreeding coefficients by birth year. There was little changes in the average inbreeding coefficient of Hanwoo cattle over the years of births. But the averages tended to decrease in the case of Chikso cattle.

Table 5 shows least squares means(LSM) of birth weight(BW), weaning weight(WW), body weight at 6 months of age(W6) and yearling weight(YW) by inbreeding. Body weight growth of Hanwoo and Korea Brindle

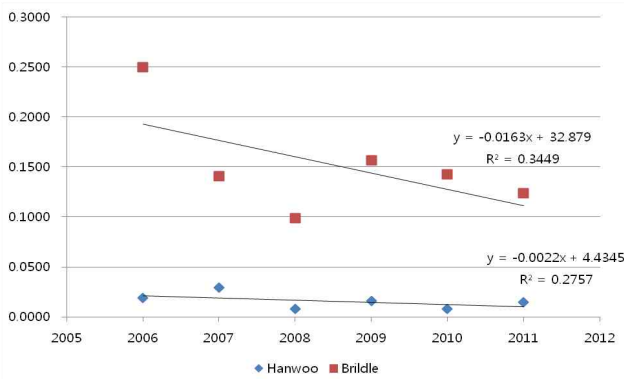

Fig. 1. Trend of averaged inbreeding coefficients by birth year.

Table 3. Average inbreeding coefficient and proportion(in parentheses) by breeds

Breed	N total	N inbred			Average inbreeding coefficient
		Total	High[1]	Low[2]	
Hanwoo	2,131 (100%)	316 (14.8%)	10 (0.5%)	306 (14.4%)	0.0209
Korea Brindle	467 (100%)	57 (12.2%)	44 (9.4%)	13 (2.8%)	1367.1

[1]High : Inbreeding coefficient $F \geq 0.125$, [2]Low : Inbreeding coefficient $0<F<0.125$.

Table 4. Trend of averaged inbreeding coefficients by birth year

Year	Hanwoo				Korea Brindle				Average inbreeding coefficient	
	No. of individuals in total	N inbred			No. of individuals in total	N inbred			Hanwoo	Korea Brindle
		Total	High[1]	Low[2]		Total	High[1]	Low[2]		
2011	101	58	2	56	98	19	11	8	0.0147	0.1234
2010	113	42	-	42	165	18	17	1	0.0082	0.1424
2009	113	39	-	39	104	8	7	1	0.0158	0.1563
2008	116	47	-	47	36	6	4	2	0.0079	0.0990
2007	108	28	-	28	10	4	3	1	0.0290	0.1406
2006	113	50	-	50	17	2	2	-	0.0192	0.2500
<2005	1,467	52	8	44	37	-	-	-	0.0426	-
Total	**2,131**	**316**	**10**	**306**	**467**	**57**	**44**	**13**	**0.0209**	**0.1367**

[1]High : Inbreeding coefficient $F \geq 0.125$, [2]Low : Inbreeding coefficient $0<F<0.125$

Table 5. Least squares means(LSM) of birth weight(BW), weaning weight(WW), body weight at 6 months of age(W6) and yearling weight(YW) by inbreeding

Trait	Hanwoo				Korea Brindle			
	Not inbred		Inbred		Not inbred		Inbred	
	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE
BW	1,126	25.6±0.1	277	24.1±0.3	144	23.5±0.4	51	24.4±0.7
WW	371	81.3±1.9	247	79.8±2.0	58	75.4±2.4	44	85.7±3.8
W6	312	146.7±3.8	222	144.6±4.1	62	134.9±5.7	33	152.7±8.2
YW	254	292.1±3.3	178	288.6±3.7	29	230.0±14.2	25	234.9±16.8

calves were compared between inbred($F>0$) groups and not inbred groups($F=0$). Least squares means of not inbred Hanwoo group vs. inbred Hanwoo group were: BW 25.6±0.1 kg vs. 24.1±0.3 kg, WW 81.3±1.9 kg vs. 79.8 ±2.0 kg, W6 146.7±3.8 kg vs. 144.6±4.1 kg, YW 292.1±3.3 kg vs. 288.6±3.7 kg. Least squares means of not inbred Korea Brindle group vs. inbred Korea Brindle group were: BW 24.3±0.4 kg vs. 23.8±0.7 kg, WW 78.6±2.4 kg vs. 77.0±3.8 kg, W6 141.9±5.7 kg vs. 139.9±8.2 kg, YW 234.9±14.2 kg vs. 230±16.8 kg. In Hanwoo breeds, body weights of not inbred calves were a little heavier than body weights of inbred calves. But in Korea Brindle cattle breeds, body weights of inbred calves were a little heavier than body weights of not inbred calves. Park *et al.*(1969) estimated regression of birth weight and weaning weight on inbreeding coefficient of individual Hanwoo calves. Their patial regression were −0.042± 0.030 kg foof birth weight and −0.292±0.153 kg for weaning weight for each increase of 1% inbreeding of calf. The patial regressions birth and weaning weights on inbreeding of dam were 0.005±0.037 and −0.421±0.188 kg. Our results also support the evidence of negative impact of inbreeding on growth performances. We conclude that Korea Brindle cattle population has higher risk of inbreeding depression than Hanwoo population because of small population size. Average inbreeding coefficient in Korea Brindle population was higher and proportion of high inbred($F \geq 12.5\%$) animals in the population was greater compared to Hanwoo population studied together. Therefore, national or regional efforts to make accurate management of pedigree information with highly specialized mating designs. And for the far future of Korea Brindle cattle breeding, various ways to increase population size targeting beef cattle industry in Korea or abroad should be considered.

REFERENCES

1. Cassell BG, Adamec V, Pearson RE (2003): Effect of incomplete pedigrees on estimates of inbreeding and inbreeding depression for days to first service and summit milk yield in Holsteins and Jerseys. J Dairy Sci 86: 2967-2976.
2. Choi JG, Jeon KJ, Lee CW, Na GJ, Lee C, Kim JB (2003): Estimation of genetic parameters of body weight by growth periods for Hanwoo using animal model. J Anim Sci & Technol (Kor.) 45:667-678.
3. Dang CG, Lee JJ, Kim NS (2011): Estimation of inbreeding coefficients and effective population size in breeding bulls of Hanwoo (Korean cattle). J Anim Sci & Technol (Kor.) 53:297-302.
4. Garrido LR, Birchmeier AN, Munilla S, Cantet RJC (2008): Estimation of effective population size using bivariate discrete distributions for modeling family size in beef cattle. Livestock Science 117:43-51.
5. Hwang JM, Park CJ, Choi GJ (2009): The inbreeding trend of Hanwoo cow population. Ann Anim Res Sci 20:1-5.
6. Ki KS, Choi TJ, Kim SD, Choi HS, Baik DH (2007): Estimation of Genetic parameters for the growth traits of performance and progeny test in Hanwoo (*Bos taurus* Coreanae) J Anim Sci & Technol (Kor.) 49:699-710.
7. Kim SD, Salces A, Min HR, Cho KH, Kim HB (2006): Inbreeding levels and pedigree structure of Landrace, Yorkshire and Duroc populations of major swine breeding farms in republic of Korea. Asian-Aust J Anim Sci 19:1217-1224.
8. Lee MY, Seol DS, Park SH, Lee SG (1992): Estimation of inbreeding coefficients in Hanwoo and Holstein. Korean Soc of Anim Sci & Technol C9219.
9. Lee SS, Yang BS, Yang YH, Kang SY, Ko SB, Jung KJ, Oh WY, Oh SJ, Kim KI (2002): Analysis of Melanocortin Receptor 1 (*MC1R*) genotype in Korean Brindle cattle and Korean cattle with dark muzzle. J Anim Sci & Technol (Kor.) 44:23-30.
10. Meuwissen THE, Luo Z (1992): Computing inbreeding coefficients in large populations. GSE 24:305-313.
11. Park YI, Lee JH, Cho YY (1969): Effect of inbreeding on birth and weaning weights in Korean Native Cattle. Korean J Anim Sci 11:36-39.
12. Parland SM, Kearney JF, Rath M, Berry DP (2007): Inbreeding trends and pedigree analysis of Irish dairy and beef cattle population. J Anim Sci 85:322-331.
13. Pollak EJ, Ufford GR (1978): Effect of inbreeding on within-herd genetic evaluation of beef cattle. J Anim Sci 47:853-857.
14. Weigel KA (2001): Controlling inbreeding in modern breeding program. J Dairy Sci (E. Suppl) 84: E177-E184.

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