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Short Communication

Effect of birth and lactation season on the growth of Korean Hanwoo calves

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ABSTRACT South Korea has a temperate climate with four distinct seasons. However, summers are extremely hot and humid, which negatively affects industrial animal production. Hanwoo are native cattle that have traditionally been raised in the natural environment of Korea. The present study investigated the effects of birth and lactation season on the birth and weaning weights of Hanwoo calves. Data were collected from 100 local breeding farms between 2016 and 2021. A total of 56,970 (males, 29,530; females, 27,440) Hanwoo calves were classified according to sex or birth and weaning season (March–May, spring; June–August, summer; September–November, fall; and December–February, winter). The birth weight of Hanwoo calves differed according to the birth season. As such, birth weight of the summer-born calves was the lowest. Additionally, the 90-day weaning weight was positively correlated with birth weight. Interestingly, however, the 90-day weaning weight was not related to the birth season but was related to the 2-month seasonal effect during the lactation period. Furthermore, the 90-day weaning weight was the lowest during the summer lactation period. In the beef cattle industry, daily weight gain is an important economic characteristic related to feed efficiency and growth. Our findings will contribute the management of Hanwoo cattle and analysis of changes in economic characteristics due to high temperatures.

Keywords: birth weight, Hanwoo, high temperature, season, weaning weight

INTRODUCTION

Hanwoo (Korean native cattle) have been raised for farming and transportation since long. With recent economic development of Korea, the production of good-quality meat has increased. According to statistics from the Korean Statistical Information Service (2022) 3,511,160 Hanwoo cattle were raised in South Korea in 2022. Therefore, with increase in Hanwoo slaughter number, the carcass auction price is expected to decrease. Accordingly, efficient management of Hanwoo farms is important.

Birth weight is a reliable economic indicator in the beef cattle industry. It is positively correlated with daily weight gain but negatively correlated with both energy efficiency of weight gain and proportion of fat in carcass gain (Bailey and Mears, 1990). We have previously reported that birth weight was significantly reduced in summer-born calves in South Korea. In addition, birth weight was positively correlated with carcass weight but negatively correlated

with slaughter month (Cho et al., 2021).

A recent study highlighted that effective early postnatal nutritional management is a crucial component of livestock production systems, and nutrient manipulation during this period exerts long-term effects on beef cattle growth and physiology. Early weaning has been used to study the metabolic imprint effect, as it allows for the nutritional manipulation of animals at a young age. This practice improved carcass characteristics in feedlot cattle and accelerated reproductive organ development in females (Harvey et al., 2021). Additionally, research in dairy cattle has shown that compared with limited feeding, enhancing the nutrient intake of calves during the preweaning phase increased milk production during their first lactation (Soberon and Van Amburgh, 2013).

In recent years, global warming has accelerated. In particular, the increase in summer temperatures in Korea has been considerably higher than that in other countries. During summer, the weather in Korea is hot and humid, as evidenced by mean climate data (Piao and Baik, 2015). Accordingly, a reduction in livestock production due to the rise in temperature and humidity was expected, although this effect was rare in Hanwoo cattle. Typically, Hanwoo are slaughtered at 55.8 (females), 29.4 (steers), and 29.2 (bulls) months of age, rendering the evaluation of the effect of environmental conditions on the production rate difficult. To this end, we analyzed the birth and weaning weights of Hanwoo calves born between 2016 and 2021 and verified the correlations of birth weight, birth season, and 90-day weaning weight.

MATERIALS AND METHODS

Data collection

Birth weight data were collected from 100 local breeding farms between 2016 and 2021 under the National Agricultural Cooperative Federation Hanwoo Genetic Improvement Center program. A total of 56,970 Hanwoo calves (males: 29,530, females: 27,440) were classified and analyzed according to sex, year, month, and season. The seasons were classified as spring, March-May; summer, June-August; fall, September-November; and winter, December-February. Birth weight was divided into three groups for each sex: BW ≤ 27, 27 < BW < 33, and 33 ≤ BW (males) and BW ≤ 26, 26 < BW < 31, and 31 ≤ BW (females). Season effects were divided over 2-month classes. The temperature result collected from Korea Meteorological Administration weather data service (Supplementary Table 1).

Statistical analysis

One-way analysis of variance (ANOVA) was used to compare average birth weight data using the Statistical Analysis System (SAS) software (version 9.4; Cary, USA). Duncan's multiple comparison test was used for comparisons among groups. All data are expressed as mean ± standard deviation (SD). The null hypothesis was rejected when the probability value was <0.05.

The general linear model procedure of SAS software was used to test the significance of 90-day weaning weight traits. The linear model for the 90-day weaning weight was as follows:

$$y_{ijke} = \mu + BW_i + SE_j + e_{ijke}$$

where y_{ijke} represents Hanwoo 90-day weaning weight, μ is the total mean, BW_i is the i^{th} fixed effect of the birth weight group (1 to 3), SE_j is the j^{th} fixed effect of the season group (1 to 4), and e_{ijke} is the residual error.

The least squares method was used to estimate the environmental and seasonal effects on the 90-day weaning weight. The linear model was analyzed using SAS (v9.4), and variance analysis was performed using a type III squared fit for unbalanced data among the four squares presented in the SAS/general linear model analysis. The statistical significance of differences between the least-squares averages of the treatments was tested with the following null hypothesis at a significance level of 1%: Ho: least-squares means (LSM) (i) = LSM (j), where LSM (i(j)) is the least-squares average of the I (j) effect (I ≠ j).

RESULTS AND DISCUSSION

Effect of birth season on birth weight

The birth weights of male calves were 31.16 ± 4.44, 30.63 ± 4.24, 31.04 ± 4.53, and 31.24 ± 4.52 kg in spring, summer, autumn, and winter, respectively (Table 1). Male Hanwoo calves born in winter were the largest, whereas those born in summer were the smallest. Winter- and spring-born calves were significantly larger than summer- and autumn-born ones. These results are not consistent with our previous reports (Cho et al., 2021). In addition, birth weights of female calves were 28.75 ± 3.84, 28.19 ± 3.81, 28.72 ± 3.90, and 28.66 ± 3.98 kg in

Table 1. The seasonal average of Hanwoo calf's birth weight in 2016-2021 period

Season	Male		Female	
	Numbers of calf	Mean of birth weight (kg ± SD)	Numbers of calf	Mean of birth weight (kg ± SD)
Spring	11,000	31.16 ± 4.44[ab]	9,828	28.75 ± 3.84[a]
Summer	6,704	30.63 ± 4.24[c]	6,626	28.19 ± 3.81[b]
Autumn	6,024	31.04 ± 4.53[b]	5,111	28.72 ± 3.90[a]
Winter	5,802	31.24 ± 4.52[a]	5,875	28.66 ± 3.98[a]

Table 2. The correlation between birth weight and weaning weight of Hanwoo calf in 2016-2021 period

Sex	Group	LSMean of 90 day weaning weight (kg ± SE)	Pr > |t|
Male	BW ≤ 27	85.518 ± 0.240	< 0.0001
	27 < BW < 33	93.915 ± 0.152	< 0.0001
	33 ≤ BW	102.741 ± 0.187	< 0.0001
Female	BW ≤ 26	81.996 ± 0.187	< 0.0001
	26 < BW < 31	89.226 ± 0.146	< 0.0001
	31 ≤ BW	96.568 ± 0.196	< 0.0001

spring, summer, autumn, and winter, respectively (Table 1). Female Hanwoo calves born in spring were the largest, whereas those born in summer were the smallest. Female Hanwoo calves born in summer were significantly smaller than those born in the other seasons. These results are consistent with our previous reports (2016-2019) (Cho et al., 2021). In a previous study, female calves, twins, and calves born to primiparous cows showed lower birth weights than male calves, singletons, and calves born to multiparous cows, respectively (Dhakal et al., 2013). According to data from 1970 to 2006, the average birth weight of Hanwoo calves is 24.35 kg, which is lower than that recorded in the present study (Hwang et al., 2008). The recent increase in the birth weight of Hanwoo calves under the Hanwoo breeding program was followed by an increase in carcass weight. In another country, with decrease in average winter temperature, calf birth weight and calving difficulty increased (Deutscher et al., 1999). Cold weather extends gestation length, thereby increasing calf birth weight. However, in the present study, we did not analyze the correlation between gestation length and birth season.

Correlation between birth weight and 90-day weaning weight in Hanwoo claves

To determine the correlation between birth weight and 90-day weaning weight, the birth weight group was divided into three classes for each sex: BW ≤ 27, 27 < BW < 33, and 33 ≤ BW (male) and BW ≤ 26, 26 < BW < 31, and 31 ≤ BW (female). Linear modeling demonstrated that the 90-day weaning weight was positively correlated with birth weight (Table 2). Among males, the 90-day weaning weight was 85.518 ± 0.240, 93.915 ± 0.152, and 102.741 ± 0.187 kg in the BW ≤ 27, 27 < BW < 33, and 33 ≤ BW groups, respectively. Among females, the 90-day weaning weight was 81.996 ± 0.187, 89.226 ± 0.146, and 96.568 ± 0.196 kg in the BW ≤ 27, 27 < BW < 33, and 33 ≤ BW groups, respectively. In a previous study, a positive genetic correlation of gestation length with birth and weaning weight has been reported, implying that selection for higher birth and weaning weights has prolonged gestation length (Hwang et al., 2008). Another study estimated that the direct heritability was moderate (0.22 ± 0.02) for birth weight and high (0.51 ± 0.03) for weaning weight, while the maternal heritability was low (0.12 ± 0.01 and 0.17 ± 0.01, respectively) for both traits (Lopez et al., 2020). Low birth weight is associated with a low growth rate after birth and small size at maturity.

Effect of lactation period season on 90-day weaning weight in Hanwoo claves

We evaluated the effect of lactation period season on the 90-day weaning weight of Hanwoo calves. Linear modeling revealed that the 90-day weaning weight was related to the lactation season. The 90-day weaning weight of male calves was 94.670 ± 0.150, 89.071

Table 3. The correlation between season effect and weaning weight of Hanwoo calf in 2016-2021 period

Sex	Season effect (birth month)	LSMean of 90 day weaning weight (kg ± SE)	Pr > |t|
Male	Spring (2, 3, 4)	94.670 ± 0.150	< 0.0001
	Summer (5, 6, 7)	89.071 ± 0.555	< 0.0001
	Autumn (8, 9, 10)	93.826 ± 0.171	< 0.0001
	Winter (11, 12, 1)	91.934 ± 0.700	< 0.0001
Female	Spring (2, 3, 4)	89.767 ± 0.136	< 0.0001
	Summer (5, 6, 7)	87.619 ± 0.573	< 0.0001
	Autumn (8, 9, 10)	88.746 ± 0.158	< 0.0001
	Winter (11, 12, 1)	88.160 ± 0.804	< 0.0001

± 0.555, 93.826 ± 0.171, and 91.934 ± 0.700 kg during spring, summer, autumn, and winter lactation periods, respectively. The 90-day weaning weight of female calves was 89.767 ± 0.136, 87.619 ± 0.573, 88.746 ± 0.158, and 88.160 ± 0.804 kg during spring, summer, autumn, and winter lactation periods, respectively. Both male and female Hanwoo calves were the smallest in the summer lactation period and the largest in the spring lactation period (Table 3). The temperature-humidity index (THI) has been used to determine the effect of heat stress on the productivity of farm animals. According to Armstrong (1994), THI < 71 indicates a thermal comfort zone, THI = 72-79 indicates mild heat stress, THI = 80-90 indicates moderate heat stress, and THI > 90 indicates severe heat stress. The THI values in South Korea are between 73 and 80 in summer, indicating mild to moderate heat stress (Piao and Baik, 2015). Therefore, heat stress in summer affects the growth of fetal and new born Hanwoo calves.

CONCLUSIONS

In conclusion, we explored the birth and weaning weight patterns of Hanwoo calves born in different seasons and evaluated the effect of seasonal heat stress on economic characteristics. Specifically, the birth and weaning weights of Hanwoo calves were significantly reduced during summer. Overall, birth and weaning weights are reliable indices of heat stress in the Hanwoo industry.

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Supplementary material can be found via https://doi.12750/JARB.37.4.298.

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