Journal of the Korean Society of Grassland and Forage Science 32(4) : 397~404, 2012
http://dx.doi.org/10.5333/KGFS.2012.32.4.397

Effect of Stocking Density on Eating Behavior of Finishing Hanwoo Steers (*Bos taurus coreanae*)

Sang Moo Lee[1], Young Chul Kwon[1,2] and Eun Joong Kim[1]

[1]Department of Animal Science and Biotechnology, Kyungpook National University, Sangju 742-711, Korea, [2]NongHyup Feed Co., Ltd., Gyeongbuk Branch, Andong, 760-862, Korea

ABSTRACT

This study was carried out to investigate the effects of stocking density on eating and ruminating behavior of Hanwoo steers (*Bos taurus coreanae*) in the finishing period. A total of 30 finishing Hanwoo steers (631.3 ± 11.4 kg, 25 months old) were allocated to one of four stocking density groups comprising 1, 2, 3, and 4 steers per 32 m^2 pen [G1 (32 m^2), G2 (16 m^2), G3 (10.7 m^2) and G4 (8 m^2), respectively] in triplicate. Eating, rumination behaviors, as well as dry matter intake of steers were measured, and the results were subjected to analysis of variance with stocking density as the main effect. The results of eating behaviors over 48 hours are summarized as follows: Total intake was significantly ($p<0.01$) higher in G1, G2, and G3 compared to G4. Eating time was not different among the treatments, whereas ruminating time increased in the order of G1 > G2 > G3 > G4 ($p<0.01$). However, resting time and chewing time (sum of eating and ruminating) were not significantly different among the treatments. Number of boluses and number of total chews were highest in G1 ($p<0.01$), whereas number of chews per bolus was highest in G3 ($p<0.01$). Ruminating time per bolus as well as number of boluses per minute was not significantly different among the treatments. Number of defecations was higher in G1 and G2 animals compared to G3 and G4 animals ($p<0.01$). However, stocking density had no effect on drinking or urination. In conclusion, increasing stocking density (i.e. G4) per pen decreased voluntary intake, ruminating time, and total chewing number in the finishing period of Hanwoo steers. However, care must be taken in discussing stocking density in the present study as the space allowance per animal was satisfactory to meet the current animal welfare regulation in Korea and in Europe, although the beef production system in Korea is more intensive than in Europe.

(**Key words** : Hanwoo, Chewing behavior, Rumination, Stocking density)

Ⅰ. INTRODUCTION

Stocking density is determined by a manager or farmer upon consideration of animal conditions, management environment, financial situation, and animal prices. It is usual practice that farm managers maintain a livestock raising system that maximizes profit per unit area through maximum stocking density. Under such a production system, quantitative expansion can be expected. On the other hand, the animal rearing environment deteriorates and disease incidence can increase. Furthermore, the amount of manure produced by livestock accumulates drastically inviting harmful effects, driving up manure treatment costs and environmental contamination (Dougherty et al., 2008). For such reasons, the animal industry in many Asian

Corresponding author : Eun Joong Kim, Department of Animal Science and Biotechnology, Kyungpook National University, Sangju 742-711, Korea.
Tel: +82 (0)54-530-1228, Fax: +82 (0)54-530-1229, E-mail: ejkim2011@knu.ac.kr

countries is moving to enact revised stocking density guidelines for livestock and animal production system.

A few studies have reported a relationship between calves or beef cattle production and stocking density or group size (Kondo et al., 1989; Li et al., 2010). An excellent review by Barnett et al. (2001) addressed the welfare issues for sows and piglets according to both grouping and space allowance. When chickens are raised in a group, certain unique behaviors, such as nest defending, aggression, and hindrance of feeding, appear that are absent from the single rearing system, thereby lowering the productivity (Yamazaki et al., 1986). In pigs, higher stocking density is associated with increased aggression as well as a reduced immune response in comparison with lower stocking density (Turner et al., 2000). In dairy cows, higher stocking density correlates with higher social competence and aggression (Fregonesi and Leaver, 2002). Although many studies have reported the effects of stocking density and/or group size on productivity, social behavior and the immune response, there has been no such examination of optimal stocking density or group size with regards to on eating behavior especially, in a Korean native breed (namely Hanwoo). Such a study will provide important information for animal production industry, particularly for the countries including Korea of which most farms adopt an intensive animal production system throughout the country. Therefore, the objective of this study was to investigate the effects of stocking density of Hanwoo steers on eating behavior in the finishing period.

Ⅱ. MATERIALS AND METHODS

1. Experimental design, animals, and management

The experiment was conducted in a commercial farm located in Chilgok, Gyeongbuk Province, Korea (36.03272°, 128.363792°). A total of 30 Hanwoo steers in the finishing period (25 months of age with an average body weight of 631 ± 15 kg) were allocated to one of four stocking density groups comprising 1, 2, 3, and 4 steers in 32 m^2 (4 m × 8 m) pens (G1, G2, G3 and G4, respectively), such that the space allowances were different among treatments (see Table 1). The experiment was conducted in triplicate (12 pens in total). In terms of feeding management, commercially available concentrates (NongHyup Feed Co. Ltd.) were offered *ad libitum* with 1 kg DM of rice straw as roughage, which follows a typical feeding program for beef cattle in Korea. Daily feed was offered equally twice a day at 8 am and 5 pm. Chemical compositions of the concentrates and rice straw, and feed ingredients of the

Table 1. Experimental design and animals used in this experiment

Item	Treatments			
	G1	G2	G3	G4
Pen sizes	4 × 8 m	4 × 8 m	4 × 8 m	4 × 8 m
No. of head per pen	1	2	3	4
Area per head	32.0 m^2	16.0 m^2	10.7 m^2	8.0 m^2
No. of replication	3	3	3	3
Total no. of steers	3	6	9	12

concentrates are presented in Table 2. Fresh water using a water cup as well as supplementary mineral blocks was available throughout the day. Feed bins containing the concentrates and roughage were set apart in opposite directions in order to minimize unnecessary competitive behavior.

2. Measurements

Eating behaviors were observed continuously over 2 d (48 h) from November 26 to November 28, 2010. Eating, ruminating, resting time, number of boluses, and defecating behavior of steers were visualized and recorded during the experiment. Thirty-six well-trained surveyors were selected, with one surveyor assigned to observe one animal in 2 h shifts individual behaviors were observed visually in 1 min intervals for 48 h and recorded on plotting paper. Feed refusals were collected the next day and weighed for determination of dry matter intake (DMI), which was measured based on the difference between the amount of feed offered and the amount refused. In terms of feed intake determination, the total amount of feed consumed per group was measured in triplicate, and feed intake was calculated based on the number of animals within each group because an individual feeding facility was not available at this commercial farm. Chewing time was the sum of eating time and ruminating time.

Table 2. Chemical composition (%) and ingredients (%) of experimental diets (dry matter basis unless otherwise stated)

Item	Concentrates	Rice straw
Crude protein	13.10	3.97
Ether extract	5.58	1.61
Crude fiber	8.60	43.18
Crude ash	6.78	11.60
Nitrogen-free extract	66.31	39.64
Neutral detergent fiber	28.76	74.80
Total digestible nutrients	83.25	41.15
Ingredients		
Corn grain, flaked	30.0	–
Wheat grain	16.5	–
Soybean meal	5.0	–
Wheat bran	10.0	–
Corn gluten feed	15.0	–
Cane molasses	3.5	–
Cottonseed hull pellet	4.0	–
Palm kernel meal	10.0	–
Wet distillers grain	2.5	–
Salt dehydrated	0.6	–
Limestone	1.5	–
Vitamin premix	0.1	–
Mineral premix	0.1	–
Others	1.2	–
Total	100	–

3. Calculation and statistical analysis

Statistical analysis of the results of the study was performed by General Linear Model Procedure, Statistical Analysis System (SAS release ver 9.1, 2002) with stocking density as the main effect, and further comparisons between means were verified at a level of 5% by Duncan's multiple range test.

Ⅲ. RESULTS AND DISCUSSION

1. Effect of stocking density on feed intake

Generally speaking, in any animal science areas, stocking density represents the number of specified animals per unit area of either land or any space at any instant whereas group size indicates different number of animals with the same space allowance per animal. The current study was conducted at a commercial farm in order to take into account practical farming and feeding management practices typical of intensive farming systems. However, the experimental design was not able to determine whether the results were due to stocking density or group size or a combination of both. Hence, the results and discussion mostly focus on the effect of stocking density.

The amount of feed intake according to stocking density is presented in Table 3. Dry matter intake of concentrates by G1 was 8.78 kg DM/d, whereas that by G4 was 7.43 kg DM/d or 16% less (p<0.01). Although there were no significant differences among G1, G2, and G3, DMI of concentrates appeared to increase in response to lower stocking density (i.e. G1 > G2 > G3). Rice straw as roughage source was restricted to 1 kg DM/d and offered prior to concentrates feeding during the feedlot period hence there was no refusal of rice straw regardless of treatment types. The results of total DMI in our study were in agreement with those of Gonyou and Stricklin (1998), whereas others found slight differences in feed intake in relation to stocking density (Huzzey et al., 2006; McConnell et al., 1987; Olofsson, 1999). Accordingly, one could speculate that increased stocking density reduces feed intake due to competitive behavior between animals, and our results may support this hypothesis. However, feed intake was measured for only 2 days, and animals were in the finishing period during which feed intake likely declines relative to body weight. Therefore results should be considered in caution. On the other hand, present study was a part of the long-term growth experiment conducted at the same farm with similar experimental condition. Interestingly total dry matter intake of the animals in G1 was numerically higher than those of G4 (9.5 kg DM/d vs. 8.9 kg DM/d for G1 and G4, respectively) over a-25 month growth period which provide similar result compared with the current experiment. The long-term growth study was published previously (Lee et al., 2012).

2. Effects of stocking density on eating, resting, and rumination

Total eating time, roughage, and concentrates eating time showed no significant differences among the treatments (Table 4). Færevika et al. (2007) previously reported no influence of group size under constant stocking density on eating time when 4, 8, and 16 calves were stocked in areas of 9.0, 18.0, and 36.0 m^2, respectively, whereas Li et al. (2010) presented conflicting results in which animals in groups of 4, 8, and 12 demonstrated an increase in eating time at

Table 3. Effect of stocking density on feed intake (dry matter basis unless otherwise stated)

Item	Treatments			
	G1	G2	G3	G4
Concentrate (kg/d)	8.78±0.34^{A}	8.67±0.17^{A}	8.51±0.14^{A}	7.43±0.60^{B}
Rice straw (kg/d)	1.0 ±0.0^{ns}	1.0 ±0.0	1.0 ±0.0	1.0 ±0.0
Total (kg/d)	9.78±0.34^{A}	9.67±0.17^{A}	9.51±0.14^{A}	8.43±0.60^{B}

^{ns} not significant.
$^{A, B}$ Means in a row with different superscripts are significantly different (p<0.05).

lower stocking density. On the other hand, González et al. (2008) reported a reduced eating time of concentrates at higher stocking density in heifers raised in a pen. The discrepancy between our results and those of previous studies can be attributed to differences in the area that each animal occupied. For example, in this experiment, area occupied per animal significantly differed according to group [G1 (32 m^2), G2 (16 m^2), G3 (10.7 m^2) and G4 (8 m^2)], whereas area occupied per animal in the previous studies was kept the same across groups. However, care must be exerted since the space allowance per animal in this study meet the current animal welfare regulation in Korea.

For ruminating time, G1 showed the longest time at 239 min, whereas G4 showed the shortest time at 163 min (p<0.01 Table 4). This result can be attributed to differences DMI. For example, G1 consumed 1.35 kg DM/d more feed than G4, as shown on Table 3. Further, there were no significant differences in resting time (standing + lying) or chewing time (eating time + ruminating time) among the treatments (Table 4). Specially, the Hanwoo breed rested 1,106 min (standing + sitting) or 77% of their daily behavior in the finishing period, which was comparable with the results by Lee and Choi (2010). Resting time is generally considered as an indicator of farm animal comfort and is more important in dairy cows than in beef cattle. It is speculated that overstocking may have an impact on resting time due to differences in space allowance per animal. The results of our study indicate that animal behavior is not compromised as long as sufficient space is provided in the finishing stage. Others have reported that resting behavior, including standing and lying, is closely related with the thermal environment such that eating time decreases and resting time increases during the hot summer season (Hayasaka and Yamagishi, 1990; McDowell et al., 1976).

Ruminating behavior according to stocking density is presented in Table 5. The number of boluses observed in a day (24 hours) ranged from 155 to 239, and there were significant differences among the treatments (p<0.01). Animals in G1 showed 84 more boluses than those in G4. There is little information available in terms of rumination behavior for the Hanwoo breed, but 156 to 191 boluses in 28-month-old Hanwoo steers (average weight of 678 kg) was reported in a study by Lee and Choi (2010), and bolus number has been closely linked to DMI

Table 4. Effects of stocking density on eating, ruminating, and chewing time

Item	Treatments			
	G1	G2	G3	G4
Eating time (min/d)	146±16.7^{ns}	117±18.3	121±29.2	161±26.9
Concentrate	101±19.1^{ns}	74±12.6	83± 5.9	99±36.6
Roughage	46±18.1^{ns}	43± 8.5	37± 8.9	63±24.7
Ruminating time (min/d)	239±33.8^{A}	203± 6.8^{AB}	186±33.1^{BC}	163±11.7^{C}
Resting time (min/d)	1,055±31.4^{ns}	1,120±32.5	1,133±59.0	1,116±56.9
Chewing time (min/d)	386±31.4^{ns}	320±15.8	307±58.7	324±56.9

^{ns} not significant.
Chewing time = Eating time + Rumination time
$^{A, B, C}$ Means in a row with different superscripts are significantly different (p<0.05).

(Deswysen et al., 1987). Likewise, regarding the total number of chews per day, G1 showed the highest number at 10,399 times/d, whereas G4 showed the lowest at 7,239 times/d ($p<0.01$), resulting from the differences in DMI. Our results were in agreement with those of previous reports, which have shown that the number of chews generally increases as DMI increases especially, when using feed with a high neutral detergent fiber (NDF) (Beauchemin, 1992; Rotger et al., 2006). The number of chews per bolus in G1 and G2 decreased compared to G3 and G4 ($p<0.01$). These differences could have been due to higher stocking density creating a more competitive environment compared to lower stocking density, thus encouraging uncomfortable behaviors such as a higher number of chews per bolus in animals more frequently approaching the feed bin. Unfortunately, as there were no differences in resting time among the treatments, it is difficult to speculate.

3. Effects of stocking density on drinking, defecation and urination

Frequency of daily water consumption ranged from 10.6 to 16.0 times/d (Table 6). Although there were no significant differences for drinking frequency according to stocking density, there were large variations between animals within each group. Likewise, trends in urination behavior (numerically higher in G1 animals) were only observed among the treatments. Regarding frequency of daily defecation, G1 showed the highest at 13.0 times/d, whereas G4 showed the lowest at 7.9 times/d ($p<0.01$). There are a limited number of studies on the defecation behavior of ruminants (Laínez and Hsia, 2004; Young, 1983), and these are largely focused on seasonal changes and physiological

Table 5. Effects of stocking density on rumination behavior

Item	Treatment			
	G1	G2	G3	G4
No. of bolus	239±7.8^{A}	202±18.9^{B}	181±8.8^{B}	155±8.9^{C}
No. of total chew	10,399±487.0^{A}	8,153±204.3^{BC}	8,684±972.1^{B}	7,239±623.8^{C}
Ruminating time/bolus (s)	60±6.3^{ns}	63±4.0	61±4.4	64±5.1
No. of chew/bolus	44±1.7^{BC}	40±2.3^{C}	48±3.0^{A}	47±3.4^{AB}
Bolus/min	1.03±0.13^{ns}	0.95±0.06	0.97±0.07	0.95±0.08

^{ns} not significant.
$^{A, B, C}$ Means in a row with different superscripts are significantly different ($p<0.05$).

Table 6. Effect of stocking density on drinking, defecation, and urination

Item	Treatments			
	G1	G2	G3	G4
Drinking (No./d)	16.0±2.2^{ns}	10.6±0.5	13.3±4.5	11.5±3.6
Defecation (No./d)	13.0±1.6^{A}	12.3±1.3^{A}	9.5±1.1^{B}	7.9±1.2^{B}
Urination (No./d)	8.3±1.7^{ns}	4.4±0.5	6.6±2.5	5.3±0.9

^{ns} not significant.
$^{A, B}$ Means in a row with different superscripts are significantly different ($p<0.01$).

status. In our study, defecation and urination behaviors were observed according to the hypothesis that stresses (if any) resulting from high stocking may induce changes. However, it remains unclear whether or not stocking density was responsible for the changes in defecation behavior, since large animal-to-animal variations were observed.

Ⅳ. CONCLUSIONS

In conclusion, higher stocking density per pen decreased voluntary intake, ruminating time, and total number of chews in the finishing period for Hanwoo steers. Although the experimental design could not elucidate whether or not the effects resulted from either stocking density or group size or a combination of both, the results provide useful information in terms of cattle behavior in an intensive farming system, which is often criticized by animal welfare and consumer groups. Care must be taken in discussing stocking density at present study as the space allowance per animal was satisfactory to meet the current animal welfare regulation in Korea and in Europe, although the beef production system in Korea is more intensive than in Europe. Further research is needed in order to determine whether or not eating and ruminating behaviors affect stress in animals and subsequently product quality (i.e. meat) in relation to the economic impact on Hanwoo beef industry in Korea.

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(Received November 30, 2012/Accepted December 10, 2012)