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Growth, Behavior, and Carcass Traits of Fattening Hanwoo (Korean Native Cattle) Steers Managed in Different Group Sizes

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ABSTRACT : This study was conducted to evaluate growth, behavior and carcass traits of fattening Hanwoo (Korean native cattle) steers managed in different group sizes. A total of 48 animals, 6 months of age, were allocated to one of three group sizes and the experiment was conducted from 12 to 30 months of age. Groups were balanced for weight and the group sizes consisted of 4, 8, or 12 steers which were named 4sG, 8sG and 12sG, respectively. When animals were 12 months of age, initial fasted body weight (BW, 304.51 ±12.40 kg) was measured. All animals were housed at a constant space allowance of 8.82 m^2 per animal, and a feeder and drinker were provided per 4 animals. The whole fattening stage was divided into three phases: phase I (from 12 to 18 month of age), phase II (from 19 to 24 month of age), and phase III (from 25 to 30 month of age). Steers managed in 12sG showed low ($p<0.05$) growth rate and feed conversion rate (FCR) in phase I and phase II when compared to other treatment groups. However, this difference was not observed for the whole fattening phase ($p>0.05$). Steers managed in 4sG had a thick ($p<0.05$) ultrasound back fat thickness at 15 and 18 months of age. However, group size had no effect on meat yield and quality traits of area and marbling score. Animals managed in 8sG yielded a better meat grade of "A" than the "B" grade in other treatment group sizes. Lean color, fat color, firmness and maturity scores did not differ among group sizes. Hanwoo steers housed under 12sG spent less time on eating concentrate, relevant higher eating rate, less frequency of allogrooming, and more time on walking ($p<0.05$). It could be concluded that a large group size retarded growth rate and back fat thickness in the fattening stage, which was mainly focused on 15 and 18 months of age. (**Key Words :** Hanwoo Steers, Group Size, Performance, Behavior, Meat Quality)

INTRODUCTION

The quality of food, including beef, is important to human well-being. Carcass quality of Hanwoo (Korean native cattle) meat is mainly determined by marbling score and castration is commonly practiced to attain high quality beef. Thus, to obtain higher growth rate, feed efficiency and carcass yield is also emphasised in Korea.

For practical reasons, fattening Hanwoo steers are usually housed as 4 to 12 heads, forming a dynamic group based on their fattening characteristics and local environmental conditions, on a full concrete slatted floor because of the low labor cost and no requirement for bedding material. Such a dynamic group is usually kept constant over a long fattening period until cattle attain heavier slaughter weights between 24 to 30 months of age, because heavier slaughter weights improve both yield and quality grades of carcasses (Park et al., 2002). Hanwoo were also found to have a unique genetic ability to deposit copious amounts of marbling similar to Japanese Wagyu (Lee et al., 2003; Seo et al., 2006). With growing per capita income over the years consumers have preferred highly marbled Hanwoo beef, as carcass quality is mainly determined by marbling score in South Korea (Park et al., 2002; Irie et al., 2006). To obtain such beef, cattle are usually fed a growing ration high in roughage between 12 to 16 months of age and thereafter switched to either restricted or *ad libitum* feeding of a finishing ration. When marbling starts to deposit and is slightly visible at 12 month of age, an ultrasound method is used to predict live cattle carcass traits at the 13th rib interface, and consequently to find and solve problems in existence before cattle are slaughtered.

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However, few studies have been conducted to evaluate the effect of group size on beef cattle growth, behavior, and carcass traits in confined conditions. Aimed at improving rearing conditions and achieving a better understanding of the effects of group size on animal performance, the present study was conducted to investigate growth, behavior, and carcass traits of Hanwoo steers managed in different group sizes comprising 4, 8 or 12 animals.

MATERIALS AND METHODS

Animals, treatments and housing

A total of 48 Hanwoo steers, 6 month of age, were purchased from a local farm in Kangwon province. At 12 months of age, initial fasted body weight (BW, 304.51±12.40 kg) was measured and animals were assigned to 3 treatments comprised of 3 group sizes each with 2 replicates in a randomized complete design. The 3 treatment groups were comprised of 4, 8, or 12 steers in each pen, and the groups were named 4sG, 8sG and 12sG, respectively. According to the fattening characteristics of Hanwoo steers, the whole fattening stage was divided into three phases, phase I (12-18 months of age), phase II (19-24 months of age), and phase III (25-30 months of age).

A schematic layout of the experimental pens is shown in Figure 1. All treatment pens were a rectangular or square shape and semi-open. Straw bedding was provided at 6 kg/animal/d in a fully-bedded loose housing system to cover any dirty or wet patches on the concrete floor and was renewed monthly (Daelemans and Maton, 1987). Pen sizes were 8.4×4.2 m, 8.4×8.4 m, and 12.6×8.4 m for 4sG, 8sG, and 12sG, respectively. Space allowance was 8.82 m^2 per animal. One separate water bowl and forage trough was provided per 4 steers, allowing animals free access to feed and water.

Six digital video-recording devices (STLV-36D, Samsung, Korea) were set up in a cabinet close to the pens to record the animals' behavior. Six digital cameras (CS-724, Samsung, Korea) were allocated in front of the feeding area of each pen at approximately 1.5 m of height.

Behavior

It was assumed that a 6-month period (from 6 to 12 months of age) was sufficient for all steers to become familiar with each other and accustomed to the facilities and daily routines.

At 12, 15, 18, 21, 24, 27 and 30 months of age, behavior of animals was video-recorded at two minute intervals on 6 days (d 1, 6, 11, 16, 21 and 26) for 10 h each day starting at 08:00 h. Dry matter intake of concentrate and baled rice straw was also recorded daily to calculate animal eating rate. Eating rates of concentrate and rice straw were calculated as the mean daily dry matter intake of the pen divided by the corresponding mean total time spent eating by all animals in the pen. Maintenance behavior of eating, drinking, lying, and standing was evaluated. Intake behavior was described as heads through or near the feed barrier, and intake of rice straw or concentrate. Drinking was recorded when the animal had its mouth in the water bowl, swallowing water or not. Lying was considered as steers recumbent sternally or laterally in the bedded floor. Standing was calculated as total duration of steers standing still, doing nothing else

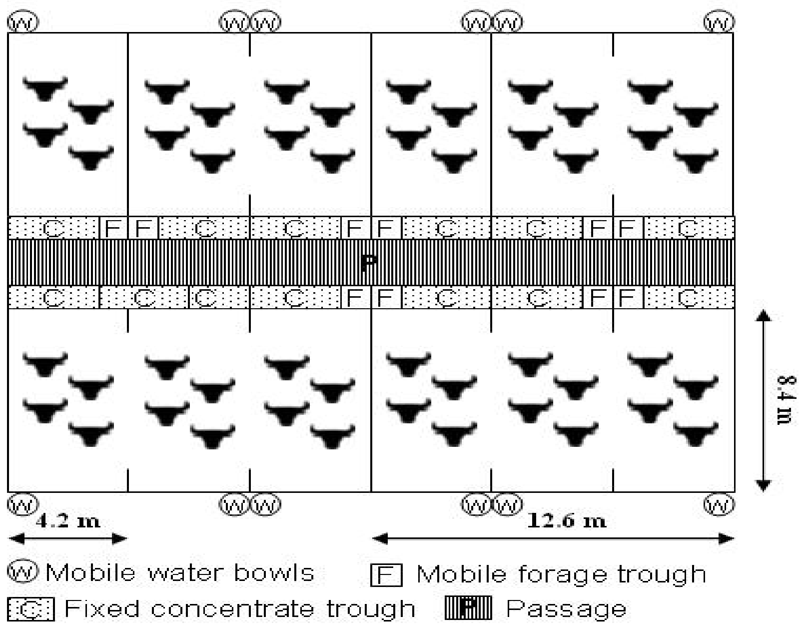

Figure 1. Schematic layout of experimental pens and its associate parameters.

over the observation period. Behavioral data from scan sampling were transformed into time by dividing per each scan. Furthermore, allogrooming, leaning and fighting frequencies were also recorded as maintenance behavior. Allogrooming was considered as steers licking the head, neck and shoulder (Bouissou et al., 2001) and was observed mostly at the feeder after feed delivery. Leaning was considered as steers leaning against each other. Fighting was displayed by head-to-head followed by head-to-neck combat.

Intake and growth performance

The nutrient composition of feedstuffs is presented in Table 1. All animals were offered the same diets, consisting of *ad libitum* access to rice straw and restricted consumption of concentrate, in a single daily distribution at 08:00. The concentrate was formulated to meet NRC (1996) requirements and contained 15.06% crude protein (CP), 70.52% total digestible nutrients (TDN) in phase I, 14.19% CP, and 72.43% TDN in phase II, and 12.31% CP, 73.75% TDN in phase III (Table 1). The concentrate was offered at 4.0 kg/head/d initially and gradually increased by 0.25 kg/head/d monthly until they were transported to the slaughter house. Baled rice straw was used because steers like access to bales and display their natural foraging behavior (Pelly et al., 1995). Fresh water was available at all times. Concentrate and baled straw was sampled separately in each phase for analysis of nutrient composition. Baled straw and concentrate dry matter intake (DMI) were aggregated weekly by weighing the amount of feed offered each day and subtracting the amount refused at the end of the week. However, consumption of rice straw was pooled for every phase for statistical analysis.

Individual weight was measured monthly for calculating average daily gain (ADG) and feed conversion rate (FCR) throughout the trial.

Live animal carcass evaluation

All steers were scanned individually using an ultrasound instrument (HS-2000, Japan) at the left side of the 13th rib and lumbar vertebra interface at 3 month intervals. Images, which reflected live animal back fat thickness, rib-eye area and marbling score, were processed and analyzed by Image-pro Express (Version 4.1, Media Cybernetics, USA) software. For each steer, three parallel images were processed each time. Image processing was carried out by the same person throughout the trial to minimize the standard errors.

Meat quality

All steers were slaughtered at a local municipal slaughterhouse at 30 months of age. After splitting and washing, warm carcasses were immediately moved to a chilling room at 4°C for 24 h and then weighed and evaluated by an official grader to determine carcass traits according to the Korean carcass grading standard (NLCF, 2004). After 24 h post-mortem, carcasses were ribbed between the last rib and the first lumbar vertebra to determine back fat thickness, rib eye area (*M. longissimus*) and quality traits. Yield grade was determined by the cold carcass weight, adjusted fat thickness and *longissimus* muscle area, and quality grade was determined by the marbling, meat color, fat color, texture and overall maturity score.

Back fat thickness was determined over the medial third part of the rib eye. Marbling in the rib eye area was scored from 1 (devoid) to 9 (abundant) according to the standard. Meat color was scored from 1 (brightly cherry red) to 7 (extremely dark red) and fat color was scored from 1 (white) to 7 (dark yellow) according to the standard. Firmness was water holding capacity and elasticity of the rib eye in the grade decision region, and was scored from 1 (firm) to 3 (soft) according to the reference index. Maturity was regarded as the ossification of the cartilage in the left semiconductor backbone thorn promontory and was scored from 1 (youthful) to 9 (mature).

Yield index was determined by the following equation:

Table 1. The nutrient composition of feedstuffs in the diet for fattening Hanwoo steers[1]

Nutrients	Concentrate			Rice straw
	Phase I 12-18 month	Phase II 19-24 month	Phase III 25-30 month	
Dry matter (% as fed)	84.42	83.55	83.18	90.09
Crude protein (% DM)	15.06	14.19	12.31	4.53
Crude fat (% DM)	3.70	3.49	4.87	2.17
Crude fiber (% DM)	6.49	4.57	4.25	27.66
Crude ash (% DM)	6.43	4.85	5.90	14.31
Ca (% DM)	1.00	0.72	0.94	0.22
P (% DM)	0.45	0.42	0.35	0.12
TDN (% DM)	70.52	72.43	73.75	37.13

[1] Each analysis was done in triplicate.

$$\text{Yield index} = 68.184-(0.625\times\text{back fat thickness (mm)}) +(0.130\times\text{rib eye area (cm}^2)) -(0.024\times\text{carcass weight (kg)}) +3.23 \text{ (for Hanwoo only)}$$

Yield grade was scored as follows.
3 = A grade (yield index≥67.50);
2 = B grade (62.00≤yield index<67.50);
1 = C grade (yield index<62.00)
Carcass quality grade was scored as follows.
5 = 1++ grade (marbling scored 8 or 9);
4 = 1+ grade (marbling scored 6 or 7);
3 = 1 grade (marbling scored 4 or 5);
2 = 2 grade (marbling scored 2 or 3);
1 = 1 grade (marbling scored 1)

Statistical analysis

Statistical analysis was conducted using the general linear model (GLM) procedure of SAS (SAS Institute, 1996) with a randomized complete block design. The treatments were the main effects. Pen was the experimental unit for the analysis of all parameters. Effects of different phases were also evaluated. Behavioral observations, growth performance, ultrasound meat characteristics and carcass quality were analyzed by Duncan's multiple range test for statistical analysis, whilst differences were considered significant at p<0.05, unless otherwise stated.

RESULTS

Behavior

The main effect of group size on behavior is presented in Table 2. Hanwoo steers housed under 12sG spent less time on eating concentrate and on relevant higher eating rate, more time on walking and less frequency of allogrooming (p<0.05). Average eating time and rate of intake of baled rice straw, average time spent on drinking water, lying and standing together with leaning and fighting frequencies were not affected by group size (p>0.05).

Intake and growth performance

Intake and growth performance of fattening Hanwoo steers managed in different group sizes are given in Table 3. Steers managed in 12sG showed low (p<0.05) ADG in phase I and phase II when compared to steers managed in 4sG and 8sG. However, this difference was not observed for the whole fattening phase (p>0.05). No difference (p>0.05) in DMI, concentrate or rice straw intake was found over the trial. Animals reared in 12sG had low (p<0.05) FCR in phase I and phase II, but no differences in FCR were noted in the whole fattening phase (p>0.05). Furthermore, steers reared in 12sG showed high ADG (p<0.05) and had less DMI (p<0.05) during phase II, which resulted in high FCR (p<0.05).

Live animal carcass evaluation

A thick (p<0.05) ultrasound back fat thickness of fattening Hanwoo steers was found in 4sG in phase I and phase II (Table 4). No differences (p>0.05) due to group size were found in ultrasound rib eye area and marbling throughout the trial.

Meat quality

Both yield (final BW, carcass weight, yield index and

Table 2. Behavior of fattening Hanwoo steers managed in different group sizes[1]

Items	Treatment[2]		
	4sG	8sG	12sG
Concentrate			
Eating time (min/h)	3.86±0.10[a]	3.52±0.08[ab]	3.15±0.13[b]
Eating rate (g DM/min)	128.08±2.22[c]	140.43±3.01[b]	156.80±2.07[a]
Baled rice straw			
Eating time (min/h)	4.78±0.24	5.16±0.18	4.83±0.35
Eating rate (g DM/min)	70.25±3.62	63.36±5.38	64.14±5.02
Drinking (min/h)	1.23±0.06	1.04±0.11	0.98±0.08
Lying (min/h)	12.87±1.03	12.53±0.96	11.78±0.88
Standing (min/h)	21.64±0.93	20.85±1.23	21.38±0.76
Walking (min/h)	0.97±0.43[b]	1.05±0.25[b]	2.22±0.37[a]
Allogrooming (n/h)	4.51±1.01[a]	3.08±0.57[b]	2.92±0.74[b]
Leaning (no./h)	0.11±0.26	0.16±0.31	0.13±0.20
Fighting (no./h)	0.52±0.21	0.47±0.25	0.44±0.20

[1] 4sG, 8sG and 12sG represents group sizes of 4, 8 and 12 steers, respectively.
[2] Values represent means±standard deviation (2 replications with each group of 4, 8, and 12 animals).
[a-b] Means within a row followed by a different letter are significantly different (p<0.05).

Table 3. Intake and growth performance of fattening Hanwoo steers managed in different group sizes[1]

Items	Treatment[2]		
	4sG	8sG	12sG
Initial BW (kg)	303.3±6.4	299.1±4.9	311.1±8.5
Final BW (kg)	715.0±18.7	694.9±14.2	698.5±15.1
ADG (kg)			
Phase I	0.80±0.03[Aa]	0.64±0.004[Bb]	0.64±0.06B[b]
Phase II	0.77±0.05[ABb]	0.93±0.004[Aa]	0.80±0.04[Ab]
Phase III	0.73±0.06[Ba]	0.63±0.002[Bb]	0.71±0.10[ABa]
Whole phase	0.77±0.12	0.73±0.09	0.72±0.15
DMI (kg/d)			
Phase I	7.52±0.23[A]	7.58±0.17[A]	7.66±0.29[A]
Phase II	6.78±0.10[B]	6.70±0.21[B]	6.64±0.15[B]
Phase III	7.38±0.22[A]	7.36±0.14[A]	7.35±0.20[A]
Whole phase	7.23±0.37	7.21±0.33	7.22±0.46
FCR (gain/feed)			
Phase I	0.093±0.001[Aa]	0.077±0.001[Bb]	0.076±0.001[Bb]
Phase II	0.096±0.002[Ab]	0.112±0.001[Aa]	0.099±0.001[Ab]
Phase III	0.083±0.001[Ba]	0.072±0.001[Bb]	0.082±0.001[ABa]
Whole phase	0.091±0.003	0.087±0.005	0.086±0.006
Concentrate (kg/d)			
Phase I	4.75	4.75	4.75
Phase II	6.38	6.38	6.38
Phase III	7.88	7.88	7.88
Whole phase	6.25	6.25	6.25
Rice straw (kg/d)			
Phase I	3.91±0.02[A]	3.97±0.04[A]	4.06±0.02[A]
Phase II	1.61±0.13[B]	1.52±0.09[B]	1.45±0.06[B]
Phase III	0.92±0.06[C]	0.90±0.03[C]	0.89±0.04[C]
Whole phase	2.15±0.18	2.13±0.20	2.13±0.16

[1] 4sG, 8sG and 12sG represents with different group sizes of 4, 8 and 12 steers, respectively.
[2] Values represent means±standard deviation (2 replications with each group of 4, 8, and 12 animals).
[A-C] Means within a column followed by a different capital letter are significantly different (p<0.05).
[a-b] Means within a row followed by a different letter are significantly different (p<0.05).

yield grade) and quality (marbling, meat color, fat color, firmness, maturity and quality grade) traits of fattening Hanwoo steers were similar (p>0.05) among treatment groups (Table 5). However, steers reared in 8sG had a low back fat thickness and a high rib eye area as compared with those reared in 4sG and 12sG. Mean meat yield grades of 4sG, 8sG, and 12sG were 2.9, 3.0, and 2.8, respectively. Mean meat quality grades of all treatment groups were the same (scored 3.5). Moreover, animals managed in 8sG yielded a mean meat grade of “A”, which was superior to that of “B” for the other two groups.

DISCUSSION

The present study was performed to evaluate growth, behavior, and carcass traits of fattening Hanwoo steers managed in different group sizes. In general, large group sizes with high densities lead to more social conflicts that may lower animal performance (Turner et al., 2000; Fregonesi and Leaver, 2002). A recommended minimum space allowance of 3 m^2/head was considered appropriate for an animal expected to reach 500 kg plus 0.5 m^2 for each 100 kg over 500 kg (EU-SCAHAW, 2001). Hence, a constant space allowance of 8.82 m^2 per animal within the pen was sufficient for all animals harvesting a live BW around 700 kg when the required minimum space allowance was around 4 m^2/head. Moreover, adequate space allowance is necessary to ensure that the animals are not disturbed when lying, and to improve animal welfare.

There was no clear effect of group size on the performance of steers over the trial. One of the reasons would be the state of bedding in the present experiment.

Table 4. Ultrasound carcass characteristics of fattening Hanwoo steers managed in different group sizes[1]

Items	Treatment[2]		
	4sG	8sG	12sG
Ultrasound back fat thickness (cm)			
12 month	1.6±0.6	1.2±0.5	1.2±0.6
15 month	2.5±0.3[a]	1.5±0.7[b]	1.3±0.5[b]
18 month	3.8±0.9[a]	2.2±0.4[b]	2.3±0.7[ab]
21 month	5.3±0.8	3.6±0.7	4.2±0.8
24 month	5.8±1.0	5.0±0.6	4.9±0.9
27 month	7.1±0.7	6.9±0.5	6.3±0.9
30 month	9.8±1.2	9.7±1.5	9.8±1.1
Ultrasound rib eye area (cm^2)			
12 month	45.1±1.7	47.7±1.4	44.7±1.7
15 month	50.8±1.2	50.9±1.4	49.4±0.8
18 month	58.1±1.0	56.5±1.1	57.0±0.9
21 month	67.8±1.5	67.6±1.9	67.7±1.3
24 month	72.7±2.0	72.6±1.6	73.1±1.5
27 month	81.0±2.4	81.0±2.8	79.4±2.9
30 month	86.3±3.0	89.1±2.4	86.8±2.6
Ultrasound marbling (1-9)			
12 month	1.0±0.0	1.0±0.0	1.0±0.0
15 month	1.0±0.0	1.0±0.0	1.0±0.0
18 month	1.0±0.1	1.0±0.0	1.0±0.0
21 month	2.3±0.2	2.3±0.3	2.7±0.2
24 month	2.6±0.3	2.4±0.3	3.0±0.4
27 month	3.8±0.3	4.4±0.2	4.3±0.4
30 month	5.4±0.5	5.6±0.2	5.4±0.6

[1] 4sG, 8sG and 12sG represents with different group sizes of 4, 8 and 12 steers, respectively.

[2] Values represent means±standard deviation (2 replications with each group of 4, 8, and 12 animals).

[a-b] Means within a row followed by a different letter are significantly different ($p<0.05$).

Several studies showed that the time spent lying and the number of lying bouts per day was increased in pens with straw-bedded floors compared to housing systems with fully-slatted floors (Ruis-Heutinck et al., 2000; Hickey et al., 2002; Gygax et al., 2007). In the present study, initial body weight of 8sG was 2.7% lower than the average of the other two treatment groups. However, this difference was 1.7% by the time steers were sent to the slaughter house. As DMI was similar throughout the trial, the difference in FCR might be due to the difference of weight gain in each phase. Therefore, negative effects on weight gain in phase I and II were partially recovered in phase III while fully recovered for the whole fattening phase. These management factors were surely stressed animals and may also lead to weight loss of animals. Similarly, Hardy (1980) also reported lower dry matter intakes in finishing beef cattle (weighing 270-375 kg) when they were accommodated on slatted floors with a space allowance of 2.1 m^2 compared to those kept in straw-bedded yard with a space allowance of 7.7 m^2. For instance, an increment of walking time was closely related to the total floor area of the pen, but when changing group size with a single space allowance, total floor area is altered simultaneously with group size. The relationship of group size, space allowance and pen attributes was illustrated in detail by Christman and Leone (2007). They also suggested a statistical method known as ridge regression (Kutner et al., 2004) in which the method of least squares was modified in order to allow biased estimators. Moreover, the need for a fattening steer housed in a certain group size to carry out a certain behavior at a certain time is still not clear. No study had been conducted to explain the influence of behavioral increment and decrease in animal meat quality theoretically.

In general, small group size contributes to social stability (Albright, 1991), smaller groups have fewer

Table 5. Carcass traits of fattening Hanwoo steers managed in different group sizes[1]

Items	Treatment[2]		
	4sG	8sG	12sG
Yield traits			
Final body weight (kg)	715.0±18.7	694.6±14.2	698.5±15.1
Carcass weight (kg)	425.0±7.4	424.4±6.1	412.7±6.6
Back fat thickness (mm)	11.0±1.1	8.6±0.9	10.8±0.8
Rib eye area (cm^2)	86.1±3.2	90.9±2.9	84.4±3.1
Yield index	65.5±2.5	67.7±2.7	65.8±3.0
Yield grade	2.9±0.1	3.0±0.1	2.8±0.1
Quality traits			
Marbling	5.3±0.4	5.6±0.3	5.5±0.4
Meat color	4.8±0.1	4.9±0.4	4.9±0.2
Fat color	2.8±0.1	2.9±0.1	2.8±0.1
Firmness	1.3±0.1	1.4±0.2	1.3±0.1
Maturity	2.0±0.1	2.0±0.0	2.0±0.0
Quality grade	3.5±0.0	3.5±0.1	3.5±0.0

[1] 4sG, 8sG and 12sG represents with different group sizes of 4, 8 and 12 steers, respectively.

[2] Values represent means±standard deviation (2 replications with each group of 4, 8, and 12 animals).

aggressions than larger groups and the aggression increases linearly as the group size increases (Kondo et al., 1989). This may be caused by the animals having greater difficulty in individual recognition as group size increases. However, if a large space is available this can be overcome by the formation of subgroups (González et al., 2008). In the current study, similar results were found in animal aggressive behavior. To minimize competition when *ad libitum* feeding is not practiced, simultaneous access for each animal to a feeding area is not necessary although it is desirable.

Allogrooming helps to maintain a healthy pelage on places where the individual cannot reach (Sato et al., 1991), and it also reduces the chances for aggressive interactions (Nakanishi et al., 1993). Many studies supported that large group size resulted in reduced need for vigilance and reduced aggression in fowl and swine (Estevez et al., 2002, 2003; Anderson et al., 2004), allowing them to spend more time in other vital activities such as foraging, resting or social grooming (Childress and Lung, 2003; Hopewell et al., 2005). In contrast to the present study, allogrooming frequency decreased when group size increased from 4 to 12 head. This may be ascribed to the increased competition when concentrate was given restrictively. Similar effects of competition on allogrooming were also noted by David et al. (2009). Large group size significantly increased animal walking time and eating rate of concentrate, but decreased their grooming frequencies and concentrate eating time. Mean time spent eating concentrate decreased linearly by 18.4% as group size increased from 4 to 12. However, steers fully compensated for this shorter concentrate eating time through a linear increase in the eating rate of 22.4%. This result accorded with the same concentrate being offered, and was also observed by Nielsen (1999) and Olofsson (1999). Han et al. (2005) reported similar results when Hanwoo steers were managed in 5 or 7 head groups and allotted to two pens of 5×10 m in a building with slate roof and open side, respectively. Furthermore, in the same research it was found that steers managed in a group of 5 head rested from 10:00 to 14:00, showing 40-80% lying down rate while steers managed in a group of 7 head rested from 12:00 to 15:00, showing a relatively low lying down rate of 20-50%. On the contrary, lying time was similar among treatment groups in the current study. This difference might be due to a relatively short observation time of 10 h in both studies.

In the present study, the main findings on carcass characteristics were that animals managed in 4sG showed a thicker ultrasound back fat than in the other treatment groups in phase I, which was mainly focused on 15 and 18 month old steers. However, these differences had no effect on final slaughtered ultrasound back fat thickness. This indicated that steers managed in 8sG and 12sG compensated during the late fattening stage. Hanwoo steers managed in 8sG had a mean yield index of 67.7, which was scored 3 and classified to “A” grade according to the standard (NLCF, 2004), higher than the mean level of other two groups. Anderson et al. (1991) reported that cattle reared in a loose-housing system had a darker meat color and a tendency for tougher meat than those in tie-stalls. However, there were limited studies of group size effect on animal carcass traits. Therefore, the difference in the present study was ascribed to composite factors including group size and associated pen attributes.

In conclusion, Hanwoo steers managed in 12sG decreased their eating time of concentrate and allogrooming frequency but increased their walking time. Increased group size retarded their growth rate and back fat thickness during the fattening stage, mainly focused on 15 and 18 months of age.

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