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Evaluation of seasonal effects on production performance of lactation sows reared in two different environments in South Korea

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Abstract

This study was conducted to evaluate seasonal effects on production performance of lactation sows reared in two different environments in South Korea. A total of 76 sows (Landrace × Yorkshire) from the Dankook University experimental farm and 120 sows (Landrace × Yorkshire) from a commercial farm were collected. In the current study, reduced ($p < 0.01$) feed intake and energy intake during lactation were observed in warm season compared with cool season in both farms. Sows in cool season had higher backfat thickness at weaning but lower back fat loss ($p < 0.01$) than those in warm season. The weaning to estrus interval was lower ($p < 0.01$) in cool season than in warm season. Piglets weaned in warm season had lower ($p < 0.01$) body weight (BW), body weight gain (BWG), and average daily gain (ADG) at weaning than did those weaned in cool season on the Dankook University farm, whereas the reduction effect was only observed during 0 - 21 d on the commercial farm ($p < 0.01$). Moreover, piglets weaned in cool season had higher BW, BWG, and ADG ($p < 0.05$) on both farms. In conclusion, our results indicate that warm season had very negative effects on feed intake and production performance of lactating sows and piglets.

Keywords: Korea, lactation sows, production performance, seasonal effect

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Introduction

The weaning weight of piglet is an important indicator of the overall growth performance and days to market weight (Mahan and Lepine, 1991). Lewis et al. (1978) had previously suggested that the weaning weight is related to the milk production. Noblet and Etienne (1989) also suggested that growth rate of piglet during lactation is highly associated with the milk production. Therefore, we hypothesized that increased production performance of piglet could be observed with enhanced milk production in sows.

Previous studies have suggested that the milk production could be influenced by numerous factors under most practical condition. A decreased milk production because of the lower feed intake and heat stress in sows (Black et al., 1993). Lactating sows were particularly sensitive to high ambient temperature, Quiniou and Noblet (1999) suggested that the reduced daily feed intake caused by high ambient temperature could negatively affect the milk productions and reproductive performance in sow (Renaudeau et al., 2005). To the best of our knowledge, most studies concerning the seasonal effect were conducted in tropical and subtropical areas, whereas studies concern about the seasonal effect in Korea is relatively limited. Therefore, it is important to understand how the Korea season environment affects the feed intake and production performance of the sows and subsequently establish an appropriate feeding strategy to improve the productive performance of the sows in Korea.

Collectively, the objectives of this study were to determine the seasonal effects on the production performance of sows and their litter.

Materials and Methods

The experimental protocols describing the management and care of animals were reviewed and approved by the Animal Care and Use Committee of Dankook University. The protocol number was DK-2-1520.

Experimental design, animals, and diets

Data of 15 farrowing groups (270 litters) with a total of 76 sows (Landrace × Yorkshire) from Dankook University experimental farm and 12 farrowing groups (120 litters) with 120 sows (Landrace × Yorkshire) from a commercial farm located in southwest of Korea were collected to investigate the season effect on the production performance of sows. The experiment period between May 2015 to April 2017. The cool season was determined as of November 2015 to April 2016 and November 2016 to April 2017, while the warm season was determined as of May 2015 to October 2015 and May 2016 to October 2016.

At 107 d of gestation, sows were moved to farrowing crates in an environmentally regulated farrowing house. Within 24 h of farrowing, sows and their offspring were assigned randomly to 1 of 2 treatments. Sows were fed on a commercial gestation (2.5 kg) diet during gestation, and received 1 kg of standard lactation diet on the farrowing day and increased feed by 1 kg each day until ad libitum to avoid overconsumption (Table 1). Feed allowance was divided into 2 daily meals. Water was provided on an *ad libitum* basis. Sows and their offspring were individually housed in farrowing crates (slatted floor; 2.4 m × 1.8 m). This space included a piglet nest which is electrically maintained at 31℃, a piglet drinking nipple, and a piglet feeder placed on a dimpled rubber matting to collect any spillage from the feed. Drinking nipples provided water ad libitum to the piglets. Litter size at birth varied from 6 to 15 piglets, and was standardized to 10 piglets per litter within 2 d after birth by cross-fostering within each batch. All piglets received injections of 1 mL of iron dextran and the male piglets were castrated 5 d after birth. At weaning, the sows were relocated to a mating room, with the piglets remaining in the pen for 1 wk (weanling pigs). Piglets were provided with the creep feed until the 7 d after the weaning (Table 2).

Experimental procedures, sampling, and assay

The daily temperatures in the farrowing room were recorded. In the Dankook University experimental farm, the temperature of the room was around 19℃. Air condition was used for the sows to regulate the temperature with a thermostat that activated at 27℃. In the commercial farm, no heater was used in the cool season, while electronic fans were used in warm season. The average high and low temperatures were calculated and reported in Table 3.

Sows were weighed 1 d before farrowing, 1 d after farrowing and 21 d (weaning). The backfat thickness of the sows was measured within a few hours after farrowing and on the day of weaning (21 d). The backfat thickness (6 cm off the midline at the 10^{th} rib) measurements were taken using a real-time ultrasound instrument (Piglot 105, SFK Technology, Herlev, Denmark). The daily feed intake of the sows was determined as the difference between feed allowance and the refusals collected before feeding. Detection of estrus was conducted twice per day from weaning onwards, at 08:30 and 16:00, other signs of estrus such as vulva swelling or reddening, or reaction to human back-pressure were used. A sow was considered to be in estrus when exhibiting a standing response induced by a back pressure test when in the presence of a boar.

Table 1. Sow diet composition (as-fed basis).

Items	Gestation diet	Lactation diet
Ingredients (%)		
Corn	57.10	51.12
Soybean meal, 46% CP	10.65	24.61
Wheat bran	12.00	4.00
Rapeseed meal	3.70	2.50
Rice bran	6.00	5.00
Tallow	3.59	6.05
Molasses	3.60	3.50
Dicalcium phosphate	1.52	1.64
Limestone	0.99	0.76
Salt	0.60	0.50
L-Lysine HCl, 78%	0.05	0.12
Vitamin premix[y]	0.10	0.10
Mineral premix[z]	0.10	0.10
Calculated composition (%)		
ME (MJ/kg)	13.19	13.44
CP	13.10	17.10
Crude fat	6.89	9.10
Lys	0.65	1.00
Ca	0.87	0.85
P	0.76	0.73

CP, crude protein; ME, metabolizable energy.
[y] Provided per kilogram of complete diet: vitamin A, 10,000 IU; vitamin D_3, 2,000 IU; vitamin E, 48 IU; vitamin K_3, 1.5 mg; riboflavin, 6 mg; niacin, 40 mg; d-pantothenic, 17 mg; biotin, 0.2 mg; folic acid, 2 mg; choline, 166 mg; vitamin B_6, 2 mg; and vitamin B_{12}, 28 μg.
[z] Provided per kilogram of complete diet: Fe (as $FeSO_4 \cdot 7H_2O$), 90 mg; Cu (as $CuSO_4 \cdot 5H_2O$), 15 mg; Zn (as $ZnSO_4$), 50 mg; Mn (as MnO_2), 54 mg; I (as KI), 0.99 mg; and Se (as $Na_2SeO_3 \cdot 5H_2O$), 0.25 mg.

Table 2. Piglet diet composition (as-fed basis).

Items	Piglet diet
Ingredients (%)	
Extruded corn	22.62
Soybean meal, 46% CP	8.00
Soy oil	4.50
Whey	24.16
Fish meal	2.50
Fermented soybean meal	10.00
Coconut oil	4.17
Lactose	8.00
Plasma powder	4.00
Sugar	3.05
Isolated soybean protein	6.15
Dicalcium phosphate	1.25
DL-Methionine, 50%	0.38
L-Lysine·HCl, 78%	0.41
L-Threonine, 89%	0.13
Zinc oxide	0.30
Choline chloride, 25%	0.10
Vitamin premix[y]	0.10
Mineral premix[z]	0.18
Calculated composition (%)	
DE (MJ/kg)	16.74
CP	22.00
Lys	1.74
Met	0.70
Ca	0.81
P	1.00

CP, crude protein; DE, digestive energy.
[y] Provided per kilogram of complete diet: vitamin A, 1,298 IU; vitamin D_3, 260 IU; vitamin E, 2.4 IU; menadione (sodium bisulfate form), 143 μg; vitamin B_{12}, 3.3 μg; riboflavin, 880 μg; d-pantothenic acid, 2.6 mg; niacin, 4.4 mg.
[z] Provided per kilogram of complete diet: Ca, 849 mg; Zn, 150 mg; Fe, 132 mg; Mn, 20 mg; Cu, 12 mg; Se, 0.31 mg; I, 0.79 mg.

Table 3. Main characteristics of climatic variables recorded during the experiment[z].

Items	Cool season	Warm season
Dankook University experiment farm		
Minimum	19.6	21.3
Maximum	24.4	31.2
Mean	21.1	27.6
Commercial farm in southwest of Korea		
Minimum	7.51	19.7
Maximum	24.5	32.3
Mean	13.4	29.2

[z] Seasons represent the mean of daily value of ambient temperature and relative humidity. Cool season included November 2015 to April 2016, November 2016 to April 2017, warm season included May 2015 to October 2015, May 2016 to October 2016.

The total number of piglets born, live, stillborn and dead during lactation was recorded for each litter. Individual piglet body weight (BW) was assessed on 0, 21 (weaning), and 7 d after weaning to calculate average daily gain (ADG). Creep feed consumption was also recorded during the 21 d to 28 d to calculate the feed intake and gain to feed (G : F) ratio.

Statistical Analysis

Data were analyzed using the GLM procedure of the SAS as a randomized complete block design (version 8.2, SAS Inst. Inc., Cary, USA). The individual sow or litter of piglets was used as the experimental unit. The effect of treatment on average sow weight, a number of pigs per litter, litter weight was determined using initial value as covariates. The probability level of $p < 0.05$ was regarded as statistically significant.

Table 4. Seasonal effects on the reproduction performance in sows reared in Dankook University farm[z].

Items	Cool season	Warm season	SEM	p-value
No. of sows	144.00	126.00	-	-
Parity	2.30	2.10	-	-
Duration of lactation (d)	21.00	21.00		
Feed intake (kg)				
Gestation	2.50	2.50	-	-
Lactation	5.94	5.57	0.19	< 0.01
Energy intake (MJ/d)				
Gestation	32.98	32.98	-	-
Lactation	79.83	74.86	1.21	< 0.01
Body weight (kg)				
Before farrowing	252.90	250.6	2.45	0.512
After farrowing	226.90	225.5	2.33	0.662
Loss during farrowing	25.97	25.06	0.81	0.441
At weaning	224.91	222.38	2.52	0.486
Loss during lactation	2.08	03.14	1.20	0.529
Back fat thickness (mm)				
After farrowing	22.63	22.60	0.43	0.942
At weaning	20.15	18.87	0.69	< 0.01
Back fat loss	2.48	3.73	0.76	< 0.01
Estrus interval	4.29	4.56	0.11	< 0.01

SEM, standard error of the mean.

[z] Seasons represent the mean of daily value of ambient temperature and relative humidity. Cool season included November 2015 to April 2016, November 2016 to April 2017, warm season included May 2015 to October 2015, May 2016 to October 2016.

Results

Climatic measurements

The minimum and maximum ambient temperature of the Dankook University experiment room for the cool season were 19.6 and 24.4℃, respectively (Table 3), whereas the corresponding value for the warm season was 21.3 and 31.2℃, respectively. The mean temperature values for the cool and warm season were 21.1 and 24.6℃, respectively. In terms of the commercial farm, the minimum and maximum ambient temperature for the cool season were 7.5 and 24.5℃, whereas the corresponding value for the warm season was 19.7 and 32.3℃, with the mean temperature value for the cool and warm season were 13.4 and 26.2℃.

Sow performance

Data from the experimental farm in Dankook University (Table 4), a reduced ($p < 0.01$) feed intake and energy intake during lactation were observed in the warm season compared with cool season. Sows in the cool season led to a high backfat thickness at weaning but lower back fat loss ($p < 0.01$) than warm season. The weaning to estrus interval was reduced ($p < 0.01$) in cool season than in warm season. Data from the commercial farm (Table 5), sows in cool reason led to a higher ($p < 0.001$) feed intake and energy intake than those in the warm season. A reduced backfat thickness and increased backfat loss at weaning was observed in the cool season compared with those in the warm season ($p < 0.05$).

Piglets production performance

Data from Dankook University experimental farm (Table 6), piglets in the warm season had a lower ($p < 0.01$) BW, body weight gain (BWG), and ADG at weaning than those in the cool season. Besides, piglets in cool season consumed more feed during lactation and led to a higher BW, BWG, and ADG in the current study ($p < 0.05$). Data from the commercial farm (Table 7), piglets in the cool season led to a higher ($p < 0.05$) BWG, ADG, and average daily feed intake (ADFI) than those piglets in the warm season.

Table 5. Seasonal effects on the reproduction performance in sows reared in commercial farm[z].

Items	Cool season	Warm season	SEM	p-value
No. of sows	60.00	60.00	-	-
Duration of lactation (d)	21.00	21.00	-	-
Feed intake (kg)				
Gestation	2.50	2.50	-	-
Lactation	6.67	5.26	0.27	< 0.001
Energy intake (MJ/d)				
Gestation	32.98	32.98	-	-
Lactation	89.64	70.70	8.54	< 0.001
Back fat thickness (mm)				
After farrowing	21.04	21.43	0.39	0.354
At weaning	18.37	17.21	0.48	< 0.001
Back fat loss	02.67	04.22	0.68	< 0.001
Weaning to estrus interval	04.94	05.66	0.31	< 0.001

SEM, standard error of the mean.
[z] Seasons represent the mean of daily value of ambient temperature and relative humidity. Cool season included November 2015 to April 2016, November 2016 to April 2017, warm season included May 2015 to October 2015, May 2016 to October 2016.

Table 6. Seasonal effects on the growth performance in piglets reared in Dankook University farm[z].

Items	Cool season	Warm season	SEM	p-value
No. of sows	144.00	126.00	-	-
Duration of lactation (d)	21.00	21.00	-	-
Litter size				
Total born	11.38	11.35	0.190	0.920
Stillborn	1.12	1.25	1.010	0.640
At weaning	9.86	9.68	0.196	0.530
Surivial rate	98.60	96.80	0.850	0.537
BW (kg)				
0 d	1.40	01.41	0.029	0.612
21 d	6.57	05.86	0.202	< 0.01
BWG (0 - 21 d)	5.17	04.45	0.297	< 0.01
ADG (0 - 21 d, g/d)	246.00	212.00	14.260	< 0.01
28 d	8.69	7.86	0.310	< 0.01
BWG (21-28 d)	2.12	2.00	0.055	< 0.01
ADG (21-28 d, g/d)	303.00	285.00	7.450	< 0.01
Feed intake (g/d)	318.00	293.00	10.100	< 0.01
G : F	0.95	0.97	0.120	0.121

BW, body weight; BWG, body weight gain; ADG, average daily gain; G : F, gain to feed ratio; SEM, standard error of the mean.

[z] Seasons represent the mean of daily value of ambient temperature and relative humidity. Cool season included November 2015 to April 2016, November 2016 to April 2017, warm season included May 2015 to October 2015, May 2016 to October 2016.

Table 7. Seasonal effects on the growth performance in piglets reared in commercial farm[z].

Items	Cool season	Warm season	SEM	p-value
No. of sows	60.00	60.00	-	-
Duration of lactation (d)	21.00	21.00	-	-
Litter size				
Total born	11.14	10.79	0.280	0.423
Still birth	2.05	2.64	0.940	0.211
At weaning	10.40	10.03	0.196	0.530
Survival rate	93.34	93.11	0.850	0.537
BW (kg)				
0 d	1.20	1.24	0.029	0.315
21 d	5.90	5.55	0.210	0.162
BWG (0 - 21 d)	4.70	4.31	0.254	0.124
ADG (0 - 21 d, g/d)	224.00	205.00	11.100	0.081
28 d	7.55	7.03	0.214	0.016
BWG (21 - 28 d)	1.65	1.48	0.079	0.021
ADG (21 - 28 d, g/d)	236.00	211.00	9.400	0.021
Feed intake (g/d)	258.00	228.00	12.600	0.031
G : F	0.92	0.93	0.023	0.315

BW, body weight; BWG, body weight gain; ADG, average daily gain; G : F, gain to feed ratio; SEM, standard error of the mean.

[z] Seasons represent the mean of daily value of ambient temperature and relative humidity. Cool season included November 2015 to April 2016, November 2016 to April 2017, warm season included May 2015 to October 2015, May 2016 to October 2016.

Discussion

In the current study, data from two different farms consistently showed that sows in warm season led to a lower feed intake and energy intake during lactation than those in cool season, which is in agreement with Azain et al. (1996), who suggested that warm season could reduce the feed intake during lactation compared with those in cool season. Previously, studies have extensively described the negative effect of high temperature on feed intake in sows (Renaudeau et al., 2001). The reduced feed intake caused by heat stress could increase the BW loss during lactation (Sun et al., 2019). Renaudeau et al. (2001) also suggested that heat stress could increase mobilization of body reserve in sows. Therefore, it is suitable to hypothesize that increased BW loss could be observed in the warm season. However, in the current study, we only measured the BW of sows in Dankook University experiment farm because of the absence of balance facility in the commercial farm. Results on the BW were out of anticipation, wherein the sow BW was not affected by different seasons, although there was a numerically increase in the warm season compared with cool season. In agreement with our study, Silva et al. (2009) also suggested that seasons did not affect the sow BW throughout the experiment. The reason for the lack of effect on the BW loss is likely to be the large individual difference among sows in the current study. But interestingly, data from different environments consistently suggested that sows in warm season reduced backfat thickness at weaning and increased backfat loss during lactation compared with those in cool season, which confirmed the increased mobilization of body reserve in warm season, and reflected the reduced feed intake and energy intake observed in the present study (Black et al., 1993; Renaudeau et al., 2005). Moreover, our results also indicated a prolonged weaning to estrus interval in the warm season compared with those in the cool season. Previous studies have reported a greater weaning to estrus interval with a high temperature in sows, and suggested that the reason for the greater estrus interval is likely to be the decreased secretion of LH in sow in a hot environment (Koketsu and Dial, 1997; Van den Brand et al., 2000). Peltoniemi et al. (2000) also suggested that a prolonged weaning to estrus interval could be observed with the negative effect of heat stress on the feed intake and the larger depletion of body reserves during lactation. Therefore, the reason for the negative effects observed in sows is likely to be the reduced feed and energy intake caused by heat stress during lactation (Renaudeau et al., 2001; Renaudeau et al., 2003).

In terms of the litter performance, a decreased weaning weight and ADG during 0 - 21 d was observed in warm season compared with cool season in Dankook University farm, which is in agreement with Auldist and King (1995), who reported a reduced piglet growth rate during the first 3 wk of lactation in warm season compared with those in cool season. It has been suggested that litter growth performance is closely related to the milk production of the sows (Noblet and Etienne, 1989). Lewis et al. (1978) had previously suggested that milk production is highly associated with the feed intake of the sow; Gourdine et al. (2006) reported that milk yield is reduced at elevated temperatures; Messias de Braganca et al. (1998) also demonstrated a direct influence of high temperatures on the milk production. Therefore, although we did not investigate the milk production in the current study, we hypothesized that the reduced BWG and ADG may be caused by the decreased milk production, which is considered as a consequence of feed intake and a direct effect of heat stress in sow (Black et al., 1993). However, season effect did affect the growth performance of the piglets in the commercial farm, although there was a tendency on the ADG during 0 - 21 d. The reason for the unexpected growth rate is unclear. It should be noted that the growth performance of the piglets in the commercial farm is lower than those in the University facility. It is well accepted that environment and social stress are major factors in determining the practical nutrient requirement for pigs, which may subsequently affect the growth performance. As suggested by the difference in two different farms, the temperature was better regulated in the University facility than the commercial farm. Therefore, we hypothesized that the reason for the difference is likely to be the different environment and social stress between two different farms.

Moreover, piglets in the cool season had a higher BWG and ADG after weaning (21 - 28 d) than those in the warm season. In the current study, since the feed intake was also increased by the cool season, we hypothesized that the reason for the increased growth performance is the increased feed intake. Previously, the BWG and feed intake during nursery is highly related to the weaning weight, wherein an increased gain and feed intake could be observed with increasing weaning weight (Mahan and Lepine, 1991). Nyachoti et al. (2004) demonstrated that a heavier pig at weaning has a higher rate of gain post-weaning compared with lighter pigs because of its more developed digestive, immune system and ability to better cope with the stresses of weaning. Our previous study also suggested that piglets weaned with higher BW could consume more feed than those with lower BW, and subsequently led to a higher growth performance (Yan et al., 2011). Therefore, our results indicated that different season could also affect the litter growth performance post-weaning.

Conclusion

Our results suggested that warm season had a great negative effect on feed intake and subsequently its production performance of lactating sows, and the negative effect was also observed on the growing performance of the litter performance.

Conflict of Interest Declaration

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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