

## Influence of season of birth, sex and paternal line on growth performance and carcass traits in pigs

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### Abstract

Participants in the pig production industry focus on feed and feed additives to improve growth performance and meat quality of pigs. Consequently, the Rural Development Administration of the Republic of Korea produced a new paternal line to improve economic traits in pigs. However, there is an absence of information on pig traits with regard to season and sex, and a comparison between the new paternal line and past paternal lines. Therefore, the authors conducted this study to investigate the influence of season of birth, sex and paternal line on growth performance and carcass traits in pigs. A total of 2888 piglets ((Landrace × Yorkshire) × Darby Duroc (DD) or Chookjin Duroc (CD)) with an average age of three weeks were tested for 22 weeks during the four seasons of the year (spring 608 piglets, summer 404 piglets, autumn 576 piglets and winter 1300 piglets). The bodyweights (BW) of individual pig were recorded, and feed consumption was recorded at weeks 2, 12 and 22, to determine growth performance. At reaching market weight, backfat thickness was determined at the last rib area. Meat was graded according to the criteria of the slaughterhouse. There were no significant differences in growth performance and carcass traits between sexes. The CD line crossbred pig had a significant higher BW at 16 weeks, and higher carcass trait values at 22 weeks than the DD line. During weeks 8 to 16 the CD line crossbred pigs showed a tendency of an increased average daily gain (ADG) and gain : feed (G : F) ratio compared with the DD line. Furthermore, pigs born in spring had significant lower ADG, average daily feed intake (ADFI) and carcass trait values than born in the other seasons. In conclusion, the new paternal line (Chookjin Duroc) improved growth performance and carcass traits compared with the DD line.

**Keywords:** sex, growth, terminal sire, meat quality, backfat thickness

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### Introduction

Traditionally, the pig breeds producing the pork consumed in Republic of Korea were (Landrace × Yorkshire) × Duroc crosses. Duroc was used because the paternal line has outstanding meat quality, and the Republic of Korea therefore imported Duroc semen. Yet sometimes there was an imbalance in supply and demand for farmers. Through genetic selection for 10 years, the Rural Development Administration of the Republic of Korea developed a new paternal line (Chookjin Duroc) which is a cross between the Duroc and a Korean native pig, in order to adjust the balance of supply and demand and improve growth performance and meat quality of pigs. From 75 to 116 kg BW, barrows had higher average daily feed intakes (ADFI) and average daily gains (ADG) than gilts, and higher ADFIs than gilts from 116 to 124 kg (Latorre *et al.*, 2004). Carcasses produced by the barrows were heavier than those of the gilts, even though other studies reported that carcass weight and yield were not affected by sex (Latorre *et al.*, 2003; 2004). Backfat thickness was

affected, with intact females having a lower backfat thickness than males (Peinado *et al.*, 2008). However, no basic investigations have been done on the new paternal line, nor comparative studies with the existing paternal line. Additionally, few studies have been conducted to find out how season influences growth performance and carcass traits and how the paternal line influences growth performance and carcass traits in pigs. As social income levels have improved, preference for better meat quality is increasing, and participants in the pig industry have focused on feeds and feed additives to improve the growth performance and meat quality of pigs. Therefore, the present study was designed to evaluate the influence of season of birth, sex and paternal line on growth performance and carcass traits of pigs.

## Materials and Methods

The experimental protocol that was used in this study was approved by the Animal Care and Use Committee of Chungbuk National University, Republic of Korea.

The experiment was conducted with 281 sows (Landrace × Yorkshire) between September 2016 and June 2018. The sows were inseminated twice at 12-hour intervals with semen from Duroc (Darby Genetics Inc., Anseong, Republic of Korea) or Chookjin Duroc (Rural Development Administration, Suwon, Republic of Korea) boars for the duration of the oestrus. Sows were fed individually twice and had ad libitum access to water. After checking for pregnancy, the sows were moved to environmentally controlled farrowing crates (5.2

**Table 1** Ingredient and calculated composition of the diet (as-fed basis)

Items	Phase 1 (0 to 8 weeks)	Phase 2 (8 to 16 weeks)	Phase 3 (16 to 22 weeks)
<b>Ingredients, %</b>			
Corn	43.35	42.75	43.85
Soybean meal, 48%	27.80	34.00	15.00
Lactose	8.00	-	-
Oats	-	12.80	32.80
Whey dried	4.00	-	-
Fish meal (Menhaden)	8.00	-	-
Lard	5.00	4.75	4.50
L-Lysine-HCl	0.20	0.30	0.20
DL-Methionine	0.40	0.40	0.40
L-Threonine	1.00	1.00	1.00
Di-calcium phosphate	1.25	3.00	1.25
Limestone	0.50	0.50	0.50
Salt	0.10	0.10	0.10
Vitamin premix <sup>1</sup>	0.20	0.20	0.20
Mineral premix <sup>2</sup>	0.20	0.20	0.20
<b>Calculated composition, g/kg<sup>3</sup></b>			
ME, Kcal/kg	3517	3361	3280
Crude protein	238.9	227.9	160.8
Calcium	8.91	6.50	5.40
Phosphorus	5.79	4.25	3.53
Ca : P ratio	1.54	1.53	1.53
Lys	15.29	14.23	8.54
Met	0.80	7.25	6.43

<sup>1</sup> Provided per kilogram of diet: 4,500 mg vitamin A, 93.75 mg vitamin D<sub>3</sub>, 37.5 mg vitamin E, 2.55 mg vitamin K<sub>3</sub>, 3 mg thiamine, 7.5 mg riboflavin, 4.5 mg vitamin B<sub>6</sub>, 24 µg vitamin B<sub>12</sub>, 51 mg niacin, 1.5 mg folic acid, 0.2 mg biotin, and 13.5 mg pantothenic acid

<sup>2</sup> Provided per kilogram of diet: 37.5 mg Zn (as ZnSO<sub>4</sub>), 37.5 mg Mn (as MnO<sub>2</sub>), 37.5 mg Fe (as FeSO<sub>4</sub>·7H<sub>2</sub>O), 3.75 mg Cu (as CuSO<sub>4</sub>·5H<sub>2</sub>O), 0.83 mg I (as KI), and 0.23 mg Se (as Na<sub>2</sub>SeO<sub>3</sub>·5H<sub>2</sub>O)

<sup>3</sup> ME (as metabolizable energy), Ca : P (calcium : phosphorus), Lys (as lysine), and Met (as methionine)

m<sup>2</sup>; 2.0 m × 2.5 m) in a building installed with a winch curtain. Average outside temperatures were: spring 12.1 °C, summer 28.7 °C, autumn 15.1 °C and winter 1.6 °C. Inside temperatures were: spring 15.1 °C, summer 24.4 °C, autumn 18.1 °C and winter 11.6 °C. Within 12 h of birth, the piglets received an injection of 200 mg iron and were provided with a heating zone, using lamps. The piglets received a second iron injection and male piglets were castrated surgically on Day 3. Individual piglets were identified by ear notching at Day 14.

Over the four seasons 2888 piglets were housed on two farms, 1444 per farm (50% DD and 50% CD line). Seasonal allocations were: spring 608 piglets, summer 404 piglets, autumn 576 piglets and winter 1300 piglets. Each growth period consisted of 22 weeks, divided into three phases, 0 - 8, 8 - 16 and 16 - 22 weeks. The ingredients and the nutrient composition of the basal diet are presented in Table 1. The diets were formulated to meet or exceed the recommendations of NRC (1998). All pigs had free access to feed and water from feeders and water nipples, respectively, and kept in humidity controlled rooms. At weeks 2, 12 and 22 weeks, body weights were measured individually, and feed consumption was recorded to determine ADG, ADFI and gain : feed (G : F) ratio.

After reaching market weight of about 115 - 120 kg, backfat thickness was measured at the last rib area (65 mm from the centre-line of the back) using real-time ultrasound (Piglog105, Denmark). The pigs were then transported to the slaughterhouse (Farm-story, Republic of Korea) where they were kept for 5.5 h and then moved to the slaughtering facility. They were stunned between the ears and eyes by electric shock equipment (259 V~270 V), where-after blood was drained through both carotid arteries for over two minutes. The bled-out carcasses were put in hot water for scraping and dehairing. Intestinal organs were removed from below the genital slit, and each carcass was split down the midline. Afterward, the head was removed, and carcass grading was done using the criteria presented in Table 2.

**Table 2** Grading criteria of the carcasses after slaughter

Grade	Scalding carcass		
	Carcass weight (kg)	Backfat thickness (mm)	Dressing percentage (%)
3	83 ~ 93	More than 14.0	More than 56.0
2	80 ~ 98	12.0	54.0
1		Not included in Grade 1+, 1	

All data were analysed as a completely randomized design with treatments arranged factorially (2 × 2 × 4), using the general linear model program of SAS (SAS Institute, 2008). The model included sex, paternal line and season of birth as the main effects. All data are presented as means; and differences are considered statistically significant at  $P < 0.05$ .

## Results

The growth performances of the pigs according to sex, paternal line and season of birth are presented in Table 3. There were no significant differences ( $P > 0.05$ ) in BW, ADG, ADFI and G : F ratio between sexes. Initial BW and BW at 8 weeks were not affected ( $P > 0.05$ ) by paternal line, but the CD line crossbred pig had a higher ( $P < 0.05$ ) BW at 16 and 22 weeks than the DD line. In weeks 0 - 8 and 16 - 22, paternal line did not affect ( $P > 0.05$ ) growth performance, but during 8 to 16 weeks the CD line crossbred pig showed a tendency of improved ADG and the G : F compared with the DD line ( $P = 0.051$ ;  $P = 0.062$ ). The ADG and G : F improved over the total period. Pigs born in autumn had lower ( $P < 0.05$ ) BWs at birth and at 22 weeks than during the other seasons. However, the ADG and ADFI of pigs born in spring were lower ( $P < 0.05$ ) at 0 - 8, 8 - 16, 16 - 22 and 0 - 22 weeks than those born during the other seasons.

Carcass traits of pigs according to sex, paternal line and the season of birth are presented in Table 4. There were no significant differences ( $P < 0.05$ ) in backfat thickness and pork grade between sexes. The CD line increased ( $P < 0.05$ ) backfat thickness compared with the DD line. Additionally, pigs born of CD had a higher pork grade ( $P < 0.05$ ) than the DD line. In the season of birth, pigs born in spring and autumn had lower ( $P < 0.05$ ) backfat thickness and pork grades than those born in the other seasons.

**Table 3** Influence of sex, paternal line and season of birth on growth performance in pigs<sup>1</sup>

Items <sup>2</sup>	Sex (G)		SEM <sup>3</sup>	Paternal line (P)		SEM <sup>3</sup>	Season of birth (SB)				SEM <sup>3</sup>	Significance <sup>4</sup>		
	CM	F		DD	CD		Spring	Summer	Autumn	Winter		G	P	BS
<b>BW, kg</b>														
Initial	6.13	6.14	0.04	6.14	6.15	0.04	6.39	6.25	5.77	6.26	0.08	NS	NS	*
8 weeks	33.41	33.55	0.14	33.37	34.30	0.17	34.89	33.14	32.40	35.11	0.21	NS	NS	*
16 weeks	77.39	77.64	0.20	77.14	78.14	0.25	77.56	78.13	77.33	78.52	0.29	NS	*	*
22 weeks	113.16	113.27	0.16	112.26	114.26	0.15	112.66	114.79	110.20	115.23	0.21	NS	*	*
<b>0 - 8 weeks</b>														
ADG, kg	0.49	0.49	0.05	0.49	0.49	0.04	0.51	0.48	0.48	0.51	0.02	NS	NS	*
ADFI, kg	0.82	0.83	0.12	0.82	0.82	0.08	0.75	0.72	0.74	0.75	0.28	NS	NS	NS
G: F ratio	0.60	0.59	0.09	0.60	0.60	0.02	0.68	0.67	0.65	0.68	0.03	NS	NS	NS
<b>8 - 16 weeks</b>														
ADG, kg	0.79	0.78	0.04	0.78	0.80	0.03	0.76	0.73	0.76	0.80	0.13	NS	0.051	*
ADF, kg l	2.30	2.32	0.09	2.32	2.32	0.02	2.15	2.23	2.24	2.33	0.03	NS	NS	*
G: F ratio	0.60	0.59	0.03	0.59	0.61	0.03	0.34	0.36	0.36	0.34	0.02	NS	0.062	NS
<b>16 - 22 weeks</b>														
ADG, kg	0.85	0.85	0.02	0.84	0.87	0.02	0.87	0.81	0.88	0.90	0.22	NS	NS	*
ADFI, kg	2.53	2.55	0.21	2.54	2.54	0.04	2.22	2.58	2.49	2.49	0.08	NS	NS	*
G: F ratio	0.56	0.55	0.16	0.55	0.58	0.01	0.31	0.34	0.31	0.36	0.12	NS	NS	NS
<b>0 - 22 weeks</b>														
ADG, kg	0.70	0.70	0.05	0.69	0.75	0.02	0.68	0.72	0.71	0.73	0.01	NS	*	*
ADFI, kg	1.59	1.58	0.17	1.60	1.60	0.17	1.52	1.60	1.56	1.59	0.02	NS	NS	*
G: F ratio	0.44	0.44	0.08	0.43	0.48	0.02	0.42	0.44	0.44	0.45	0.02	NS	*	NS

<sup>1</sup> CM: castrated male; F: female; DD: Darby Duroc, CD: Chookjin Duroc<sup>2</sup> BW: body weight; ADG: average daily gain; ADFI: average daily feed intake; G : F ratio: gain to feed ratio<sup>3</sup> SEM: standard error of mean<sup>4</sup> NS: no significant difference\*  $P < 0.05$

**Table 4** Influence of sex, paternal line and season of birth on carcass traits in pigs<sup>1</sup>

Items <sup>2</sup>	Sex (G)		SEM <sup>2</sup>	Paternal line (P)		SEM <sup>2</sup>	Season of birth (BS)				SEM <sup>2</sup>	Significance <sup>3</sup>		
	CM	F		DD	CD		Spring	Summer	Autum n	Winter		G	P	BS
Backfat thickness	22.04	21.85	0.52	21.90	22.98	0.22	20.51	21.81	21.21	22.17	0.08	NS	*	*
Pork grade	1.82	1.81	0.22	1.81	1.97	0.07	1.32	1.85	1.42	1.85	0.09	NS	*	*

<sup>1</sup> CM: castrated male; F: female; DD: Darby Duroc; CD, Chookjin Duroc

<sup>2</sup> SEM: standard error of mean

<sup>3</sup> NS: no significant difference

\* $P < 0.05$

## Discussion

The current trend in the pig production is to improve the reproductive performance such as parity, growth, and meat quality of sows. Sows have been developed steadily to meet these requirements. Additionally, many researchers have studied essential traits such as growth performance, nutrient digestibility and meat quality because pigs are changing genetically. As a new paternal line was developed and pigs changed, it was necessary to investigate the effects of sex, the new paternal line, and the season of birth on these basic traits of pigs.

Many researchers reported that barrows had better growth than gilts owing to their greater feed intake (Langlois & Minvielle, 1989; Leach *et al.*, 1996; Augspurger *et al.*, 2002). However, Renaudeau *et al.* (2006) reported that sex did not affect growth performance. In the current results, there was no significant difference ( $P < 0.05$ ) in growth performance between sexes. These results suggest that the current pigs were not affected by sex when they were in the same environmental conditions such as temperature and rearing density. Additionally, the reduction of sex difference on growth rate is considered in the new paternal line because results by Cisneros *et al.* (1996) showed that sex difference could vary with genotype.

Duroc crossbred pigs showed a tendency to increase initial BW compared with Iberian (IB) when they were at similar ages. Moreover, Duroc crossbred pigs grew about 20% faster than IB over the growth period (Ventanas *et al.*, 2006). The Duroc had an outstanding growth rate compared with other paternal line. The Chookjin Duroc was developed for 10 years in the Republic of Korea through selecting and using Duroc pigs with high performances. In the present results, CD crossbred pigs had higher ( $P < 0.05$ ) BW at eighth and 22 weeks, and ADG and G : F ratios over the total period than DD crossbred pigs, but there was no significant difference in ADFI among the offspring of the paternal lines. This improvement of the CD line might be due to differences in the genetics programme reported in the results of Ramírez & Cava (2007) for example.

With regard to the effect of the season on growth, pigs born in autumn had lower initial BW than pigs born in other seasons. Summer heat stress causes many health problems such as anoestrus, low farrowing rates and depressed litter size (Bertoldo *et al.*, 2012). All sows that gave birth in autumn underwent heat stress. Thus, depressed growth in piglets in autumn was due to lower circulating immunoglobulin G similar to the results of Machado-Neto *et al.* (1987), and low supplementation of milk from the sow. Furthermore, low initial weight in piglets in autumn lasted until the end of the experiment. Generally, food intake and weight gain of growing and finishing pigs decreased with rising environmental temperatures (Quiniou *et al.*, 2000). In the present results, pigs born in spring had a lower ( $P < 0.05$ ) ADG and ADFI than in other seasons, except for autumn. This is because they underwent heat stress during the growing-finishing phase. Additionally, this reduction was because of decreasing feed intake owing to heat stress.

The present results showed that there was no significant difference in backfat thickness and pork grade between sexes. Previous studies showed that sex did not affect carcass yield and dressing percentages (Fortin, 1980; Leach *et al.*, 1996; Hamilton *et al.*, 2000; Lebret *et al.*, 2001). Moreover, Latorre *et al.* (2003) did not observe differences in carcass yield between sexes. However, Langlois & Minvielle (1989) and Ellis *et al.* (1996) reported that gilts had higher carcass yields than barrows. The discrepancy in results between the current study and other studies is considered to be related to differences in the method used for grading the pork. The standard values (that is, of slaughterhouses in the Republic of Korea) in the current experiment showed significant variation. In the results of the paternal line, pigs from the CD line had higher ( $P < 0.05$ ) backfat thickness and pork grades than those from the DD line. Some researchers reported that traits of fatness generally have a high heritability, with heritability estimates for ultrasonic backfat thickness ranging from 0.35 to 0.72 (Hoque *et al.*, 2007; Solanes *et al.*, 2009). Therefore, the improvement in carcass traits was due to increasing fat in the CD line. Moreover, further research is needed to understand the relationship between sex and paternal line on carcass traits.

Heat stress can reduce carcass traits directly. In the current results, pigs born in spring had lower ( $P < 0.05$ ) backfat thickness and pork grades than those born during other seasons except for autumn. This is in agreement with the findings of Spencer *et al.* (2005) and White *et al.* (2008), who found that carcass fat quality decreased when heat stress occurred.

## Conclusion

This experiment showed that after castrating, growth performance and carcass traits were not affected by sex. Also, improved growth performance and carcass traits were evident in the new paternal line, Chookjin Duroc, but resistance to heat stress did not change.

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### Authors' Contributions

JHC and HBK were in charge of project design. WY and DJY supervised the course of the study. SDL, CHL, WGK, HJO and JSA were in charge of measurement of body weight and sample collection in pigs. JHL and MHS summarized the results and wrote the manuscript and revised it.

### Conflict of Interest Declaration

The authors declare that they have no conflict of interest.

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