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Interactive effects of weaning age and creep feed on the performance of sows and their piglets

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ABSTRACT

The study was conducted to determine the interactive effects of creep feed and different weaning age of piglets on the production performance of lactating sows and performances of piglets. Our study indicated that the piglets provided with creep feed led to a higher BW, ADG at nursery and weaned pigs, and also significant difference on ADFI during nursery phase. Different weaning age had increased ADFI and G:F ratio in pre- and post-weaned pigs. Interactions between creep feed and weaning age had significant difference on growth performances among nursery and weaned pigs. Furthermore, the obtained data suggested that the inclusion of creep feed with increased weaning age may reduce the estrus interval in sows and improve the growth performance of piglet during lactation and post-weaning.

Key words: Creep feed, Piglets, Sows, Weaning age factor

Now-a-days, the swine industry has shifted to the earlier weaning system to optimize farrowing crate utilization and profitability of pork operation with alternative and extensive farming methods. The immediate post-weaning period is often characterized by a reduced feed intake (FI), digestive disorder, and poor growth performance because of the abrupt transformation from a liquid to solid diet. The substantial discrepancy in creep feed expenditure may explain some of the differences in post-weaning performance. Previous studies also confirmed that creep feeding and increasing weaning age of piglets could greatly improve the weaning weight, post-weaning growth performance and reproductive performance of sows (Main *et al.* 2004, Yan *et al.* 2011a,b). Creep feed utilization varies markedly within and between litters, with intake influenced by factors including litter size, age and duration of period creep feed is offered to piglets (Collins *et al.* 2013). Therefore, the objective of the study was to determine the interactive effects of creep feed and different weaning age of piglets on the production performance of lactating sows and their piglets.

MATERIALS AND METHODS

The protocol for these experiments was approved, and animals were cared for, according to the guidelines of the Animal Care and Use Committee of Dankook University, Cheonan, South Korea. A total of 160 multiparous sows (Landrace × Yorkshire, average parity 1.5, SD=0.48) and their litters were used in this trail. The data covered the period between July 2010 and May 2012. On day (d) 108 of gestation, sows with an average weight of 252.23 kg were randomly allotted to a 2 × 2 factorial arrangement of treatments with the factors being different weaning age (21 or 27 days of age) with or without creep feed supplementation for their piglets. During gestation, sows were housed in individual stalls that consisted of a 0.80 m concrete solid floor and a 1.05 m concrete slatted floor. Approximately 10 d before the expected time of parturition, sows were moved to farrowing rooms, each with 2.20 × 1.60 m^2 area. The concrete solid floor was equipped with floor heating. All rooms were equipped with auto-controlled heating and mechanical ventilation systems. Supplemental heat was provided for pigs using heat lamps. All piglets were individually weighed within 24 h of birth and tagged for identification. Cross-fostering of piglets took place within 2 days of parturition and occurred only among sows of the same experimental treatment to 10 piglets per sow and the numbers of weaned piglets were duly recorded. Creep feed was offered among treatments from 9 days of age to weaning. The diets used for sows as basal diets during gestation and lactation period as described previously (Balasubramanian *et al.* 2016) and piglets (Table 1) were formulated to meet or exceed the nutrient concentrations recommended by National Research Council (NRC 2012). After nursery phase, piglets were moved to a commercial weaner facility where they were housed in an

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Table 1. Composition of basal diets (g/kg, as-fed basis)

Ingredient	Nursery piglet	Weaning pig	
		0-3 wks	4-6 wks
Extruded corn	226.2	320.0	451.0
Extruded oat	—	60.00	—
Bakery byproducts	—	50.0	90.0
Soybean meal, 44%	80.0	180.0	296.5
Fermented SBM	100.0	82.0	-
Fish meal	25.0	40.0	25.0
Soy oil	45.0	48.0	30.0
Lactose	80.0	60.0	-
Whey	241.6	100.0	68.5
Milk product	—	60.0	20.0
Dicalcium phosphate	12.5	—	—
Monocalcium phosphate	—	10.0	6.0
Sugar	35.0	20.0	—
Plasma powder	40.0	—	—
L-Lys·HCl, 78%	4.1	2.5	1.6
DL-Met, 50%	3.8	1.5	1.4
L-Thr, 89%	1.3	0.8	
Choline chloride, 25%	1.0	1.0	1.0
Zinc oxide	3.0	—	—
Vitamin premix[a]	1.0	1.0	1.0
Trace mineral premix[b]	1.8	2.0	2.0
Limestone	—	2.0	3.0
Salt	—	3.0	3.0
Calculated composition, g/kg			
ME, MJ/kg	16.74	14.8	14.6
CP	22.00	210.0	205.0
Lysine	1.74	14.1	13.3
Methionine	0.70	4.9	4.7
Calcium	0.81	7.8	7.5
Total P	1.00	7.6	6.4

[a]Provided premix per kg of diet: vitamin A, 11,025 IU; vitamin D_3, 1,103 IU; vitamin E, 44 IU; vitamin K, 4.4 mg; riboflavin, 8.3 mg; niacin, 50 mg; thiamine, 4 mg; d-pantothenic acid, 29 mg; choline, 166 mg; and vitamin B_{12}, 33 µg. [b]Provided premix per kg of diet: Fe ($FeSO_4 \cdot 7H_2O$), 80 mg; Cu ($CuSO_4 \cdot 5H_2O$), 12 mg; Zn ($ZnSO_4$), 85 mg; Mn (MnO_2), 8 mg; I (KI), 0.28 mg; and Se ($Na_2SeO_3 \cdot 5H_2O$), 0.15 mg.

environmentally controlled room based on creep feed/ weaning age factor treatment. The stainless steel pens were 0.6 × 2.0 m with a slatted plastic floor and a cage height of 0.5 m. Each pen was provided with a stainless steel feeder and a nipple drinker that allowed for *ad lib.* access to feed and water throughout the experiment.

Live piglets were weighed immediately after cross-fostering at the commencement of creep feeding (9 days of age) and at weaning to calculate ADG. The feed consumed during experimental period was recorded to calculate average daily feed intake (ADFI) and gain:feed ratio (G:F) of piglets. Number of piglets born and weaned pigs were also recorded to calculate the survival rate. On the day of 19, 20, 21, and 25, 26 of after birth, the fecal samples from all piglets were taken using fecal loops. The colour of each sample was immediately determined visually. A green colour of the feces indicated that the pig had eaten creep feed (Barnett *et al.* 1989). After three assessments, individual piglets were categorized as good, moderate and small eaters according to the method of Pluske *et al.* (2007). The body weights (BW) of the sows were recorded on day 108 of gestation, immediate after complete farrowing (d 0) and at weaning by separation of piglets to calculate BW loss and back-fat thickness (BFT) of sows during that trail period (Lee *et al.* 2016). Blood samples from sows were collected via jugular venipuncture into K_3EDTA vacuum tubes and centrifuged for 15 min at 3000 × g at 4°C to obtain serum; stored at 4°C until determination for serum cortisol, norepinephrine (NE) and epinephrine (EPI) by ELISA Kit (Rodent Cortisol ELISA Kit, Endocrine Technologies, Minneapolis, USA).

All statistical analysis was conducted as 2 × 2 factorial arrangement using the GLM procedure of SAS/STAT® 9.2 (Statistical Analysis System, Inst. Inc., Cary, NC). The individual sow or litter of piglets was used as the experimental unit. The effect of treatment on average sow weight, number of pigs per litter, litter weight was determined using factors creep feed and weaning age as covariates.

RESULTS AND DISCUSSION

In the present study, piglets that consumed creep feed had increased ADG and ADFI ($P<0.05$) compared to those without creep feed during lactation (Table 2), which was in agreement with Yan *et al.* (2011b). Previously, it is well suggested that the inclusion of creep feed increased the ADG of piglets during lactation (Wolter *et al.* 2002, Yan *et al.* 2011b), because the ingestion of solid food during lactation could stimulate acid production and speed the induction of amylase and protease enzymes in the gut (De Passille *et al.* 1989).

Further, inclusion of the creep feed increased ($P<0.05$) final BW of weaned pigs; greater ADG at nursery and weaned pigs, and also on ADFI during nursery phase. Our results were consistent with Yan *et al.* (2011a) who reported that creep feeding, could improve the post-weaning performance of young piglets due to the improved gut physiological maturity. There was no effect of creep feed intake on the G:F ($P>0.05$) in our entire experiment. According to Yan *et al.* (2011b), creep feeding subsequently helped the weaning pig to ease the transition from milk to solid feed during weaning. Indeed, results of current study indicated that piglets provided with creep feed had higher ADG and ADFI than those without creep feed during nursery phase. Therefore, our study confirmed the effect of creep feeding on the piglet growth performance during lactation and post-weaning.

Generally, weaning period could present many challenges to the young pig, and these challenges included an abrupt change from a liquid to a solid diet that may not be easily utilized by the young pigs (Wolter and Ellis 2001). Worobec *et al.* (1999) also suggested that pigs weaned at earlier age exhibited more escape behaviour, less feeding time than the pigs that weaned at an older age. Therefore, we hypothesized that weaning piglets at an older age would

Table 2. Effects of creep feed and weaning age on the production performance in piglet

Particular	No creep feed		Creep feed		SEM	P-value[b]		
	21 d	27 d	21 d	27 d		CF	WA	C×W
Litter size								
Total born	11.52	11.28	11.67	12.0	0.21	NS	NS	NS
Still birth	1.03	0.99	0.96	1.12	0.56	NS	NS	NS
At weaning	9.43	9.77	9.56	9.61	0.21	NS	NS	NS
Survival rate	94.3	97.7	95.6	96.0	2.13	NS	NS	NS
Body weight, kg								
Post foster, 0 d	1.41	1.37	1.40	1.41	0.53	NS	NS	NS
Day 9	2.16	2.94	3.08	3.42	0.42	NS	NS	NS
Nursery, kg	5.86	6.87	6.57	7.84	0.46	NS	*	*
Weaned, kg	20.28	21.78	22.56	24.05	0.68	**	*	NS
ADG (average daily gain), g/d								
Post foster	212	229	246	268	16	*	NS	*
Nursery	412	426	457	463	20	**	NS	NS
Weaned	532	541	513	556	14.26	*	NS	*
ADFI (average daily feed intake), g/d								
Lactation	0	0	221	246	0.25	NS	*	NS
Nursery	496	548	544	598	23	*	**	*
Weaned	582	584	589	596	17.42	NS	NS	NS
G:F (gain:feed ratio)								
Nursery	0.831	0.778	0.840	0.774	0.02	NS	*	NS
Weaned	0.643	0.657	0.658	0.693	0.04	NS	*	*

CF, creep feed; WD, weaning age; C×W, interactive effect between creep feed and weaning age; SEM, standard error of mean; NS, nonsignificant (P>0.05). [b]Probability of contrast: *, P<0.05; **, P<0.01.

Table 3. Effects of creep feed and weaning age on individual creep feed consumption pre-weaning piglets

Particular	Creep feed consumption			Total number of pigs assessed
	Good eaters	Moderate eaters	Small eaters	
Piglets weaned 21 days	26 (31.7%)	34 (41.5%)	22 (26.8%)	82
Piglets weaned 27 days	29 (33.7%)	39 (45.3%)	18 (20.9%)	86
Body weight, kg				P -value
Nursery	7.64	6.76	5.96	NS

increase the growth performance because of its physiological maturity at weaning and less nervousness after weaning. Weaning factor had significant difference on ADFI and G:F (P<0.05) of pre- and post-weaned pigs with no influence of ADG in this study, which is in agreement with findings of Main *et al.* (2004), who suggested that piglets weaned at an older age had higher ADFI than those weaned at earlier age. Pigs which were fed creep feed during the pre-weaning period consumed more feed during the weaning than those not fed with creep diet. Piglets weaned at 27 d had a greater weaning weight than those weaned at 21 d, which was in accordance to Wolter and Ellis (2001), who reported a favourable correlation between weaning age and weaning weight in piglets. Interactive effects between creep feed and weaning age had significant difference (P<0.05) on BW at nursery phase, ADG during post foster and weaned pigs, ADFI at nursery phase and G:F at weaned pigs. However, creep feed consumption and weaning age had no influence on the litter size (P>0.05) among the treatment during the entire experiment (Table 2), where the effect of weaning age on the ADG and weaning weight were enhanced by the creep feed supplementation. As the reason for the interaction is unknown and further study needs to undertaken to investigate the exact mechanism that underlines this interactive effect.

The influence of creep feed and weaning age on individual creep feed categorization (good, moderate, non-eaters) and reproduction performance in sows are shown in Tables 3 and 4, respectively. Individual creep feed consumption, as indicated by the presence or absence of the dye in the feces, was also variable between pigs within the same litter (Pluske *et al.* 2007). Bruininx *et al.* (2002) provided the first evidence that 'good eaters' of creep feed in lactation grew faster in weaning compared to 'small-eaters' and piglets that were not provided creep feed during lactation (Callesen *et al.* 2007, Sulabo *et al.* 2008). In the present study, higher BW was observed in piglets that consumed more creep feed, but it was statistically non-significant.

Yan *et al.* (2011a) had previously suggested that the behaviour and reproductive performance of sow could be influenced by creep feeding. Pajor *et al.* (2002) also reported a reduced weaning to estrus interval of sows with creep feed. In agreement with these studies, results of present study also indicated a reduced weaning to estrus interval (P<0.05) with creep feed exposition (Table 4). However, the increasing weaning age did not affect the estrus interval

Table 4. Effects of creep feed and weaning age on the reproduction performance in sows

Particular	No creep feed		Creep feed		SEM	P -value[b]		
	21 d	27 d	21 d	27 d		CF	WD	C×W
Body weight, kg								
After farrowing	233.0	227.2	227.3	219.5	8.9	NS	NS	NS
At weaning	211.1	207.5	206.9	200.7	7.5	NS	NS	NS
Body weight loss[c]	21.9	19.7	20.4	18.8	2.3	NS	NS	NS
Back fat thickness, mm								
Parturition	22.51	22.24	23.15	22.76	2.15	NS	NS	NS
Weaning	19.95	19.28	20.97	20.15	2.09	NS	NS	NS
Back fat loss[d]	2.56	2.96	2.18	2.61	1.03	NS	NS	NS
Weaning to estrus interval, d	4.30	4.55	4.10	4.15	0.243	*	NS	NS
Blood profiles								
Epinephrine, pg/ml	29.5	26.8	23.1	24.5	3.65	*	NS	NS
Norepinephrine, pg/ml	176.5	192.4	145.5	156.4	19.8	*	NS	NS
Cortisol, nmol/l	78.90	66.76	70.63	65.11	0.04	**	NS	NS

CF, creep feed; WD, weaning age; C×W, interactive effect between creep feed and weaning age; SEM, standard error of mean; NS, nonsignificant (P>0.05). [b]Probability of contrast: *, P<0.05; **, P<0.01. [c]Body weight loss, from farrowing to weaning. [d]Back-fat thickness loss, from farrowing to weaning.

in this study, which is inconsistent with Lee *et al.* (2016), who reported that increasing lactation length could decrease weaning to first service interval. The decreased nutrient loss (milk) and the different cortisol and catecholamines in sows due to reduced suckling times of piglets and different suckling stimulus of the piglets respectively may be the rationale for the reduced estrus interval (Ganesh Kumar *et al.* 2012). However, there were no differences (P>0.05) in sow weights after farrowing, at weaning, or lactation weight loss between sows with litters provided with and without creep feed or weaning age. The measurement of cortisol secretion and basal levels of NE and EPI could be considered as a valid indicator of stress in pigs (Smulders *et al.* 2006). In the present study, inclusion of creep feed significantly reduced (P<0.05) the NE, NPI and cortisol compared to those without creep feed supplementation, whereas the different weaning age did not affect (P>0.05, Table 4) the blood profiles. Similarly, our previous studies (Yan *et al.* 2011a, b) also suggested that creep feeding reduced the peripheral plasma cortisol and endorphins of sows and could be considered as a reflection of the reduced stressful effects of the suckling stimulus. According to Turner *et al.* (1999), sustained high plasma cortisol concentration could impair ovulation in female pigs.

Therefore, the difference in cortisol and catecholamine in sows may reflect the lower estrus interval in the current study. It was concluded that the creep feed with older weaning age improved the growth performance of piglet during lactation and post-weaning, and reduced the estrus interval in sows. Different weaning age and interactive effects did not affect the productive performance of sows. Therefore, creep feeding with increased weaning age focuses on encouraging more suckling piglets to eat thereby producing weanling pigs that are better adapted to weaning and improved post-weaning performance.

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