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ANIMAL SCIENCE

Influence of creep feeder position on the behavior and performance of preweaning piglets and sows in a hot climate environment

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Abstract: The use of creep feeding for preweaning piglets is important to improve the performance of the piglets. The objective of this experiment was evaluate the effect of using or altering the position of piglet's creep feeder during lactation on piglet's performance and on behavior of piglets and sows kept in a hot climate environment. Forty-five sows and their litters at 10 days of lactation were randomly distributed into three treatments: front feeder (FF) - near the side of the sow's head; back feeder (BF) - near the side of the rump of the sow; and no feeder (NF). All piglets were weighed individually to evaluate the average weight, weight gain and coefficient of variation of the weight. Behavior assessments of the piglets and sows were recorded in 3 period. At 15 and 21 d, piglets of the FF treatment were heavier ($P \leq 0.0001$) than piglets of the other treatments. At 10-21d piglets of FF treatment had 76.2% less belly nosing behavior than the NF piglets ($P=0.015$). The treatments had no impact on behavior of the sows. The creep feeders positioned in the front of the farrowing crate increased piglet growth rate and decreased frequency of belly nosing behavior.

Key words: farrowing, feed intake, heat stress, management, pig, swine.

INTRODUCTION

Nutrient intake by preweaning piglets is based on the sow's milk production. However, in order to improve litter performance, it is a common practice to provide preweaning piglets with a diet with high biological value nutrients, from seven to ten days of age until weaning, especially for the heavier piglets of a litter as they tend to eat more creep feed than their littermates of lower birth weight (Pajor et al. 1991).

The use of creep feeding for preweaning piglets is important to improve performance of piglets before and after weaning (Adeleye et al. 2014). Lactating sows mobilize body reserves to produce milk as it is common for modern lactating sows to not consume an adequate amount of feed to meet their nutritional requirements (Cole 1990, Schinckel et al. 2010). Also, sows submitted to heat stress have reduced voluntary feed intake, reduced milk production, decreased piglet performance (Ribeiro et al. 2018, Cabezón et al. 2016), and increased death rate (D'Allaire et al. 1996).

It is well known that creep feed intake is very low during lactation (Kuller et al. 2010, Middelkoop et al. 2018) and that increasing the amount creep feed consumed is essential to improve preweaning growth rate and increase postweaning growth rates (Sulabo et al. 2010).

One way to increase piglet creep feed intake is to allow the piglets to observe the sow consuming feed. The presence of a demonstrator (sow eating) can affect the motivation of the piglet, or it may draw their attention to parts of the environment that they had not previously noticed, such as the presence of the feeder. The use of demonstrator animals can be called social enhancement. The use of demonstrator animals can result in imitation behavior, as an animal copies the physical movements and reproduces the results of the actions of a demonstrator animal (Nicol 2006).

Nevertheless, it is difficult for piglets to learn to consume feed, since the sow's feed is offered in tall feeders, which makes visualization and access to feed more difficult for them (Wattanakul et al. 2005). For this reason, it is necessary to use a special creep feeder for the piglets. Also, the position of the creep feeding could affect feed consumption, by the piglets observing the sow consume her feed and consequently mimic the sow's behavior.

The aim of the present experiment was to evaluate the effect of using or altering the position of piglet's feeder at lactating phase on performance, as well as the effect of these feeder positions over the behavior of piglets and sows kept in a hot climate environment.

MATERIALS AND METHODS

All procedures and housing adopted in this trial were approved by the Ethic Committee on Animal Use of Federal University of Rural Amazon (Belem, PA, Brazil) under protocol number 074/2017.

Animals and husbandry procedures

The experiment was performed between June and July of 2018 at a commercial farm with 1,800 sows located at latitude 3°14'41.7"S and longitude 47°18'22.0"W, 176 meters above sea level in Paragominas, PA, Brazil. According to Köppen-Geiger, the climate is classified as "Am" which is characterized as Tropical monsoon climate.

In the breeding sector, each farrowing room housed 60 individual farrowing crates. The crates of the sows were equipped with automatic feeders, and nipple drinkers. Nipple drinkers were available for the piglets, and the feeders for the piglets were available according to the treatment that the piglets were allocated.

To characterize the internal environment of the farrowing rooms, one temperature and relative humidity sensor was used per room, attached to a datalogger (Instrutherm, HT-500, São Paulo, Brazil), and installed at a height of 1 m. Data were collected every 10 min throughout the experimental period.

Experimental design

A total of 45 litters of a PIC genetic line was evaluated, the parity of the sows was evenly distributed between treatments, being 3.8 average parity. At 10 days of lactation, the litters were standardized with a total of 12 piglets with similar mean weight. All piglets were weighed individually to evaluate the mean weight, weight gain and coefficient of variation of the weight. These data were recorded at the beginning of experiment (10 days of age) and at 15 and 21 days of age).

The 45 litters used were randomly distributed into three treatments: front feeder (FF) with the creep feeder positioned near the side of the nut head (T1; n = 15), back feeder (BF) with creep feeder positioned near the side of the rump of the sow (T2; n = 15), and no feeder (NC) without feeding (T3; n = 15). Fifteen replicates per treatment were performed, as the litter was considered the experimental unit.

For feed used in the creep feeder (treatments FF and BF), was a commercial prestarter feed (Multilac Gold – Agroceres Multimix, Brazil) used by the farm. The basic ingredients composition of the diet was: corn, pre-gelatinized corn, soybean meal, degummed soybean oil, soy lecithin, ground rice hulls, limestone, biscuit meal, powdered whole milk, whey powder, sugar, blood plasma, fishmeal, viscera meal, autolyzed sugar cane yeast, dicalcium phosphate, vitamin premix, trace mineral premix, DL-Methionine, L-Lysine, L-Threonine, L-Tryptophan, L-Valine, silicon dioxide, monosodium glutamate, vanilla flavor, sodium saccharin, neosperidine, propionic acid, citric acid, butyl hydroxyanizole, butylated toluene hydroxide, ethoxyquin, and chlorohydroxyquinoline. The nutritional composition of the diet was: crude protein: 18%; total lysine: 1.38%; metabolizable energy: 3600 kcal/kg; lactose 21%; crude fiber 1.22%; total phosphorus 0.55% and calcium: 0.71%. The creep feed was weighed and fed to the piglets twice a day in rotary creep feeder without a feed supply tank (MS Clickfeeder mini - MS Schippers, The Netherlands). The feed leftovers at the creep feeder were weighed at each feeder twice a day for the evaluation of the average daily feed intake. For the sows the feed used was the same as that adopted by the farm during the lactation phase. Water was available throughout the trial period in nipple drinkers.

Behavioral assessment

Among the monitored 45 litters, 24 litters were randomly selected, with 24 sows and 288 piglets from these litters evaluated for their behavior. The behaviors of the piglets and sows were evaluated by direct observation in three distinct moments of the lactation: days 10-11 (immediately after the beginning of the feed supply), 15-16, and 20-21 days of lactation, each evaluation period lasted 48 hours and the behaviors were evaluated at every 10 min.

The behaviors observed in the piglets were: Sleeping; Suckling; Comfort Movement; Feeding; Drinking; Belly nosing (pressing and massaging the belly button of other piglets); Playing; Agonistic Behavior; Play Behavior; Interaction; Standing; Agglomerate; Lying down; Sitting; and Digging. The behaviors observed in the sows were: Drinking; Eating; Stereotypies; Ventral *decubitus*; Lateral *decubitus*; and Standing.

Statistical analysis

The values of all variables measured were tested for normality by the Shapiro–Wilk test before analysis, and any variable that failed to follow normal distribution was transformed through the RANK procedure of SAS (SAS Inst. Inc., Cary, NC). The PROC RANK statement with the NORMAL option was used to produce

a normalized transformed variable. The piglet's performance data was analyzed as a complete randomizes design, totaling 15 replicates per treatment. The MIXED procedure of SAS was used, and least squares means were compared using the Tukey test with $P < 0.05$ being considered significant.

The piglet behavioral data were analyzed using the NPAR1WAY procedure of SAS. Variables that were rejected by the Kruskal-Wallis test at 5% probability level were compared by Dunn's test as a post hoc for pairwise multiple comparisons with $P < 0.05$ being considered significant.

RESULTS

The maximum and minimum temperature during the trial period was 32.8 at 14h and 24.4ºC at 6h, respectively (Fig. 1), with an average temperature of 27.7 ± 3.0ºC. For the relative humidity, the maximum and minimum values were observed

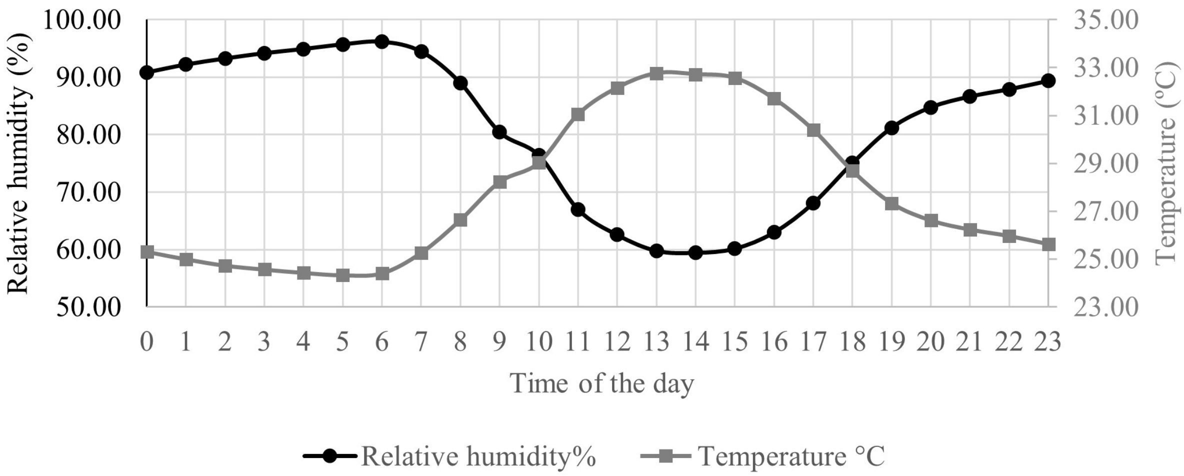

Figure 1. Relative humidity and temperature on the farrowing room for 24h of the day during the trial period.

at the same time points; however, in an opposite way being the maximum humidity of 96.2% at 6h and the minimum of 59.4% at 14h, with an average relative humidity of 80.9 ± 13.2%. The dew point for the greatest and lowest temperature was 23.8ºC and for the average temperature it was 24.1ºC.

Piglets of the FF treatment were heavier at 15d and 21d ($P \leq 0.0001$) than the piglets of the BF and NF treatments (Table I). Also, average daily gain between 10-15d and 10-21d were greater ($P \leq 0.0001$) for piglets of the FF treatment. Average daily feed intake did not differ between piglets of the FF and BF.

As expected, piglets of the FF and BF treatments spent a greater amount of time at the feeder ($P \leq 0.001$) compared with piglets from the NF at all periods evaluated 10, 15, and 21d (Table II). At 21d of age, piglets of the FF treatment had 76.19% less belly nosing behavior than the NF piglets (P=0.015). The treatments had no impact on the behavior of the sows during the trial period (Table III).

DISCUSSION

During lactation, two distinct thermal environments must be provided to ensure good performance of the animals. Lactating sows have a comfort temperature range from 16° to 22°C, in comparison to piglets, which have a comfort range from 30° to 32°C (De Bragança et al. 1998). Temperatures above the thermal comfort zone of lactating sows causes heat stress, which, in turn, affects their productive capacity (Prunier et al. 1997, Williams et al. 2013, Ribeiro et al. 2018). Besides the effect on sow performance, heat stress has a substantial impact on animal welfare and alters animal behavior (Parois et al. 2018).

As verified in our trial, sows exposed to a heat stress environment have decreased voluntary feed intake, reduced milk production and, consequently, decreased piglet growth performance (Renaudeau et al. 2003). Moreover, modern breeding sows are specialized for high prolificacy and milk production, increased thermogenesis and decreased voluntary food consumption, which makes them more vulnerable to high temperatures (Cabezón et al. 2017, Renaudeau 2005). Although sow feed intake was not quantified, it can be inferred that high temperatures reduced their feed intake and, consequently, milk supply to the piglets.

The utilization of creep feeding is a nutritional strategy that can help to minimize

Table I. **Performance of piglets from 10 to 21 days after farrowing with different positions of piglet feeder on the farrowing crate or without piglet feeder.**

Variable	Treatment						SEM	P value
	Front feeder		Back feeder		No feeder			
N litters	15		15		15		-	-
N piglets	180		180		180		-	-
Body weight day 10, kg	2.897		2.895		2.894		0.037	0.985
Body weight day 15, kg	3.788	A	3.430	B	3.457	B	0.051	<0.0001
ADG 10-15 days, kg/day	0.178	A	0.107	B	0.113	B	0.010	<0.0001
Body weight day 21, kg	5.038	A	4.636	B	4.737	B	0.071	0.0001
ADG 10-21 days, kg/day	0.195	A	0.158	B	0.168	B	0.006	0.0001
ADFI 10-15 days, g/day	1.938	A	1.729	A	0.000	B	0.098	<0.0001
ADFI 10-21 days, g/day	2.156	A	2.006	A	0.000	B	0.086	<0.0001

Front feeder: Feeder for the piglets on the side of the head of the sow on the front of the farrowing crate; Back feeder: Feeder for the piglets on the side of the hind of the sow on the back of the farrowing crate; No feeder: No feeder for the piglets on the farrowing crate; SEM: Standard error of the mean; ADG: Average daily gain; ADFI: Average daily feed intake; Within a row, means with different letters differ by Tukey test (P < 0.05).

the impact of heat stress on the performance of the piglets, especially because it can fill the gap between the increased nutritional needs of suckling piglets and the nutrients provided by the lactating sow, and further adapt the piglet to the feed provided after weaning (Lee & Kim 2018).

It is known that during the last phase of the lactation period, from 21 to 28 days of age, milk production decreases by 12.5% (Whittemore & Morgan 1990) and the metabolizable energy intake of piglets increases (NRC 2012). Some authors (Kuller et al. 2007, Sulabo et al. 2010) suggested that the use of creep feed may be dependent on the age and not on how many days it is offered to the litter. However, they commented that the increase in creep feed intake is directly related to the increased demand for nutrients by litter. We also should consider that creep feed is especially beneficial for piglets raised in large litters (Barnett et al. 1989), as with the current hyperprolific sows.

The greater body weight and average daily gain observed in the piglets of the FF confirm that piglets need extra sources of energy and nutrients particularly for heat stressed sows, similar results of piglet performance improvement were also observed by Lee & Kim (2018) and Heo et al. (2018).

However, the impact of creeping feeding is inconsistent in the literature. Some researchers (Sulabo et al. 2010, Yan et al. 2011, Muns & Magowan 2018) that did not find any effect of creep feeding on piglet performance during the pre-weaning period. Nevertheless, other researchers have stated beneficial effects of creep feeding on the post weaning performance of the animals, as the consumption of a dry, grain-based diet induces the maturation of digestive enzyme secretion (Owsley et al. 1986), acid production (Cranwell et al. 1976) and nutrient absorption in the small intestine (De Passillé et al. 1989). In addition, it has been reported that piglets that consume creep feed may become familiar with a solid diet earlier

Table II. Piglets behaviour at 10-11, 15-16, and 20-21 days after farrowing with different positions of piglet feeder on the farrowing crate or without piglet feeder.

Variable	Treatment						SEM	P value
	Front feeder		Back feeder		No feeder			
Behaviour 10-11 days								
Sleeping, %	43.92		46.83		46.18		3.67	0.341
Suckling, %	21.70		21.97		22.35		3.27	0.808
Comfort, %	3.45		3.73		4.20		1.72	0.701
At feeder, %	0.45	A	0.58	A	0.00	B	0.38	0.0007
At drinker, %	0.12		0.20		0.29		0.20	0.202
Belly Nosing, %	0.39		0.69		1.12		0.75	0.213
Playing, %	0.46		0.64		0.73		0.50	0.582
Agonistic, %	0.28		0.34		0.39		0.22	0.699
Ludic, %	0.14		0.29		0.28		0.30	0.229
Interaction, %	1.03		1.60		1.66		0.81	0.225
Standing, %	1.60		1.13		2.12		1.01	0.169
Agglomerated, %	19.73		15.70		15.58		4.83	0.135
Lying, %	3.11		3.00		2.75		1.06	0.948
Seated, %	0.36		0.27		0.44		0.25	0.525
Rooting, %	3.27		3.04		1.93		2.06	0.552
Behaviour 15-16 days								
Sleeping, %	52.73		50.31		49.21		4.61	0.182
Suckling, %	22.00		24.44		23.78		3.80	0.428
Comfort, %	1.90		1.93		3.44		1.40	0.055
At feeder, %	0.74	A	0.80	A	0.00	B	0.49	0.0007
At drinker, %	0.29		0.29		0.36		0.25	0.623
Belly Nosing, %	0.21		0.62		0.79		0.73	0.307
Playing, %	0.52		0.65		0.68		0.49	0.597
Agonistic, %	0.33		0.47		0.49		0.38	0.463
Ludic, %	0.20		0.21		0.38		0.22	0.160
Interaction, %	1.38		1.58		1.88		0.97	0.694
Standing, %	1.01		0.46		1.41		1.01	0.178
Agglomerated, %	10.77		10.02		10.54		3.77	0.926
Lying, %	2.81		2.50		3.10		1.40	0.522
Seated, %	0.20		0.22		0.37		0.20	0.183
Rooting, %	4.91		5.51		3.58		2.26	0.242
Behaviour 20-21 days								
Sleeping, %	57.04		55.71		52.31		5.87	0.639
Suckling, %	22.26		23.55		24.78		4.24	0.861

Table II. Continuation

Comfort, %	1.80		1.55		4.03		2.04	0.117
At feeder, %	1.28	A	1.63	A	0.00	B	0.95	0.001
At drinker, %	0.28		0.24		0.31		0.21	0.948
Belly Nosing, %	0.20	B	0.45	AB	0.84	A	0.48	0.015
Playing, %	0.65		0.55		1.06		0.74	0.173
Agonistic, %	0.23		0.26		0.48		0.31	0.616
Ludic, %	0.12		0.18		0.32		0.22	0.090
Interaction, %	1.17		1.70		1.39		1.14	0.767
Standing, %	0.91		0.56		1.17		0.73	0.310
Agglomerated, %	4.19		4.73		5.58		3.14	0.830
Lying, %	3.12		2.67		3.36		1.17	0.331
Seated, %	0.49		0.19		0.38		0.50	0.610
Rooting, %	6.25		6.04		3.99		2.86	0.408

Front feeder: Feeder for the piglets on the side of the head of the sow on the front of the farrowing crate; Back feeder: Feeder for the piglets on the side of the hind of the sow on the back of the farrowing crate; No feeder: No feeder for the piglets on the farrowing crate; SEM: Standard error of the mean; Within a row, means with different letters differ by Dunn´s test (P < 0.05).

and begin to consume feed more quickly after weaning (Bruininx et al. 2002, López-Vergé et al. 2015).

Although they also received food in the feeder, piglets from the BF treatment had lessor body weight and weight gain compared to piglets from the FF treatment. To start eating unfamiliar foods, younger animals rely on older, more experienced animals to learn about what, or how to eat. Piglets can learn to consume solid food through social facilitation, as they have the opportunity to imitate their mother by eating feed (Wattanakul et al. 2005). Perhaps because they received feed closer to their mothers' heads, FF piglets were quicker to learn how to feed and thus had better productive performance. Other aspect that could had impact the performance of the piglets of the BF group are the sanitary conditions, as the feed may have been contaminated with feces and urine since the feeder was near the rear part of the sow.

Another important observation that must be highlighted which can demonstrate that piglets are more satiated and in better welfare is the less frequent observation of belly nosing behavior of piglets receiving feed (FF and BF). According to Colson et al. (2006), belly nosing is a behavior that predicts that the animal is in a state of stress. The greater frequency of this behavior in NF piglets, which averaged 0.84% of the time lying or standing, pushing the abdomen, front or rear of another piglet or its mother with its nose, may be related to low amount of mother's milk. Therefore, this stress-indicating behavior suggests that NF piglets were not receiving adequate amount of nutrients from their sow's milk production.

Time spend at the creep feeder and amount of feed consumed by piglets were greater with increased lactation age. Similar results were found by Barnett et al. 1989, Bruininx et al. 2002, Huting et al. 2017). This was expected as at the end of the lactation period the piglets' nutrient requirements increase and the sows are not able to fulfill the pigs' requirements with their level of milk production (Barber et al. 1955, Algers et al. 1990). Therefore, at later stages of the lactation, piglets should pass some threshold of digestive maturity, so that even the smaller piglets can consume and assimilate creep feed and compensate for the poor gains they were achieving from milk (Pajor et al. 1991).

Heat stressed sows spend more time lying in a lateral position because this position sows increases the animal surface in contact with the floor compared to sternal lying, increasing heat loss through conduction. In our study sows spent approximately 75% of the time in lateral recumbency, similar results were found by Muns et al. (2016) and Canaday et al. (2013) evaluating the behavior of heat stressed sows. Added to that sows in our trial spend approximately 3.85% at the drinker on the last evaluation period,

Table III. **Sows behaviour at 10-11, 15-16, and 20-21 days after farrowing with different positions of piglet feeder on the farrowing crate or without piglet feeder.**

Variable	Treatment			SEM	P value
	Front feeder	Back feeder	No feeder		
Behaviour 10-11 days					
At drinker, %	3.78	3.16	4.12	2.50	0.751
At feeder, %	4.18	4.54	4.62	1.87	0.747
Stereotypes, %	0.13	0.43	0.80	0.89	0.596
Ventral recumbency, %	16.90	14.47	21.81	14.81	0.751
Lateral recumbency, %	73.19	75.59	66.57	14.76	0.410
Standing, %	1.81	1.81	2.09	1.00	0.768
Behaviour 15-16 days					
At drinker, %	2.91	1.74	2.98	2.19	0.311
At feeder, %	4.64	4.40	3.66	1.42	0.545
Stereotypes, %	0.74	0.58	0.75	0.89	0.892
Ventral recumbency, %	17.23	16.54	23.26	15.58	0.634
Lateral recumbency, %	73.31	74.79	67.58	15.71	0.699
Standing, %	1.17	1.96	1.77	1.62	0.375
Behaviour 20-21 days					
At drinker, %	3.62	3.82	4.13	2.29	0.891
At feeder, %	5.84	5.64	5.07	1.52	0.549
Stereotypes, %	0.26	0.18	0.75	0.48	0.363
Ventral recumbency, %	16.67	12.28	11.61	9.35	0.731
Lateral recumbency, %	71.55	76.52	77.25	10.12	0.664
Standing, %	2.06	1.56	1.20	1.49	0.872

Front feeder: Feeder for the piglets on the side of the head of the sow on the front of the farrowing crate; Back feeder: Feeder for the piglets on the side of the hind of the sow on the back of the farrowing crate; No feeder: No feeder for the piglets on the farrowing crate; SEM: Standard error of the mean.

similar results are shown by Parois et al. (2018) for heat stressed sows that were not with cooling pads turned on.

CONCLUSIONS

Suckling piglets raised under a hot climate environment, have greater growth performance when they receive creep feeding positioned in the front of the farrowing crate, next to their mothers' heads.

Piglets that do not receive any type of feeding during lactation show a greater frequency of stereotypic behavior such as belly nosing which is indicative of stress.

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REFERENCES

ADELEYE OO, GUY JH & EDWARDS SA. 2014. Exploratory behaviour and performance of piglets fed novel flavoured creep in two housing systems. Anim Feed Sci Tech 19: 91-97.

ALGERS B, JENSEN P & STEINWALL L. 1990. Behaviour and weight changes at weaning and regrouping of pigs in relation to teat quality. Appl Anim Behav Sci 26: 143-155.

BARBER RS, BRAUDE R & MITCHELL KG. 1955. Studies on milk production of Large White Pigs. J Agr Sci 46: 7-18.

BARNETT KL, KORNEGAY ET, RISLEY CR, LINDEMANN MD & SCHURIG GG. 1989. Characterization of creep feed consumption and its subsequent effects on immune response, scouring index and performance of weanling pigs. J Anim Sci 67: 2698-2708.

BRUININX EM, BINNENDIJK GP, VAN DER PEET-SCHWERING CMC, SCHRAMA JW, DEN HARTOG LA, EVERTS H & BEYNEN AC. 2002. Effect of creep feed consumption on individual feed intake characteristics and performance of group-housed weanling pigs. J Anim Sci 80: 1413-1418.

CABEZÓN FA, SCHINCKEL AP, RICHERT BT, PERALTA WA & GANDARILLAS M. 2017. Technical Note: Application of models to estimate daily heat production of lactating sows. Prof Anim Sci 33: 357-362.

CABEZÓN FA, SCHINCKEL AP, RICHERT BT, STEWART KR, GANDARILLAS M & PERALTA WA. 2016. Analysis of lactation feed intakes for sows including data on environmental temperatures and humidity. Prof Anim Sci 32: 333-345.

CANADAY DC, SALAK-JOHNSON JL, VISCONTI AM, WANG X, BHALERAO K & KNOX RV. 2013. Effect of variability in lighting and temperature environments for mature gilts housed in gestation crates on measures of reproduction and animal well-being. J Anim Sci 91: 1225-1236.

COLE DJA. 1990. Nutritional strategies to optimize reproduction in pigs. J Reprod Fertil Suppl Supplement 40: 67-82.

COLSON V, ORGEUR P, FOURY A & MORMÈDE P. 2006. Consequences of weaning piglets at 21 and 28 days on growth, behaviour and hormonal responses. Appl Anim Behav Sci 98: 70-88.

CRANWELL PD, NOAKES DE & HILL KT. 1976. Gastric secretion and fermentation in the sucking pig. Br J Nutr 36: 71-86.

D'ALLAIRE S, DROLET R & BRODEUR D. 1996. Sow mortality associated with high ambient temperatures. Can Vet J 37: 237-239.

DE BRAGANÇA MM, MOUNIER AM & PRUNIER A. 1998. Does feed restriction mimic the effects of increased ambient temperature in lactating sows? J Anim Sci 76: 2017-2024.

DE PASSILLÉ AM, PELLETIER B, MENARD G & MORISSET J. 1989. Relationships of weight gain and behavior to digestive organ weight and enzyme activities in piglets. J Anim Sci 67: 2921-2929.

HEO PS, KIM DH, JANG JC, HONG JS & KIM YY. 2018. Effects of different creep feed types on pre-weaning and post-weaning performance and gut development. Asian-Australasian J Anim Sci 31: 1956-1962.

HUTING AMS, ALMOND K, WELLOCK I & KYRIAZAKIS I. 2017. What is good for small piglets might not be good for big piglets: The consequences of cross-fostering and creep feed provision on performance to slaughter. J Anim Sci 95: 4926-4944.

KULLER WI, SOEDE NM, VAN BEERS-SCHREURS HMG, LANGENDIJK P, TAVERNE MAM, KEMP B & VERHEI-JDEN JHM. 2007. Effects of intermittent suckling and creep feed in-take on pig performance from birth to slaughter. J Anim Sci 85: 1295-1301.

KULLER WI, TOBIAS TJ & VAN NES A 2010. Creep feed intake in unweaned piglets is increased by exploration stimulating feeder. Livest Sci 129: 228-231.

LEE SI & KIM IH. 2018. Creep feeding improves growth performance of suckling piglets. R Bras Zootec 47: e20170081.

LÓPEZ-VERGÉ S, SOLÀ-ORIOL D & GASA J. 2015. Is the lactation period the main variable responsible for reducing the efficiency of the swine production? J Anim Sci 93: 184-184.

MIDDELKOOP A, CHOUDHURY R, GERRITS WJJ, KEMP B, KLEEREBEZEM M & BOLHUIS JE. 2018. Dietary diversity affects feeding behaviour of suckling piglets. Appl Anim Behav Sci 205: 151-158.

MUNS R & MAGOWAN E. 2018. The effect of creep feed intake and starter diet allowance on piglets' gut structure and growth performance after weaning. J Anim Sci 96: 3815-3823.

MUNS R, MALMKVIST J, LARSEN MLV, SØRENSEN D & PEDERSEN LJ. 2016. High environmental temperature around farrowing induced heat stress in crated sows. J Anim Sci 94: 377-384.

NICOL C. 2006. How animals learn from each other. Appl Anim Behav Sci 100: 58-63.

NRC - NATIONAL RESEARCH COUNCIL. 2012. Nutrient requirements of swine, 11th ed., Washington: The National Academies Press, 420 p.

OWSLEY WF, ORR DE & TRIBBLE LF. 1986. Effects of age and diet on the development of the pancreas and the synthesis and secretion of pancreatic enzymes in the young pig. J Anim Sci 63: 497-504.

PAJOR EA, FRASER D & KRAMER DL. 1991. Consumption of Solid Food by Suckling Pigs: Individual Variation and Relation to Weight Gain. Appl Anim Behav Sci 32: 139-155.

PAROIS SP, CABEZÓN FA, SCHINCKEL AP, JOHNSON JS, STWALLEY RM & MARCHANT-FORDE JN. 2018 Effect of Floor Cooling on Behavior and Heart Rate of Late Lactation Sows Under Acute Heat Stress. Front Vet Sci 5: 223.

PRUNIER A, BRAGANÇA MM & LE DIVIDICH J. 1997. Influence of high ambient temperature on performance of reproductive sows. Livest Prod Sci 52: 123-133.

RIBEIRO BPVB, LANFERDINI E, PALENCIA JYP, LEMES MAG, ABREU MLT, CANTARELLI VS & FERREIRA RA. 2018. Heat negatively affects lactating swine: A meta-analysis. J Therm Biol 74: 325-330.

RENAUDEAU D. 2005. Effects of short-term exposure to high ambient temperature and relative humidity on thermoregulatory responses of European (Large White) and Carribbean (Creole) restrictively fed growing pigs. Anim Res 54: 81-93.

RENAUDEAU D, NOBLET J & DOURMAD JY. 2003. Effect of ambient temperature on mammary gland metabolism in lactating sows. J Anim Sci 81: 217-231.

SCHINCKEL AP, SCHWAB CR, DUTTLINGER VM & EINSTEIN ME. 2010. Analyses of Feed and Energy Intakes During Lactation for Three Breeds of Sows. Prof Anim Sci 26: 35-50.

SULABO RC, JACELA JY, TOKACH MD, DRITZ SS, GOODBAND RD, DEROUCHEY JM & NELSSEN JL. 2010. Effects of lactation feed intake and creep feeding on sow and piglet performance. J Anim Sci 88: 3145-3153.

WATTANAKULA W, BULMANB CA, EDGEB HL & EDWARDS SA. 2005. The effect of creep feed presentation method on feeding behaviour, intake and performance of suckling piglets. Appl Anim Behav Sci 92: 27-36.

WILLIAMS AM, SAFRANSKI TJ, SPIERS DE, EICHEN PA, COATE EA & LUCY MC. 2013. Effects of a controlled heat stress during late gestation, lactation, and after weaning on the thermoregulation, metabolism, and reproduction of primiparous sows. J Anim Sci 91: 2700-2714.

WHITTEMORE CT & MORGAN CA. 1990. Model components for the determination of energy and protein requirements for breeding sows: a review. Livest Prod Sci 26: 1-37.

YAN L, JANG HD & KIM IH. 2011. Creep Feed: Effects of Feed Flavor Supplementation on Pre- and Post-weaning Performance and Behavior of Piglet and Sow. J Anim Sci 24: 851-856.

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