Immunocrit, colostrum intake, and preweaning body weight gain in piglets after split suckling based on birth weight or birth order[1]

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ABSTRACT: Preweaning survival and growth are compromised in litters with larger numbers of piglets. We evaluated two approaches for altering initial nursing with the goal to improve access to colostrum by groups of piglets that are known to have reduced access to colostrum. Therefore, we temporarily (1.5 h) removed either the heaviest six piglets in the litter (WT) or the first half of the piglets born (ORD) to provide a short period of nursing with reduced competition for the remaining piglets. We found that WT piglets were heavier ($P \leq 0.05$) at 7 d after farrowing and gained more body weight (BW) from farrowing to day 7 than control (CON) piglets which were raised in litters with ad libitum nursing during the same period. Further, we found that the heaviest piglets consumed more ($P < 0.001$) colostrum and gained more ($P < 0.001$) BW during the preweaning period but did not have ($P > 0.10$) greater immunocrits. Although ORD piglets had similar colostrum intake, immunocrits, and preweaning weights as controls, we found that overall the piglets born in the first half of litters had greater ($P < 0.01$) immunocrits than piglets born in the last half of the litter. Therefore, both birth weight and birth order have effects on traits that are important for prenatal growth and survival, but they differ in that birth weight is more closely related to colostrum intake and birth order affects immunocrit.

Key words: colostrum, nursing, pig

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INTRODUCTION

Genetic selection and management have substantially increased litter size in pigs. However, these improvements are constrained from their full impact by a negative relationship between increased litter size and individual birth weights, piglet survival, and performance (Kerr and Cameron, 1995; Roehe, 1999; Sorensen et al., 2000; Feldpausch et al., 2016). In part, this situation might be addressed by ensuring adequate colostrum consumption soon after birth (Le Dividich and Noblet, 1984; Herpin et al., 1994, Sangild, 2003). Because low birth weight (LBW) piglets and piglets born later in the birth order often do not receive adequate colostrum (Dividich et al., 2005; De Vos et al., 2014), these piglets are considered critical for managing colostrum access.

A procedure to increase access to colostrum by disadvantaged groups of piglets is the temporary

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removal of part of the litter (split suckling) soon after farrowing. The goal of split suckling is to reduce competition for colostrum. Here, we report evaluation of two protocols for split suckling that are individually based on birth weight or birth order. To evaluate these methods, we determined colostrum intake, immunocrit, and piglet body weight (BW) throughout lactation.

MATERIALS AND METHODS

The Institutional Animal Care and Use Committee at Kansas State University reviewed and approved the protocol for this experiment.

Split Suckling Treatments

Thirty sows (DNA Line 241, n = 10 per treatment, balanced by parity) were observed when they neared farrowing. Time of the first piglet born was recorded. At birth each piglet (n = 412, sired by DNA line 610) was dried with a towel and the umbilical cord tied and trimmed to approximately 1.2 cm. Piglets were weighed, ear tagged, and returned to the farrowing crate directly behind the sow.

Treatments were randomly assigned to litters and were: 1) controls, all piglets allowed to suckle ad libitum (CON); 2) weight-based separation, the six heaviest piglets were removed for 1.5 h (WT); or 3) birth-order-based separation, the first half of the litter born was removed for 1.5 h (ORD). Birth order was defined as the sequence of piglets born and, for litters with an odd number of piglets, the number of piglets separated was one less than the number allowed to nurse. Birth weight categories were LBW (<1.11 kg), middle birth weight (MBW; ≥1.11 and <1.45 kg), and high birth weight (HBW; ≥1.45 kg). Almost all sows completed farrowing by 4.5 h after birth of the first piglet and litter separation began at 6 h after the first piglet was born. Two WT sows and one ORD sow had farrowing durations between 4.5 and 7.5 h and separations began 9 h after birth of the first piglet. Sows that had a farrowing duration longer than 7.5 h or farrowed fewer than nine live piglets were not included in the experiment.

During separation from the sow, the piglets were placed in plastic storage boxes behind the farrowing crate and a heat lamp was used to prevent chilling. The piglets that remained with the sows were observed to confirm at least one successful suckling occurred during separation. After 1.5 h, all piglets were returned to the sow and allowed to nurse ad libitum.

Piglets were weighed 24 h after birth of the first piglet and blood (0.5 mL) collected from a cephalic or mammary vein. After clotting, the serum was separated by centrifugation (18,000 × g, 4 °C) and frozen (−80 °C) until analysis. Cross fostering was done between 24 and 48 h after birth by moving piglets within treatment to standardize litter size (n = 11 to 15 piglets) nursed. Most nursing litters were 13 or 14 piglets (9, 8, and 8 for CON, WT, and ORD, respectively) and averaged 13.2, 12.9, and 13.1 for CON, WT, and ORD, respectively. Piglets were weighed 7 and 20 d postpartum. No scours or other disease problems were observed during the experiment and pigs not surviving to day 20 died from failure to grow or were apparently crushed during the nursing period.

Immunocrit and Colostrum Intake

Immunocrits were determined according to Vallet et al. (2013). Briefly, serum was combined with 40% (wt/vol) ammonium sulfate in distilled water (50 µl each) to precipitate immunoglobulins and then loaded into hematocrit centrifuge tubes and centrifuged (12,000 x g) for 10 min at room temperature. Immunocrit was determined by the ratio of the precipitate length divided by the total length of diluted serum and ranged from 0.0 to 0.3. Colostrum intake was estimated from the first 24 h gain in BW as described by Amdi et al. (2013). First 24 h gain was determined as the 24 h BW-birth weight before nursing.

Statistics The assignment of piglets to the experiment is presented in Table 1. Data were analyzed using Proc GLIMMIX of SAS (Version 9.4, SAS Institute Inc., Cary, NC) as a split-plot design. The model included treatment, birth weight category, birth order, treatment × birth weight category, treatment × birth order, and birth weight category × birth order interactions. Sow was the experimental unit and sow within treatment was the random statement. Simple correlations were evaluated using Proc Corr of SAS between weight, and immunocrit and colostrum intake. Data were considered significant at $P \le 0.05$ and a tendency at $P \le 0.10$.

RESULTS

Nursing treatments did not differ for birth weight, 24 h gain, day 1 BW, day 20 BW, overall (day 0 to 20) gain, colostrum intake, or immunocrit ($P > 0.10$; Tables 2 and 3). Weight-based split nursing resulted in greater ($P = 0.04$) BW gain to day 7 and day 7 BW ($P = 0.05$) compared with controls. No ($P > 0.10$) treatment by birth weight category interactions was observed.

Piglets in the HBW classification had greater ($P < 0.001$; Table 4) weight gain and BW at birth and days 1, 7, and 20 compared with MBW and LBW piglets, and there were no ($P > 0.10$) birth weight category by treatment or birth weight category by birth-order interactions for weights or gains. HBW piglets consumed more ($P < 0.001$; Table 5) colostrum than MBW and LBW piglets, and MBW piglets consumed more colostrum than LBW piglets. Immunocrit was not ($P > 0.10$) affected by birth weight category. There was no ($P > 0.10$) birth weight category by treatment or birth order by treatment (Table 5) interactions for colostrum intake or immunocrit.

Piglets born in the first half of the litter tended ($P \leq 0.10$) to be heavier at birth and to have greater BW gain to day 7 (Table 6) and had greater ($P = 0.01$) immunocrits (Table 7) than piglets born in the second half of the litter.

Overall, there was a negative correlation ($P < 0.0001$) between the number of piglets born alive/litter and birth weight (−0.367), 24 h weight (−0.413), colostrum intake (−0.40), and immunocrit (−0.206). There was a positive correlation between colostrum intake and immunocrit ($P < 0.0001$; Table 8), and the correlations between colostrum intake and weight at birth and days 1, 7, and 20 were between 0.44 and 0.61 ($P < 0.0001$). The correlations between immunocrit and weights at birth and day 7 were low and nonsignificant ($P > 0.10$). Correlations between immunocrit and BW at 24 h and 20 d after farrowing were 0.13 ($P < 0.05$).

Table 1. Experimental design

	Birth weight category[†]			
Nursing treatment[*]	HBW	MBW	LBW	Total
CON	57	53	22	132/10[‡]
WT	60	48	29	137/10
ORD	41	52	50	143/10
Total	158	153	101	412/30

[*]CON = control, ad libitum nursed; WT = the heaviest half of the piglets were removed for 1.5 h; ORD = the first half of the piglets born were removed for 1.5 h.

[†]HBW ≥ 1.45 kg; MBW ≥ 1.11; LBW < 1.11 kg.

[‡]Pigs/litters.

Table 2. BW and gain of piglets as affected by treatment

	Treatment[*]				*P*-value	
Weight, kg	CON	WT	ORD	SEM	Treatment	Treatment × birthweight category
Birth weight	1.27	1.28	1.27	0.02	0.92	0.21
24 h gain	0.105	0.118	0.107	0.016	0.85	0.82
Day 1 BW	1.38	1.40	1.38	0.027	0.79	0.31
Day 7 gain	1.14[a]	1.33[b]	1.20[a]	0.051	0.04	0.47
Day 7 BW	2.44[a]	2.65[b]	2.50[a]	0.058	0.05	0.38
Day 20 gain	4.30	4.58	4.20	0.17	0.47	0.91
Day 20	5.61	5.89	5.48	0.18	0.24	0.89

*Control (CON), weight-based split suckling (WT), and birth-order based split suckling (ORD).

[a,b] Means with different superscripts differ ($P < 0.05$).

Table 3. Colostrum intake, immunocrit, and survival to day 20 as affected by treatment

	Treatment[*]					*P*-value
	CON	WT	ORD	SEM	Treatment	Treatment × birthweight category
Colostrum intake[†], g	246.34	273.94	267.16	21.61	0.64	0.81
Immunocrit	0.145	0.152	0.148	0.009	0.87	0.13
Survival to day 20, %	86.4	88.3	85.3			

[*]Control (CON), weight-based split suckling (WT), birth-order based split suckling (ORD).

[†]Intake was estimated from the first 24 h gain in BW as described by Amdi et al. (2013).

Table 4. Effects of birth weight category on weight and gain of piglets

	Birth weight category*				*P*-value		
Weight, kg	HBW	MBW	LBW	SEM	Birth weight category	Treatment × birth weight category	Birth weight category × birth order
Birth weight	1.63	1.30	0.90	0.017	<0.001	0.21	0.39
24 h gain	0.142	0.115	0.074	0.01	<0.001	0.82	0.38
Day 1 BW	1.76	1.40	0.99	0.022	<0.001	0.31	0.70
Day 7 gain	1.43	1.3	0.94	0.044	<0.001	0.47	0.54
Day 7 BW	3.07	2.61	1.90	0.052	<0.001	0.38	0.81
Day 20 gain	4.78	4.51	3.79	0.141	<0.001	0.91	0.93
Day 20 BW	6.40	5.82	4.76	0.15	<0.001	0.89	0.94

*HBW ≥ 1.45 kg; MBW ≥ 1.11; LBW < 1.11 kg.

Table 5. Effects of birth weight category on colostrum intake and immunocrit

	Birth weight category[1]					*P*-value
	HBW	MBW	LBW	SEM	Birth weight category	Treatment × birth weight category
Colostrum intake, g	311.3[a]	266.0[b]	210.1[c]	15.52	<0.001	0.81
Immunocrit	0.147	0.152	0.146	0.017	0.42	0.13
Survival to d 20, %	87.3	87.2	85.6			

*HBW ≥ 1.45 kg; MBW ≥ 1.11; LBW < 1.11 kg.

[a,b,c]Means with different superscripts differ ($P < 0.001$).

Table 6. BW and gain of piglets as affected by birth order

	Birth order*			*P*-value		
Weight, kg	First half	Second half	SEM	Birth order	Birth order × treatment	Birth order × birth weight category
Birth weight	1.29	1.26	0.013	0.09	0.14	0.39
24 h gain	0.11	0.11	0.009	0.33	0.13	0.38
Day 1 BW	1.39	1.37	0.017	0.21	0.19	0.70
Day 7 gain	1.25	1.20	0.033	0.10	0.18	0.54
Day 7 BW	2.55	2.50	0.038	0.25	0.21	0.81
Day 20 gain	4.40	4.32	0.107	0.42	0.84	0.93
Day 20 BW	5.70	5.62	0.110	0.39	0.81	0.94

*Birth-order categories are determined by the sequence of piglets born. For litters with an odd number of piglets, the number of piglets in the first half was one less than the number in the second half.

Table 7. Effects of birth order on colostrum intake and immunocrit

	Birth order			*P*-value		
	First half	Second half	SEM	Birth order	Birth order × treatment	Birth order × birth weight category
Colostrum intake, g	267.15	257.81	13.20	0.31	0.13	0.42
Immunocrit	0.155	0.142	0.006	0.01	0.46	0.98

Table 8. Correlations between immunocrit, colostrum intake, and preweaning weights

	Colostrum intake	Birth weight	Day 1 BW	Day 7 BW	Day 20 BW
Immunocrit	0.4940	0.0355	0.1341	0.0804	0.1271
P	<0.0001	0.4789	0.0072	0.1265	0.0163
n	400	400	401	363	357
Colostrum intake		0.4433	0.6189	0.5547	0.4784
P		<0.0001	<0.0001	<0.0001	<0.0001
n		400	400	362	356

DISCUSSION

Colostrum intake is needed to supply initial energy before piglets deplete their glycogen reserves for energy and thermogenesis (Gondret et al., 2011) and for a maternal supply of immunoglobulins. Allowing LBW piglets or piglets born later to nurse without competing with their larger or earlier-born litter mates could allow them to have as many as two milk ejection time periods in the 1.5 h split suckling provided in our experiment (Dividich et al., 2005). Providing more access to colostrum is expected to improve survival by allowing more piglets to consume at least 150 g colostrum/kg of BW as recommended by De Vos et al. (2014). Colostrum quality changes as it transitions to milk (Dividich et al., 2005). Therefore, early spilt suckling as applied in this experiment may be an effective management to improve access to colostrum by piglets disadvantaged by being late in the birth order.

In our experiment, a 1.5 h removal of the heaviest piglets improved piglet BW at day 7 and gain to day 7 but did not change other measures of preweaning growth. Removing the first half of piglets born did not affect BW, gain, colostrum intake, or immunocrit. However, evaluation of all the data revealed that HBW piglets consumed more colostrum but did not have greater immunocrits and that piglets born early in the birth order had greater immunocrits but not increased colostrum intakes. These findings are generally in agreement with Cabrera et al. (2012) who reported that birth order and sow colostral immunoglobulin G (IgG) affected piglet serum IgG but there was no relationship of birth weight and piglet IgG. The lack of relationship in our data between birth weight and immunocrit may be due to variation in colostral IgG as reported by Cabrera et al. (2012) and its effect on piglet IgG. Therefore, both increasing colostral IgG and colostrum intake may be important for increasing piglet immunocrit.

Correlation analysis revealed that both birth weight and birth order had important effects on the critical traits of BW gain, colostrum intake and immunocrits. We found that number of piglets born alive was correlated negatively with birth weight, BW gain, colostrum intake, and immunocrit. This confirms the generally accepted idea that when more piglets compete for limited quantities of colostrum the amount per piglet may be inadequate. Weight-based split suckling may be the most commonly applied method for split suckling because most farrowing workers do not record birth order (Donovan and Dritz, 2000).

From our results and those of Cabrera et al. (2012), it appears that both litter order and piglet birth weight affect access to colostrum and maternal IgG but their effects differ with birth weight more strongly affecting colostrum intake and birth order having a greater effect on immunocrit. Taking into account both of these effects along with sow colostral IgG will be important as the swine industry continues to increase litter size born. Further, it would be useful to evaluate a split suckling strategy that included both birth weight and birth order. Future research could evaluate the effects of providing the small piglets in the second half of the birth-order access to nursing without competition by their early born, heavier littermates. This strategy might provide maximum benefit for the most challenged piglets in the litter.

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