PRE-FARROWING PREDICTION OF LITTER SIZE: TOWARDS IMPROVING SOW METABOLIC STATUS DURING THE PERI-PARTUM PERIOD

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Executive Summary

Rising feed prices are making it increasingly difficult for pig producers to maintain profit margins. It is, therefore, essential that feed or nutrient intake closely match sow requirements for optimal body composition and reproduction. Optimal reproductive performance and sow longevity can be achieved by maximizing energy and lysine intake during lactation. However, the optimal feeding strategy for gestating sows is less clear and is complicated by the need to satisfy maternal and fetal requirements for growth, as well as ensuring the sow is adequately prepared for lactation. Failure to achieve these targets can have negative consequences for sow longevity and lactation and reproductive performance, as well as progeny survival and performance.Current gestation feeding strategies normally involve an increase in sow feed intake during the last 3 weeks of gestation intended to ensure nutrient intake for the rapidly developing conceptus is sufficient to maximise birthweight and early post-natal survival. However, early reports of a beneficial effect of higher feeding levels in late gestation on piglet birthweight and survival are contradicted by more recent evidence that late gestation feed intake does not affect piglet birthweight or survival. However, nutrient requirements during gestation appear to be affected by gestated litter size, with first parity sows gestating large litters having lower body condition at first farrowing and an increased probability of lactation failure and premature culling. Consequently, the ability to accurately predict litter size would enable nutrient intake to be matched to maternal and fetal requirements essentially preventing gestation body reserve mobilisation and excessive weight gain in sows gestating large and small litters, respectively.

Therefore, the current study had two overall aims: one, to determine whether plasma oestrone sulphate could be used to accurately predict litter size; and two, to determine the effect of gestated litter size, parity and feeding level on sow and progeny performance. Three studies were conducted. Studies one and two were designed to establish whether feeding and time of day affected peripheral oestrone sulphate levels and to develop a prediction equation for litter size based on oestrone sulphate levels 23 days post-oestrus detection. The third study used 841 sows and compared the effects of parity (primiparous (gilt) versus multiparous), gestated litter size (LARGE; $\geq$12 versus SMALL; < 12) and gestation feeding level from day 85 of gestation to farrowing (HIGH versus LOW) on sow and progeny performance. Based on the data from the sows in studies two and three (n = 959 sows), there was a significant, positive correlation between oestrone sulphate on day 23 of gestation and total litter size ($r2 = 0.143$; $P < 0.05$). However, the accuracy with which oestrone sulphate predicted large and small litters was 60.5% and 63.5%, respectively. In study three, parity and litter size exerted the greatest effect on piglet weights at birth and day 21 of lactation and pre-weaning survival. However, HIGH gestation feeding did positively affect some aspects of piglet birthweight and survival. Specifically, minimum piglet birthweight (BW) tended to be higher, the number of piglets with a BW < 1 kg tended to be lower and the CV% of birthweight was significantly lower for litters from HIGH fed animals, indicating that higher feeding levels in late gestation promote growth of the smaller foetuses. In addition, stillbirth rates tended to be lower for HIGH fed sows. Based on the current data, it appears that HIGH feeding levels in late gestation exert subtle, but potentially, beneficial effects on piglet birthweight. However, these beneficial effects need to be balanced against the additional feed costs associated with HIGH level feeding in late gestation.

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1. Introduction

The rising cost of feed is making it increasingly difficult for pig producers to maintain profit margins. There is, therefore, an increased need to improve breeding herd feed conversion efficiency by closely matching feed or nutrient intake with requirements for optimal body composition and reproduction. While it is generally accepted that optimal reproductive performance and sow longevity can be achieved by maximizing energy and lysine intake during lactation, the optimal feeding strategy for gestating sows is less clear. The development of appropriate gestation feeding strategies is complicated by the need to meet maternal and fetal requirements for growth, as well as ensuring the sow is prepared for lactation. Failure to achieve these targets can have negative consequences for sow longevity and lactation and reproductive performance, as well as progeny survival and performance.

Current gestation feeding strategies normally involve an increase in sow feed intake during the last 3 weeks of gestation. This step up in intake varies, but usually entails an increase of 0.5 to 1.0 kg (i.e. from 2.5 to 3.0 or 3.5 kg), and is designed to ensure nutrient intake for the rapidly developing conceptus is sufficient to maximise birthweight and early post-natal survival. Although, early studies (Einarsson and Rojkittikhun, 1993; Cooper et al., 2001) support a beneficial effect of higher feeding levels in late gestation on piglet birthweight and survival, in a more recent study, Hughes and van Wettere (2012) reported no effect of late gestation feed intake on piglet birthweight or survival. The failure of higher feeding levels to affect piglet birthweight and survival could be attributed to the ability of sows to mobilise body reserves to buffer the developing litter against inadequacies in nutrient intake. By not stepping up sow diets during late gestation it would be possible for producers to save between 23 and 50 kg of feed per sow per year (based on a step up of 0.5 or 1.0 kg, and 2.2 farrowings per sow per year), which on a 1000 sow herd equates to a saving of between 23 or 46 tonnes of feed per year.

However, the failure to provide sows with sufficient nutrient intake during late gestation can have profound, negative consequences both for the sow and progeny. Consequently, it is important to further investigate the effects of late gestation feeding on sow and piglet performance. In particular, recent studies demonstrate that sows which mobilise body reserves during late gestation have lower feed intakes during early lactation and as a consequence experience greater weight loss during lactation and have an increased risk of reproductive failure post-weaning (Mosnier et al. 2010; Mullan et al., 2009). Australian breeding herd data (Bunter, pers.comm) indicated that when litter size is very small (< 6 piglets born), both sow and piglet requirements are met by current gestational feeding regimes. However, primiparous sows gestating large litters have lower body condition at first farrowing, suggesting they are mobilising body reserves to maintain foetal growth, and an increased probability of lactation failure and subsequent culling (Bunter, pers. comm). The ability to identify sows carrying large litters early in lactation would, therefore, enable feed intake to be modified to ensure they attain the appropriate body condition and weight at farrowing. Equally, the feed intake of sows carrying small litters could be modified to prevent excessive weight and fat gain during gestation, with previous studies demonstrating that sows carrying too much fat at farrowing are predisposed to low lactation feed intakes, excessive levels of fat mobilisation during lactation and poor subsequent reproductive performance.

In the pregnant sow, conceptus secreted oestrogens are conjugated with sulphates by the endometrium and enter the maternal circulation. Oestrone sulphate is the predominant oestrogen conjugate present in maternal blood, and has been shown to increase in concentration between day 17 and 30 of pregnancy and decrease thereafter. Importantly, a number of studies have demonstrated a positive relationship between plasma concentrations of oestrone sulphate on days 22 to 28 of gestation and either conceptus number on approximately day 30 of gestation or litter size at term (Stone et al., 1986; Frank et al., 1987; Moenter et al., 1992). However, the majority of these studies involved either small numbers of animals or the collection of samples on a range of days between day 20 and 28 of gestation, with the variation in day of collection reducing the accuracy of any analysis due to naturally occuring chronological increases in oestrone sulphate. For example, 8 conceptuses will produce more oestrogens for conjugation on day 26 of gestation compared to the concentration of oestrogens secreted by 10 conceptuses on day 23, thus making predictions based on samples collected on different days innacurate and invalid. In a recently completed project (Pork CRC project 2D-110) blood samples were collected from pregnant sows in summer and winter (51 and 62 sows, respectively) on days 19, 23 and 27 of gestation and analysed for oestrone sulphate. The key findings from this analyses were that oestrone sulphate on day 23 of gestation was significantly correlated with subsequent litter size ($P < 0.001$; $R^2 = 20\%$), with concentrations on day 27 a poorer predictor of litter size. This finding is consistent with that of Guastad-Aas et al. (2002) in which oestrone sulphate on day 24 but not day 28 were correlated with litter size at term. Importantly, oestrone sulphate concentrations on day 23 were significantly lower ($P < 0.001$) for sows farrowing small (< 10 piglets) compared to large (> 12 piglets) litters, which is consistent with earlier studies concluding that oestrone sulphate could be used to differentiate between sows carrying small (< 5 piglets), medium (6 - 10 piglets) or large (> 11 piglets) (Atkinson and Williamson, 1987) or between sows carrying small (< 10 piglets) or large (> 10 piglets) litters (Guastad-Aas et al., 2002).

In light of these data, the current project had two primary objectives. One, to determine whether plasma levels of oestrone sulphate on day 23 of gestation could be used to accurately predict litter size. Two, to determine whether gestated litter size, maternal parity and late gestation feeding levels affect piglet birthweight and survival, as well as lactation and reproductive performance of the sow.

2. Methodology

Study One: determining the effect of feed consumption on peripheral concentrations of oestrone sulphate

This study was conducted at the University of Adelaide's, Roseworthy Piggery during September 2010 and used seven multiparous Large White / Landrace sows. At first detection of oestrus post-weaning sows were artificially inseminated with a second insemination occurring approximately 24 hours later. On day 22 after first detection of oestrus, ear vein catheters were inserted non-surgically. On day 23 post-first insemination, 3 ml samples were collected at 30 minute intervals over a 7 hour period (15 samples in total per sow). Sampling commenced at 8 am, with sows fed 2.2 kg of a dry sow diet (13.0 MJ/kg DE) at 9 am. Samples were maintained on ice, with centrifugation (2000 rpm for 10 minutes) occurring with 10 minutes of collection, at which point plasma was collected and stored at -20°C until assayed.

Estrone Sulphate was measured in plasma (100ul) by double antibody RIA (Beckman Coulter; DSL5400) according to the manufacturer's instructions. The lowest detectable concentration was 0.05ng/ml

Study Two: Development of prediction equations for litter size based on oestrone sulphate concentrations

This study was conducted at a large commercial breeding sow unit in South Australia. Blood samples were collected from 383 sows on day 23 after first detection of oestrus. Sows received their first insemination within 6 hour of first detection of oestrus, approximately. All sows were inseminated between the 1st and 24th November 2010, with blood sample collection occurring between the 28th November and 21st December, 2010. Blood samples were collected by jugular venepuncture into lithium heparin coated vacutainers. Samples were maintained on ice until processing, with samples centrifuged at 2000 rpm for 15 minutes within 2 hours of collection. Following centrifugation plasma was removed and stored at -20°C until assayed.

The fate of all sows was recorded. Incidences of early pregnancy failure (negative preg check at ultrasound on day 28 - 35 post-insemination), late pregnancy failure (post-pregnancy check) and culling for structural and health reasons were recorded. At farrowing, the number of piglets born alive and dead (stillborns) as well as the number of mummified fetuses were recorded and used to calculate total litter size (total born). The relationship between oestrone sulphate levels and the total number of piglets born was calculated using a simple linear regression (GenStat Version 11, VSN International, England, United Kingdom).

Only samples from sows which maintained their pregnancy and farrowed were assayed, resulting in the collection of oestrone sulphate levels for 135 primiparous and 191 multiparous (parity 3.4 ± 0.11 (Mean ± SEM); range 2 – 7;) sows.

Study Three: Effect of predicted litter size, parity and late gestation feeding level on sow and progeny performance.
Animals, housing and experimental design

This study was conducted at a large commercial breeding sow unit in South Australia. Blood samples were collected from 841 sows on day 23 after first detection of oestrus. Sows received their first insemination within 6 hour of first detection of oestrus, approximately. All sows were inseminated between the 15th August and 24th October 2011, with blood sample collection occurring between the 7th September and 16th November 2011. Blood samples were collected by jugular venepuncture into lithium heparin coated vacutainers. Samples were maintained on ice until processing, with samples centrifuged at 2000 rpm for 15 minutes within 2 hours of collection. Following centrifugation plasma was removed and stored at -20°C until assayed.

The prediction equation developed in study two was used to divide sows into two categories, those with a predicted litter size of 12 or more (LARGE) or less than 12

(SMALL). Within predicted litter size treatment and parity grouping (gilts versus sows), sows were randomly allocated to one of two feeding regimes from day 85 of gestation to farrowing shed entry. However, due to variation in the accuracy with which the total litter size was predicted, further analysis was conducted based on actual litter size. Specifically, there was a prediction accuracy of 66% and 58% for LARGE and SMALL total litter size, respectively.

Consequently, the experimental design was a 2 x 2 x 2 factorial, incorporating two parity groups (gilts versus sows), two litter size groups (LARGE versus SMALL) and two feeding levels from day 85 of gestation until farrowing shed entry (LOW versus HIGH). Feeding levels for gilts were 2.2 kg and 2.8 kg / day for the LOW and HIGH treatments, respectively, and 2.3 kg and 2.9 kg / day for sows in the LOW and HIGH treatment groups, respectively. Diet composition varied slightly throughout the experimental period, therefore mean values are presented here. Gilts were fed a gilt developer diet (14.02 MJ/DE/kg, 15.29% Protein, 3.35% Fat, 3.32% Fibre, 0.70% avail. Lysine) and sows a dry sow diet (13.12 MJ/DE/kg, 14.54% Protein, 3.83% Fat, 4.39% Fibre, 0.54% avail. Lysine). The High feeding level was designed in conjunction with piggery management and designed to be the highest level of intake thought to be achievable for this genotype during late gestation and the late spring / summer period. Throughout gestation sows were housed in straw-based ecoshelters in groups of approximately 100, and fed their daily ration via electronic sow feeders. During lactation gilts were fed a gilt lactation diet (14.2 MJ/DE/kg, 19.3% Protein, 5.26% Fat, 4.33% Fibre, 1.02% avail. Lysine), and sows a diet containing 14.01 MJ/DE/kg, 17.1% Protein, 4.93% Fat, 4.00% Fibre, 0.87% avail. Lysine.

The fate of all gilts and sows was recorded, with all animals which failed to farrow excluded from the analysis. Consequently, data was collected for 337 gilts) and 296 sows (parity 2.8 ± 0.5 (Mean ± SEM); range parity 1 - 4).

Measurements

Litter size data was recorded for all gilts and sows, specifically the total number of piglets born, the number of piglets born alive and dead, as well as the number of mummified foetuses expelled. Total litter weight was recorded within 24 hours of birth, prior to and after cross fostering, as well as at 21 days of age. The number of piglets present on day 21 and at weaning was also recorded. The timing and reason for piglet deaths or removal from the litter were also recorded. Lactation length and subsequent reproductive performance were recorded, specifically weaning to oestrus interval (WOI), pregnancy outcome and litter size data. Daily gestation feed intake was also recorded.

For all litters, cross fostering occurred in the first 24 hours when deemed essential for the health of the piglets and the maintenance of lactation, and was conducted as follows: the heaviest piglets in a litter greater than 14 were cross-fostered out; sows with small litters had heavy piglets cross fostered onto them to a litter size of 10. If required a second cross-fostering occurred 3 days after farrowing, as per normal herd requirements, once live piglet number had been recorded.

A subset of gilts and sows were randomly chosen to have more intensive measures taken. Specifically, sows were weighed and P2 backfat measured on day 85 of gestation, day 1 of lactation and weaning. Piglets were weighed individually at birth, day 3 and 21 of lactation.

The number of animals in each treatment group and each measurement category (normal and intensive) are presented in Table 1.

Table 1 - Total number of gilts and sows, and the number of gilts and sows from which intensive measures were collected, for each treatment group.

Treatment			Total number of sows	Sows used for intensive measures
Parity	Gestation Feeding level	Actual litter size Group		
Gilts	LOW	SMALL	82	52
Gilts	LOW	LARGE	87	53
Gilts	HIGH	SMALL	85	54
Gilts	HIGH	LARGE	83	53
Sows	LOW	SMALL	69	42
Sows	LOW	LARGE	86	65
Sows	HIGH	SMALL	65	46
Sows	HIGH	LARGE	76	53
Gilts			337	206
Sows			269	212
	LOW		324	212
	HIGH		309	206
		SMALL	301	194
		LARGE	332	224

Analysis and calculations

Data is presented as Mean ± SEM, unless stated otherwise. Energy requirements for maintenance (MJ/DE) were calculated as 0.45 x sow body weight $0^{.75}$. Energy requirements for conceptus growth during late gestation (day 110) were calculated as 0.151 MJ DE per kg litter birthweight (adapted from Verstagen et al., 1987) with the efficiency of DE utilisation estimated to be 45% (Noblet et al., 1997). Therefore, the equation used to calculate DE utilised for pregnancy was DE (MJ/d) = (0.151 x total litter birthweight)/0.45.

Treatment effects on all variables measured were analysed using a general analysis of variance (ANOVA) model, unbalanced design. Relationships between variables were analysed using a simple linear regression models. The effect of treatment on pregnancy rates were analysed as a chi-squared. ANOVAs and regressions were conducted using GenStat software Version 11 (VSN International, England, United Kingdom).

3. Outcomes

Study One: determining the effect of feed consumption on peripheral concentrations of oestrone sulphate

On day 28 post-insemination, one sow was found not to be pregnant, and this was confirmed by her oestrone sulphate levels on day 23 post-insemination which 0.1 ng / ml. As a consequence her data was removed from the analysis. Based on the data presented in Figure 1 it is evident that neither feed consumption of time of day affect circulating levels of oestrone sulphate.

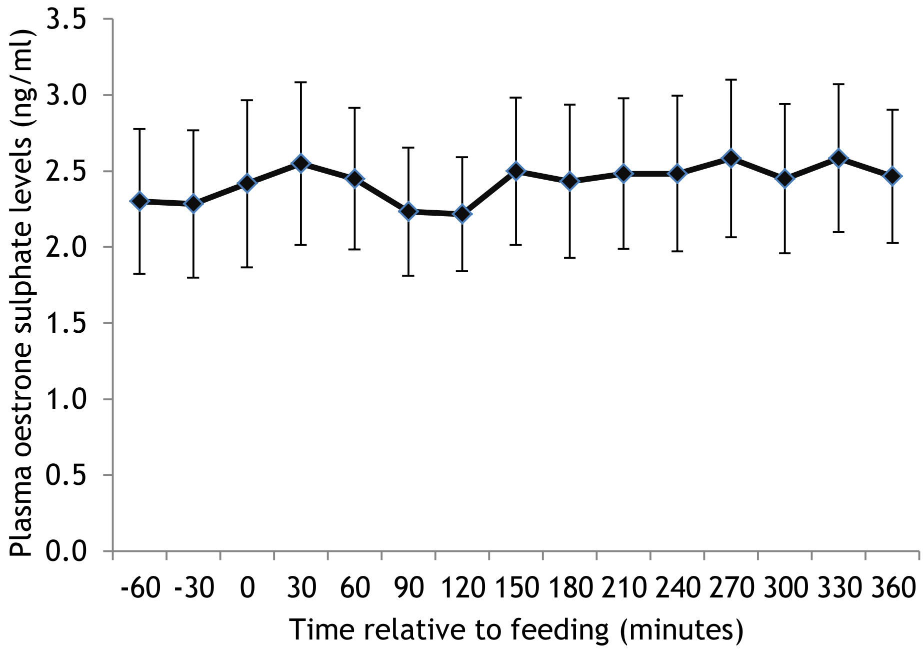

Figure 1 - Oestrone sulphate concentrations present in plasma collected from pregnant sows at 30 minute intervals fron 60 minutes prior to feeding until 360 minutes post-feeding. Sows were fed at 9 am.

Study Two: Development of prediction equations for litter size based on oestrone sulphate concentrations

Summary data for litter size and oestrone sulphate levels is presented in Table 2.

Table 2 - Summary data for oestrone sulphate and litter size

	Oestrone Sulphate (ng/ml)	Total Born	Born Alive	Still born	Mummified fetuses
Mean	2.06	12.0	10.8	1.0	0.17
SEM	0.05	0.23	0.88	0.12	0.03
Minimum	0.2	2.0	0	0	0
Maximum	4.0	20.0	18	12	2
Lower quartile	1.5	10.0	9.0		
Median	2.0	12.0	11.0		
Upper Quartile	2.6	14.0	13.0		

There was a significant, positive correlation between oestrone sulphate levels on day 23 post-first insemination and the total number of piglets born ($R^2 = 0.1778$; $P < 0.001$; Figure 1). Using this correlation, total litter size can be calculated using the following equation:

$$\text{Total litter size} = 8.02066 + (1.8215 \times \text{oestrone sulphate})$$

Oestrone sulphate levels were also calculated for sows with a total litter size greater than or equal to the median (Small, < 12 versus Large, $\geq$ 12) and for sows in the lower quartile (< 10), middle quartiles (10 – 13) and upper quartile ($\geq$ 14) (Table 3).

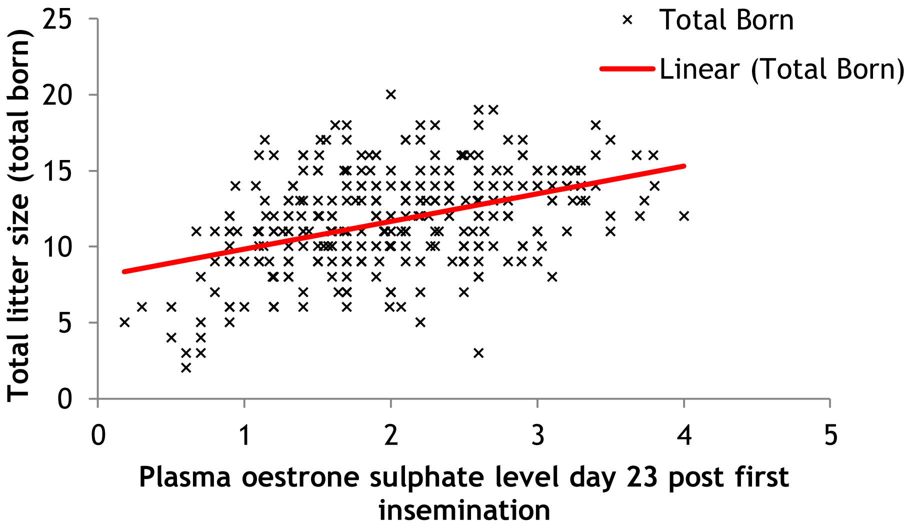

Figure 2 - Relationship between plasma oestrone sulphate on day 23 after first insemination and total litter size

Table 3 - Plasma oestrone sulphate levels on day 23 of gestation for sows with different total litter sizes

	Total born: grouping 1		Total born: grouping 2		
	Small; < 12	Large; > 12	Small; < 10	Medium; 10 - 13	Large; > 14
Mean	1.84[a]	2.37[b]	1.78[a]	2.17[b]	2.41[c]
SEM	0.07	0.07	0.08	0.08	0.09
Minimum	0.18	0.9	0.18	0.67	0.94
Maximum	6.1	7	6.1	7.0	4.6
Lower quartile	1.2	1.8	1.2	1.51	1.8
Median	1.7	2.3	1.7	2.1	2.4
Upper Quartile	2.3	2.9	2.2	2.6	3

[abc] different superscripts within total born groupings indicate significance; $P < 0.05$

Study Three: Effect of predicted litter size, parity and late gestation feeding level on sow and progeny performance.

As intended, gilts and sows on the HIGH gestation feeding level consumed significantly more feed, digestible energy (DE), protein and lysine than their counterparts on the LOW feeding level (Table 4). There was a significant interaction between parity and gestation feeding level and for parity and litter size for daily feed intake, DE, protein and lysine intake (Table 4).

At farrowing, DE requirements for maintenance were significantly higher for sows compared to gilts (30.6 ± 0.15 versus 24.0 ± 0.14 MJ DE / day). Estimated DE requirements for pregnancy were significantly higher for sows compared to gilts (5.8 ± 0.06 versus 5.1 ± 0.06 MJ DE/day) and for gilts with a LARGE compared to SMALL litter (6.1 ± 0.06 versus 4.6 ± 0.06 MJ DE/day). Estimated energy availability for growth during gestation was significantly lower for sows compared to gilts (-1.8 ± 0.25 versus 5.5 ± 0.24 MJ DE/day), for animals on the LOW compared to HIGH gestation feeding level (-2.2 ± 0.24 versus 6.2 ± 0.25 MJ DE/day) and for sows with a LARGE compared to SMALL litter size (1.3 ± 0.23 versus 2.8 ± 0.26 MJ DE/day).

Sow body composition data, absolute values and changes in body composition, are presented in Table 5. At all measurement points sows were significantly higher than gilts, with sows also having significantly higher P2 backfat levels on day 85 of gestation and weaning than gilts. By chance, sows allocated to the high feeding level were significantly lighter on day 85 of gestation then those allocated to the low feeding level (213.2 ± 1.35 versus 216.6 ± 1.34 kg). There was a significant interaction between parity and litter size for LW on day 85 of gestation (Table 5). Gilt LW was unaffected by litter size farrowed; where sows farrowing a LARGE litter were significantly heavier than those farrowing a SMALL litter (256.4 ± 1.81 versus 244.2 ± 2.10 kg). Due to differences in LW on day 85 of gestation, sow LW on day 1 of lactation was unaffected by gestation feeding level; however, HIGH fed sows gained significantly more weight than LOW fed sows (11.8 ± 0.93 versus 9.2 ± 0.93 kg). Sows farrowing LARGE litters gained significantly less weight during gestation than those farrowing SMALL litters (7.3 ± 0.90 versus 14.3 ± 0.97 kg). Sows gained significantly more weight during gestation than gilts (12.7 ± 0.95 versus 8.5 ± 0.91 kg). There was a significant interaction between all treatments for P2 backfat gain during gestation (Table 5). During lactation, sows lost significantly more weight (17.5 ± 1.06 versus 12.7 ± 0.99 kg) but significantly less P2 backfat (0.26 ± 0.17 versus 1.14 ±0.16 mm). Futhermore HIGH fed sows lost more backfat during lactation than LOW fed sows, which may indicate a lower voluntary feed intake during lactation in these sows.There was a significant interaction between gestation feeding level and litter size farrowed for P2 backfat loss during lactation. Specifically, P2 backfat loss was similar for HIGH fed animals regardless of litter size farrowed; however, HIGH fed animals farrowing a SMALL litter lost significantly more P2 backfat than LOW fed animals.

Treatment effects on litter size are presented in Table 6. Compared to gilts, sows had a higher total litter size (11.6 ± 0.11 versus 11.2 ± 0.10) and produced more piglets born alive (10.8 ± 0.12 versus 10.6 ± 0.11) and born dead (0.96 ± 0.08 versus 0.76 ± 0.08). LOW fed sows produced more total piglets ($P < 0.05$) and live born piglets ($P = 0.05$) than HIGH fed sows and LOW and HIGH fed gilts. LARGE litters resulted in more piglet born dead and more mummified fetuses compared to SMALL litters (1.1 ± 0.07 versus 0.6 ± 0.08 and 0.19 ± 0.03 versus 0.07 ± 0.03, respectively). Gestation feeding level (HIGH versus LOW) tended to decrease the number of piglets born dead (0.77 ± 0.08 versus 0.94 ± 0.08; $P = 0.09$) and also tended to increase the number of mummified fetuses (0.16 ± 0.03 versus 0.10 ± 0.03; $P = 0.06$).

There was a significant effect of parity (Sows versus gilts) on litter weight at birth (16.5 ± 0.17 versus 14.5 ± 0.17 kg) and day 21 post-partum (55.6 ± 0.82 versus 49.3 ± 0.77 kg). Total litter weight at birth and day 21 was significantly higher for LARGE compared to SMALL litters (17.4 ± 0.17 versus 13.2 ± 0.18 kg and 55.1 ± 0.76 versus 48.9 ± 0.82 kg, respectively). There was a significant interaction between parity and litter size for mean piglet birthweight (Figure 3). Mean piglet weight on day 21 post-partum was higher for sow compared to gilt litters (6.4 ± 0.04 versus 5.6 ± 0.04 kg) and for SMALL compared to LARGE litters (6.3 ± 0.04 versus 5.8 ± 0.04 kg).
There was a significant interaction between actual litter size and parity for litter size suckled on day 0 (after cross-fostering) (Table 6). Litter size suckled on day 21 post-partum was significantly higher for LARGE compared to SMALL litters (9.6 ± 0.12 versus 7.9 ± 0.13). There was a significant interaction between parity and litter size farrowed for piglet mortality rates between day 0 and 3 post-partum (Figure 3). The number of piglets dying between day 4 and 21 post-partum was significantly higher for gilt compared to sow litters (0.53 ± 0.05 versus 0.32 ± 0.05 piglets), LOW compared to HIGH fed animals (0.50 ± 0.05 versus 0.36 ± 0.05 piglets) and for LARGE compared to SMALL litters (0.51 ± 0.05 versus 0.33 ± 0.06 piglets).

Treatment effects on more detailed aspects of piglet birthweight and early post-natal survival are presented in Tables 7 and 8. HIGH gestation feeding significantly reduced the CV% of birthweight and tended ($P = 0.09$) to increase minimum piglet birthweight (18.3 ± 0.43 versus 19.3 ± 0.43% and 0.99 ± 0.02 versus 0.96 ± 0.02kg, respectively). Parity and litter size interacted to affect mean, minimum and maximum piglet birthweight (Figure 4).

The CV% of birthweight was significantly higher for sow compared to gilt litters (20.6 ± 0.44 versus 17.5 ± 0.43%) and for LARGE compared to SMALL litters (20.8 ± 0.42 versus 16.6 ± 0.45%).

There tended ($P = 0.08$) to be a reduction in the number of piglets below 1 kg in birthweight for HIGH compared to LOW litters (1.3 ± 0.12 versus 1.5 ± 0.12 piglets). The number and proportion of piglets in each size category was affected primarily by parity and litter size (Figure 5). Compared to low gestation feeding, the HIGH feeding level tended ($P = 0.06$) to reduce mortality rates of 1.51 to 2.0 kg BW piglets (0.04 ± 0.02 versus 0.10 ± 0.02 piglets). Litter size was the primary determinant of piglet mortalities during the first 3 days post-partum (Table 8). Total mortality rates were significantly higher for LARGE compared to SMALL (0.07 ± 0.01 versus 0.04 ± 0.01 and 0.93 ± 0.07 versus 0.37 ± 0.08 piglets). Total litter size was positively correlated with piglet mortality rates prior to day 3 post-partum ($r = 12.7$; $P < 0.05$). A lower number of piglets with a BW of < 1 kg and 1.1 – 1.5 kg died in SMALL compared to LARGE litters (0.14 ± 0.05 versus 0.45 ± 0.05 piglets and 0.17 ± 0.05 versus 0.38 ± 0.04 piglets).

Gestation feeding level did not affect WOI, subsequent farrowing rate or litter size. Compared to gilts, sows had significantly shorter WOI (4.1 ± 0.08 versus 4.8 ± 0.07 days), and farrowed more dead piglets (1.1 ± 0.09 versus 0.70 ± 0.10 piglets) and mummified fetuses (0.31 ± 0.04 versus 0.06 ± 0.04 fetuses). There was an interactive effect of parity and litter size for subsequent total born and born alive (Figure 6). There was a significant interaction between parity group, gestation feeding and actual litter size for subsequent farrowing rate (Figure 7). In addition, subsequent pregnancy rates were significantly higher for sows compared to gilts (0.80 versus 0.69)

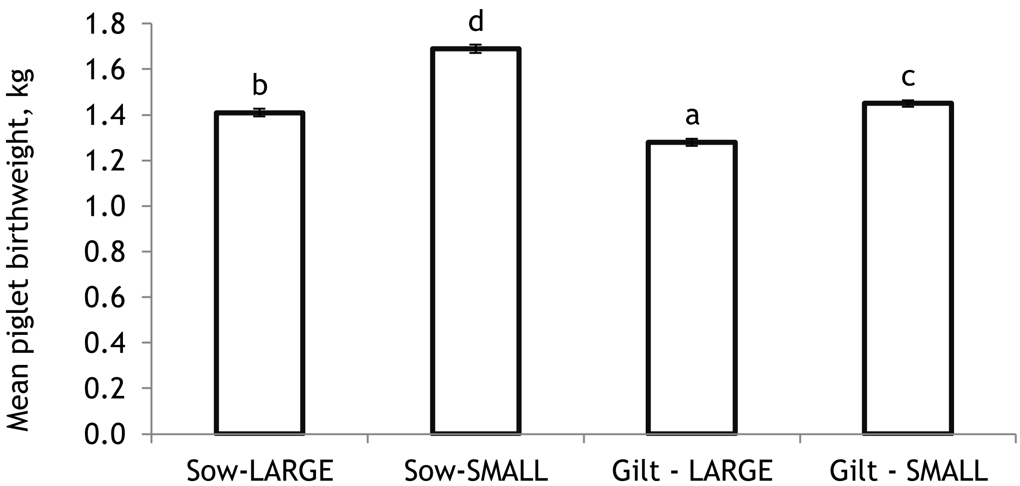

Figure 3- Effect of parity (sow versus gilt) and litter size (LARGE versus SMALL) on mean piglet birthweight. [abcd] indicates significant difference; $P < 0.05$

Figure 4 - Effect of parity (sow versus gilt) and litter size (LARGE versus SMALL) on piglet mortality between day 0 and day 3 post-partum. [abcd] indicates significant difference; P < 0.05

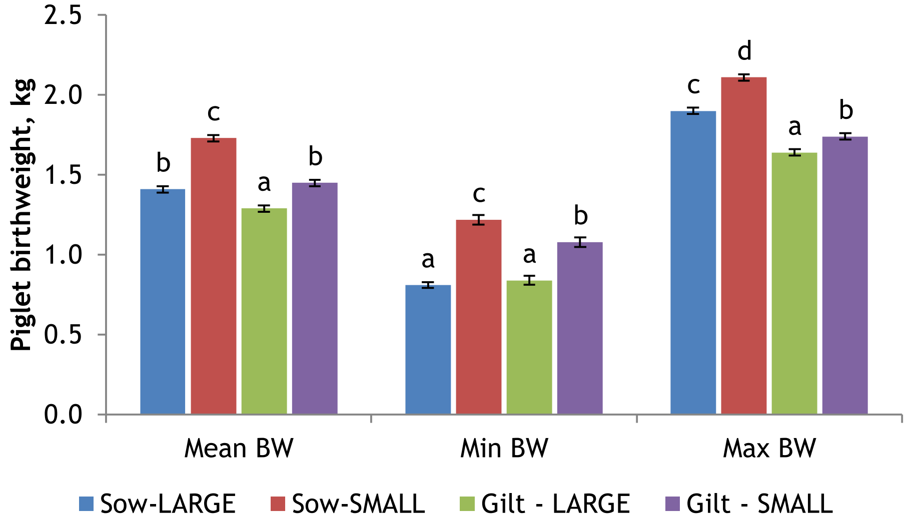

Figure 5 - Effect of parity (sow versus gilt) and litter size (LARGE versus SMALL) on mean, minimum and maximum piglet birthweight. [abcd] within variate indicates significant difference; P < 0.05

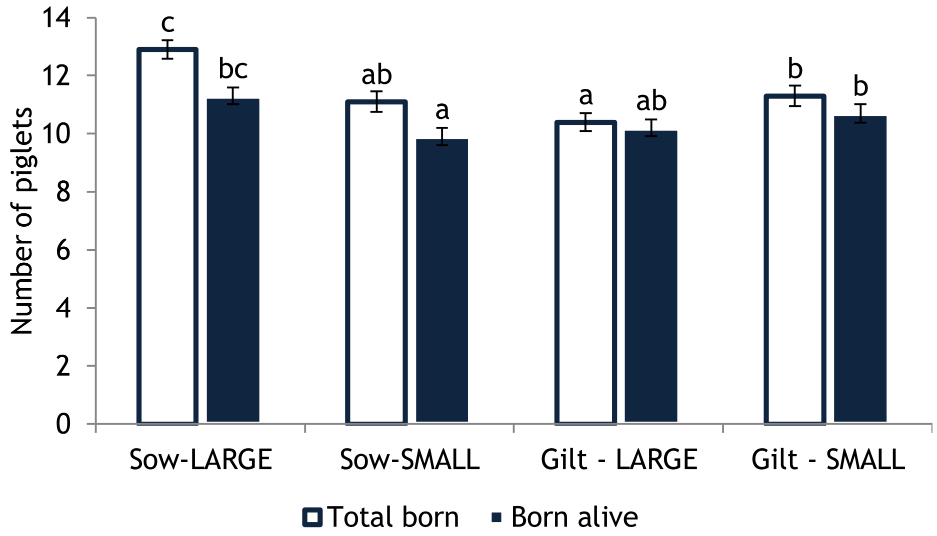

Figure 6 - Effect of parity (sow versus gilt) and litter size (LARGE versus SMALL) on subsequent total born and born alive. [abc] within variate indicates significant difference; $P < 0.05$

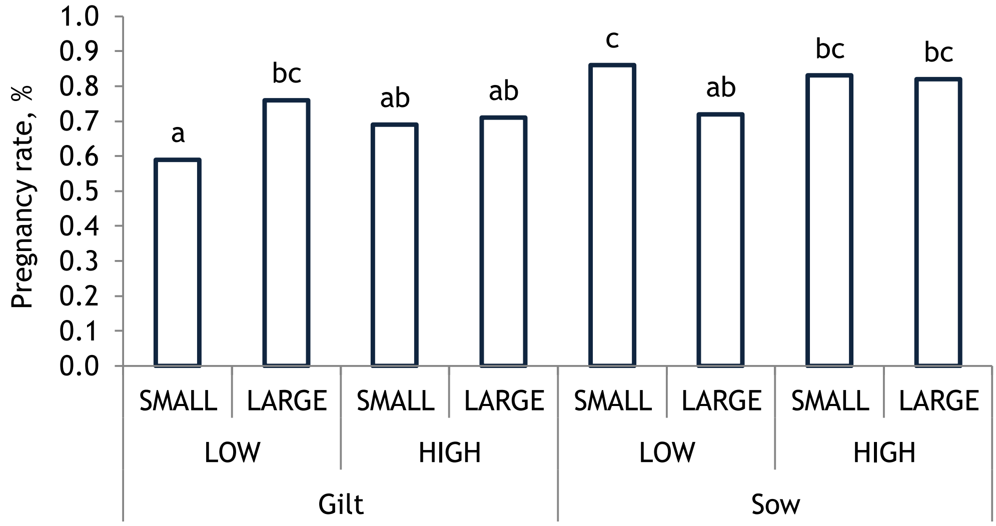

Figure 7 - Effects of parity (sow versus gilt), feeding level (HIGH versus LOW) and litter size (LARGE versus SMALL) on subsequent pregnancy rates. [abc] indicates significant difference; $P < 0.05$

Table 4 - Effect of parity group (P), gestation feeding level (GF) and litter size (LS) on feed and nutrient intake and requirements for digestible energy

Parity Group	Gilt				Sow				*SEM*[A]	Significance[B]						
Gestation feeding level	LOW		HIGH		LOW		HIGH									
Actual Litter size	SMALL	LARGE	SMALL	LARGE	SMALL	LARGE	SMALL	LARGE		P	GF	LS	P.GF	P.LS	GF.LS	P.GF.LS
Nutrient intake																
Feed, kg/day	2.19	2.24	2.74	2.76	2.33	2.31	2.97	2.91	*0.01*	<0.05	<0.05	0.97	<0.05	<0.05	0.16	0.80
DE, MJ/day	30.71	31.37	38.35	38.61	30.70	30.47	39.18	38.41	*0.16*	0.09	<0.05	0.89	<0.05	<0.04	0.16	0.83
Protein, g	335.1	342.3	418.4	421.3	338.4	335.9	431.9	423.5	*1.89*	0.67	<0.05	0.91	<0.05	<0.05	0.16	0.83
Avail lysine, g	15.3	15.7	19.2	19.3	12.6	12.5	16.0	15.7	*0.11*	<0.05	<0.05	0.66	<0.05	<0.04	0.16	0.95
DE requirements																
Maintenance[1], MJ/d	24.1	24.0	24.2	23.8	30.3	31.0	30.6	30.5	*0.21*	<0.05	0.65	0.90	0.65	0.17	0.29	0.62
Conceptus??, MJ/d	4.2	5.4	4.3	5.8	5.1	6.5	4.8	3.4	*0.09*	<0.05	0.46	<0.05	0.31	0.05	0.17	0.52
DE avail. growth	2.84	0.58	9.71	9.16	-5.36	-6.98	3.69	1.92	*0.34*	<0.05	<0.05	<0.05	0.07	0.66	0.23	0.18

[A] standard error for parity group x gestation feeding level x actual litter size
[B] Parity group (P); Gestation feeding levels (GF); Actual litter size (LS)
[1] estimated using sow LW on day 1 of lactation

Table 5 - Effect of parity group (P), gestation feeding level (GF) and litter size (LS) on sow liveweight, sow P2 backfat and liveweight and P2 backfat change

Parity Group	Gilt				Sow				SEM[A]	Significance[B]						
Gestation feeding level	LOW		HIGH		LOW		HIGH									
Actual Litter size	SMALL	LARGE	SMALL	LARGE	SMALL	LARGE	SMALL	LARGE		P	GF	LS	P.GF	P.LS	GF.LS	P.GF.LS
LW, kg																
Day 85	179.5	185.9	180.4	180.9	245.4	259.3	242.5	253.5	*2.01*	<0.01	0.05	<0.01	0.45	<0.05	0.25	0.70
Day 1	192.3	189.4	190.5	189.3	258.6	267.6	262.8	262.1	*2.15*	<0.01	0.57	0.66	0.87	0.17	0.40	0.21
Weaning	180.6	179.1	177.5	174.9	245.5	247.6	243.3	243.2	*2.12*	<0.05	0.14	0.81	0.99	0.53	0.75	0.91
P2, mm																
Day 85	13.4	13.8	13.6	13.6	13.7	14.2	14.7	14.6	*0.14*	<0.05	0.31	0.48	0.25	0.97	0.37	0.84
Day 1	13.4	13.3	14.0	13.5	12.8	13.5	14.5	13.6	*0.13*	0.74	<0.05	0.36	0.47	0.64	0.06	0.21
Weaning	12.6	12.2	12.4	12	13.3	13.2	13.4	13.7	*0.14*	<0.01	0.90	0.52	0.42	0.36	0.71	0.88
LW change, kg																
Day 85 - day 1	11.3	3.4	10.4	7.7	14.4	8.3	20.3	9.0	*0.66*	<0.01	<0.05	<0.01	0.59	0.18	0.92	0.12
Day 1 - Wean	-11.0	-10.4	-12.8	-14.8	-14.8	-18.4	-18.6	-18.3	*0.71*	<0.01	0.1	0.40	0.59	0.73	0.88	0.25
P2 change, mm																
Day 85 - day 1	0.11	-0.52	0.38	-0.16	-0.89	-0.34	0.46	-0.68	*0.11*	0.15	0.11	0.05	0.89	0.47	0.09	<0.05
Day 1 - Wean	-0.70	-1.01	-1.39	-1.46	0.37	-0.25	-1.33	0.02	*0.12*	<0.01	<0.05	0.92	0.99	0.31	0.03	0.07

[A] standard error for parity group x gestation feeding level x actual litter size

[B] Parity group (P); Gestation feeding levels (GF); Actual litter size (LS)

Table 6 - Effect of parity group (P), gestation feeding level (GF) and litter size (LS) on litter size, litter characteristics and performance during lactation for all experimental sows

Parity Group	Gilt				Sow				*SEM*[A]	Significance[B]						
Gestation feeding level	LOW		HIGH		LOW		HIGH									
Actual Litter size	SMALL	LARGE	SMALL	LARGE	SMALL	LARGE	SMALL	LARGE		P	GF	LS	P.GF	P.LS	GF.LS	P.GF.LS
Total Born	8.6	13.2	9.2	13.4	8.9	14.6	8.4	14.2	*0.14*	<0.05	0.63	<0.05	<0.05	<0.05	0.52	0.41
Born Alive	8.2	12.4	8.7	12.7	8.3	13.2	8.1	13.0	*0.16*	<0.05	0.93	<0.05	0.05	<0.05	0.84	0.70
Still born	0.57	1.00	0.67	0.75	0.71	1.38	0.33	1.24	*0.10*	<0.05	0.09	<0.05	0.50	<0.05	0.76	0.19
Mummified fetuses	0.00	0.14	0.16	0.19	0.00	0.23	0.13	0.19	*0.04*	0.52	0.06	<0.05	0.45	0.50	0.11	0.72
Total litter weight																
Day 0	12.4	15.9	12.7	16.6	14.3	18.5	13.7	18.9	*0.24*	<0.05	0.46	<0.05	0.31	0.05	0.17	0.52
Day 21	46.4	51.6	46.1	52.3	52.7	57.3	50.9	60.3	*1.03*	<0.05	0.74	<0.05	0.79	0.59	0.53	0.41
Piglet weight																
Day 0	1.46	1.28	1.44	1.29	1.70	1.38	1.68	1.43	*0.02*	<0.05	0.40	<0.05	0.33	<0.05	0.15	0.56
Day 21	5.88	5.36	5.88	5.44	6.61	6.18	6.79	6.20	*0.06*	<0.05	0.17	<0.01	0.65	0.90	0.78	0.33
Litter size suckled																
Day 0	10.1	11.8	10.1	11.9	10.1	12.5	10.1	12.2	*0.08*	<0.05	0.41	<0.05	0.14	<0.05	0.58	0.23
Day 21	7.9	9.6	7.9	9.7	8.0	9.3	7.7	9.7	*0.16*	0.62	0.98	<0.05	0.79	0.79	0.21	0.30
Lactation length	25.3	24.3	25.6	26.3	22.2	22.1	22.3	22.0	*0.23*	<0.05	<0.05	0.54	<0.05	0.77	0.08	0.07
Piglet mortality																
< day 3	0.33	0.73	0.42	0.73	0.23	1.19	0.29	0.93	*0.07*	0.06	0.73	<0.05	0.29	<0.05	0.21	0.45
Day 4 to 21	0.60	0.60	0.25	0.62	0.25	0.51	0.18	0.30	*0.07*	<0.05	<0.05	<0.05	0.98	0.94	0.35	0.09

[A] standard error for parity group x gestation feeding level x actual litter size

[B] Parity group (P); Gestation feeding levels (GF); Actual litter size (LS)

Table 7 - Effect of parity group (P), gestation feeding level (GF) and litter size (LS) on litter characteristics at birth

Parity Group	Gilt				Sow				*SEM*[A]	Significance[B]						
Gestation feeding level	LOW		HIGH		LOW		HIGH									
Actual Litter size	SMALL	LARGE	SMALL	LARGE	SMALL	LARGE	SMALL	LARGE		P	GF	LS	P.GF	P.LS	GF.LS	P.GF.LS
Birthweight																
Mean, kg	1.45	1.28	1.45	1.31	1.75	1.38	1.70	1.43		<0.05	0.202	<0.05	0.90	<0.05	0.09	0.32
CV, %	16.1	19.4	15.0	17.7	18.0	23.4	17.4	22.8	*0.61*	<0.05	<0.05	<0.05	0.62	0.05	0.81	0.81
Min, kg	1.07	0.80	1.08	0.88	1.23	0.81	1.22	0.82	*0.03*	0.22	0.09	<0.05	0.55	<0.05	0.42	0.63
Max, kg	1.74	1.63	1.75	1.65	2.17	1.89	2.06	1.92	*0.02*	<0.05	0.97	<0.05	0.29	<0.05	0.10	0.17
Range, kg	0.67	0.83	0.66	0.77	0.94	1.09	0.84	1.10	*0.02*	<0.05	0.12	<0.05	0.84	0.27	0.64	0.15
Lower Quartile, kg	1.30	1.13	1.33	1.16	1.54	1.17	1.50	1.22	*0.02*	<0.05	0.10	<0.05	0.91	<0.05	0.30	0.26
Upper Quartile, kg	1.61	1.45	1.60	1.47	1.98	1.62	1.92	1.67	*0.02*	<0.05	0.48	<0.05	0.78	<0.05	0.05	0.31
No. piglets																
< 1 kg BW	0.75	2.18	0.67	1.91	0.43	2.45	0.50	1.93	*0.17*	0.62	0.08	<0.05	0.76	0.25	0.25	0.55
1.1 -1.5 kg BW	4.00	7.86	4.74	8.26	1.86	6.63	2.04	6.10	*0.25*	<0.05	0.94	<0.05	0.09	0.14	0.30	0.69
1.51 – 2 kg BW	4.08	4.89	3.59	2.83	4.50	4.80	4.24	4.96	*0.24*	<0.05	0.51	0.27	0.70	<0.05	0.37	1.00
> 2.0 kg BW	0.12	0.02	0.17	0.04	2.46	0.56	1.81	0.78	*0.11*	<0.05	0.91	<0.05	0.56	<0.05	0.08	0.05
% piglets:																
< 1 kg BW	8.1	16.2	7.1	14.2	4.1	16.3	5.0	13.3	*1.30*	0.48	0.14	<0.05	0.99	0.29	0.34	0.57
1.1 -1.5 kg BW	43.3	60.6	50.3	63.4	18.7	45.2	21.9	43.1	*1.90*	<0.05	0.41	<0.05	0.20	<0.05	0.54	0.90
1.51 – 2 kg BW	45.9	53.1	40.4	22.1	50.0	34.5	50.5	37.7	*2.30*	<0.05	0.98	<0.05	0.26	0.15	0.41	0.83
> 2.0 kg BW	2.7	0.1	2.2	0.3	27.1	3.9	22.5	5.9	*1.90*	<0.05	0.88	<0.05	0.94	<0.05	0.21	0.30

[A] standard error for parity group x gestation feeding level x actual litter size; [B] Parity group (P); Gestation feeding levels (GF); Actual litter size (LS)

[C] expressed as a percentage of all dead piglets

Table 8 - Effect of parity group (P), gestation feeding level (GF) and litter size (LS) on piglet mortality before day 3 post-partum

Parity Group	Gilt				Sow				*SEM*[A]	Significance[B]						
Gestation feeding level	LOW		HIGH		LOW		HIGH									
Actual Litter size	SMALL	LARGE	SMALL	LARGE	SMALL	LARGE	SMALL	LARGE		P	GF	LS	P.GF	P.LS	GF.LS	P.GF.LS
No. piglets dying < day 3																
All	0.29	0.98	0.54	0.92	0.31	0.99	0.37	0.79	*0.11*	0.80	0.87	<0.05	0.39	0.96	0.18	0.90
< 1 kg BW	0.08	0.42	0.24	0.47	0.10	0.55	0.13	0.36	*0.07*	0.86	0.92	<0.05	0.13	0.67	0.22	0.66
1.1 – 1.5 kg BW	0.17	0.51	0.26	0.43	0.05	0.26	0.20	0.34	*0.06*	0.06	0.47	<0.05	0.41	0.56	0.37	0.73
1.51 – 2.0 kg BW	0.04	0.05	0.04	0.02	0.14	0.17	0.04	0.08	*0.03*	<0.05	0.06	0.63	0.19	0.62	0.81	0.74
> 2.0 kg BW	0.00	0.00	0.00	.000	0.02	0.00	0.00	0.02	*0.01*	0.15	0.96	0.84	0.96	0.83	0.13	0.12
Piglet deaths < day 3, %																
All	2.8	7.6	5.7	6.9	3.3	6.8	4.0	5.8	*0.82*	0.50	0.73	<0.05	0.41	0.84	0.11	0.58
< 1 kg BW[C]	27.1	39.7	36.8	49.1	33.3	58.3	38.5	45.5	*4.36*	0.29	0.98	0.08	0.24	0.81	0.57	0.56
1.1 – 1.5 kg BW[C]	56.3	53.7	52.6	49.7	16.7	25.9	46.2	44.4	*6.09*	<0.05	0.21	0.87	0.08	0.66	0.72	0.73
1.51 – 2.0 kg BW[C]	16.7	6.7	10.5	1.2	41.7	15.8	15.4	9.0	*2.88*	<0.05	0.10	<0.05	0.49	0.52	0.34	0.35
> 2.0 kg BW[C]	0.0	0.0	0.0	0.0	8.3	0.0	0.0	1.0	*0.81*	0.21	0.50	0.18	0.55	0.18	0.10	0.08

[A] standard error for parity group x gestation feeding level x actual litter size; [B] Parity group (P); Gestation feeding levels (GF); Actual litter size (LS)

[C] expressed as a percentage of all dead piglets

Table 9 - Effect of parity group (P), gestation feeding level (GF) and litter size (LS) on subsequent (post-lactation) reproductive performance

Parity Group	Gilt				Sow				*SEM*[A]	Significance[B]						
Gestation feeding level	LOW		HIGH		LOW		HIGH									
Actual Litter size	SMALL	LARGE	SMALL	LARGE	SMALL	LARGE	SMALL	LARGE		P	GF	LS	P.GF	P.LS	GF.LS	P.GF.LS
WOI	4.5	4.9	5.0	4.8	4.2	4.1	4.1	4.1	*0.10*	<0.05	0.50	0.60	0.37	0.52	0.27	0.23
Pregnancy rate; %	0.59	0.76	0.69	0.71	0.86	0.72	0.83	0.82		<0.05	>0.5	>0.5	<0.05	<0.05	>0.05	<0.05
No. sows farrowing	40	61	50	55	58	71	54	71								
Subs. Litter size																
Total born	11.1	10.3	11.2	10.8	10.7	13.2	11.1	13.2	*0.26*	<0.05	0.31	<0.05	0.86	<0.05	0.98	0.60
Born alive	10.9	10.3	10.6	10.4	9.5	11.6	10.0	11.4	*0.23*	0.60	0.71	<0.05	0.78	<0.05	0.86	0.36
Still born	0.57	0.79	0.67	0.63	1.01	1.17	1.00	1.39	*0.10*	<0.05	0.74	0.22	0.58	0.50	0.99	0.37
Mummified fetuses	0.03	0.07	0.07	0.04	0.27	0.39	0.27	0.32	*0.04*	<0.05	0.74	0.46	0.72	0.46	0.50	0.97

[A] standard error for parity group x gestation feeding level x actual litter size

[B] Parity group (P); Gestation feeding levels (GF); Actual litter size (LS)

Prediction equations for litter size based on oestrone sulphate concentrations from studies two and three

There was a significant, positive correlation between oestrone sulphate levels on day 23 post-first insemination and the total number of piglets born (R^2 = 0.143; $P < 0.001$; Figure 8). Using this correlation, total litter size can be calculated using the following equation:

$$\text{Total litter size} = 8.6116 + (1.4476 \times \text{oestrone sulphate})$$

Using this equation, the accuracy of predicting small litters was 63.5% and large litters was 60.5%.

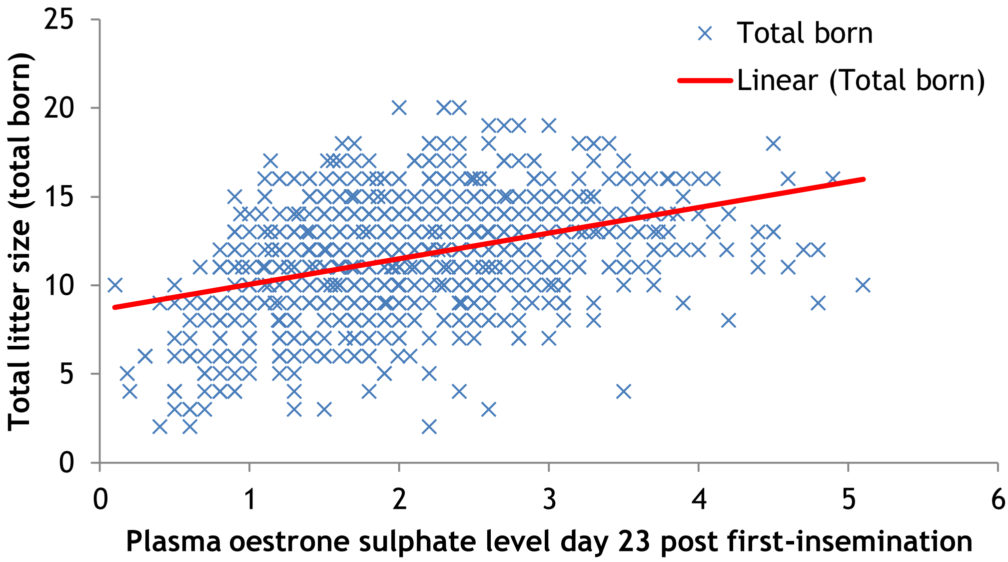

Figure 8 - Relationship between plasma oestrone sulphate on day 23 after first insemination and total litter size

4. Application of Research

Overall, the current data indicate that a single measure of oestrone sulphate can increase the chances of identifying whether sows are gestating a large ($\geq$ 12) or small (<12) litter. However, based on the prediction accuracy, the labour and assay costs, the commercial application appears limited.

Importantly, the current data indicate that increasing feeding level during the last 4 weeks of gestation can positively affect piglet birthweight and survival; however, the improvements are small. Specifically, increasing energy intake by 25% tended to reduce incidences of stillbirths and the number of light (< 1 kg) piglets, and significantly reduced the variation in piglet birthweight. The effects of increasing feeding level in late gestation on piglet survival were minor. Mortality rates of large (1.5 – 2.0 kg) piglets prior to day 3 post-partum tended to be lower for litters farrowed by HIGH fed sows, while significantly fewer piglets in HIGH fed sow litters died between day 4 post-partum and weaning. In contrast to previous reports that increased gestation energy intake increases piglet birthweight (Einarsson and Rojkittikhun, 1993; Cooper et al., 2001), absolute birthweight was not significantly affected. However, it is worth noting that based on estimations of energy requirements for pregnancy and maintenance it was only sows on the LOW feeding level that appeared to be in a negative energy balance n late gestation.

In addition to optimizing piglet performance, it is imperative that late gestation feeding prepares the sow for lactation, thus maximizing lactation performance but also ensuring a rapid and fertile return to reproductive function post-weaning. As intended the HIGH feeding level resulted in increased weight gain during late gestation. However, this increased weight gain did not affect lactation weight loss, possible due to the lack of a difference in absolute weight at farrowing. Equally, previous reports of an adverse effect of high gestation weight gains, and high fat levels at farrowing, on lactation feed intake and performance have generally occurred at the upper extremes of sow body composition (Revell et al., 1996). The lack of an effect of gestation feeding level on subsequent litter size also reflects a lack of a distinctive difference in body composition and body composition change during lactation. However, it is worth noting that the number of piglets gestated significantly affect sow liveweight and P2 backfat gain during gestation, with sows farrowing larger litters gaining less weight and putting on less P2 backfat than those farrowing small litters.

There appears to be a fairly complex relation between parity, gestation feeding level and litter size with regards to how they affect subsequent reproductive performance. Specifically, sows which farrowed a large litter produced more piglets at the subsequent farrowing; however, subsequent total born was lower for gilts which farrowed a large litter at their first farrowing. Although the cause of this finding cannot be elucidated from the current data, it can be speculated upon. It is plausible that sow fertility and fecundity are less sensitive to the negative effects of lactation, as is demonstrated by their shorter WOI, with more fecund sows (i.e. those producing larger litters) continuing to do so. In contrast, gilt reproductive function is more sensitive to the negative effects of lactation. Gilts which farrowed large litters also weaned more piglets, suggesting the negative effects of large litter size on subsequent litter size reflect an increased metabolic drain during lactation.

Overall, the current data provide important information for producers, nutritionists and consultants when deciding on how to feed sows and gilts during late gestation. Based on the feed and energy intakes used in this study, there appear to be no benefits for sow performance of increasing feed intake in late gestation, with only subtle improvements in progeny performance evident in response to higher feeding in late gestation. Although increasing feed intake in late gestation does exert positive effects on litter characteristics and progeny performance the commercial benefits of these have yet to be elucidated. However, it is worth noting that by not increasing feed in late gestation producers can save between 23 and 50 kg of feed per sow per year (based on a step up of 0.5 or 1.0 kg, and 2.2 farrowings per sow per year), which on a 1000 sow herd equates to a saving of between 23 or 46 tonnes of feed per year.

5. Conclusion

In conclusion, it is evident that litter characteristics previously associated with improved progeny performance are subtly improved when late gestation feeding levels are increased. Specifically, a higher feeding level in late gestation decreased incidences of still births, reduced variation in piglet birthweight and improved survival between day 4 of lactation and weaning. It is also clear that the different feeding levels used in this trial did not alter maternal performance or subsequent reproductive performance.

6. Limitations/Risks

The primary limitation to these data relate to genotype and the level of feed used. It is plausible that different genotypes may respond differently to feed intake in late gestation, and that lower or higher feeding levels may have a greater effect of piglet and litter characteristics as well as post-partum performance and survival.

7. Recommendations

As a result of the outcomes in this study the following recommendations have been made:

- HIGH feeding levels in late gestation positively affect stillbirth rates, reduce variability in litter weight at birth, increase the size of the smallest piglet and decrease the number of piglets with a birthweight < 1kg.
- In late gestation, feeding levels should be increased in situations where litter sizes are large (i.e. where the incidences of small piglets is likely to be high) and where low piglet birthweights are a concern.
- The potential benefits of increasing feeding level in late gestation should be considered in conjunction with the additional feed costs of such a practice.
- Future work is required to determine if higher feeding levels during late gestation than currently used exert a greater effect on piglet birth characteristics.
- Large suckled litter size negatively affected subsequent litter size of first parity sows, whereas suckled litter size exerted no effect multiparous sows. It is, therefore, suggested that strategies to reduce the metabolic drain on first parity sows during lactation be investigated. For example, using cross-fostering to reduce suckled litter size of first parity sows, by transferring these piglets to older parity sows.
- The long-term effects of not increasing feeding level in late gestation on gilt longevity should be investigated.

8. References

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