5A-102: Reducing stillbirth & pre-weaning mortality rates through better gestation feeding (2D-122)

Report prepared for the Co-operative Research Centre for High Integrity Australian Pork

By

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Executive Summary

This research project addressed the problem of high rates of stillbirths & pre-weaning mortality in sows. Specifically, it considered whether or not increasing maternal nutrition late in gestation would reduce these losses either via a direct effect on sow energy status at parturition or via increased piglet birth weight. In addition, a study was conducted to investigate the potential interaction between gestation feeding level & housing hygiene in determining piglet birth weight & survival.

The first experiment conducted used 180 sows at a commercial piggery. The three treatments used involved feeding sows either 2.3kg/d of a Dry Sow Diet throughout gestation or increasing this feed level to 3kg/d for the last 21 or 42 days of gestation. To assess the impact of the feed treatments stillbirth rates, piglet birth weights & early pre-weaning mortality rates were measured. The results from this experiment suggested that neither stillbirth nor pre-weaning mortality were affected by maternal nutrition in late gestation. In addition, piglet birth weights were only marginally increased in the higher feeding treatments &, even then, the proportion of low birth weight piglets (i.e. at-risk piglets) remained the same across all treatments.

The second experiment was conducted at the Roseworthy Piggery & used 123 sows. It aimed to identify the effect of feeding level in late gestation, when gestating sows are housed in hygienic or standard housing conditions, on stillbirth & pre-weaning mortality rates. It was hypothesised that, an increase in feed allowance, from day 86 to 112 of gestation, would not alter piglet birth weight or viability when gestating sows were housed in high hygiene conditions, but that differences would be noted in sows housed in standard hygiene conditions, due to the greater nutrient requirements of their immune systems. Two feed treatments, standard (2.3 kg/d) and high (3.3 kg/d), and two hygiene treatments, standard and high, were implemented in late gestation in a 2X2 factorial experiment. Results indicated that hygiene does not alter the immune system enough to affect the nutritional requirements of sows in late gestation. No changes in piglet weight, the number of stillborn piglets, placental: foetal weight ratio, farrowing duration or neonatal survival to 72 hours post-farrowing were observed ($p > 0.05$).

The third experiment used 800 sows & gilts at a commercial piggery. These were fed either 2.4kg/d (LOW) or 3.0kg/d (HIGH) from day 90 of gestation to farrowing shed entry. As with Experiment 1 this study failed to identify any advantage that was gained by higher feeding of sows in late gestation.

In summary, all three studies found there was no benefit to be gained by increasing nutrient supply to sows over the final weeks of gestation. Additionally, study 2 indicated that the sow's nutrient requirements in late gestation were not significantly altered by the hygiene status of the accommodation provided. These data indicate that increased feeding for sows in late gestation does not lead to improvements in subsequent sow or piglet performance.

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1. Introduction

It is clear that stillbirth & pre-weaning mortality rates are too high in Australian herds at a total value of approximately 18% (Australian Pig Annual, Target 25). In many large herds these figures can be much higher. As an example, one herd with which we've worked recorded stillbirth rates of 6.8%, 10.6% & 15.0% for sows in parities 1-3, 4-6 & 7+, with pre-weaning mortalities of 12.6%, 15.0% & 15.9% for the same parity groups. This represents an average of approximately 24% loss from farrowing to weaning or about 2.8 piglets/litter.

There is no doubt that stillbirths & pre-weaning mortality primarily reflect the genotype, management & facilities of a piggery. In particular, piggeries with a high proportion of younger sows (<7 parities) have lower stillbirth rates as do those units that employ farrowing induction (assuming it is conducted at the correct time & competent staff are present during the induced births). Equally, pre-weaning mortality rates reflect gestation management (particularly nutrition) of the sow, farrowing management & the facilities & staffing provided during the critical 3-4 days post-farrowing.

For an individual piglet its two major risk factors for being stillborn are it's birthweight & the duration of the farrowing of the litter in which it's born (Zaleski & Hacker, 1993; Leenhouwers et al, 1999; Roehe & Kalm, 2000; Borges et al, 2005; Canario et al, 2006; Knol et al, 2008). Similarly, while much has been written about how to maximise pre-weaning piglet survival rates (e.g. see Hughes, 1993; Varley, 1995) the facts remain that the drivers of early piglet death are facility design (overlays & chilling), undernutrition (low birthweight/vigour, poor milk supply) & disease. For example, Tuchscherer et al (2000) identified the key factors for a piglet to survive to weaning were to be heavy at birth, be born early in the birth order, to reach the udder quickly to facilitate intake of colostrum & to have a minimal drop in rectal temperature in the first hour after birth. More recently it has been recognised that piglet activity/vigour in the hours immediately following birth is fuelled by liver glycogen stores. This is critical as most neonates possess limited energy reserves (Seerley et al, 1974), & what reserves they do have tend to be used up maintaining homeothermic conditions in the hours after birth. Thus, unless these liver glycogen reserves are sufficient to both facilitate homeothermy & competitive suckling in the first hours after birth piglets will rapidly become hypoglycaemic leading to hypothermia, lethargy & possible death (see Bate & Grimmelt, 1991). This may well explain the observation of Knol et al (2008) that piglets with the best survival expectations had the heavier livers.

So how can we practically reduce stillbirth & pre-weaning mortality rates? One likely way to reduce stillbirth rates is to increase the sow's energy status at farrowing to permit greater exertion & thus reduce total farrowing time. This may be particularly beneficial in those herds where farrowing induction is not used. Indeed, one commercial nutritional supplement (ParturAid) has been demonstrated to achieve just this outcome with reported improvements in stillbirth rates of 0.43 live piglets in standard herds & 0.70 live piglets in herds with a stillbirth problem. Equally, now that it is recognised that a strong positive relationship exists between pre-weaning survival rate & piglet liver glycogen stores at birth, the latter may be modified by maternal nutrition during gestation. Since the foetus develops the ability to deposit glycogen in the liver from approximately day 80 of pregnancy it may prove optimal to increase nutrient supply from 5-6 weeks pre-partum onwards. Such a move should also increase average piglet birthweight (see Pluske et al, 1995) although such an effect may be limited in gilts & those sows that were already destined to have a high average birthweight (Baker et al, 1969; Close & Cole, 2000; King et al, 2006). While these effects are usually considered to be primarily due to dietary energy supply, there is also limited evidence that the fate of the foetal piglets may also be affected by maternal protein supply during late gestation (McPherson et al, 2004). Hence, it is suggested here that provision of a nutrient dense top dressing to the sow's normal diet in the last 3-6 weeks of gestation may reduce stillbirth rates & pre-weaning mortality. Indeed, these two are linked in that litters with more stillborn piglets have been shown to also have a higher pre-weaning mortality among live born piglets (Leenhouwers et al, 1999).In practice this outcome may be achieved by provision of a daily supplement of 0.5kg/d of a top dressing (comprising a mixture of glycerine, sugars, starches, oils & quality proteins including branched-chain amino acids) for the last 3-6 weeks of the gestation. The exact composition of this supplement is being formulated by Tony Edwards of ACE Livestock Consulting Pty. Ltd. While testing the value of such a nutrient dense top dressing in terms of it's effect on farrowing duration, stillbirth rate & pre-weaning mortality, care needs to be taken to measure any effects of increased nutrient intake in gestation on sow performance post-farrowing. In particular it will be necessary to assess lactation feed intake of sows & their milk output as both may be adversely affected (see Pluske et al, 1995).

2. Methodology

Experiment 1.

This study was run in 2 replicates, each of 90 sows (30 sows/treatment), housed in groups but individually fed using electronic sow feeders (ESFs) at a commercial piggery. The three treatments used were:

Treatment 1: Sows fed 2.3kg/d of a Dry Sow Diet* throughout gestation

Treatment 2: Sows fed 2.3kg/d of a Dry Sow Diet* for days 1-93 of gestation then 3kg/d of the same Dry Sow Diet* for the remaining 21 days of gestation

Treatment 3: Sows fed 2.3kg/d of a Dry Sow Diet* for days 1-72 of gestation then 3kg/d of the same Dry Sow Diet* for the remaining 42 days of gestation

*The composition of the Dry Sow diet is given in Tables 1.

At farrowing litter size data (piglets born alive, piglets born dead & mummified foetuses) were collected. No cross-fostering was permitted for the first 3 days of the lactation. Thus, early pre-weaning mortality rate was assessed by counting surviving piglets at 72 hours post-farrowing. Sow reproductive performance post-weaning up to the next farrowing was also collected.

Table 1 Composition of the Dry Sow Diet (% as fed basis)

Ingredients	%
Wheat (11%)	15.00
Barley (8%)	31.35
Triticale (10%)	13.75
Lupins	5.00
Peas	6.00
Millmix	15.00
Oat hulls	2.00
Canola – exp meal	6.00
Meatmeal (57%)	2.75
Tallow mixer	1.0
Salt	0.2
Limestone	1.25
Dicalphos	0.425
Ronozyme P-5000	0.015
L/A 1964 Sow PMX + Bioplex	0.275
Calculated nutrient composition	%
DE	13.00
NE	8.84
Protein	14.52
Fat	3.99
Fibre	6.15
Lysine	0.70
Threonine	0.54
Tryptophan	0.17
Met + Cys	0.54
Calcium	0.90
Phosphorus	0.60

The data was analysed using Genstat, 11th Edition (VSN International, UK), using either a general analysis of variance (ANOVA).

Experiment 2.

Animal management and treatments

This study was carried out at the University of Adelaide's Piggery, Roseworthy, South Australia. The study involved 123 mixed parity Large White x Landrace sows, and was conducted in four blocks between April and August, 2012. Six sows were excluded from the trial, due to death, being non-pregnant, needing antibiotics for infective foot lesions and spontaneous abortion (due to unknown reasons). Sows were introduced into the trial at day 86 of gestation (28 days before farrowing) and were randomly allocated to either high hygiene treatment housing or standard hygiene treatment housing. Each pen of 4 sows was then randomly allocated, within hygiene treatment, to receive either 2.3 kg (29.9 MJ DE) or 3.3 kg (42.9 MJ DE) per day of a standard gestation diet (Table 3). Prior to the commencement of the treatment, sows had been receiving 2.5 kg/d of the same diet. The sows were fed once daily, in the morning, with 4 distinct drops, to discourage sharing. The sows remained on these diets for the duration of the experiment. Water was freely available throughout the experimental period.

Table 3: Composition & specifications of the dry sow diet used.

Ingredients	*%*	*Calculated Nutrient composition*	*%*
Barley	19.25	Protein	13.83
Wheat	42.33	Fat	3.44
Millrun	30.0	Fibre	5.00
Canola Expeller Se 36/8.5	2.1	Lysine	0.69
Meat Meal	3.0	Threonine	0.49
Tallow	0.5	Tryptophan	0.17
Choline Chloride	0.07	Methionine + Cysteine	0.54
Limestone	1.45	Methionine	0.22
Biofos Mdcp	0.23	Calcium	0.93
Salt (Sodium Chloride)	0.35	Phosphorus	0.43
Lysine Sulphate	0.25	Isoleucine	0.47
Threonine	0.01	Linoleic Acid	1.21
Alimet	0.003		
Phyzyme Xp 5000 Liquid	0.01		
Breeder Premix + Bioplex	0.25		
Biofix	0.2	DE	13.0*MJ/kg*

*Diet produced by Lienert Australia, Roseworthy

The high hygiene treatment housing was cleaned prior to sows being moved in. This involved cleaning all surfaces, by pressure cleaning (SpitWater HP201/SAE pressure cleaner), disinfection (Virkon S, produced by DuPont, distributed by Lienert Australia, Roseworthy) and covering of the floors with hydrated lime (calcium hydroxide, Adelaide Brighton Cement Ltd.), which inactivates most viruses and bacteria. For the duration of the experiment, the high hygiene housing was pressure cleaned every Monday, Wednesday and Friday after sows had been moved into a separate pen. Standard hygiene sows were similarly moved, to avoid introducing unwanted variation caused by differences in human handling and movement between treatment arms, but their pens were not cleaned. For the duration of the trial, the sows remained in the piggery's dry sow shed. Each pen of 4 sows allowed 1.95 m^2 of floor space per sow. At three days prior to the expected farrowing date, sows were moved to the farrowing house, where they were allowed to farrow naturally. At entry into the farrowing shed, all treatments ceased. The litters were then monitored during the 72 hours post-farrowing to determine neonatal mortality.

Sow liveweight and body composition

Sows were weighed (with Test EziWeigh 2 scales) and P2 back fat depth was measured on entry to the sow shed and prior to being moved into the farrowing house. The P2 back fat depth was measured using real time ultrasound over the last rib, 65 mm from the midline with a 5 MHz linear probe (Aquila Vet, Pie Medical Equipment).

Collection of blood samples

Single blood samples were taken on entry into the dry sow shed and prior to being moved into the farrowing rooms. Samples were collected by jugular venipuncture into Vacuette 9ml EDTA tubes for determination of full blood counts with differential white cell counts.

Reproductive measurements - Piglet and placenta
Farrowing was observed throughout and the times of piglet births were recorded. Piglets (including stillbirths but excluding mummified foetuses) were weighed individually at birth, using a Wedderburn, UWHS Digital Hanging Scale, with 7.5kg capacity and 5g accuracy. The number of stillborn and mummified foetuses was recorded. Birth weight is one of the major factors positively correlated with piglet survival but can be detrimental for farrowing performance, with larger piglets potentially increasing the risk of dystocia (Walker *et al.* 1981; King *et al.* 2006). The variance within litter weights was examined, as it is an important factor in the survival and growth of piglets up to weaning (Campos *et al.* 2012). The proportion of piglets under 1.0 kg was recorded, as these piglets have a reduced chance of survival and their performance in lactation is also poor (Quiniou *et al.* 2002). At the end of farrowing, the placenta was collected and weighed (Wedderburn, UWHS Digital Hanging Scale). The ratio of placenta to foetal weights allowed analysis of the changes in piglet weight following the time at which the placenta stopped growing, coinciding with the beginning of our treatment period (Vallet & Freking 2007; Vallet *et al.* 2009;). Low placental weight and low foetal weight are positively correlated (Myatt 2006).

Reproductive measurements - Survival post-farrowing
At 72 hours after completion of farrowing the number of piglet deaths was recorded, along with the reason for the death. Survival to 72 hours post-farrowing was studied because this is the period in which 80% of preweaning mortality occurs, and is known to be negatively correlated with piglet birth weights (Tuchscherer *et al.* 2000).

Analysis of full blood counts
A Cell Dyn 3700 automated cell counter was used to measure red blood cells (RBC), white blood cells (WBC) and Platelet counts. Flow cytometry was used to measure the Optical WBC count and differential. Following this, a manual differential cell count was done. A blood film was made by placing a drop of blood onto a clean slide and a blood film spreader was used to create the film. The blood film was then stained with Wright Giemsa stain and 100 cells assessed, using an Olympus BX53 microscope.

Statistical analyses
The data were analysed using IBM SPSS 20.0 (Statistics Package for Social Sciences), using both mixed models and general linear models. For parts of the analysis, using mixed models, the piglet was the unit, allowing for close analysis of the effects of the treatments on each individual piglet. For the majority of the analysis, the sow was the unit, and in these cases a general linear model was used for the analysis. The model included parity and litter size as covariates and the pen, block and treatment as fixed effects. A total of 117 sows completed the trial but, due to some incomplete measurements, only 113 sows were used in the final analysis of the data. The neutrophil: lymphocyte ratio was calculated as a simple ratio between the absolute neutrophil and lymphocyte counts. Haematology from block 4 was discounted because collection of pre-farrowing samples was not completed as a result of early farrowing. Data are expressed as least squares means ± the standard error of the mean (SEM).

Experiment 3.
This study was nested inside a larger study conducted by Dr. William van Wettere conducted at a commercial piggery. Experimental sows were group-housed & individually fed via ESFs. Based on predicted litter size (determined using oestrone sulphate value on day 23 of gestation), sows and gilts were allocated to one of two feeding treatments during late gestation (day 90 to farrowing shed entry). Consequently the eight treatment groups were as follows (n = 100 gilts/sows per treatment):

1. Gilt High High– gilts with a large predicted litter size fed 3.0 kg in late gestation

2. Gilt Low High – gilts with a small predicted litter size fed 3.0 kg in late gestation

3. Gilt High Low– gilts with a large predicted litter size fed 2.4 kg in late gestation

4. Gilt Low Low – gilts with a small predicted litter size fed 2.4 kg in late gestation

5. Sow High High– sow with a large predicted litter size fed 3.0 kg in late gestation

6. Sow Low High – sow with a small predicted litter size fed 3.0 kg in late gestation

7. Sow High Low– sow with a large predicted litter size fed 2.4 kg in late gestation

8. Sow Low Low – sow with a small predicted litter size fed 2.4 kg in late gestation

All animals were fed the same diet, with the feed intake of sows on the High feeding level stepped up over the course of 4 days, with step up commencing on day 88 of gestation. Cross fostering only occurred after day 3 of lactation.

Experimental measures:
For all sows:
- First mating date was recorded and used to calculate day of bleeding
- A single blood sample was collected by jugular venipuncture on the 23rd day after first insemination (first day of insemination = day 0).
- Sows/gilts were weighed and P2 backfat measured on day 90 (+/- 2 days) of gestation as well as farrowing shed entry
- Piglet mortalities between birth and day 3 of lactation and day 3 and weaning
- Total litter size, the number of piglets born alive, stillborns and mummified fetuses
- Subsequent reproductive performance
- Longevity and reason for culling (parity at culling etc) recorded

Focus sows: (subset of 20 sows and litters per treatment (160 in total))

- Sows/gilts weighed and P2 backfat recorded on day 1 of lactation and weaning
- Piglet birth weights (< 24 hrs of birth) day 3 and 21 of lactation.

3. Outcomes

Experiment 1.

The results for this study are presented in Table 4.

Table 4. Effects of gestation feeding on piglet & sow performance.

	CONTROL	HIGH 3	HIGH 6
No. sows	58	58	56
Litter size (total)	13.0	13.3	12.5
Stillbirths (%)	4.9	4.1	4.7
Litter size (live)	12.4	12.7	11.9
Mean birth wt. (kg)	1.48	1.51	1.54
Birth wt. <1kg (%)	8.6	7.8	8.1
Birth wt. <1.4kg (%)	37.2	36.0	34.3
PWM to d3 (%)	8.1	7.7	7.8
Litter size weaned	10.0	10.2	10.5
Mean WOI (d)	5.3	4.8	5.8
Culled – lame or age	4	5	1
WOI <8d	47	48	46
Subsequent farrowing rate* (%)	86.0	93.2	96.2
Subsequent litter size (total born)	12.5^{ab}	12.8^{a}	11.5^{b}
Subsequent litter size (born alive)	11.9^{ab}	11.9^{a}	10.8^{b}

a,b: within a row, values that do not have a common superscript differ (P<0.05)
*Adjusted to remove non-reproductive culls

There is no clear indication in the data that either litter size or stillbirth rate was affected by gestation feeding regimen. Equally, mean piglet birthweight did not increase significantly or substantially with higher feeding levels in late gestation, & these higher gestation feeding regimens failed to reduce the proportion of the piglets that were born light (<1.0kg or <1.4kg). Lactation performance & subsequent return to oestrus post-weaning do not appear to be significantly improved by the higher gestation feeding regimens, although litter size weaned tended to increase with increasing gestation feeding. While subsequent farrowing rate may be slightly enhanced in sows high fed in the previous gestation this difference was not significant. The subsequent litter size data shows no positive effects of the higher gestation feeding regimens but do suggest that excessive high feeding in the previous gestation (treatment 3) may adversely affect the size of the next litter. If this effect is substantiated in future work we speculate that it may reflect sows gaining greater body condition during gestation, this reducing lactation feed intake & thus increasing lactation body condition loss. The negative effects of excessive body condition loss on subsequent litter size have been extensively reported. Finally, a significant (P<0.05) negative correlation was detected between litter size weaned & the size of the subsequent litter.

Given that many earlier reports support the value of high-plane fed for the last 3-4 weeks of gestation we speculate that either:

1. The modern pig genotype no longer benefits greatly from high-plane fed for the last 3-4 weeks of gestation, or
2. The birthweight is already quite high (1.5 kg) and sow nutrient intake does not limit piglet birthweight, but the extra nutrients result in extra maternal gain.
3. That the conditions under which the gestating sows are housed determine whether or not a benefit will be seen when high-plane fed for the last 3-4 weeks of gestation is employed.

Specifically, we suggest that the hygiene standards used for gestation housing may determine the need or otherwise for additional feeding in late gestation. Certainly there is anecdotal evidence (Peter Mackenzie, pers. comm..) & limited research evidence (Opschoor et al, 2010) that gestation housing hygiene may markedly affect piglet birthweights &, possibly, placental integrity & infection status.

Experiment 2

Sow liveweight and body composition

The change in sow weight from the beginning of the feeding trial to farrowing did not differ between treatments – see Table 5. Across all treatments, the sows

Table 5: Sow weight & P2 backfat change in the last 4 weeks of gestation whilst being high or low fed & housed in standard or high hygiene conditions.

	High fed High hygiene	High fed Standard hygiene	Low fed High hygiene	Low fed Standard hygiene
Sow weight gain (kg)	15.5	21.9	12.5	12.7
Sow P2 fat change (mm)	-0.8	+0.3	-1.9	-0.4

gained 15.8 kg on average in the last four weeks of their gestation. There was no significant difference in the change in P2 back fat thickness between the treatments. All sows lost back fat independent of treatment, with the average loss being 0.9mm. The mean weight gain was different between blocks. Weight gain in block 1 was significantly less compared to block 2 ($p<0.005$), block 3 ($p<0.05$) and block 4 ($p<0.05$) (Table 6).

Table 6: Sow weight change, following subjection to high and standard hygiene and high (3.3 kg/d) and standard (2.3 kg/d) feed, in the last 4 weeks of gestation (least squares means ± SEM)

	Block 1 (n=30)	Block 2 (n=26)	Block 3 (n=30)	Block 4 (n=27)
Sow weight change (kg)	7.55 ± 2.90^{a}	20.60 ± 2.91^{b1}	17.18 ± 2.63^{b2}	17.85 ± 2.85^{b2}

Values that do not have a common superscript (^{a}, ^{b}) differ significantly, $^{a, b1}$ ($p< 0.005$), $^{a, b2}$ ($p<0.05$)

Blood samples

There were no significant differences between the treatment groups in the neutrophil: lymphocyte (n:l) ratio. There were large variances in the results of these tests between sows. A non-significant increase in the n:l ratio was observed in the standard hygiene treatment (Figure 1).

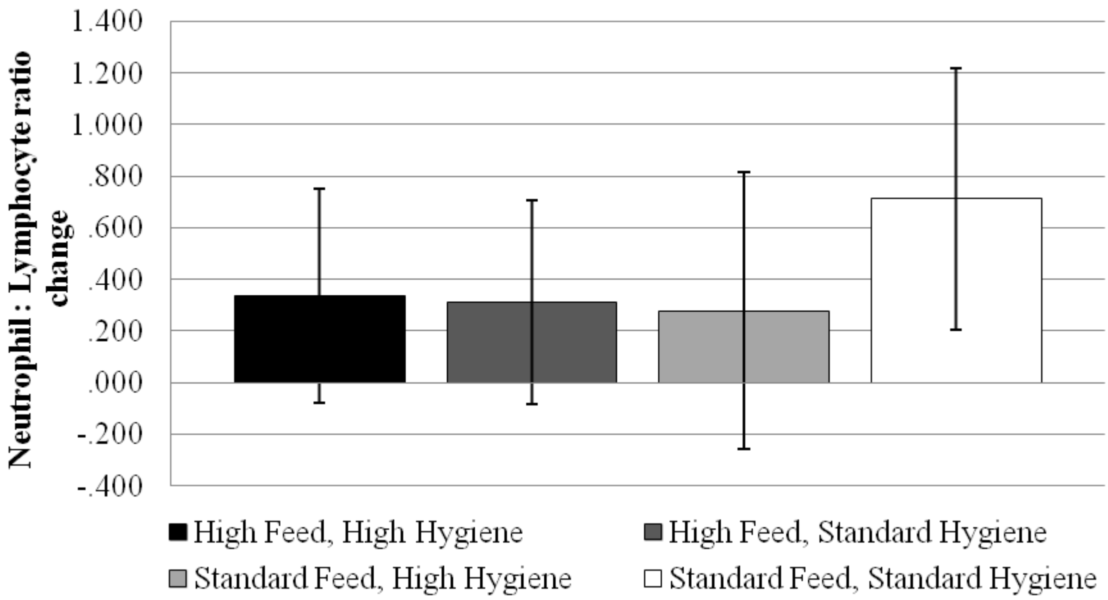

Figure 1: The change in Neutrophil : Lymphocyte ratio, in sows subjected to high and standard hygiene and high (3.3 kg/d) and standard (2.3 kg/d) feed, in the last 4 weeks of gestation (least squares means ± SEM)

There was a significant difference found for the effect of block on this ratio, with block 1 and block 2 differing significantly from each other ($p > 0.05$, Figure 2). Please note that haematology from block 4 was discounted because collection of pre-farrowing samples was not completed as a result of early farrowing.

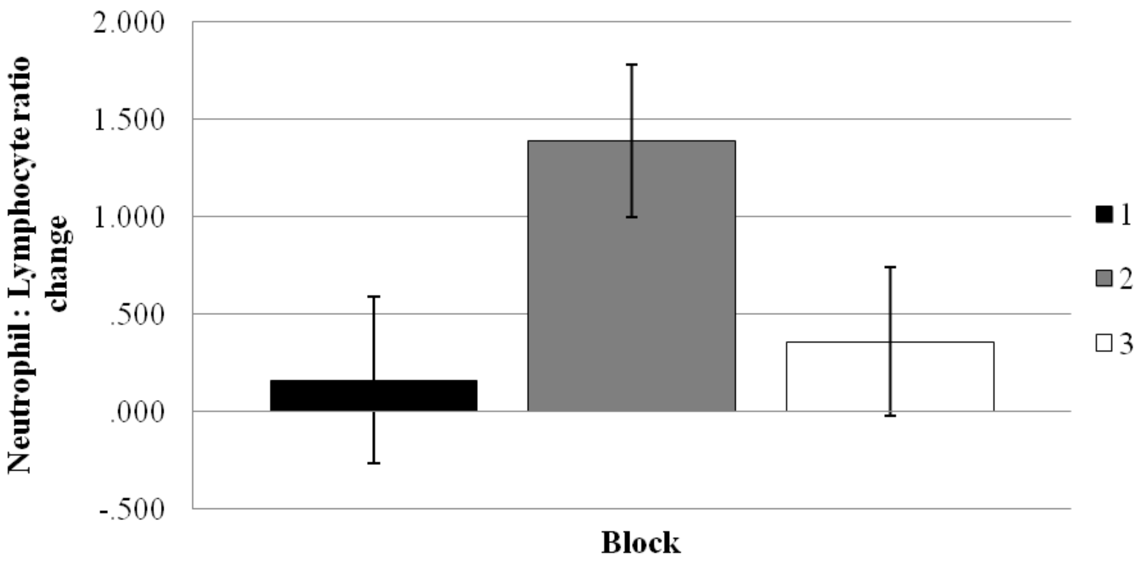

Figure 2: The change in Neutrophil : Lymphocyte ratio, in sows subjected to high and standard hygiene and high (3.3 kg/d) and standard (2.3 kg/d) feed, in the last 4 weeks of gestation (least squares means ± SEM), as affected by block.

Reproductive measurements
Piglet birth weight was not significantly altered by treatment (Table 7). There were significant differences in piglet birth weight associated with piglet gender and the litter size. In all treatments, males were significantly heavier than females ($p<0.001$) and, as litter size increased, the birth weight of the piglets decreased ($p<0.001$). The uniformity of the piglet birth weights within litters was assessed using analysis of the standard deviation of piglet birth weight.

Table 7: Piglet weights, deviation of piglet weights from the mean and the percentage of piglets weighing under 1 kg at birth, in sows subjected to high and standard hygiene and high (3.3 kg/d) and standard (2.3 kg/d) feed, in the last 4 weeks of gestation, with no significant differences created by treatment (p>0.05) (least squares means ± SEM)

	High Hygiene		Standard Hygiene	
	High Feed (n=31)	Standard Feed (n=28)	High Feed (n=28)	Standard Feed (n=26)
Mean litter size born alive	11.8	12.4	11.2	11.7
Piglet birth weight (kg)	1.464 ± 0.041	1.477 ± 0.042	1.528 ± 0.045	1.473 ± 0.047
Within- litter variation (kg)	0.30 ± 0.015	0.30 ± 0.017	0.27 ± 0.016	0.28 ± 0.017
Piglets < 1 kg at birth (%)	9.2 ± 1.9	7.0 ± 2.1	7.1 ± 2.0	8.1 ± 2.1
Mean piglet deaths to 72h post partum (%)	7.6	4.5	4.1	6.9

There were no significant differences in the uniformity of the litters among treatments (Table 7). The variability in weights of piglets within the litter altered with litter size, with an increase in litter size increasing the uniformity ($p<0.005$). The proportion of piglets in a litter that weighed less than 1.0 kg was not influenced by the treatments (Table 7), but increased with litter size ($p>0.001$).

Treatment had no effect on stillbirth numbers or survival of neonatal piglets. Litter size was positively correlated with the number of stillborn piglets in a litter ($p<0.001$, Figure 3). Sow parity also had an effect, with sows over parity five producing greater numbers of stillborn piglets ($p<0.05$, Figure 4).

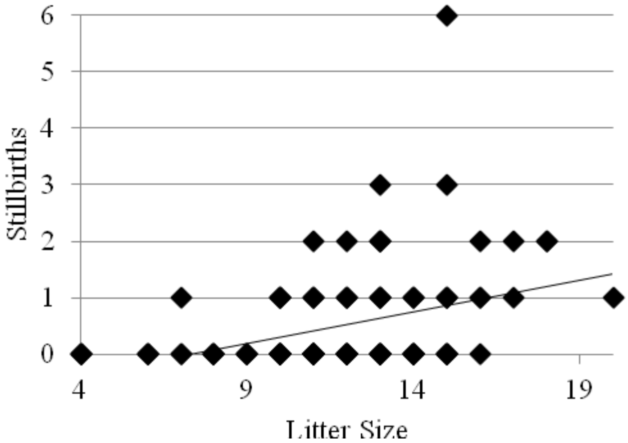

Figure 3: The effect of litter size on stillbirths, in sows subjected to high and standard hygiene and high (3.3 kg/d) and standard (2.3 kg/d) feed, in the last 4 weeks of gestation

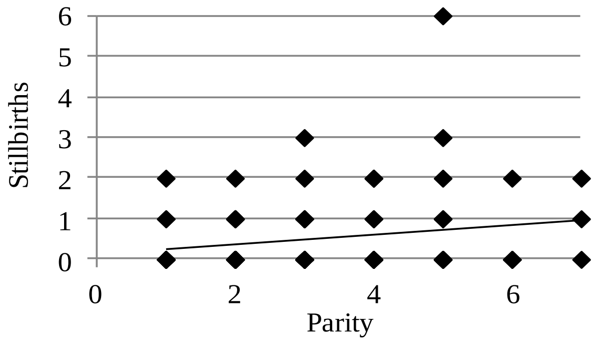

Figure 4: The effect of parity on stillbirths, in sows subjected to high and standard hygiene and high (3.3 kg/d) and standard (2.3 kg/d) feed, in the last 4 weeks of gestation

Following pairwise analysis, a block effect, on the proportion of piglets surviving to 3 days, was noted, with blocks 2 and 4 being significantly different from each other ($p<0.05$, Table 8).

Table 8: Effect of block on piglet survival to 72 hours post-farrowing, in sows subjected to high and standard hygiene and high (3.3 kg/d) and standard (2.3 kg/d) feed, in the last 4 weeks of gestation (least squares means ± SEM)

	Block 1 (n=30)	Block 2 (n=26)	Block 3 (n=30)	Block 4 (n=27)
Proportion survival (%)	96.0 ± 1.1^{ab}	91.3 ± 1.7^{a}	93.1 ± 1.6^{ab}	96.8 ± 1.7^{b}

^{a,b} Within rows, values that do not have a common subscript differ ($p<0.05$)

The placental: foetal weight ratio, farrowing duration and the average time between piglet deliveries were not affected by the treatment and none of these variables were affected by non-treatment factors (eg. block or parity).

Experiment 3

The results of this study are presented in Table 9.

Table 9. Effects of gestation feeding on piglet & sow performance.

	CONTROL	HIGH FED
No. sows	332	326
Sow wt. gain d85-farrowing (kg)	11.8	9.0
Sow P2fat change d85-farrowing (mm)	-0.2	-0.5
Litter size (total)	11.3	11.4
Stillbirths (%)	6.6	6.6
Litter size (live)	10.6	10.7
Mean birth wt. (kg)	1.45	1.45
PWM to d3 (%)	7.1	7.1
Litter size weaned	9.1	9.2
Litter weaning wt. (kg)	54.2	55.5
Mean WOI (d)	4.4	4.5
Subsequent farrowing rate- adjusted* (%)	71.4	74.4
Subsequent litter size (total born)	11.2	11.6

*Adjusted farrowing rate is the ratio of sows mated to sows farrowed once deaths & culls for non-reproductive reasons have been removed.

As with Experiment 1 this study failed to identify any advantage that was gained by higher feeding of sows in late gestation.

4. Application of Research

This project set out to identify a cost-effective supplementary feeding system for gestating sows that raised subsequent litter size at weaning by 1 piglet via an improvement in the survival of piglets at birth & pre-weaning. Since the use of supplementary feeding failed to improve litter size at weaning, we believe commercial pig producers can be advised that there is no advantage to the piglet or sow from an increase sow feeding level in the last 3-6 weeks of gestation. Indeed, there is some suggestion in our data that high plane feeding for 6 weeks pre-farrowing may reduce the appetite of sows during lactation & adversely affect subsequent reproductive performance.

5. Conclusion

We conclude that feeding level in late gestation does not affect stillbirth & pre-weaning mortality rates.

6. Limitations/Risks

This project failed to verify that additional nutrient intake in late gestation would improve survival of piglets at birth & pre-weaning.

7. Recommendation

As a result of the outcomes in this study it is recommended that pig producers do not attempt to improve stillbirth & pre-weaning mortality rates by increasing the feed intake to sows in late gestation.

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