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Effect of maternal backfat levels and feed allowance during gestation on offspring growth

Key external stakeholders:
Pig farmers, Advisers, Animal and Human nutritionists, Infant formula Companies

Practical implications for stakeholders:
The main outcomes from this work are:

- P_2 backfat of gilts should be targeted at ~19mm by the time of first insemination.
- During gestation a daily feed allowance of ~2.5kg of gestation diet (6.2 g/kg lysine, 13.0 MJ DE /kg) should be provided between day 25 and 90 of gestation.
- Following these guidelines will maximize growth to slaughter in offspring.

Main results:

Feed-restricted gilts had higher salivary cortisol levels during gestation and gave birth to lighter piglets. This response to restricted feeding was greatest for the fat gilts. Body condition of gilts and feed level during gestation altered the fat percentage and profile of sows' milk, with thin gilts having higher levels of saturated fat than fat gilts. Weaning weights were heavier and average daily gain from birth to weaning was greater in piglets born to fat gilts. Body condition of gilts at insemination had a greater influence on offspring post-weaning growth than feed level during gestation. Gilts with a backfat depth of ~19mm at insemination, which is close to current recommendations, gave birth to pigs that were heavier and fatter at ~158 days of age than those born from gilts with ~ 12mm backfat depth at insemination. Only transitory effects of gestation feed allowance were observed for ADG and FCE of offspring and when considering these the control feed allowance of 2.5kg/day which is close to current recommendations appeared optimum. Manipulating maternal body condition and feed allowance during gestation did not eliminate the poor growth performance associated with low birth weight piglets

Opportunity / Benefit:

P_2 backfat of gilts should be targeted at ~19mm by the time of first insemination. During gestation a daily feed allowance of ~2.5kg of gestation diet (6.2 g/kg lysine, 13.0 MJ DE /kg) should be provided between day 25 and 90 of gestation. Following these guidelines will maximize growth to slaughter in offspring.
Maternal food intake and weight play an important role in susceptibility to obesity and insulin resistance in children. The pig model developed here is a tool to examine diet and intake of the pregnant mother and the outcome for the offspring. Such a tool could be useful in developing formulations for pregnant women to benefit the health of the child.

Collaborating Institutions:

Royal Veterinary College, University of London.

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1. Project background:

Inadequate prenatal nutrition can negatively influence both the birth weight and subsequent development of offspring. Altering feeding levels at different time points during the gestation period of the sow can influence piglet growth rates and subsequent sow reproduction both of which are key factors for efficient and profitable pig production. As a commercial pig spends nearly half its life *in-utero*, optimum nutrition and environmental conditions during this time are essential to maximise pig productivity. Body composition of the mother during gestation may also affect offspring development. In humans, babies born from obese mothers had increased body fat percentage, higher rates of diabetes and higher rates of insulin resistance. However, little is known about maternal feed level and body condition interactions during pregnancy and how they influence offspring growth and development. Our hypothesis was that postnatal growth in pigs is influenced by both the mother's body condition and her gestation feed allowance. This hypothesis was tested in a 2 x 3 factorial design experiment which examined the effect of backfat depth at service (Thin, 12 ± 0.6 mm P2 backfat and Fat 19 ± 0.6 mm P2 backfat) and feed allowance (1.8kg/d, 2.5kg/d and 3.5kg/d) between d25 and d90 of gestation in gilts on the lifetime growth and carcass quality of offspring at 158d of age.

2. Questions addressed by the project:

Does maternal feed allowance during gestation influence the growth and development of offspring pigs?
Does Maternal back-fat thickness at insemination influence the growth and development of offspring pigs?
Are there maternal feed allowance and maternal back-fat thickness interaction effects on the growth and development of offspring pigs?

3. The experimental studies:

Gilts (Large White x Landrace) were selected as replacement breeding stock at birth on a commercial breeding company's (Hermitage AI, Sion Road, Kilkenny, Ireland) multiplier farm and were exposed to the same housing and feeding regime up to 22 weeks of age. At this time backfat depth of gilts was measured at the last rib and 65 mm from the back bone using an ultrasound scanner (Lean-meater, Renco Corporation, Minneapolis, Minnesota, USA) on both the left and right side and the mean value was recorded.

One hundred and forty gilts were selected based on their backfat depth at 22 weeks of age and Thin (N=68; P2 backfat ~ 8 mm) and Fat (N=72; P2 backfat ~ 12 mm) groups were formed. The difference in backfat depth between groups was accentuated by feeding different diets up to service at 32 weeks. The Thin gilts were restricted to 1.8kg/d of gestation diet (13.0MJ DE/Kg and 6.2g/kg Lysine) and the Fat gilts were provided with *ad-libitum* access to a gilt developer diet (14.3MJ DE/Kg and Lysine 5.9g/kg) up to 2 weeks before service. All gilts were provided with *ad-libitum* access to a lactation diet (14.2MJ DE/kg and 9.1g/kg Lysine) for flushing for two weeks prior to insemination (30 to 32 wk). To allow each gilt to exhibit at least one standing oestrus before insemination, they were provided with constant boar contact from an adjoining pen for four weeks before planned mating. Gilts were synchronised to oestrus and artificially inseminated at onset of standing oestrus and again 24 hours later using semen pooled from eight closely related Hylean Large White boars (Hermitage AI, Sion Road, Kilkenny). At Insemination back-fat depth was 12 ± 0.6 mm and 19 ± 0.6 mm for the Thin and Fat gilts, respectively

Immediately after insemination, pregnant gilts were moved to individual gestation pens (2.4 m x 0.6 m; O'Donovan Engineering, Coachford, Ireland) and fed once per day 1.8 kg/d (23.4 MJ DE/d) of a gestation diet (Table 1) until d 25 of gestation. On d 25 of gestation, pregnant gilts from each body condition group (Thin or Fat) were blocked according to weight and expected farrowing date and allocated at random to one of three feeding allowances of the gestation diet: (a) Restricted (1.8 kg/d), (b) Control (2.5 kg/d) or (c) High feed level (3.5 kg/d), until d 90 of gestation. The experiment was a 2 x 3 factorial design with 2 factors for gilt backfat and 3 factors for gestation feed allowance. From d 90 to weaning at 28 days all gilts were treated the same.

Three same gender pigs (light birth weight, medium birth weight and heavy birth weight) were selected within litter at weaning, with litter representation balanced for the treatments so that in total 270 pigs were allocated to individual pens to be followed through to slaughter at d 130 post-weaning. From weaning, these pigs were individually fed 2 kg of commercial starter diet (16.25 MJ DE/ kg; 16 g/Kg lysine I), until consumed followed

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by 5 kg of a commercial link diet (15.4 MJ DE/kg; 15.0 g/kg lysine) until consumed after which a weaner diet (14.1MJ DE/Kg and 13.1g/kg Lysine) was fed to d 49 post-weaning. A finisher diet (13.7 MJ DE/kg; 11.1/Kg lysine) was fed from d 49 post-weaning to slaughter. At all times feed was available on an *ad-libitum* basis. Pig weights were recorded at birth, weaning, d 14, d 28, d 49, d 91 post-weaning and at slaughter. Feed disappearance was measured between d 0 (weaning) and d 14, d 14 and d 28, d 28 and d 49, d 49 and d 91 and between d 91 and d 130 postweaning. Average daily gain (ADG) and average daily feed intake (ADFI) were calculated for each of the growth stages above.

4. Main results:

During gestation restricted gilts had higher levels of cortisol than high and control fed animals. Piglets born to fat gilts had higher average daily gain during the lactation period and higher weaning weights at day 28 than piglets born to thin gilts. Gilts on a high feed level during gestation had heavier piglets than those provided with restricted and control allocations. Fat gilts had less saturated fat in their milk at day 21 of lactation and higher unsaturated fat levels. No differences were found in the n-6:n-3 PUFA ratio in the milk between thin and fat gilts.

At day 80 of gestation (d 80), Thin Restricted gilts had lower serum IGF-1 concentrations than Thin High or Thin Control fed gilts ($P < 0.001$). Pigs born from Fat gilts had greater backfat depths ($P < 0.05$), a lower lean mean yield ($P < 0.05$) and were heavier ($P < 0.05$) at slaughter than pigs born from Thin gilts. Gilt gestation feed allowance had only transitory effects on average daily gain and feed conversion efficiency and had no effect on pig weight at slaughter ($P > 0.05$) or lean meat yield ($P > 0.05$).

5. Opportunity/Benefit:

P2 backfat of gilts should be targeted at ~19mm by the time of first insemination. During gestation a daily feed allowance of ~2.5kg of gestation diet (6.2 g/kg lysine, 13.0 MJ DE /kg) should be provided between day 25 and 90 of gestation. Following these guidelines will maximize growth to slaughter in offspring.
We offer an animal model to food companies to investigate foods for the pregnant mother and to examine the outcome for her child (growth, weight management, diabetes, cardiovascular health).

6. Dissemination:

Main publications:

1. Amdi, C., Giblin, L., Hennessy, A.A., Ryan, T., Stanton, C., Stickland, N.C., and Lawlor, P.G. (2013). 'Feed allowance and maternal backfat levels during gestation influence maternal cortisol levels, milk fat composition and offspring growth' *Journal of Nutritional Science* 2(e1): 1 - 10. doi:10.1017/jns.2012.20
2. Amdi, C., Giblin, L., Hennessy, A.A., Ryan, T., Stanton, C., Stickland, N.C., and Lawlor, P.G. (2013), 'Maternal backfat depth has a greater influence than maternal feed level during pregnancy on growth performance and insulin-like growth factor-1 concentrations in pig offspring'. *Animal* (Accepted)
3. Amdi C., Stickland NC., Giblin L., McNamara L., Ryan T., Walsh M & PG Lawlor (2010) Effect of piglet birth weight on serum triglyceride levels at weaning and at slaughter. Advances in Animal Biosciences 1:185

Popular publications:

1. Amdi, C., Giblin, L., Stickland, N.C. and Lawlor, P. G. (2011). Influence of body condition and feed allowance on the cortisol levels of pregnant sows. In: International Oskar Kellner Symposium. Metabolic flexibility in animal and human nutrition, Warnemunde, Germany, 9th Sept, 2011
2. Amdi, C., Giblin, L., Stickland, N. and Lawlor, P.G. (2011). Influence of body condition and feed level of pregnant sows on prenatal muscle development. In: 2nd Workshop meeting of the former COST Action 925: The importance of prenatal events for postnatal muscle growth in relation to the quality of muscle based foods, Fribourg, Switzerland, 22nd Aug, 2011
3. Amdi, C., Stickland, N., Walsh, M., Ryan, T, Mc Namara, L., Giblin, L. and Lawlor, P. G. (2010). The effect of sow back fat and gestation feeding level on serum IGF-I levels of progeny. In Proceedings "The Power of Programming" International Conference on Developmental Origins of Health and Disease, Munich, 6th May, 2010, p.102
4. Amdi, C., Stickland, N.C., Giblin, L., McNamara, L., Ryan, T., Walsh, M., and Lawlor, P.G. (2010). Effect of piglet birth weight on serum triglyceride levels at weaning and at slaughter. In: 'Advances in animal Biosciences'. Proceedings of BSAS and the Agricultural Research Forum, Belfast, 12-Apr-2010, p. 185.

7. Compiled by:

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