FEEDING PREGNANT SOWS IN GROUP HOUSING SYSTEMS

AN UPDATE

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IN NOVEMBER 2010 THE AUSTRALIAN PORK INDUSTRY AGREED TO PURSUE THE VOLUNTARY PHASE OUT OF GESTATION STALLS BY 2017.

The industry definition of “Gestation Stall Free” was that sows and gilts should be kept in loose housing systems from five days after service until one week before farrowing. Associated with this voluntary phase out of sow stalls by industry has been increased emphasis on stall free gestation housing systems by the major retailers. Consequently, the Australian pork industry’s move away from the use of sow stalls is making substantial progress, with over 50 per cent of sows (in 2013) now spending their pregnancy in group housing systems.

The nutritional needs of the sow when she is housed under loose group housing systems during gestation require much further attention than when the sow is housed in stalls where individual feeding may be more closely controlled. The aim of this document is to update the information about the nutritional management of sows during gestation as the industry moves to group housing systems, together with the results and implications of some of the gestational nutritional studies conducted within the Pork CRC (CRC for an Internationally Competitive Australian Pork Industry).

ENERGY AND FEED REQUIREMENTS DURING GESTATION

The requirement of pregnant sows for energy is the sum of that required for maintenance, maternal body gain, and conceptus and foetal development. Several simulation models for the gestating sow have been described and applied with good success in describing and predicting energy requirements and responses. In these models, the dietary nutrients are partitioned between maintenance, conceptus gain, and what is left deposited as maternal body gain.

Maintenance requirements: By far the most variable energy requirement is for maintenance and this is particularly affected by housing and environmental conditions. Under thermoneutral conditions the maintenance energy requirements have been estimated at 455 kJ DE/kg metabolic bodyweight (bodyweight$^{0.75}$). Thus for animals between 120 kg and 300 kg body weight, the daily maintenance energy requirement will increase from 16.5 MJ DE to 32.8 MJ DE respectively, or an increase of 16.3 MJ DE (or about 1.25 kg feed per day) feeding level between gilts and older sows.

Foetal development: The energy required for conceptus and foetal development is relatively stable. The requirement for reproductive gain represents only about 5 per cent of the total energy requirement. The energy requirements for the growth of the litter increases as pregnancy progresses, but over a 112 day gestation period, the average daily energy requirement is equivalent to a requirement of only 1.6 MJ DE/day (or about 120 g feed/day) for a litter size of 12.

Maternal gain: The rate of maternal gain allowable during pregnancy will depend upon the body weight of the sow, her condition and parity. The amount of energy required for maternal body gain is also dependent upon the amount and composition of weight gain desired during pregnancy. The amount of maternal gain recommended decreases with parity from up to 35 kg for the first pregnancy down to almost zero as the sow approaches her mature body weight at higher parities.

The amount of dietary energy and protein required for maintenance, conceptus gain and maintenance values of the sow during pregnancy under thermoneutral and optimum housing conditions has been well established in the literature. The major changes since this basic research is the likely change in genotype which may cause some differences in maintenance requirements and nutrient requirements for maternal gain, particularly as the modern younger sow is likely to be capable of depositing considerably more lean and less fat than her counterparts of 20-30 years ago. However, the basic principles of nutrient partitioning during gestation remain. Table 1 provides an estimate of the average requirements of the sow during pregnancy under thermoneutral and optimum housing conditions.

During pregnancy there is a daily increase in requirement of about 7 MJ DE between mating and parturition as the animal becomes heavier (higher maintenance requirement) and foetal deposition increases. The requirement for maintenance is by far the largest component (Table 1) but will be affected quite significantly by housing systems, environmental conditions and health status of the individual herd.

TABLE 1: The energy requirements of the sow during gestation (Close and Cole, 2000)

Body Weight at Mating (kg)	Net Weight Gain Desired (kg)	Maintenance Energy Requirement (MJ DE/d)	Maternal Gain (MJ DE/d)	Conceptus Gain (MJ DE/d)	Total Requirements (MJ DE/d)	Total Feed Requirement (kg/d when sow diet contains 13.0 MJ DE/kg)
150	35	22.5	6.7	1.6	30.8	2.35
200	25	26.7	4.8	1.6	33.1	2.55
250	15	30.4	2.9	1.6	34.9	2.70
300	10	34.3	1.9	1.6	37.8	2.90

Environmental conditions: The lower critical temperature (LCT) is the lowest temperature at which heat loss is minimal. Estimates from the literature indicate that the LCT for pregnant sows varies from 12ºC to 23ºC depending upon feeding level, bodyweight and housing systems. The preferred LCT value for an individually-housed sow living indoors in an optimum environment, but without bedding is about 20ºC. Each 1ºC decrease in LCT is associated with an increase in energy required for maintenance of about 19 kJ/kg bodyweight$^{0.75}$. For an individually housed 200 kg sow, this represents an increased energy intake of up to about 6 MJ DE/day for a 5ºC decrease in LCT from 20ºC to 15ºC. In other words, if sows are cold then feed level must be increased otherwise body condition, and possibly reproductive performance, will be affected.

Housing systems: Housing systems can significantly affect the maintenance energy requirement of sows during gestation, both through the housing system per se as well as the effects of the housing system on LCT. Firstly, sows kept in individual stalls may require an extra 2.5 MJ DE/day (or about 0.2 kg/day) because their activity is greater through the potential development of behavioural stereotypies in stall systems. Thus their energy requirement for maintenance is greater than that for group housed sows. In addition, the individually housed sows usually have a higher LCT than sows kept in groups because of the ability of group housed sows to lie together. In addition, the presence or absence of bedding can markedly alter the sow's microclimate and a good deep bed of straw has been shown to reduce the LCT by up to 5ºC in comparison to an insulated wooden floor. Sows kept on concrete, particularly wet concrete, will again have a much higher LCT and thus require greater levels of feeding, particularly at lower temperatures.

Overall, under colder conditions, group housed sows may require up to 8.5 MJ DE/day less than stall housed sows for maintenance energy requirements. Thus the feeding level of group housed sows may be reduced by an average of 0.6 kg/day to achieve the same maternal gain during pregnancy. However, the variation in body weight gain of group housed (and group fed) sows is expected to be much greater and any reduction in feeding level going from a stall housing system to a group housed system should be monitored closely by assessment of individual body condition or P_2 back fat levels.

TAKE HOME MESSAGES:

- There is no simple recipe for determining the optimum feeding level for sows during pregnancy.
- Feeding levels need to be adjusted depending upon environmental temperature, housing system, sow size and health status.
- When sows are moved from stall housing systems to loose housing systems, there will be significant changes to the partitioning of nutrients between maintenance and maternal gain that should be taken into account.
  - The sow requires an extra 4.0 MJ DE/day (or about 0.3 kg/day) for an increase of 50 kg in maternal body weight.
  - The sow requires an extra 6.0 MJ DE/day (or about 0.45 kg/day) for each 5ºC below the lower critical temperature.
  - Sows kept in stalls require an extra 2.5 MJ DE/day (or about 0.2 kg/day) because their energy requirement for maintenance is greater than that for group housed sows.
  - The above effects are generally additive (i.e. a 50 kg heavier sow that is cold could require 0.75 kg/day more feed).
  - Thus group housed sows are likely to have lower energy requirements than the stalled sow and consequent feeding levels may be reduced in group housing systems, particularly in winter months.
  - There is scope to reduce feeding levels as producers go from stall systems to group housing systems, particularly where individual feeding is available as in electronic sow feeding systems.
  - But any reduction in feeding level for pregnant sows going from a stall housing system to a group housed system should be monitored closely by observing changes in the individual body condition of sows due to competition for feed.

There is a tendency to feed sows, and in particular gilts, at a "low" feed level during early gestation to reduce the possibility of adverse effects on embryo survival. The results of several studies conducted in the 1980s suggest that a high feed level in early gestation leads to a reduction in embryo survival. However, recent studies conducted by the Pork CRC in Australia by Dr Pieter Langendijk and Rebecca Athorn have shown that feed levels as high as 2.8 kg/d (37 MJ DE/d) fail to have a detrimental effect on embryo survival, or on litter size in gilts (Table 2). These results have been confirmed in other studies conducted with gilts and parity 1 sows in commercial situations, showing not only positive effects of a high feed level on embryo survival, but also pregnancy rates (Virolainen *et al.*, 2004; Hoving *et al.*, 2011).

In a commercial study with gilts (Pork CRC project 2D-112), Langendijk and Athorn investigated three feeding levels between days zero and 25 of gestation. The feeding levels investigated were 1.6, 2.35 and 3.2 kg/d. Plasma progesterone measured on days seven and eight was highest for gilts fed at the lowest level but feeding level had no significant effect on any measure of reproduction, with pregnancy rate being highest (91 per cent) for gilts fed at the higher feeding level of 3.2 kg/day in early gestation.

TAKE HOME MESSAGE:

- "High" feeding levels during early gestation don't necessarily adversely impact reproductive performance for that pregnancy.

TABLE 2: Pregnancy rate and embryo survival at day 35 of gestation in gilts fed at a low or high feeding level of a standard diet or diets with increased fat or fibre during early pregnancy (Athorn et al., 2012)

Feeding Level	LOW 20 MJ DE/d	HIGH 37 MJ DE/d	HIGH 37 MJ DE/d	HIGH 37 MJ DE/d
Cereals replaced by	Standard	Standard	Fat (11%)**	Fibre (8%)**
Number of sows	31	21	23	23
Sow wt gain, g/d	320^{b}	1000^{a}	919^{a}	1055^{a}
Ovulation rate	15.4	14.9	15.3	16.3
Pregnancy rate	94% (31/33)	91% (21/23)	96% (23/24)	96% (23/24)
Total embryos	12.2	11.9	11.6	11.6
Embryo survival	80%	77%	76%	76%

^{a,b} means with different superscripts are statistically different, in the absence of superscripts there is no significant difference between treatments; *corrected for ovulation rate; **Fat was mainly tallow, fibre sources were mill mix and oat hulls and the standard diet had 2.5 per cent fat and 4.5 per cent crude fibre.

GROUP HOUSING AND RISK OF LOW FEED INTAKE IN EARLY GESTATION

With the transition of the pork industry to group housing in early gestation, feed strategies have to take into account that this transition creates different conditions to the requirements of sows and gilts. In an established group housing situation, sows and gilts are likely to require less energy for maintenance because they are generally less active and benefit from each other's body heat in cold conditions. However, on the other hand, in early stages after mixing of sows, and also in established groups with suboptimal space allowance or otherwise suboptimal conditions, there may be increased activity due to aggression between sows. More importantly, in early gestation when sows may be mixed, subordinate sows may not succeed in achieving the required feed intake for optimal growth during gestation.

The results of recent research from Europe indicates that sows that eat significantly less than their group mates in early gestation are at a higher risk of losing pregnancy. This is paralleled by the observation that weight and back fat gain during early gestation is positively related to pregnancy rate and litter size in group housing situations. A recent Pork CRC study in Australia conducted by Dr Pieter Langendijk showed that gilts that were fasted for 36 hours around day 10 of gestation, to simulate serious off-feed incidents, experienced a 2.5 piglet drop in litter size. These observations suggest that there is a risk of feeding sows at a too low feed level, and of temporary underfeeding.

Thus under group housing and feeding systems, it is recommended not to drop below approximately 2.0 kg/day for gilts and 2.5 kg/day for sows in early gestation and ensure that most individual sows achieve these levels. If individual sows consume higher levels than these allocated levels under group feeding systems, the results of research identified above show that it is unlikely that higher feed intakes have any adverse effects on subsequent reproductive performance. Thus under group housing it appears better to err on the higher levels of feed intake in early gestation to ensure that individual sows in a group housed and feeding system consume at least 26 MJ DE/day and 32 MJ DE/day, for gilts and sows respectively.

TAKE HOME MESSAGES:

- To minimise pregnancy loss, individual feed intakes during early gestation shouldn't drop below 2.0 kg/day for gilts and 2.5 kg/day for sows.
- It is unlikely that reproductive performance will be adversely affected if individual sows consume higher levels of feed.

FEEDING SOWS DURING LATE GESTATION

This is the period of gestation when most of the foetal and mammary growth and development occurs and there is a significant increase in the nutrient requirements of the sow. Thus there is a general belief that increasing sow feed levels in late gestation will be beneficial as it will prevent the sow going catabolic, and is likely to improve her energy status at farrowing by presumably speeding up the birth process and reducing stillbirth rate. In addition, it is argued that higher feeding levels in late gestation will "set the sow up" for good feed intakes post-farrowing.

However, the results of many recent studies suggest that using gestation feeding to increase piglet birth weights, and thus increase piglet survival rates, has little value. The extra energy from higher feed levels is likely to be deposited in maternal tissue rather than in the developing foetuses, particularly if piglet birth weight is already satisfactory (1.5 kg). Recent Pork CRC-funded research conducted by Dr Paul Hughes and Dr Will van Wettere has looked at the value of high plane feeding for sows in the last three to six weeks of the gestation. The results of the three studies with sows found no significant improvement in piglet birth weights from increasing sow feed level by up to 1.0 kg/day over the last three to six weeks of gestation. In addition, litters from the higher-fed sows did not have fewer stillbirths or lightweight piglets (less than 1.0 kg) and the survival of the piglets was unaffected by sow feed level. Overall, there doesn't appear to be significant benefits to warrant increasing late gestation feeding levels, particularly as the cost of this nutritional intervention may be considerable. The extra nutrients provided to sows in late gestation were diverted to maternal tissue and may compromise subsequent lactation feed intake and performance.

There is a strong linear relationship between feed intake during gestation and voluntary feed intake in the subsequent lactation. Dr Pieter Langendijk reported that increasing the feeding level of gilts in late gestation, from 2.5 to 3.5 kg/d of a conventional gestation diet, reduced feed intake in the subsequent lactation by 12.2 per cent (Langendijk and Chen, 2012). In an extensive sow feeding study conducted by King *et al*. (2006) at Rivalea, sows were fed at 2.2, 2.6, 3.0, 3.4 and 3.8 kg/day for the last six weeks of gestation.

The significant linear relationship between average daily energy intake during gestation and voluntary feed intake in the subsequent lactation revealed that for every 10 MJ DE increase in DE intake during gestation, daily voluntary feed intake during lactation decreased by 1.1 kg. Close and Cole (2000) also reported that daily voluntary intake during lactation in sows decreased by 1.7 kg for every 10 MJ DE/day increase in gestation energy intake.

There is now sufficient research data available to conclude that feeding of sows in mid-late gestation:

- Has minimal effect on farrowing rate and litter size unless feeding level falls below 2 kg/d.
- Has little impact on birth weights in modern genotypes.
- Has no effect on stillbirth rate or pre-weaning survival of piglets.
- Is likely to reduce sow voluntary feed intake in lactation, which may adversely affect subsequent reproductive performance.

In the last three to four weeks of gestation, feeding of both gilts and sows should continue at the same levels as fed between days 30 and 85. If a decision is taken to increase feed level at this stage of gestation it should only be increased to a maximum of 3.0 kg/d (about 40 MJ DE/day). If these higher levels are used then producers should monitor effects of higher feed level on sow feed intake in lactation.

TAKE HOME MESSAGES:

- There doesn't appear to be significant reproductive benefits to warrant increasing late gestation feeding levels.
- If feeding in the last three to four weeks of gestation is increased, it should only be to a maximum of 3.0 kg/d (about 40 MJ DE/day) and producers should monitor its effect on feed intake during lactation.

HIGH FIBRE DIETS FOR SOWS DURING GESTATION

Pregnant sows are excellent candidates for high fibre diets. Pregnant sows are usually fed restricted levels of feeding during gestation that are well within the voluntary feed intake of these animals. Formulation of dry sow diets allows the flexibility of using higher fibre ingredients that may be at a significantly lower cost. High fibre diets may also provide additional benefit throughout pregnancy since the extended feeding times and possible distension of the gastro-intestinal tract may overcome feelings of hunger in the feed-restricted sow. This may reduce both aggression around feeding episodes and the development of stereotypic behaviours, and thus improve sow welfare.

In a study conducted by Anthony Martyniuk, a Pork CRC Honours student, sows housed in stalls or in groups of six were fed either a low or high fibre diet at 34 MJ DE/d from day five to day 34 after mating. The low and high fibre diets contained 5 per cent and 25 per cent crude fibre respectively and were fed to provide sows with 32 MJ DE/day intake during the 29 days of the study. The high fibre diet contained 40 per cent cereal straw, 14 per cent oat hulls and 13 per cent oats. Neither the housing system nor the diet affected reproductive performance or the number of sows removed from the herd for locomotory reasons. However, the high fibre diet reduced aggression after feeding in group housed sows by 75 per cent and increased the time sows spent feeding by 150 per cent.

One fibre source that has received a great deal of attention with feeding to pregnant sows is sugar beet pulp. The inclusion of sugar beet pulp in dry sow diets in Europe is now quite common. Sugar beet pulp appears to have unique properties; it appears to induce satiety (feeling of fullness) when offered in dry sow diets by increasing water holding capacity, delaying stomach emptying and modifying hindgut fermentation. The particular fibre fraction of sugar beet pulp responsible for the satiety effect is likely to be the non-starch polysaccharides, particularly pectin and hemicellulose. Sugar beet pulp is available in Australia, but is unlikely to be an economically viable option for general dry sow diets here, unless the results of Pork CRC studies currently in progress (2013) suggest it may have a role to improve sow behaviour and welfare during strategic periods of sow production, such as around the immediate period of mixing sows into groups.

Previous investigations have failed to identify local high fibre ingredients that have similar positive effects on satiety and aggression as sugar beet pulp. More recently, a couple of commercial sources of eubiotic fibre preparations that influence the microflora of the gastrointestinal tract have become available in Australia. These preparations have high water binding capacity and may provide useful supplements to dry sow diets in attempts to improve satiety amongst these sows.

The Pork CRC has recently (2013) supported projects which will investigate certain ingredients, such as non-starch polysaccharides, pectin and hemicelluloses, that affect water holding capacity and/or alter fermentation patterns in the sow to determine whether they may play a role in the nutritional satiety of the pregnant sow and improve behaviour and reduce aggression in dry sows. In future, careful selection of dietary fibre ingredients and fibre supplements for dry sow diets may allow higher levels of feeding with consequent improvements in satiety and sow welfare. Inclusion of these dietary fibre ingredients in sow gestation diets may only be required around the critical periods of mixing/grouping sows and during early gestation.

TAKE HOME MESSAGES:

- High fibre diets may overcome feelings of hunger in the feed-restricted sow and reduce aggression at feeding.
- Further research is needed to identify ingredients available to Australian producers which can influence satiety and sow behaviour.
- High satiety diets may only be required around the critical periods of mixing/grouping sows and during early gestation.

AMINO ACID REQUIREMENTS DURING GESTATION

The protein and amino acid needs for pregnancy, like energy, are for maintenance, conceptus and for maternal gain. The amino acid and protein requirements for gestation are much lower than for lactation, and the pregnant sow, particularly the older sow, is able to withstand protein and amino acid deprivation by protecting the developing foetus at the expense of maternal tissue. The amino acid requirements during gestation are quite low and often the total lysine requirement for sows during gestation has been suggested to be of the order of 10-11g/day for mature sows (Agricultural Research Council, 1981). Usually the requirement for other essential amino acids is expressed as a ratio to lysine requirements. However, recent research indicates that the balance of other essential amino acids may change according to parity, litter size and more particularly, stage of gestation.

Dr Ron Ball and his group in Canada suggest requirements change dramatically between early and late gestation. In particular, they suggest that the threonine to lysine ratio increases from 53 per cent to 74 per cent between early and late gestation for parity 2 sows and from 62 per cent to 95 per cent between early and late gestation for parity 3 sows. Based on these increases in threonine requirements, threonine could be the first limiting amino acid for sows in late gestation. Dr Ron Ball and his group are now recommending phase feeding for gestating sows using diets with different available lysine levels and different amino acid balances in early (0-85) and late (86-112) gestation. They hypothesise that this strategy may improve piglet viability/survival, sow longevity and general reproduction of the sow. This concept however, requires further research and to be tested commercially.

TABLE 3: The estimated requirement for available amino acids (g/day) by pregnant sows between breeding and 90 days and after 90 days of pregnancy (levels shown in brackets) (National Research Council, 2012)

Parity and Weight (kg) at Breeding Anticipated Litter Size	1 - 140 12.5	3 - 185 13.5	4+ - 205 13.5
Essential amino acid			
Lysine	10.6 (16.7)	7.8 (13.1)	6.3 (11.1)
Methionine	3.0 (4.7)	2.2 (3.7)	1.7 (3.1)
Methionine + cysteine	6.8 (10.8)	5.4(8.9)	4.5 (7.8)
Threonine	7.6 (11.5)	6.2(9.7)	5.3 (8.5)
Tryptophan	1.9 (3.2)	1.5 (2.7)	1.3 (2.4)
Isoleucine	6.1 (8.8)	4.6 (6.9)	3.7 (5.7)
Leucine	9.6 (15.6)	7.3 (12.6)	6.0 (10.8)
Arginine	5.6 (8.8)	4.1 (6.9)	3.2 (5.8)
Valine	7.5 (11.8)	5.8 (9.5)	4.9 (8.3)

Note that the requirements for amino acids during gestation are unlikely to be affected by how sows may be housed. However, diet formulation may need to take into account any changes in feeding levels due to housing systems, to ensure the daily intakes of amino acids meet the requirements of the sow.

Interestingly, in a smaller scale study, Kim *et al*. (2009) reported that sows fed diets based on an "ideal" balance of amino acids gained more weight in late gestation (fed at the same level as the control) and had much higher pre-weaning survival than their control counterparts. The "ideal" balance of amino acids proposed and investigated by Kim *et al*. (2009) was that suggested by National Research Council (2012) and levels differed somewhat from those suggested by Dr Ron Ball. For the period 60 to 114 days of gestation the ideal available threonine to lysine ratio was 71 per cent.

The latest recommendations from the National Research Council (2012) incorporates some of these findings about the greater levels of amino acids required in late gestation and are summarised in Table 3. However, these recent estimates of requirement do not reflect the considerable change in the threonine to lysine ratio between early and late gestation suggested by Dr Ron Ball. More work needs to be done in the area of amino acid balance in late gestation to validate some of these R&D results appearing recently from overseas. The sow electronic feeding systems that are now available in research facilities in Australia are ideal facilities to undertake such studies on amino acid requirements and balances for sows during various stages of gestation.

TAKE HOME MESSAGES:

- The amino acid requirements during gestation are quite low and often the total lysine requirement for sows during gestation has been suggested to be of the order of 10-11 g/day for mature sows.
- However, recent evidence suggests that the lysine requirements may be considerably higher in late gestation. Furthermore, the balance of some other essential amino acids relative to lysine may also be higher than previously identified.
- More work is needed on amino acid requirements and balances for sows during various stages of gestation. Producers and their nutritionists should consider requirements listed in Table 3.
- Amino acid requirements and balances aren't specific to group housed sows.

OMEGA 3 FATTY ACIDS FOR SOWS DURING GESTATION

Fatty acids in pigs are essential in several important metabolic pathways. Dietary fats provide a rich source of energy for maintenance and production, as well as specific fatty acids that form components of cell membranes and supply substrates for metabolism. For the sow to produce a large number of offspring over several years of productive life, the dietary supply of certain fatty acids is essential. Currently, the omega-3 long-chain polyunsaturated fatty acids (PUFA) such as eicosapentaenoic acid or EPA (C20:5) and docosahexaenoic acid or DHA (C22:6) are not considered essential, however, evidence from other species suggests that increasing the supply of these omega-3 PUFA may provide a new nutritional approach to increasing reproduction in the breeding herd.

In a series of Pork CRC studies in sows and gilts conducted by Dr Rob Smits, fish oil was fed as a partial replacement for tallow in diets fed at different stages of the reproductive cycle to determine the responsiveness and mechanism as to how omega-3 PUFA supplementation of EPA and DHA influences reproduction. Experiments were conducted in gilts using different durations of feeding supplemented diets, followed by a dose-response study. In multi-parity sows, the feeding period was investigated either during gestation, during lactation and before mating, and/or after mating in early pregnancy.

In two experiments with multiparous sows, the use of 3 g/kg fish oil in lactation and 6 g/kg fish oil in early gestation improved litter size by 0.9 piglets with no effect on farrowing rate, post-weaning oestrus or weaning to oestrus interval. This was associated with an increase in embryo survival rate of 10 per cent after embryo implantation. This increase in embryo survival appears to be related to positive effects of PUFA on oocyte quality as supplemented sows had proportionally more larger follicles. The oocytes collected from supplemented sows were also more advanced after *in vitro* fertilisation. The response to fish oil was more apparent in the older parity sows which may be due to a greater effect on embryo survival which is lower in parities 4-8.

In two experiments with gilts, feeding a diet for up to six weeks prior to mating at 31 weeks of age had no effect on gilt litter size or farrowing rate when bred on 2nd or 3rd oestrus. However, in a follow-up gilt study the results showed that continuing to feed a diet with 3 g/kg fish oil after insemination increased embryo survival at 25 days of pregnancy.

In a large commercial study with almost 1000 sows per treatment, diets were supplemented with fish oil throughout gilt gestation, lactation and the parity 1 gestation cycle and the results showed that the incidence of subsequent sow deaths and culling due to locomotion disorders was halved compared to sows fed unsupplemented diets.

TAKE HOME MESSAGES:

- Supplement breeder diets with omega-3's from low levels of fish oil (0.3 per cent of diet) to achieve a daily intake of at least 2.9 g EPA+DHA.
- Formulate breeder diets to an omega-6: omega-3 ratio of less than approximately 10 in lactation and early gestation by increasing the level of fish oil if necessary.
- Cost of supplementation varies between \$9 and \$15/tonne of finished feed. Based upon the results of these Pork CRC projects, the Benefit: Cost Ratio of using 3 g fish oil/kg in sow diets is about 5:1.

B-VITAMIN AND METHYL DONOR SUPPLEMENTATION FOR SOWS DURING GESTATION

Litter size and the number of litters produced per sow per year determine breeding herd efficiency. These are limited initially by the number of ova shed, and subsequently by the failure of the maternal environment to recognise the presence of the developing conceptuses, resulting in early pregnancy loss or the death of initially viable embryos before day 50 of gestation.

In pregnant gilts and sows, metabolic demand for folate and vitamin B_{12} increases dramatically during the first 30-60 days of gestation. However, current recommendations for B-vitamin intakes are based on the minimum levels required to prevent signs of deficiency in genotypes of 20-50 years ago, and it is suggested that the optimal B-vitamin intake required to maximise reproductive performance may be higher, particularly in modern, prolific sows. In addition to promoting normal embryonic function and cell proliferation, folate, in conjunction with vitamin B_{12} and glycine, is integrally involved in the remethylation of methionine from homocysteine. Elevated homocysteine levels result in abnormal embryo development and increased pre-natal mortality in several species, and have been observed in sows experiencing early pregnancy failure. Betaine, a readily available nutritional supplement, converts homocysteine to methionine and can alleviate the effects of heat stress in poultry. In light of this, a series of studies were conducted by Dr Will van Wettere in two Pork CRC projects to investigate the effects of adding betaine and extra folate/vitamin B_{12} to gestation diets on reproductive performance.

Supplementing gilt diets with 2 g betaine/kg during summer increased ovulation rate by 1.1 ova, with this effect most evident during periods of prolonged ambient temperatures in excess of 35°C, and also tended to reduce the interval from start of boar contact to puberty attainment. Supplementing gestation diets with betaine to provide between 7.5 and 9.0 g supplemental betaine to the sow each day increased total litter size of higher parity sows mated during summer by 1.6 piglets and also increased total litter size of higher parity sows mated during autumn/winter, albeit the increase was smaller.

The common supplementation rates for gestation diets are 2.0 mg/kg folic acid and 20 µg/kg vitamin B_{12}. Adding an extra 20 mg/kg folic acid and 150 µg/kg vitamin B_{12} to sow gestation diets increased total litter size of parity 2 and 3 sows by 0.6 piglets and decreased incidence of early pregnancy loss across all parities.

TAKE HOME MESSAGES:

- Betaine supplementation of pre-mating gilt diets during summer improves growth rate and may improve reproductive performance. The estimated cost is 4.2 c/day/gilt (based on intake of 3 kg/day and on a retail cost of $7/kg for betaine).
- Supplementary betaine during gestation improves litter size of older parity sows, particularly during summer. The estimated cost is $6.00 – $7.20/sow/gestation (or 5.3 to 6.3 c/day based on a retail cost of $7/kg for betaine).
- Supplementary folate and vitamin B_{12} improves litter size of early parity sows and may reduce the incidence of early pregnancy loss across all parities. Any expected response is likely to be independent of season. The estimated cost of this extra supplementation is $0.80/gestation (or 0.7 c/day based on $3/tonne).

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