Sow feed intake and lifetime reproductive performance

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Introduction

For many breeding companies, performance testing in maternal lines is generally confined to traits such as average daily gain (ADG), back fat (BF) and perhaps loin muscle depth or area (LMD or LMA), along with litter size traits such as number born alive (NBA) or total born (TB). More sophisticated breeding programs will also accommodate traits associated with sow performance, longevity or piglet survival, using data from traits such as weaning to conception interval, and litter birth or weaning weights, amongst others. Despite these breeding efforts, poor overall reproductive performance, as measured by pigs weaned per sow per year, and poor sow longevity are common problems in modern pig production systems.

There are many factors that affect sow reproductive performance and longevity, both environmental and genetic. Walters (2006) noted that selection has resulted in modern sows with higher maintenance costs and milk yield, but reduced body fat reserves and appetite. This combination of characteristics would be expected to predispose sows to greater body weight loss during lactation through limited feed intake, poorer rebreeding performance, and thus a higher risk of early culling. However, for maternal lines generally there are relatively little data to illustrate a reduction in feed intake resulting from selection. This is largely because feed intake data is typically recorded for terminal line males, if at all. Thus, inferences for the effects of selection on feed intake and reproductive performance are generally made for lines where little selection emphasis has been placed on reproductive performance, and where reproductive performance is already compromised relative to that of maternal lines.

It is possible that the different selection emphasis in maternal compared to terminal lines limits the decline in feed intake under selection relative to that observed in terminal lines. If this were the situation, poorer longevity and reproductive performance are unlikely to solely result from lower voluntary feed intake in maternal lines *per se*. In fact, the most prolific dam line with the best longevity in the maternal line genetic evaluation program (operated by the National Pork Producers Council, 2000) ate the least feed during lactation but had the same (fixed) feeding level during gestation. In reality, sows are rarely given the opportunity to express appetite because of restricted feeding practices throughout ~65% of their reproductive life. Thus, it is possible that the type of feed restriction throughout the rest of a sows lifetime, which is typically not a function of sow appetite, is the primary key affecting sow longevity and performance, rather than a decline in voluntary feed intake.

Generally, we do not know enough about how sow feed intake affects sow longevity and performance. The purpose of this paper is to present information on background research into associations between sow feed intake and reproductive performance. A new project, funded through the Pork CRC, will be outlined.

Studies on sow feed intake

Standard management practices for female pigs constrain opportunities to generate meaningful records for sow feed intake. Generally, feed intake under (semi) *ad-libitum* conditions will only occur when females are recorded for feed intake as finishers, or pre-mating in systems where *ad-libitum* feeding is continued post-selection until mating; although the latter is not a widely recommended practice for gilt development. In addition, it is common for gilts and sows to be fed restricted rations during gestation, while during lactation many production systems deliberately restrict sow feed intake early in lactation (eg through step-up feeding) or unintentionally limit intake capacity (eg small troughs, or infrequent feed delivery). Any form of restricted feeding will mask some of the natural variation between individual sows for feed intake. Further, due to the above constraints, data tends to be relatively limited, arising typically from small studies only. Nevertheless, there are numerous studies that examine some of the relationships between sow feed intake, sow reproductive performance and the performance of piglets.

1. The importance of intake during pregnancy and lactation

High feed intake during lactation increases litter weight gain and reduces weight and back fat loss of the sow (Eissen et al. 2000). Since milk production has priority during lactation, sows will mobilise body tissue in an attempt to maintain milk production (NRC, 1987), thereby losing weight. Excessive weight loss during lactation as a result of insufficient feed intake has been shown to have a negative impact on subsequent reproductive performance through increased weaning to oestrus interval, increased incidence of anoestrus, decreased conception rate and higher embryonic mortality rate (see review by Eissen et al., 1999). Clowes et al. (2003) estimate that losses of greater than 9-12% of estimated parturition protein mass will have an increasing detrimental effect on ovarian function and lactation performance. Thus, poorer lifetime reproductive performance could be expected for sows with lower than necessary lactational feed intakes. Interestingly, Guillemet et al. (2006) demonstrated that characteristics of diet provided during pregnancy altered feeding patterns, but not total feed intake, during lactation. This work was conducted to test whether the provision of high fibre diets during pregnancy helped gilts adapt to *ad-libitum* diets during lactation.

<u>High VFI improves growth performance of offspring</u>.

Milk production of the sow limits growth rate of the sucking piglet commencing around 8 to 10 days of lactation (Harrell et al. 1993, cited in Williams, 1995). The two main factors influencing milk production at this stage are the protein and energy supply in the diet along with sow body reserves (Williams, 1995). The effect of an increased feed intake on piglet weight gain was analysed by Eissen et al. (2000) for three modern genotypes. For each of these lines, total litter weight gain increased by 0.058, 0.19 and 0.12 kg/d when voluntary feed intake (VFI) of the sow during lactation increased by one kg per day, equivalent to an increase in piglet growth of 5.5, 18.1 and 11.4 g/d for a

given litter size of 10.5 piglets per litter. Higher pre-weaning performance also has a "carry-over" effect on the post-weaning performance. Mahan et al. (1998) showed that piglets with higher weaning weight also had higher post-weaning growth until slaughter and consumed less feed from weaning to 105 kg body weight than piglets with lower weaning weight. Consistent with this observation, Hermesch (2002) reported phenotypic correlations of 0.32 and 0.26 between lifetime average daily gain and weight at or gain to 14 days of age.

High VFI improves reproductive performance of the sow.

Kongsted (2006) demonstrated in group-housed sows that pregnancy rate and resulting litter sizes were positively correlated with sow back fat gain (a proxy for intake) from weaning to three weeks post weaning. At this time, sows that were not observed feeding in at least 20% of all observed feeding events also had a significantly higher risk of returning to oestrus compared to sows that fed more regularly. This outcome was consistent with the conclusions from a previous review by Kongsted (2005), that a low energy intake before mating resulted in impaired litter size for gilts, and also for sows that experienced severe weight loss during the previous lactation. It is likely that in this situation, sow longevity would be compromised under culling policies that include returns.

Based on commercial data (PigChamp), Koketsu and Dial (1997) showed that a high VFI during lactation was associated with improved subsequent reproductive performance through reduced weaning to service interval, and increased farrowing rate, litter size and litter weight at weaning (Table 1). Koketsu and Dial (1997) further suggested that a high feed intake during lactation alleviates at least some of the detrimental effects of short lactation (through early weaning) on subsequent reproductive performance.

Table 1. Change in reproductive performance resulting from an increase of daily feed intake during lactation from 2 kg to 6 kg, by parity group (Koketsu and Dial, 1997).

Parity	Weaning to service interval	Farrowing rate (%)	Litter size (piglets)	Litter weight at weaning (kg)
First parity	8.4 to 7.3	82.5 to 89.1	10.5 to 10.8	42.5 to 46.7
later parities	5.5 to 5.0	82.0 to 89.2	10.9 to 11.5	45.5 to 50.5

Under conventional weaning, it is likely that the underlying mechanism of VFI on sow reproductive performance is mediated at least partly through the influence of sow body composition. Hughes et al. (1993) demonstrated that weight and back fat levels at weaning were significantly related to weaning-to-oestrus interval. Sows with a P2 backfat at weaning of less than 10 mm had a weaning to oestrus interval of 8.1 days. In comparison, sows with a P2 backfat of more than 13 mm had a weaning to oestrus interval of 5.8 days.

2. What intake levels have been observed?

During 1999/2000, voluntary feed intake during lactation was recorded at QAF Meat Industries Pty Ltd (QAF) on a small sample of sows. Mean VFI during lactation was less in the first parity (5.78 kg/d) than in the second and third parities (6.34 kg/d and

6.58 kg/d), and considerable variability between sows was evident (Table 2). QAF sow feed intakes were consistent with the NRC (1987) summary of intake from several sources. For comparison, Cooper et al. (2001) reported mean intake values for corresponding parities of 6.90, 7.40 and 7.20 kg/day. A later study at QAF (2002) with 4×per day feeding also exhibited higher feeding rates of 6.5 kg/day for primiparous sows, or 7.6 to 7.8 kg/day for older sows. The difference between mean levels of intake for the QAF studies shows the importance of feed delivery strategies for accurately measuring maximum levels of sow feed intake. In comparison, the range of differences between lines in lactational feed intake from a line evaluation trial was 8.7 kg (Moeller et al.,2004) or 0.58 kg/day over a 15-day lactation.

Table 2. Number of records (N), mean, standard deviation (SD) along with minimum and maximum for VFI (kg/d) of the sow during lactation (QAF data).

Parity	N	Mean (SD)	CV(%)	Minimum	Maximum
First parity	237	5.78 (0.82)	14	3.67	7.80
Second parity	166	6.34 (0.75)	12	4.43	7.91
Third parity	98	6.58 (0.76)	12	4.20	8.20

Voluntary feed intake of the lactating sow is also influenced by season (Figure 1 from QAF data). Data on VFI during lactation were available from October 1999 to July 2000. A clear seasonal trend was apparent with VFI being lowest in the summer months and highest during winter. This difference in daily VFI between winter and summer exceeded 1 kg/d. However, sows may vary in their capacity to retain a high feed intake over summer, and this difference may be captured through measuring individual VFI. It is important to note that some research suggests that altered lactation performance at high ambient temperatures is only partially explained by reductions in sow feed intake (de Braganca et al., 1998; Farmer and Prunier, 2002). Thus, identifying sows that can maintain feed high intakes during summer is unlikely to be an effective by itself as a strategy to resolve summer reproductive issues.

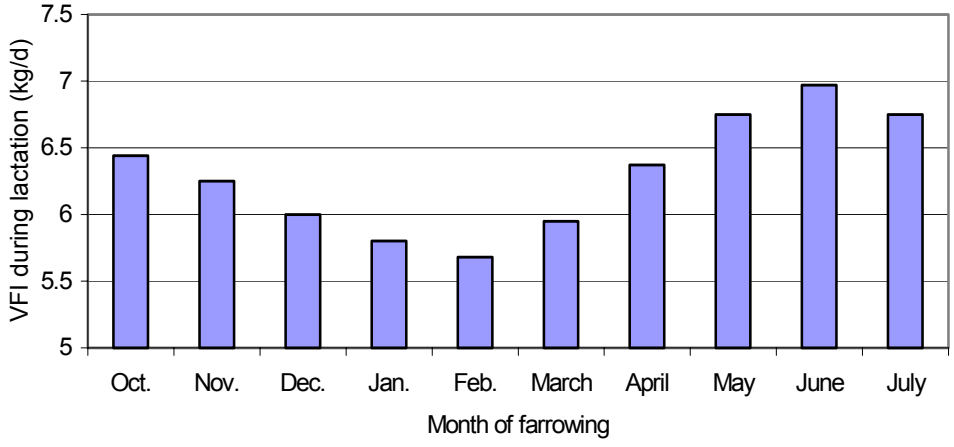

Figure 1. Mean VFI during lactation for different months of farrowing

3. Is sow lactational intake related to finisher intake?

Sows spend much of their life under restricted feeding, but are expected to greatly expand their feed intake capacity in a very short period of time for lactation. Sows are typically fed only 2-3 kg/day during gestation. However, daily intake levels may treble during lactation. Does their ability to increase feed intake during lactation solely relate to their intake as a finisher (ie their appetite, as presented in a group-housing situation) or does it also reflect the ability of their digestive physiology to adapt to this enormous change in feed intake during lactation? Recording daily feed intake during lactation in an "unrestricted" *ad-libitum* feeding system is required to evaluate the latter.

The general consensus is that voluntary feed intake of sows during lactation may be correlated with feed intake and performance during the grower/finisher phase. Selection for improved efficiency may thus have resulted in reduced lactational intake of sows, and increasing problems with poor sow longevity (Smits et al, 2005). Even if appetite and feed intake capacity of the modern sow were not reduced through the selection process, Eissen (2000) indicates that higher maintenance requirements and increased milk production of the modern sow place heavy demands on maintaining high enough levels of intake.

Currently, limited data are available to examine the relationship between gilt feed intake and sow feed intake during lactation. The small data set of van Erp et al. (1998) demonstrated that sow lactational feed intake was heritable and likely correlated with finisher intake (rg: 0.92±0.50), but their parameter estimates were very imprecise. Appeldorn (1999; cited in Walters, 2006) reported that gilts with high feed intake as finishers had high feed intakes in their subsequent lactation. Generating more detailed data in this area will facilitate development of a breeding program that considers reproductive performance of a sow over her lifetime along with traits targeted to improved efficiency of production in growing pigs.

4. Are there alternatives to direct measures of lactational feed intake?

In the absence of automated feeding systems for farrowing crates, measurement of lactational feed intake under *ad-libitum* feeding is labour intensive and difficult to achieve in reality. Previous studies have shown that feed intake of the finisher is genetically (rg) and phenotypically (rp) correlated (averages of rg: 0.41; rp: 0.09) with IGF-I measured in weaner pigs (Bunter et al., 2005). Of note here, the low phenotypic correlation results from negligible residual correlations between feed intake and IGF-I because these traits were measured at very different ages. Thus, measuring IGF-I of the sow at weaning could be an alternative to measuring lactational feed intake directly. More importantly, it may be a better indicator of sow physiological status at weaning and therefore rebreeding success than actual feed intake measures.

Moyes (2004) indicated that in mature cows IGF-I is a good measure of energy status. However, a small study (N=25 sows) by Clowes et al (2003) showed no association between plasma IGF-I concentrations measured during lactation and sow body composition or ovarian function. In contrast, van den Brand et al. (2001) had previously shown that in primiparous sows, plasma IGF-I concentrations recorded during lactation were associated with sow body condition and the intensity of the pre-ovulatory LH surge. In dairy cattle, there is increasing evidence that IGF-I recorded during lactation is low in cows with high milk production, subsequently having a negative association with

ovulation and fertility (eg Taylor et al, 2004). Moyes (2004) has suggested that plasma IGF-I can be used to predict reproductive performance of dairy cows. It is also plausible that through identifying sows in poor energy balance at the end of lactation, it will be possible to develop management interventions that will improve the chance of their rebreeding success.

The ultimate sow feed intake project?

The Australian Pork CRC has funded a large-scale project at QAF Meat Industries based around the recording of voluntary feed intake in gilts post-finishing and their subsequent intake during lactation. This project attempts to address a number of deficiencies in existing data relating to sow feed intake, although there is no such thing as an "ultimate" project. The records taken are summarised in Table 3. Other proposed records include indicators of mature sow size and piglet mortality post-weaning. Through this project we hope to:

- Estimate the heritability for sow voluntary feed intake recorded during lactation, and the genetic correlation between finisher feed intake and VFI
- Assess the hypothesis that high sow VFI during lactation improves lifetime reproductive performance, pre- and post-weaning piglet growth, and subsequently lifetime performance of the growing pig
- Evaluate whether IGF-I concentrations recorded in sows at weaning is a heritable trait, related to sow VFI, and correlated with lifetime reproductive performance.

Ultimately, the project is intended to obtain the necessary data for evaluating alternative breeding program options involving sow feed intake. Look out for results in 2009!

Table 3. Summary of traits recorded according to class of animals

Animal Category	Trait recorded	Target number of animals
Finisher gilts (becoming project sows)	P2 (evaluate P4), MD and weight (20 weeks) Feed intake (20-25 weeks) and weights Pre-mating weight and scan traits (29 weeks)	3000 2850
Farrowing project sows	Entry farrowing shed+farrowing date Farrowing (NBA, SB & MUM) details Sow and piglet health (including farrowing assistance and treatments) Lactational feed intake Sow IGF-I at weaning Weight and scan traits at weaning (to end parity 2) Sow longevity (at least to parity 4)	2500 litters: 1700-1800 first parity and 700-800 2nd parity *1st and 2nd parity project sows (maximise 1st parity)
Project litter records	Total litter birth weight Total litter weight at 14 days Litter health (including treatments) All cross-fostering details (including weight of piglets added or removed) and piglet survival	2500 litters
Finisher progeny	Gilts entering project as above Other finishers – P2, MD and weight	

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