NEW TOOLS TO MANAGE VARIABILITY THROUGHOUT THE PORK PRODUCTION CHAIN

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ABSTRACT

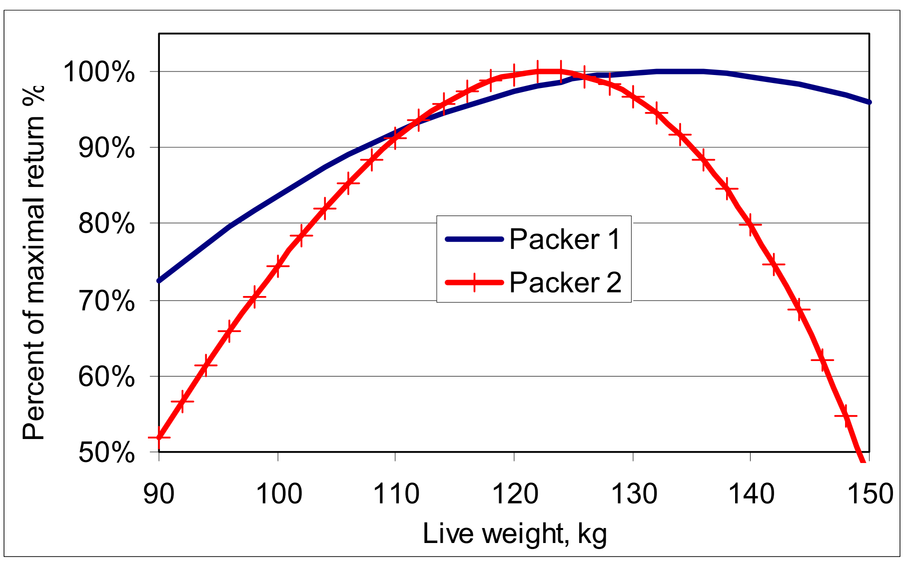
Reducing variation in the process of producing pigs has received considerable discussion over the last 10 to 15 years. Many people have argued that increased integration within the industry would lead to less seasonal variation in the number of pigs produced, decreased variation in production measures, and decreased variation in market weights. In reality, the real variation in the industry is as great as ever. More and more people are starting to understand that eliminating variation in a biological system is impossible. Most system design and productivity advances have led to a shift in averages, such that our industry is more productive and efficient, but without great reductions in variation measures. While we continue to work on system design and management changes that provide some reduction in variability, the most profitable pork chain systems have been designed to manage the variability in production. The alternative, of course, is forcing excess cost into the production segment in attempts to reduce variability.

End product variability can be reduced by sorting product in the plant and targeting segmented markets for each product or it can be reduced by attempting to control size of product entering the plant. Sorting pigs strictly by weight before sending to market also reduces variation in product size, but often adds production cost through increased labor and decreased facility utilization. Sort systems have been developed to reduce the labor cost, but they don't solve the decreased facility utilization issue. Some system design components, such as parity segregation, split-sex housing, use of opportunity barns, increased weaning age, and decreased fill time, do reduce variation in weights at market, but cannot be easily adopted within all production systems. The advantages of high health systems on improving productivity and reducing variation are clear, although maintaining a high health system is easier said than done. We are just in our infancy of understanding the impact of selection for litter size, and resultant high ovulation rate, on pig weight variation and whether we can moderate any negative impact by altering fetal development. Finally, there are some management strategies being used by producers, such as sorting pigs into the barn or excessive cross-fostering that decrease visual variation in the barn, but do not reduce weight variation in the barn. All aspects of the pork chain should be considered in managing variability. The greatest impact on product variability appears to be accomplished through system design changes and sorting and segmenting product in the plant.

STARTING WITH THE END IN MIND

The market available for products exiting the processing plant helps dictate the variation in size of cuts for pigs entering the plant. For a processor that has a high proportion of value added cuts with relatively few market streams, controlling weight of market pigs is critical. An example of the discount for pigs that don't meet the weight goals of this type of processor is shown as Packer 2 in Figure 1. In contrast, Packer 1 has a wider range of products, higher proportion of product that is sold in the fresh market and can accept a wider range in product weights. For a producer marketing pigs to Packer 1, there is much less incentive to sort pigs at market. There is still value to not sell excessively heavy pigs or light pigs; however, the reduction in market weights that this grid allows greatly increases facility utilization and weight generated per unit space in the barn. The heavier weights allowed before discounts are received also allows the production system to spread fixed costs over more total weight to achieve a lower production cost. Similarly, the packer's fixed costs of processing a pig are spread over more weight to reduce the processing cost per pig. Thus, the producer and packer participating in this production chain can accept a lower price for their product and still be more profitable. Conversely, Packer 1, because of the lower variation in weight entering the plant has the opportunity to add more value to a more consistent product, and thus, has the potential to extract a higher value. Both of these production systems can be successful. As more and more vertical coordination occurs in the industry, communication is required to help explain to Packer 2 why a higher price must be paid because of the higher production cost incurred by the producer. Conversely, the producer supplying pigs to Packer 1 also must understand that they may have to accept a lower market price because of the increased variation in product stream being delivered to the processor.

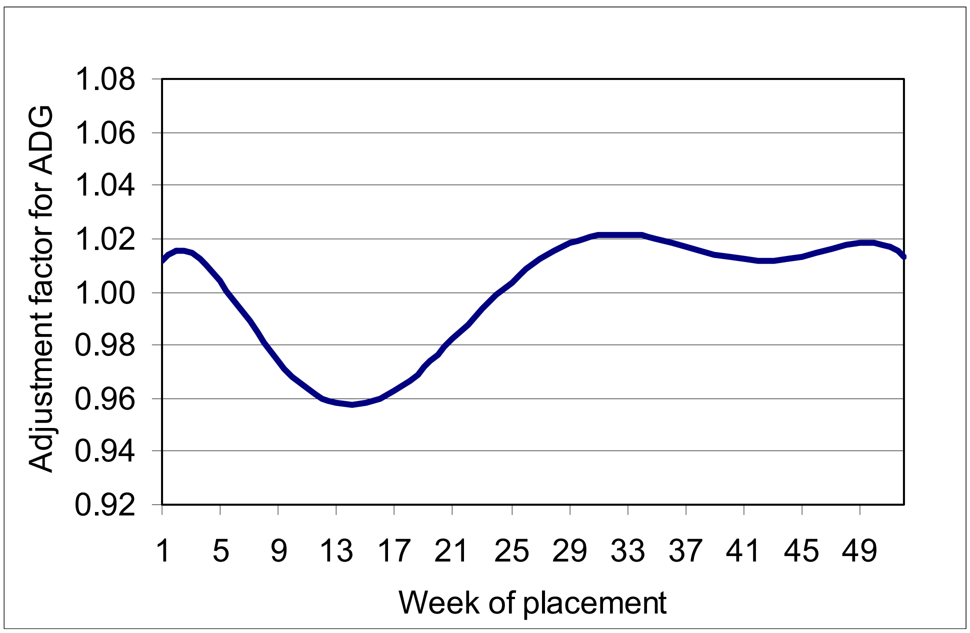
Figure 1. Maximal return at two different processors as influenced by average market weight of a group of pigs delivered to the plant.



REDUCING SEASONAL VARIATION IN MARKET WEIGHTS

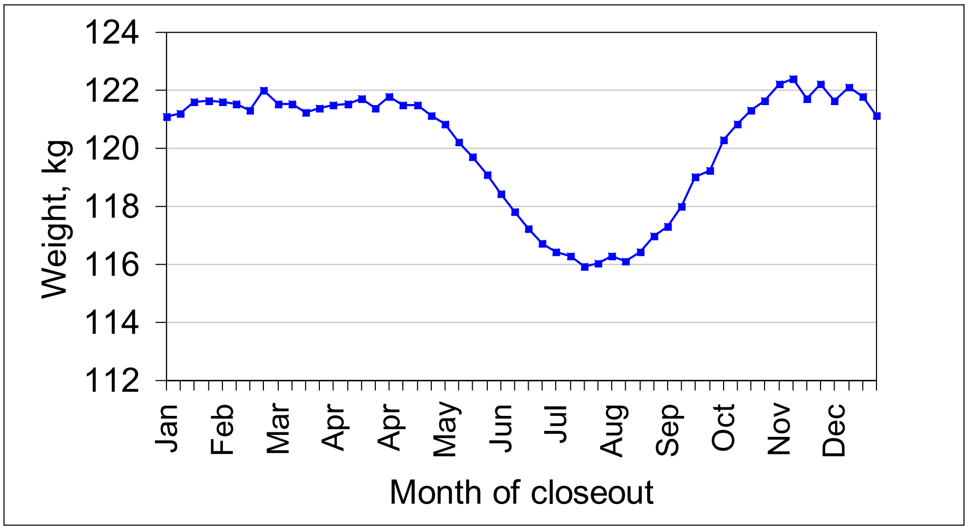
Although great strides have been made in managing the environment in barns, seasonal variation in growth rate remains a major obstacle within a production system. Pigs placed in the late summer through the early winter months grow faster than pigs placed in late winter months and spring (Figure 2). As a result, market weights are reduced by 4 to 6 kg for pigs marketed in June through mid September (Figure 3). Market price is normally highest during this same time period. For many production systems 75 to 80% of the net profit for the year is obtained during these summer months. The most profitable systems have determined methods to maintain market weights through the summer months.

Figure 2. Variation in ADG as influenced by week of placement (adapted from Bahnson and Dial, 1995).



The only way that weights can be maintained is by increasing growth rate for groups of pigs finished at this time or increasing days in the barn. Growth rate can be increased by increasing the energy density of the diet or by using Paylean seasonally during the summer months. If dietary energy is already at the economic maximum and Paylean is already being used, pigs must be given more days to grow to obtain the same market weight on the lower seasonal growth rate. Finding extra days is not easy, but the production system needs to be built with this flexibility. For example, wean to finish barns offer flexibility as they can be double or triple stocked in the summer months to allow pigs in other barns more time before the facility is needed. Similarly, heavier stocking density in nurseries in summer months reduces the finishing barn requirements. Heavier stocking density will reduce growth rate of these pigs; however, they will be marketed during the winter months when space is normally not a problem.

Figure 3. **Seasonal variation in market weight (adapted from Bahnson and Dial, 1995).**



MANAGING VARIATION ON THE FARM WITHOUT REDUCING VARIATION IN GROWTH

Even within systems that manage the seasonal variation in group average ending weight, variation of within group final weights is still a challenge. Changing the system to reduce variation is difficult after the system is built. Thus, methods of managing the variation without reducing it must be used to control market weight. The two most effective ways of managing variation without reducing it are through sorting at market and by increasing the growth rate of the entire group of pigs.

Sorting at Market

Sorting pigs visually without a weight has proven to not always be an effective means of removing the heaviest pigs from the barn. People often remove a normally distributed group of pigs from the barn rather than only the heaviest pigs. Manual weighing is an effective means of finding the heaviest pigs, but is also very time consuming. Auto-sort barns have increased in popularity and use in the industry. The barns greatly reduce the amount of labor required to sort and market pigs and can be effective to increase profit when marketing to a processor with a narrow optimal weight window (example: Packer 2 in Figure 1). The optimal design of auto-sort barns is still being debated. Many early versions didn't allow adequate feeder space and thus, weight gain was reduced in these barns. The longevity of the equipment is improving, but still a question. While limited research has been conducted with auto-sort technology, they appear to have a place within some systems. Their success largely appears to depend on the producer's technological ability and narrowness of the packer weight window.

The auto-sort barns have provided another opportunity to weigh pigs more easily at market. Some producers only use the auto-sort when pigs near market weight and move the pigs through the scale at a set time after placement or after a certain portion of the feed budget has been consumed to start pulling heavy pigs. By using the system only as a weighing system at market, it requires fewer scale heads, but is more labor intensive at marketing than if the pigs have been trained to use the auto-sorter throughout the growing period.

If an auto-sorter is not used, two options can be used to help determine when to market the pigs. First, test weighing or a weight tape can be used on a sample of pigs starting at a designated time post placement. Because of the seasonality in ADG and variation between groups, it is a mistake to use days after placement as the only method to determine when pigs should be marketed. A second option would be to use feed delivery and an estimate of the amount of feed that should have been consumed by a certain weight to determine the average weight of the pigs in the barn. Using previous variation data, the number of pigs that should have reached the optimal market weight can be determined. Some systems use the feed delivery and a standard growth curve with a seasonal adjustment to provide two estimates of when pigs should be nearing market weight. Then test weighing is used to more accurately estimate the actual weight in the barn. Number of pulls and number of pigs marketed at each pull is adjusted, mainly based on the amount of time remaining before the barn must be emptied.

Increase Growth Rate of the Entire Group

Increasing the growth rate of the entire group will not reduce variation or the need to sort pigs at market, but it will increase the weight of the slow growing pigs, which is the main marketing issue. Producers should focus on areas where they can increase the growth rate of the entire group, such as:

1) Use of genetics capable of high growth rate in commercial conditions
2) Maintenance of high health status
3) Feeding of Paylean
4) Increased weaning age
5) Use of sows with high milk production
6) High feed intake in the farrowing house to increase weaning weight
7) Increase energy density of diet to increase growth rate
8) Feed correct amino acid levels (slightly higher levels than optimal for cost/lb may decrease downside risk, especially in the late finisher).

Increase the Weight Discount Window

For the reasons discussed in the first section of this paper, narrow packer weight windows are one of the biggest limitations to profitability for producers marketing pigs in the Canadian packing system and with some U.S. packers. Wide weight windows encourage heavier market pigs and improved facility utilization. Some producers in the U.S. also have the opportunity to market to multiple packers to sell light pigs to a packer that desires light weights and heavy pigs to a packer that rewards for heavy weights. What are the options for increasing your sort window? Similar to some of our producers, you are left with only a few options, such as owning your own processing plant, negotiating a wider sort window in a packer contract, or selling to multiple packers (i.e. sending heavy weight pigs to a U.S. packer with those specifications). The cost of a narrow sort window is too great for the industry to ignore.

In summary of this section, the most effective methods to manage variation in weight gain are to have a wide sort window and to increase weight gain of all the pigs in the barn (health, energy, lysine, increased weaning age).

DESIGNING A SYSTEM WITH REDUCING VARIATION IN MIND

If the coefficient of variation (CV) for market weight is already below 10 to 12% in your system, you will be frustrated in your attempts to further reduce variation. Real reductions in variation can be achieved, especially if current CV is above 12%; however, in most situations they require major changes to the production system. Systems must be designed from the outset to be low variation systems in order to achieve the greatest and longest lasting improvement in this area. Many of the design factors require critical mass to implement. If you don't have large enough sow farms, it is difficult to implement technologies, such as segregated parity production or split sex housing; however, other technologies, such as increased weaning age can be effectively implemented with all size farms.

Segregated Parity Flow

Having the offspring of gilts reared separately from the offspring of sows will reduce variation. The offspring from the gilts will grow faster when reared separately than when reared with offspring from multiple parity sows. The advantages are thought to be due to improvement in health status of pigs within both groups (Moore, 2003).

High-Health Systems

Although "high-health systems" is a nebulous term, it is meant to encompass the many factors that improve the health status of pigs within a group. Schinckel et al. (2002) has demonstrated that pigs reared in an all-in, all-out manner have less variation in growth rate and market weight than pigs reared in a continuous flow manner. The CV for the all-in, all-out pigs was 7.5% compared to 8.8% for the continuous flow pigs. Other system design factors that can lead to sustained improvements in health status, such as reduction in sources of pigs, location of the source herd, and location of the growing barns themselves, would be expected to also reduce variation in weight gain.

Because health status has a profound impact on weight variation at market, prompt treatment of clinical bacterial disease with injectable antibiotics can reduce variation. Promptly treating clinical disease to enhance recovery and reduce spread of the bacteria within the group will reduce the number of light weight pigs at market and, thus, reduce variation.

Split-Sex Housing

Simply put, raising the gilts separate from the barrows will reduce the variation in weight gain in the group, simply because the barrows grow faster than the gilts. Although simple in concept, the production system must be large enough to fill a barn or site with one sex within a reasonable amount of time. Filling a site or barn over multiple weeks or from multiple sources enters other large sources of variation (variation in weaning age and health status) that may overwhelm any advantage of single sex housing.

Increase Weaning Age and Reducing Variation in Weaning Age

Main et al. (2004) demonstrated the impact of weaning age on pig weight and the variation in pig weight at the end of the nursery and finishing stages (Table 1). This data indicates that variation in weaning age is one of the biggest drivers of variation in final market weight in swine farms. From this dataset, the percentage of pigs in each weight category at the end of the experiment (d 156 after weaning) can be calculated (Figure 4).

Table 1. Influence of weaning age on weight and variation in pig weight[a]

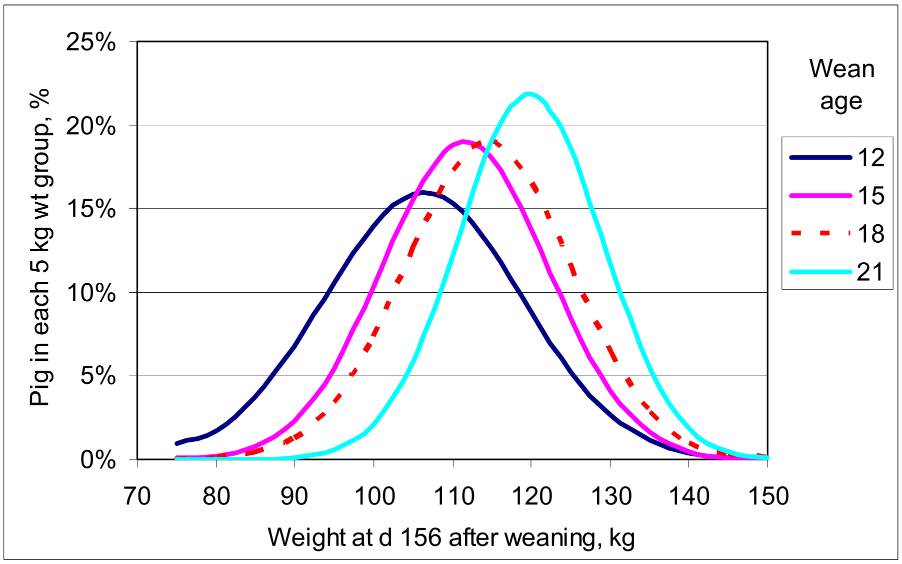
	Weaning age, d			
Item	12	15	18	21
Wt at 42 d postweaning, kg	16.9	20.3	22.6	25.8
CV of wt at 42 d postweaning, %	20.0	15.6	14.4	12.9
Wt at 156 d postweaning, lb	103.9	109.1	112.0	117.3
CV of wt at 156 d postweaning, %	12.4	10.4	10.4	9.0

[a]Main et al., 2004

The data in Table 1 demonstrate the impact of weaning age when pigs are weaned within a day of age of each other. If age at weaning is highly variable, variation in market weight is further increased because the younger pigs grow slower than older pigs. Thus, if pigs are weaned over a seven day period, final market weight will encompass the variation caused by having younger pigs in the group and the variation in weight gain around each age group.

Reducing the variation in weaning age requires weaning multiple times per week. The number of weaning events per week is often limited by the system design, transport, or health protocols; however, it is often possible to increase weaning age by one to three days without any facility changes. Many of our production systems have increased farrowing capacity to increase average weaning age. The payback for adding marginal farrowing crates can be quite large. For example, adding the equivalent of one half of one weeks worth of farrowing capacity will allow you to increase the weaning age of all pigs on the farm by three days. Thus, the payback from the investment comes from all pigs weaned rather than just the pigs weaned from the added crates. Certainly, another way to increase weaning age is to increase the number of days farrowing crates contain lactating sows by increasing the date of gestation sows are moved into the farrowing room and reducing the time it takes to clean the room after weaning. Limiting bump weaning (weaning the largest pigs in the litter at a younger age) can reduce weight variation at weaning, but has not been proven to effectively reduce variation at market. The weaning age of Main et al., (2004) indicates that early weaning of the biggest pigs may actually contribute to increased weight variation at market.

Figure 4. Distribution in pig weight at 156 d after weaning (adapted from Main et al., 2004).

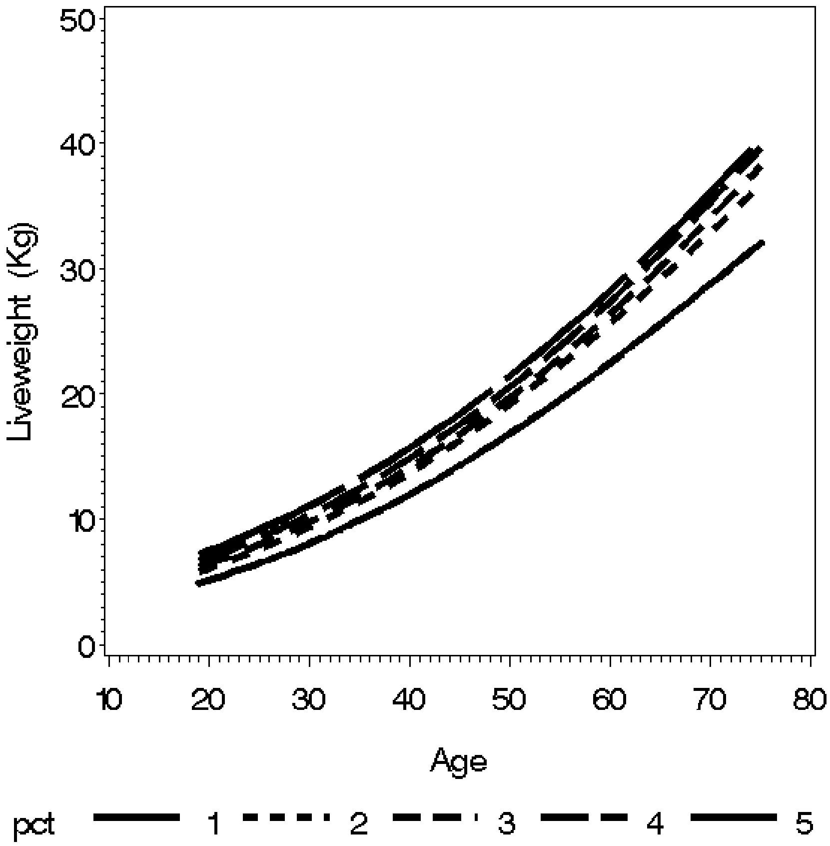


Use of Opportunity Barns

Opportunity barns are used within some production systems to separate the smallest pigs (5 to 25% of pigs depending on the system) from the remaining pigs and rear them separately. In some systems, the pigs are reared on entirely different nursery sites and flow through different finishing sites. In other systems, pigs are simply separated into a different barn or room within the barn in the nursery stage and then moved to a separate finishing site. Management of the smallest pigs in these opportunity barns also varies across systems. Some systems provide supplemental milk replacer or special diets in an attempt to "normalize" growth rate. Other systems simply separate the pigs and treat them similarly to the other pigs, accepting that they will be slower growing and simply need additional days to reach market weight. The net result is variation in the original weaning group is not reduced, but variation within the production unit (barn or site) is reduced by removing the smallest pigs from the group.

Schinckel et al. (2004) demonstrated that the smallest 20% of the pigs at birth grow significantly slower after weaning and are responsible for a majority of the variation in pig weight at various ages after weaning (Figure 5). Thus, use of opportunity barns can effectively remove these slower growing pigs from the system. Again, the system must be large enough and designed with opportunity barns in mind to be able to take advantage of this method of reducing variation.

Figure 5. Relationship between body weight and age for five percentile groups of pigs based on birth weight (Schinckel et al., 2004). Note that the lowest 20% of birth weight pigs continue to deviate from the weight of the other pigs with increasing time after weaning.



Increase Weight Gain of the Smallest Pigs in the Group

There are several procedures that can be used to increase the weight gain of the smaller pigs in the group in an attempt to reduce variation. These include: split suckling, use of complex nursery diets, use of supplemental milk, or shifting the smallest pigs to higher producing sows. These technologies all have been proven to slightly increase the weight gain of the small pigs and thus, they can reduce variation at market weight. However, the impacts are all relatively small and thus, the economic payback is small to nonexistent.

Donovan and Dritz (2000) demonstrated that split-nursing (allowing the smallest 50% of pigs access to the sow for 2 h within 24 h after farrowing) reduced variation in ADG and, thus, numerically reduced the variation in weaning weight. However, the impact is relatively small (about 2% lower CV). Wolter et al. (2002) found that offering milk replacer in the farrowing house can effectively increase weaning weight by approximately 0.9 kg/pig during hot weather. However, the difference did not increase during the nursery or finishing stage. Thus, the 0.9 kg advantage at weaning remains at market, but it must pay for the entire cost of the milk replacer. Similarly, trials with complex nursery diets have demonstrated increased weight gain in the nursery. Although data has not been entirely consistent, the advantage often does not become larger during the finishing stage. In any event, these changes in pig weight are relatively small compared to the differences caused by weaning age, sex, or health status.

Selecting Sires with Similar Indexes

Reducing variation by selecting sires with similar indexes or by using fewer sires also has been cited as a method to reduce variation in weight at market. Although this is outside my area of expertise, Dr. Allan Schinckel indicated that sires only account for about 1/4 of genetic variance. Selecting sires with similar ADG EBV's with accuracy of .5 will cause CV to be reduced to 96.875% of original. Thus, if market weight CV was 12% originally, it could be reduced to 11.625%. Thus, 95% of pigs with a mean weight of 260 lb would be in a market weight range of 199.6 to 320.5 instead of the original range of 197.6 to 322.4. Again, selecting boars with similar indexes is a means of reducing variation; however, the change will be relatively small. Creating all half sibs by using only using one sire would only reduce market weight CV to 96.25% of the original CV. Using full sibs (via embryo transfer or using cloned females and only one male) would reduce the CV to 92.5% of the original CV. Because of the high impact of environment on variation, even using clones will only reduce the CV to 83.5% of the original CV.

Feeding Multiple Diets within a Group

Dividing a group of pigs based on sex in order to feed higher amino acid levels to the gilts has been practiced in the industry for some time. We hypothesized that dividing the group based on weight in order to feed the lighter pigs a higher energy diet may be more useful to reduce variation in market weight. Hastad et al. (2005) conducted two studies to test this concept. They divided the group of pigs into light, heavy or mixed weight groups at entry to the finishing barn and fed diets with either 0 or 6% added fat. Results from one of the experiments are shown in Table 2. For the overall trial, there were no fat × initial sort category interactions. Pigs fed 6% added fat had greater ADG; however, there was no difference in CV for ADG during the overall study. For initial sort category, regardless of diet, heavy pigs grew faster than either the light or mixed pigs. Although no interactions existed for growth or carcass data, there was a fat x weight category interaction for the financial response of margin over feed cost. Heavy pigs in both studies had greater margin over feed than either light or mixed pigs; however, when comparing 0 and 6% added fat within initial sort category, the increase in margin over feed was greater for light pigs fed added fat than heavy pigs fed added fat. These studies indicate that because adding fat to the diets of lighter weight pigs improves their growth rate, dietary fat can be used selectively in the barn to increase the weight of the lightest 50% of the pigs.

Feeding two diets to offer higher amino acid levels to the lighter pigs in the group is often cited as a possible means of increasing weight gain of the smaller pigs. In reality, the lightest pigs in the group may not actually have a higher amino acid requirement than the heavy pigs in the group. Weight doesn't accurately depict the pig's amino acid requirements within a population. Rate of protein accretion and feed intake are the major determinants of amino acid requirements. Therefore, the heavier, faster growing pigs may actually have a higher amino acid requirement because they have higher protein deposition even though they consume more feed. With current knowledge, we formulate diets for the light and heavy groups to have similar amino acid:calorie ratios based on their average weight.

The importance of water intake also should be considered. Providing adequate water access has been shown to reduce variation as compared to insufficient water access (Dewey et al., 2001).

Table 2. Effects of added fat and initial sort on weight variation, carcass traits, and economic value in grow-finish pigs (Hastad et al., 2005)[a]

							Main effect *P*-value		
Added fat:	No fat			6% added fat			Fat	Heavy	Sorted[b]
Item Wt group:	Heavy	Light	Mixed	Heavy	Light	Mixed		vs. light	vs. mixed
D 0 to 95									
ADG, kg	0.88	0.85	0.87	0.91	0.89	0.90	0.01	0.02	0.91
ADFI, kg	2.70	2.28	2.46	2.51	2.09	2.27	0.01	0.01	0.25
Feed/gain	2.78	2.63	2.70	2.44	2.33	2.38	0.01	0.01	0.68
Pig weight, kg									
D 0	37.7	32.5	35.3	37.6	32.6	35.1	0.83	0.01	0.87
D 95	121.2	113.6	117.5	123.0	117.0	119.9	0.01	0.01	0.97
Pig weight, CV									
D 0	9.33	12.56	15.85	9.99	12.08	15.88	0.91	0.01	0.01
D 95	7.23	9.78	9.78	7.47	8.67	9.65	0.41	0.01	0.01
Economic value									
Feed cost, $/kg gain	0.36	0.34	0.35	0.37	0.35	0.36	0.03	0.01	0.82
Sort discount, $/pig	-2.83	-2.13	-2.71	-3.87	-1.66	-3.72	0.26	0.03	0.23
Margin over feed, $/pig[c]	96.69	88.53	92.56	95.88	91.72	92.29	0.25	0.01	0.23

[a] A total of 1,176 gilts (28 pigs per pen and seven pens per treatment) with an initial average weight of 35.1 kg.
[b] Sorted vs. mixed is the average of the light and heavy pigs compared with the mixed pigs.
[c] Margin Over Feed was calculated with corn at $0.85/kg, soybean meal at $0.205/kg, fat at $0.294/kg, and carcass base price at $1.00/kg.

Because the response to Paylean is consistent for different weight pigs, Paylean can also be used to increase the growth rate of the lightest pigs in the group to make them grow similar to the heaviest pigs. The difference between Paylean and increased diet energy density is that feeding Paylean is often economical regardless of whether the weight gain is needed or not. The economic value to Paylean is much greater in pigs that require the extra weight gain; however, the improvements in feed efficiency and carcass parameters (loin depth and yield) usually make it economical in heavy pigs also. Thus, if Paylean was only used in the light pigs in the group, the potential increase in profit on the heavy pigs would be lost.

REDUCING VARIATION IN WEIGHTS AT BIRTH

Total and live born litter size has been increasing dramatically in the last six to seven years. The rate of progress since 2000 has been approximately 0.2 pigs/litter each year. This dramatic increase in litter size has been accomplished through the application of genetic improvement focusing on ovulation rate (Foxcroft & Town, 2004). Unfortunately, an increased number of stillborns and lower pig birth weights have been observed along with the increased litter size.

Many factors affect fetal growth and development including sow ovulation rate, uterine capacity, genotype, nutrition, and feeding regimens. Researchers are beginning to understand that uterine capacity, which determines the number of fetuses maintained during pregnancy (Vallet et al., 2003) is one of the greatest limitations to litter size (Ford, 1997; Foxcroft & Town, 2004). Litter weight is directly related to litter size. Pigs from large litters have lighter fetuses at term because of the decreased placental surface area (Pére et al., 1997). Additionally, mobilization of energy substrates increases in sows with larger litters. Glucose is a major energy substrate for fetuses and has been shown to decrease in sows with large litters (Pére, 1995) due to the high energy requirement for the uterus and fetuses.

Two ways to solve the problem of variability in piglet weight at birth would be to either solve it genetically (ex. moderate ovulation rate with high embryonic survival to reduce light weight fetuses) or by increasing nutrient availability to the lightest fetuses to increase their size. Research has shown secondary muscle fiber development, which is an important determinant of postnatal growth, can be improved by increasing maternal feed intake during d 25 to 50 of gestation (Dwyer et al., 1993 and 1994; Bee, 2004) or after d 70 of gestation (McPherson et al., 2004). But, high energy intake during gestation results in greater expense, decreased feed intake during lactation, and impairment of mammary gland development. Additionally, the high intake in gestation doesn't always increase birth weight, secondary muscle fiber number or carcass parameters (Musser et al., 2006).

The addition of L-carnitine, a water-soluble vitamin-like compound, to gestation diets has demonstrated increased litter weights at birth and weaning (Musser et al., 1999). During gestation, the addition of 50 ppm (100 mg/d; d 5 to 112) of L-carnitine increased sow body weight gain and last rib fat depth. In addition, sows fed supplemental L-carnitine had increased total litter (34.2 vs. 32.2 lb) and pig (3.4 vs. 3.2 lb) birth weight, increased litter weaning weight (99.2 lb vs. 91.1 lb; Musser et al., 1999), and increased fetal number (Waylan et al., 2005). Other researchers have observed similar results with increased sow weight gain and improved average fetal weight at d 70 of gestation in sows fed supplemental L-carnitine (Brown et al., 2005).

In addition to increased birth and weaning weights, researchers have observed an increase in the cross-sectional area and more total muscle fiber numbers in the semitendinosus muscle in pigs from sows fed supplemental L-carnitine (Musser et al., 2001). Specific growth factors, such as insulin-like growth factor I (IGF-I), insulin-like growth factor II (IGF-II), insulin-like growth factor binding protein-3 (IGFBP-3) and insulin-like growth factor binding protein-5 (IGFBP-5) have been shown to have promoting proliferative and differentiation effects on the muscle cells of pigs (Hembree et al., 1996; Johnson et al., 1999). Researchers have shown the addition of L-carnitine lowers the expression of IGF-II and numerically increases the expression of IGF-I in porcine embryonic myoblasts or muscle cells (PEM; Waylan et al., 2005). Insulin-like growth factor-I has potent proliferative effects on PEM. This means the muscle cells keep multiplying when this growth factor is present. Insulin-like growth factor-II induces the expression of another gene, myogenin, which promotes the muscle cells to stop their proliferative capacity and differentiate into mature muscle fibers (Florini et al., 1991). Therefore, the increase in IGF-I and decrease in IGF-II due to supplementing the sow L-carnitine is allowing more muscle fiber cells to be developed, which increases birth weight. This research is supported by decreased levels of circulating IGF-II levels in fetuses at d 70 gestation (Brown et al., 2005). The significant changes in gene expression due to supplementing the sow L-carnitine is involved in the regulation of muscle fiber development of the fetus and improved pig and litter weight at birth.

Genetic improvement for selection of increased ovulation rate has increased sow litter size, but a decrease in pig weight at birth has been observed. Many factors may affect this including uterine capacity, genotype, nutrition, and feeding regimens. The addition of nutrient compounds, like L-carnitine, may be an option to improve pig and litter weights and to decrease the number of lightweight pigs at birth.

METHODS THAT REDUCE VISUAL VARIATION BUT COST PRODUCTIVITY

Over time, producers have instituted various strategies to attempt to reduce variation in pigs within a group. The attempts have focused on reducing visual variation within the point of reference (i.e., litter or pen of pigs) without full knowledge of how these efforts impact variation of the overall group (i.e., weaning group or barn). The two most common strategies that fit this description are sorting by size in the nursery or finisher and aggressive cross-fostering in the farrowing house.

Sorting into the Nursery or Finisher

Sorting pigs to create a pen of pigs with similar weights will reduce the variation within the pen at placement; however, several experiments have demonstrated that sorting reduces ADG without a reduction in variation (Gonyou et al., 1986; O'Quinn et al., 2001).

Continual Cross-Fostering in the Farrowing House

Continual movement of pigs in the farrowing house is another practice used within the farm to reduce variation within the subgroup (litter). At least two experiments have demonstrated that the aggressive cross-fostering will reduce the variation within the litter. However, growth rate of the entire farrowing group is reduced (Milligan et al., 2001). Therefore, the reduction in variation appears to be because of reducing growth rate of the fastest growing pigs, rather than increasing growth rate of the smallest pigs in the litter. Thus, there is not a net benefit of improving facility utilization because the growth rate of the smallest pigs has not been improved.

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