Variation in the Finishing Barn

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1. INTRODUCTION

Prior to the widespread adoption of all-in-all-out production systems, variation in growth was largely a "hidden" cost. Pigs were selected from pens when they reached market weight, and the fact that some pigs required 4 to 6 weeks longer than others went largely unnoticed, or at least ignored. Furthermore, in continuous-flow systems, downtime due to variable growth rates affects pen usage, while in all-in-all-out (AIAO) systems, it affects room or barn usage. The economic impact is therefore much greater in AIAO systems. There is also the annoyance factor, because from a labour and management perspective, dealing with tail-end pigs in a room or barn is also greater than in pens. Thus, the cost of variation has always been with us, but it is now exaggerated and much more obvious.

Variation also costs producers money due to its impact on sort losses. In a 1992 study in Saskatchewan, the industry was losing more than $3 per pig as a result of sort losses.

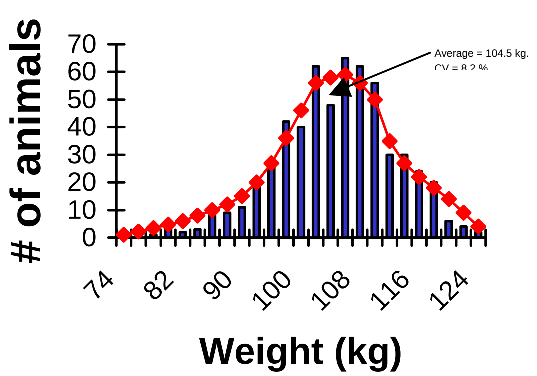
Because increased attention is being paid to variability in growth, the industry's previous singular focus on "average" growth rate is now increasingly being replaced by "average" growth rate and the "range" in that growth.

The industry has developed an array of management techniques to deal with problems associated with variability. Perhaps the most obvious is cross-fostering, such that sows with smaller litters receive piglets from sows with larger litters, to "even out" lactation performance and reduce stress on the sow. However, because variability in performance in all phases of pork production is so costly, there is an increasing motivation to develop and implement additional strategies to minimize its economic impact.

2. MEASURES OF VARIATION

Statistically, variation can be defined in a variety of ways; the most common terms are standard deviation (SD) and coefficient of variation (CV), although range may also be useful. Most people have heard of the "bell curve" which shows the typical distribution of measurements within a group. It is surprising how many measurements can be described by a bell curve: weight, height, etc. If the measurement of a group or population is made and when plotted, displays a bell shape, it is called a "normal" distribution. If the data do not follow the bell shape, the data are called "skewed." The body weights of 632 twenty week-old pigs is charted in Figure 1; it shows a very typical distribution in body weight of pigs at this age. This distribution is almost "normal" but slight skewing to the left is clearly seen, reflecting the exaggerated number of tail-enders in the group.

FIGURE 1. A PLOT OF PIG WEIGHTS AT 20 WEEKS OF AGE SHOWING THE TYPICAL NORMAL DISTRIBUTION OR 'BELL CURVE'



The shape of the bell curve reveals a great deal about the population or group. For example, if the bell is narrow, the population is relatively uniform, because most of the measurements are close to the mean; if the bell is wide, the population is less uniform, because more measurements are found further from the mean. One useful measure of the width of the bell curve is called the standard deviation; the wider the bell, the larger the standard deviation and the greater is the variability of the group of animals. Following are definitions of important statistics that are used to describe variation in a group of pigs. This information is provided as background or reference information for those interested. I will not be discussing them in my presentation.

2.1. Mean

The mean is the average of all weights within a group of pigs. It provides no indication of the variability of weights within the group of pigs.

2.2. Median

The median is determined by aligning all pig weights in order of magnitude (eg. from smallest to largest or vice versa) and selecting the middle observation.

2.3. Mode

The mode is the observation that occurs with the greatest frequency.

If the weights of the pigs are normally distributed, the mean, median and mode will all be the same. The more these three numbers differ, the less normally distributed the data. This is of little practical significance, because it is unlikely that a farm will individually weigh all of its pigs!

2.4. Minimum and Maximum

The minimum and maximum are self-evident; they are the lightest and heaviest weights within the group. The difference between the minimum and maximum is called the range; the wider the shape of the bell curve, and thus the less uniform the group of pigs, the larger will be the range. Typically, the range in weights declines as the pigs get heavier, when the range is expressed as a percentage of the mean.

2.5. Standard Deviation (SD)

The standard deviation is a measure of dispersion. The greater the variation in weight of a group of pigs, the larger will be the standard deviation. In a normal distribution, 1 standard deviation about the mean will include 68.3% of the pigs in the total group. For example, in Table 1 below, for the 19 day-old pigs, the standard deviation has been calculated to be 1.21 kg, with a mean of 5.39 kg. Thus, we can estimate that 68.3% of the pigs, or 863 pigs in this group will weigh between 4.18 kg (5.39 – 1.21) and 6.60 kg (5.39 + 1.21). Two standard deviations take in 95.45% of the pigs; thus, 1,206 pigs weigh between 2.97 kg and 7.81 kg. Three standard deviations will include 99.73% of the pigs. Therefore, 1,261 pigs weigh between 1.76 kg and 9.02 kg. Of course, these numbers are approximate, because data might not be perfectly normally distributed, as we see in Figure 1 and in Table 2, or because insufficient numbers of animals were weighed to adequately estimate these parameters.

2.6. Coefficient of Variation (CV)

The coefficient of variation is calculated by dividing the standard deviation by the mean, and then multiplying by 100. Referring again to the example in Table 1, the standard deviation of 1.21 kg can also be presented as a coefficient of variation of 22.4%. The standard deviation becomes larger as the mean increases. Therefore, in order to determine if relative variation is increasing or decreasing as pigs grow, the coefficient of variation is often used. In Table 1, while the standard deviation increases as the pigs become heavier, the coefficient of variation decreases, indicating that relative variability among pigs under commercial conditions typically declines as they grow.

Table 1. Measured variation in body weight at three ages within an unselected population.

	Average Age, days		
	19	**68**	**140**
No pigs	1264	700	632
Weight, kg			
Mean	5.39	29.14	103.72
Median	5.40	29.10	104.40
Mode	5.40	30.95	98.10
Minimum	2.40	23.80	74.40
Maximum	9.20	40.90	124.90
Range	6.80	17.10	50.50
Range, % of mean	121	59	48
Standard Deviation, kg	1.21	3.74	8.31
Coefficient of variation, %	22.4	12.82	8.02

Body weights determined on whole groups of animals without pre-selection at weaning (19 days) nursery exit (68 days of age) and at 20 weeks of age before the first market pull. All were collected at the PSC Elstow Research Farm. The weights were collected at different times, so the three groups of pigs are not related to each other. The ages represent means, although the range in ages would be plus/minus three or 4 days.

3. MEASURING VARIATION ON-FARM

There is surprisingly little information on normal distributions of bodyweights on commercial farms. Because it requires the weighing of many animals, in order to accurately estimate the CV, it is not commonly done on most farms. Furthermore, most research data in the literature cannot be used as reference points, because in most experiments, animals are pre-selected to obtain a uniform group of pigs to increase experimental precision. Geneticists have this information, because variation is essential in selection programs; however, even this information is not widely available.

However, it is important that we develop an understanding of “normal” or “typical” variation, because this helps us to develop strategies for dealing with the problem on individual farms or systems. As discussed below, standards can be used to determine if a given farm is better advised to manage variation or to minimize it. The difference between the two represents a critical management decision.

In order to address this limitation in data, large numbers of animals at three different ages were weighed at the PSC Elstow Research Farm, a 600-sow commercial research facility operated by the Prairie Swine Centre. Table 1 above presents a summary of this information. The limited amount of data on the subject suggest that much larger variation is seen in some circumstances; Dewey et al. (2001) reported CV’s of 20 to 31% among commercial farms and at different ages.

The minimum number of pigs that must be weighed in order to estimate a mean, a standard deviation or a coefficient of variation is not constant, but rather depends on the intrinsic variability within the population. At weaning, because variability is so high, weighing even 100 piglets provides a poor estimate of the CV. However, at nursery exit, or at first pull in grow out, weighing as few as 50 pigs, selected at random throughout the barn, will provide satisfactory information. Random selection of the animals for weighing is very important, because weighing too many or too few of the lighter and heavier pigs within the group will skew the results. If too many “outliers” are weighed, variation will be over-estimated; if too few are weighed, variation will be under-estimated.

Using the weights of pigs at the time of marketing does not provide an accurate estimate of variability, because this represents a group of animals pre-selected according to their weight. For this reason, we prefer to use the weights of pigs at first pull, because all animals can be included. However, this is not a particularly convenient number to generate on most farms, so alternatives must be developed.

4. CAUSES OF VARIATION

Many factors can affect the degree of variability observed on a given farm. Without question, a certain amount of variability is “programmed” in that it is defined by the time the pig is born. Smaller birth weight piglets are compromised physiologically and socially and their expected performance will fall short of that expected of heavier birth weight contemporaries. In addition to these innate contributors to variability, there are many external forces that come into play as well, including health status, access to “resources” such as feed and water, poor ventilation, etc.

Certainly, there are procedures that barn managers can implement in order to minimize the impact of these various influences, such that variability can be minimized. Alternatively, and this will be discussed in a later section, procedures can be put into place to minimize the impact of variation, rather than minimize variation itself. The following section discusses the various factors that contribute to variability.

4.1. Pre-natal influences

Variation begins on the vary day piglets are born; Le Dividich (1999) reported that even within a litter, the CV for birth weight is between 22 and 26%. Variation expressed as CV is greater in smaller litters, not larger litters; this surprising result is more likely a statistical artefact, since the calculation of CV involves division by the number of pigs weighed, and obviously with smaller litters, the number of pigs is less.

As litter size increases, the average birth weight declines by about 36 g for every additional piglet in the litter (Le Dividich, 1999). While differences in birth weight are obvious to any farrowing technician, what is less clear is the relationship between birth weight and physiological “competency” at birth. For example, differences associated with low birth weight have been observed in reduced number and height of intestinal villi, lactase and lipase activity (Xu et al., 1994), reduced muscle respiratory enzyme activity (Hayashi et al., 1987), fewer muscle thyroid hormone receptors (Dauncey and Geers, 1990), lower IGF-1 levels in the blood (Herpin et al., 1992) and fewer muscle fibres (Handel and Stickland, 1987).

4.2. Post-natal influences

After birth, additional factors contribute to variability. For example, heavier birth weight piglets consume about 30% more milk than their lighter littermates (Pluske and Williams, 1996). In addition, heavier birth weight piglets, or at least those that win the most fights early in life, tend to suckle the anterior teats on the sow, which are known to deliver higher milk volumes (Gonyou, 2001). Hoy and Puppe (1992) observed that pigs nursing the anterior teats were 1.5 kg heavier at weaning than those adopting the posterior teats. Lower milk intake is not only associated with slower growth, but whole-body protein synthesis is also reduced (Marion et al., 1999). These authors also reported that tripling milk intake during the first week of life quadrupled the piglet’s protein deposition rate.

4.3. Post-weaning influences

One of the most predictable contributors to variability in the post-weaning period is the variability in weaning weight. For example, the correlation (r) between weaning weight and nursery exit weight was found to be 0.73 (Cooper at al., 2001). Numerous authors have related weaning weight to nursery exit weight by suggesting that for every 1 kg increase in weaning weight, nursery exit weights will increase by X kg. It is our experience that this relationship varies widely among farms; at PSC Elstow Research Farm, we have found that for every 1 kg increase in weaning weight, there is a concomitant 1.9 kg increase in nursery exit weight (56 days of age) and a 4.2 kg increase in market weight (Cooper et al., 2001). Similar results have been reported by others (Mahan and Lepine, 1991; Mahan, 1993; Tokach et al., 1992; Kavangh et al., 1997).

4.4. Other influences

4.4.1. Herd health and pathogen exposure

While factors inherent to the pig itself, including birth weight, weaning weight and suckling habits impact on later variability, there are many other "external" forces at play as well. Perhaps the most important of these is disease status of the herd, a factor known to probably have the greatest impact on variability. Because the extent of disease exposure differs among animals, and because the impact of that exposure on animal health and performance also differs among individuals, it is not surprising to observe that herd health status can have a major impact on variability. This was confirmed by the study of De Grau et al. (2001), who reported a strong correlation between herd health status and CV of body weight at all ages.

4.4.2. Feed and water

Access to "resources" such as feed and water is also a potential contributor to variability. As discussed below under the social behaviour model of variability, if feed or water access is limited, dominant pigs in a pen will have an advantage over subordinate pigs, resulting in a greater disparity in growth.

5. SOCIAL BEHAVIOUR MODEL

There is a very interesting social behaviour model for describing variability (Brännäs, 2001). In this model, one would consider the average performance of a group of pigs, along with the magnitude of the variation about this mean. If average performance is very good and the degree of variation is low, one can assume that the conditions in which the pig is being reared are good, and there is no depression in growth due to aggressive behaviours. In the opposite circumstance, where performance is sub-optimal, and variation is high, one can assume there is competition for resources, such as food and water. Over-crowding is not a likely issue in this scenario, because space is not a resource that pigs can hoard away from other pigs in the pen. However, pigs can prevent others from eating or drinking, and this uneven distribution of feed and water leads to increased variability. In the third and final scenario, performance is poor but variability is low, indicating an overall impairment due to a poor environment. Crowding could be an example of this scenario, because crowding, unless severe, will uniformly depress growth, but not increase variability.

6. ADDRESSING VARIABILITY

There are a variety of management techniques that producers can adopt to address the issue of variability. We believe they fall into two categories: "reducing" variability and "managing" variability. Suffice to say that if variability within a barn is already quite low, producers are more likely to achieve success by seeking ways to "manage" variability. On the other hand, if variability is high, then clearly there are deficiencies within the barn that are impairing performance and should be addressed. In this instance, it should be possible to "reduce" variability.

Reasonable targets for variability in the barn can be based on CV as described above. On the basis of our admittedly limited information on "normal" variation, we suggest the following thresholds for CV: 20% of weaning weights, 12 to 15% for nursery exit weights and 8 to 12% for weight at first pull from the finishing barn. In other words, if the CV for body weight at weaning is around 20%, or at nursery exit is 12 to 15% or at first pull is 8 to 12%, then it makes sense for barn managers to seek ways to "manage" variability rather than "reduce" it, as we suspect it is already close to the lower practical limit. These targets may change in the future as we develop more information on CVs under commercial conditions.

6.1. Reducing variability

It must be very clear that reducing variability refers to increasing the uniformity of all pigs within a group. Removing small or large pigs from the group does not reduce variability; it merely separates it into sub-groups of increased uniformity. Overall variability remains the same. However, if the smaller pigs can be made to grow faster, or the heavier pigs made to grow slower, uniformity will be enhanced. Certainly, there is absolutely no logic to slowing the growth of the faster growing pigs, so the objective of the barn manager, in terms of reducing variability, is to enhance the performance of the slower growing pigs.

Improving herd health is clearly a winning objective, if it can be achieved in a sustainable and economical manner. De Grau et al. (2001) and Dewey at al. (2001) conducted a survey on 9 commercial farms of varying size, health status and management types. They reported that the presence of disease increased weight variation and that multi-site production and all-in-all-out management were associated with a lower CV. Removing, or reducing, the impact of pathogens on individual pigs will not only improve performance of the overall group, it will also create a "tighter" group of pigs because the tail-enders will be minimized. Improving herd health can be achieved, for example, by not mixing pigs from multiple sources, by isolating barns from other pig barns to the greatest extent possible or by sourcing pigs from high health sow barns. If CV within a barn is too high, herd health should be the first target for attention.

A related practice would be to minimize the impact of existing disease in a barn through careful attention to nutrition, ventilation, herd health management and the removal of social and environmental stressors to the greatest extent possible.

Access to feed and water is also important. Restricted access to the feeder or to the drinker will adversely affect some pigs in the group, resulting in increased variability. It would appear that restricted access must be carefully defined. For example, Smith et al. (2004) reported that adjusting nursery feeders too tightly reduced growth rate, but the impact on CV was quite modest.

6.2. Managing variability

There are many ways to manage variability; however, the key issues become capital and labour costs to implement them. It is possible, for example, to improve barn throughput by culling out the bottom 5% or 10% of the pigs at weaning, or at nursery closeout, but the cost of such sorting and the cost of obtaining alternative housing for the culled animals must be balanced against potential savings. With this balance in mind, the following list identifies a number of strategies that can be used to manage variability such that its impact on profits is minimized.

Resorting pigs at marketing is often employed as a means of improving barn space utilization. However, after re-grouping, pig performance temporarily declines – in the order of 10 to 15% (Stookey and Gonyou, 1994) – so the practice may actually end up reducing barn utilization.

6.2.1. Pre-planned segregation

Pre-planned segregation refers to the practice of splitting a group of pigs into sub-groups on the basis of expected differences in future performance. For example, split-sexed housing is a common example of pre-planned segregation, because everyone knows that barrows will go to market, on average, 5 to 7 days before gilts (Cooper at al., 2001). Thus, pens, rooms or barns housing barrows will turn over about 1 week faster than those housing gilts, such that facility usage is increased. This works only if, for example, rooms are reduced in size to accommodate housing sexes separately; if not, this practice only works well with very large sow herds, as smaller operations cannot fill a room or barn with one sex within one fill period. This practice also flies in the face of the current trend to housing animals in much larger groups than has previously been the case.

Another example of pre-planned segregation is to remove smaller pigs at weaning, or at nursery close-out. In any all-in-all-out system, it is the slower growing pigs that dictate the turn-over rate of a room or barn. Removing the lighter weight pigs will help to remove those pigs most likely to be the tail-enders and thus the pigs that slow barn throughput. The logic of this practice was tested to determine if the removal of the lighter pigs would, in fact, allow the remaining pigs to grow at their normal rate and thus achieve close-out sooner, or would the smaller pigs in the remaining group themselves slow down (Patience et al., 2004). We found no evidence that removing faster growing (or slower growing) pigs from a group altered the performance of the remaining animals.

Lighter pigs certainly contribute to slower barn throughput. Table 2 illustrates the performance of various sub-groups within a total population of 2,110 pigs, sorted according to their weaning weights. The lightest 12% of the pigs weighed only 4.1 kg at weaning, compared to a total population average of 5.9 kg, and weighed 26.7 kg at nursery exit, compared to a total population average of 31.5 kg (unpublished, Beaulieu). Although these data end at nursery close-out, it is clear that lighter entry weights result in slower growth in the nursery, and subsequently in the grow out barn (Mahan, 1993).

Table 2. Performance of sub-groups within an overall population of pigs.

	Percentile counting from bottom			Percentiles counting from top		
	12th	25th	50th Light	50th Heavy	10th Heavy	100th
Weaning wt, kg	4.1	4.5	5.0	6.9	8.1	5.9
Nursery exit wt, kg	26.7	27.7	29.1	33.8	36.5	31.5

Pigs were weaned at an average age of about 19 days and nursery exit occurred 50 days later. Beaulieu et al, unpublished data.

6.2.2. Parity segregation

Parity segregation refers to the separate housing of gilts and their offspring, as compared to those of older parity animals. Depending on the system, the gilts will be mixed with older parity animals at the time of breeding or farrowing of their 2nd litter. The report of Moore (2001) indicated that when housed separately, gilt offspring will grow faster as compared to conventional blended housing systems. Moore suggests that gilt off-spring are less competent immunologically than off-spring of older sows, and that mixing of parities places them at a disadvantage.

6.2.3. Increasing weaning age

It has been suggested that weaning at an older age will also reduce variability (Main et al, 2004). Without question, pigs weaned at 21 days of age had a lower CV at marketing than those weaned at 12 days of age; however, they were also heavier pigs, so the smaller CV is partly an artefact of the mathematics of calculating CV. However, the standard deviation was also reduced, indicating that older weaning ages are modestly beneficial.

6.2.4. Increasing overall weight gain

As mentioned previously, it is the tail-end pigs that dictate the rate at which a barn or room can turn over. It is therefore quite logical that if the performance of all of the pigs in a group grow faster, the impact of the tail-enders will be lessened. Indeed, for every 50 g/d increase in average daily gain in the grow out period, there is a 50% reduction in the number of tail-end pigs in a room. In this instance, a tail-end pig is defined as one that will not meet the minimum core marketing weight within the defined grow out period in the barn. Of course, if growth rate increases, there is a great temptation to build fewer grow out weeks into future construction to reduce costs, with the net result that the problem of tail-enders returns!!

Listing the many strategies that can be undertaken to increase growth rates is a talk unto itself (Patience et al., 2001a). Suffice to say that the opportunity exists in many barns to increase growth rate in an economical fashion.

6.2.5. Weigh pigs at marketing

Weighing market pigs is probably as popular as power washing; yet, the economic benefits can be substantial. Unfortunately, many grow out facilities have not been designed for easy weighing of pigs, which compounds the problem. Auto-sort technologies are becoming increasingly popular, and although there are many questions regarding the details of their use, they are a promising alternative to allow accurate selection of animals for market.

6.3. Practices that do not reduce or increase variability

Because the industry's focus on variability is relatively recent, some incorrect conclusions have been drawn regarding practices that increase or decease variability. This is not surprising, as it is part of the normal learning process. Nonetheless, it is important to separate what we currently believe to be correct (we are under no allusions that as we learn more about the subject, some of our current "truisms" will be refined or even proven incorrect) from what we know for certain is incorrect.

The first misconception is that sorting pigs into pens of uniform weights at weaning or at growout entry will reduce variability. This has been proven wrong in numerous studies, so there is no need to waste time and effort in sorting pigs for this purpose (Gonyou et al., 1986). The only reason to sort pigs into pens is to achieve split sex feeding or to house pigs according to a predetermined management need; for example, at weaning, smaller pigs are often sorted from larger pigs so they can be given greater quantities of the Phase 1 and Phase 2 starter diets.

Another misconception is that crowding increases variability. In truth, as long as access to feed and water is not limited, and unless the degree of crowding is extreme, crowding has not been shown to increase variability. It certainly reduces performance, but not variability.

7. CONCLUSIONS

Variability is becoming a topic of increased interest in the pig industry, due to the recognition of its substantive impact on net income. This has become more obvious in all-in-all-out systems where tail-end pigs are more obvious than in a continuous flow system. While variability has earned extra attention, there is much to learn, such as how much variability is inherent and must therefore be accepted, and how much is excessive and therefore, at least theoretically, can be reduced. Poor herd health, itself a poorly defined term, is believed to be a major contributor to variability, but inadequate access to feed and water can also contribute. Managing variability will be the focus of most farms, and requires imaginative strategies, based on facts and not specious logic, to be successful. Unfortunately, many procedures known to effectively manage variation require either changes in physical facilities or increased labour input, neither of which is viewed with much enthusiasm at this point in the pork production cycle! Nonetheless, there are substantial rewards to those producers who reduce or manage variability effectively, because the costs of not doing so are substantial.

Variation is measured as either standard deviation or coefficient of variation. Reasonable targets for CV are 20% of weaning weights, 12 to 15% for nursery exit weights and 10 to 12% for weight at first pull from the finishing barn. The number of animals that must be weighed in order to accurately estimate CV is greater than that required to estimate the average weight. More animals must be weighed at younger ages, because variation as a proportion of the mean is much higher. If the CV for bodyweight in the feeder barn is above 15%, reducing it is a reasonable possibility. If the CV in growout is less than 8 to 12%, then the best strategy is to manage variability, as reducing it further will be very difficult.

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