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Managing variation on the way in: Weaning weight

M. D. Tokach[1], PhD, S. S. Dritz, R. D. Goodband, and J. L. Nelssen

[1]Kansas State University, Manhattan, KS 66502

We set upon a quest a few years ago to try to reduce the number of lightweight pigs at weaning by reducing variation in pig weights. A few production techniques will reduce variation and, thus, decrease the number of lightweight pigs at weaning. We have realized that these techniques, while of value, do not reduce numbers of lightweight pigs to the extent that we desired. Increasing weaning weight, instead of trying to influence variation, has been extremely successful in reducing the number of lightweight pigs. This paper will highlight our efforts in these areas.

What is "normal" weaning weight variation?

We have examined the variation in individual pig weight from several groups of pigs at weaning and have found that the standard deviation (STD) of individual pig weight is consistently close to 2 lb. Also, the distribution of pig weight commonly approximates a normal distribution or the classic bell-shaped curve. Therefore, 68% of the pig weights will be within 1 standard deviation of the mean, 28% of the pig weights will be within one to two standard deviations, while the weight of the remaining 4% will be more than two standard deviations from the mean. A normally distributed population of pigs with an average weaning weight of 10 lb and STD of 2 lb is presented in **Figure 1**. Due to the consistent variation in weaning weight, an approximate proportion of pigs in 2-lb weight increments can be easily calculated. One standard deviation or 2 lb below the mean will encompass 34% of the pig weights. Between 1 and 2 standard deviations from the mean will encompass 14% of the pig weights. Approximately 2% of pig weights will be more than 2 standard deviations or 4 lb from the mean. For example, in a group of pigs with an average weaning weight of 10 lb, approximately 2% will weigh less than 6 lb, 14% from 6 to 8 lb, 34% from 8 to 10 lb. The proportions are similar for the pigs that weigh more than the mean with 34% weighing from 10 to 12 lb, 14% from 12 to 14 lb, and 2% greater than 14 lb. Thus, plus and minus 2 lb from the mean weight will encompass 68% of the pigs with 16% greater than 1 STD from the mean on each end (16% greater than 2 lb above the mean and 16% greater than 2 lb below the mean).

Another way that the variation in pig weights within a weaning group can be depicted is as the cumulative distribution of pig weights. The cumulative distribution of pig weights within a population that has an average weaning weight of 9, 11, or 13 lb is shown in **Figure 2**. The proportion of pigs greater than 10 lb is approximately 95% for the 13-lb average weaning weight, 70% for the 11-lb average, and only 30% for the 9-lb average. This type of information can be used in two ways, First, it demonstrates the importance of weaning weight. Second, it depicts the normal range in pig weights at a given weaning weight. For example, setting an incentive program that dictate that no pigs should weigh less than 8 lb is not realistic when the average weaning weight is 11 lb or less.

Based on the 2-lb standard deviation of weaning weight, we have developed the following tables to assist in deter-

Figure 1. Distribution of pig weights at weaning

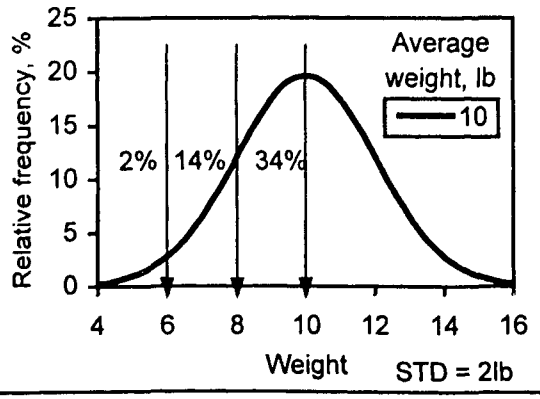
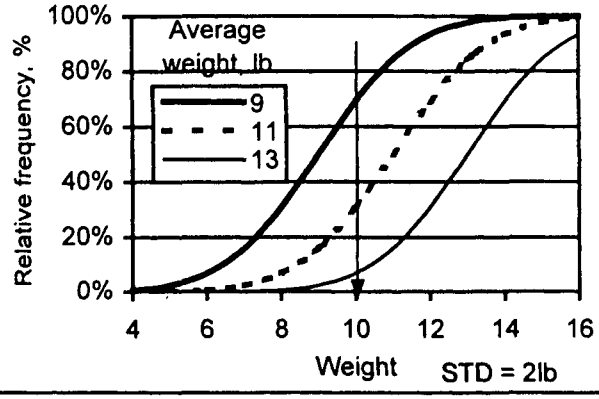


Figure 2. Cumulative distribution of pig weights



mining the number of pigs in each weight category. Listed in **Table 1** is the percentage of pigs within each 1-lb weight group with weaning weights ranging from 8 to 13 lb. The cumulative percentage of pigs within each 1-lb weight group is shown in **Table 2. Tables 3** and **4** list the number of pigs for a 600 and 6,000-head group, respectively, within each 1-lb weight group. This data can be adapted to the weaning weight and group size for any system to establish sorting procedures and for developing nutritional programs.

Methods to reduce variation

Given the normal weaning weight variation, we are often asked for methods that can be used to reduce variation within a group. Split weaning or bump weaning and split nursing are two technologies that can reduce weaning weight variation.

Split weaning/bump weaning

Variation can be managed by altering the weaning age slightly. This will effectively maximize the age of the smallest pigs in the litter within the confines of the maximum weaning age set for the farm. In practice, the largest pigs in the litter are either weaned or moved to a nurse sow for a few days prior to weaning to allow the smallest pigs access to the udder for a few extra days. Research indicates split weaning will increase weight gain of the pigs remaining on the sows compared to pigs on sows where the litter remained intact and was not split weaned (Vesseur et al., 1997).

Unfortunately, split weaning does not work effectively unless pigs are weaned on 2 or more days during each week on the farm. Because most systems are setting a maximum weaning age for health control, the heavier pigs in the litter will be too young to wean a week before the rest of the pigs. For example, if the maximum weaning age is 21 days, the spread in weaning age is 15 to 21 days with an average of 18 days in a weekly weaning system. If the heaviest pigs in each litter are weaned a week prior to weaning the rest of the pigs, they will only be 8 to 14 days old at weaning creating a weaning age spread of over 10 days.

TABLE 1: Percentage of pigs between each weight grouping

	Average Pig Weaning Weight					
Weight, lb	8	9	10	11	12	13
<2	0.1%					
2 to 3	0.5%	0.1%				
3 to 4	1.7%	0.5%	0.1%			
4 to 5	4.4%	1.7%	0.5%	0.1%		
5 to 6	9.2%	4.4%	1.7%	0.5%	0.1%	
6 to 7	15.0%	9.2%	4.4%	1.7%	0.5%	0.1%
7 to 8	19.1%	15.0%	9.2%	4.4%	1.7%	0.5%
8 to 9	19.1%	19.1%	15.0%	9.2%	4.4%	1.7%
9 to 10	15.0%	19.1%	19.1%	15.0%	9.2%	4.4%
10 to 11	9.2%	15.0%	19.1%	19.1%	15.0%	9.2%
11 to 12	4.4%	9.2%	15.0%	19.1%	19.1%	15.0%
12 to 13	1.7%	4.4%	9.2%	15.0%	19.1%	19.1%
13 to 14	0.5%	1.7%	4.4%	9.2%	15.0%	19.1%
14 to 15	0.1%	0.5%	1.7%	4.4%	9.2%	15.0%
15 to 16		0.1%	0.5%	1.7%	4.4%	9.2%
16 to 17			0.1%	0.5%	1.7%	4.4%
17 to 18				0.1%	0.5%	1.7%
18 to 19					0.1%	0.5%
>19						0.1%

TABLE 2: Cumulative percentage of pigs at each weight

	Average Pig Weaning Weight					
Weight, lb	8	9	10.0	11.0	12	13.0
2.0	0.1%	0.0%				
3.0	0.6%	0.1%	0.0%			
4.0	2.3%	0.6%	0.1%	0.0%		
5.0	6.7%	2.3%	0.6%	0.1%	0.0%	
6.0	15.9%	6.7%	2.3%	0.6%	0.1%	0.0%
7.0	30.9%	15.9%	6.7%	2.3%	0.6%	0.1%
8.0	50.0%	30.9%	15.9%	6.7%	2.3%	0.6%
9.0	69.1%	50.0%	30.9%	15.9%	6.7%	2.3%
10.0	84.1%	69.1%	50.0%	30.9%	15.9%	6.7%
11.0	93.3%	84.1%	69.1%	50.0%	30.9%	15.9%
12.0	97.7%	93.3%	84.1%	69.1%	50.0%	30.9%
13.0	99.4%	97.7%	93.3%	84.1%	69.1%	50.0%
14.0	99.9%	99.4%	97.7%	93.3%	84.1%	69.1%
15.0	100.0%	99.9%	99.4%	97.7%	93.3%	84.1%
16.0		100.0%	99.9%	99.4%	97.7%	93.3%
17.0			100.0%	99.9%	99.4%	97.7%
18.0				100.0%	99.9%	99.4%
19.0					100.0%	99.9%
20.0						100.0%

TABLE 3: Number of pigs less than each weight in a group of 600 pigs

	Average Pig Weaning Weight					
Weight, lb	8	9	10	11	12	13
<6	95	40	14	4	1	-
<7	185	95	40	14	4	1
<8	300	185	95	40	14	4
<9	415	300	185	95	40	14
<10	505	415	300	185	95	40
<11	560	505	415	300	185	95
<12	586	560	505	415	300	185
<13	596	586	560	505	415	300

TABLE 4: Number of pigs less than each weight in a group of 6,000 pigs

	Average Pig Weaning Weight					
Weight, lb	8	9	10	11	12	13
<6	952	399	135	36	7	-
<7	1,851	951	399	135	36	7
<8	3,000	1,850	951	399	135	36
<9	4,149	2,999	1,850	951	399	135
<10	5,048	4,147	2,999	1,850	951	399
<11	5,599	5,047	4,147	2,999	1,850	951
<12	5,863	5,598	5,047	4,147	2,999	1,850
<13	5,963	5,862	5,598	5,047	4,147	2,999

Split nursing

Split nursing follows the same principle as split weaning, except pigs are provided the extra access to milk during the first 24 hours after birth instead of just prior to weaning. For this procedure, the largest half of the litter is removed from the sow for a 2-hour period within the first 24 hours to allow the smallest pigs in the litter access to the udder. The goal is to ensure that all pigs have adequate colostrum intake. Research has demonstrated that split nursing will reduce variation in weaning weight (Donovan and Dritz, 1997). The reduction in standard deviation (1.8 vs 2.1) is relatively small and moves the tail of the weaning weight curve only slightly (**Figure 3**). However, the small change does reduce the number of lightweight pigs (**Table 5**).

The reduction in variation found by Donovan and Dritz (1997) with split nursing would reduce the number of pigs weighing less than 8 lb from 31 to 12 pigs in a 1000 head group and the number weighing less than 9 lb from 83 to 47 pigs. Closer examination of the curves in **Figure 3** and data in **Table 5** reveal that a 0.5 lb increase in pig weaning weight would provide similar benefits in reducing the number of lightweight pigs as split nursing.

Figure 3. Distribution of pig weights at weaning as influenced by split nursing or a 0.5 lb increase in weaning weight

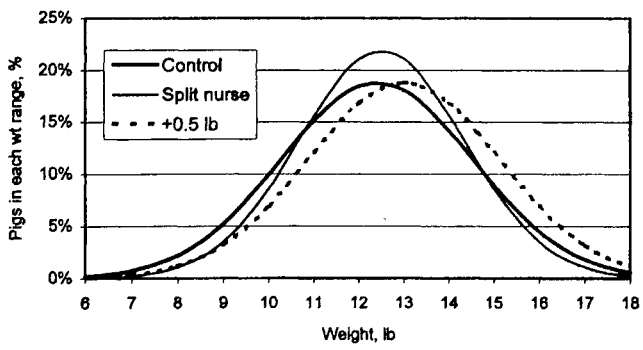


TABLE 5: Number of pigs in a 1,000 head group weighing less than each weight as influenced by split nursing and weaning weight[a]

Weight, lb	Control	Split nurse	0.5 lb[b]
6	2	0	1
7	9	2	4
8	31	12	16
9	83	47	48
10	182	132	117
11	333	288	238

[a]Adapted from data of Donovan and Dritz (1997). Average weaning weight of the control was 11.9 lb.
[b]Same standard deviation as the control with a .5 lb increase in pig weaning weight.

Increasing weaning weight as a means of reducing number of lightweight pigs

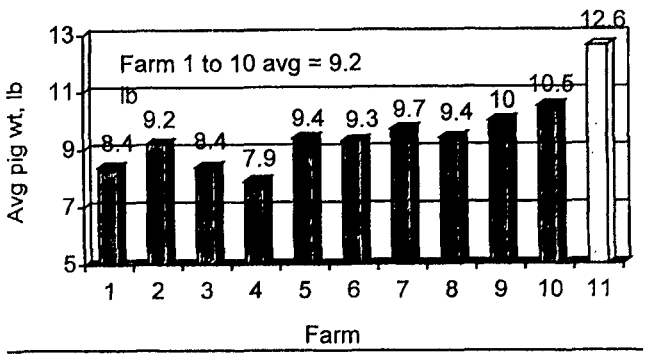
The data on split weaning and split nursing indicate that these management techniques can successfully reduce weaning weight variation; however, their impact is relatively small. We have had more success in reducing the number of lightweight pigs by concentrating on increasing weaning weight instead of just increasing the weight of the smallest pigs in the litter. As demonstrated in **Table 2**, an increase in average pig weaning weight from 10 to 11 lb reduces the percentage of pigs weighing less than 8 lb from 15.9% to 6.7%. These percentages correspond to a reduction from 95 to 40 pigs weighing less than 8 lb in a 600 head group or 950 pigs to 400 pigs in a 6,000 head group. An increase in average pig weaning weight to 12 lb would reduce the percentage weighing less than 8 lb to 2.3% or 14 pigs in a 600 head group.

Discussing increasing average weaning weight by 1 or 2 lb is easy, but how easy is it to accomplish? For many production systems, we would argue that an increase in total litter weaning weight of 10 to 20 lb is easily achievable if emphasis is placed in the correct areas and common management misconceptions are changed. We have worked with several production systems in the last year that have adjusted 21-day litter weaning weights of 100 to 120 lb. Other production systems with the same genetics are achieving adjusted 21-day weights of 130 lb or greater. What is the major difference between these systems? One answer resounds true in almost every case: feed intake in lactation.

Feed intake in lactation

The following case study illustrates the type of differences in litter weaning weight that we find between production systems with the same genetics. The average pig weaning weights from the first 20 weeks of production for 11 farms are listed in **Figure 4**. The first 10 farms were part of one production system with the 11th farm being part of another system. All farms have the same genotype and nutritional program. Average weaning age was 16, plus or minus 1 d. Average pig weaning weight from the first 10 farms was 9.2 lb with the best farm averaging 10.5 lb. The average pig weight from farm 11 is 3.4 lb greater than the average of the first 10 farms or 2.1 lb greater than the best of the first 10 farms. Also, note in the figure of the litter weaning weight that the increased weight per pig is not due to decreased litter size. The litter weaning weight of farm 11 is nearly 30 lb heavier than the better of the first 10 farms. Using **Table 2**, we can determine the number of pigs that would be expected to weigh less than 10 lb in each production system. In the

Figure 4. Average pig weaning weight (d 16) for two production systems



system with the 9 lb average pig weight, approximately 70% of the pigs weigh less than 10 lb. However, in the farm with a 12 lb average weight, only 16% of the pigs weigh less than 10 lb. Pigs from the farm with the 12 lb average pig weight will be much easier to manage in the nursery than pigs from the farm with a 9 lb average pig weight.

Why are the individual pig weights so much greater in farm 11? Farm 11 employees have made a commitment to have feed in the sow feeder at all times. They feed multiple times per day and readily investigate for reasons why a sow is not eating. We also believe that the multiple feedings of smaller amounts of feed prevent sows from "gorging" and going off feed. Personnel in farms 1 to 11 truly believe that they are feedings sows as much as they will consume; however, visits to the farms reveal that sows are not aggressively fed during the first week of lactation. The employees are so worried about sows "going off feed" that they limit consumption.

We have calculated that the extra feed to obtain the increased litter weaning weight in farm 11 compared to the other farms is approximately 4 lb per d. We have confirmed from actual feed deliveries that farm 11 lactation feed usage is 4 lb greater per day.

Why is lactation feed intake a problem on most farms?

The importance of sow feed intake during lactation is well understood. Why does it remain a problem in the industry? We suggest that the problem lies in three main areas.

1. Producers are concerned with sows going off feed, so they limit consumption in early lactation to prevent dips in feed intake.
2. Sows are often not fed correctly during gestation causing lower lactation feed intake.
3. Many producers use feed intake cards as a crutch. This allows them to believe that feed intake is higher than actual disappearance.

A case study

The following case study demonstrates a common problem with the use of lactation feed intake cards to determine feeding levels. This example is from a 3,000-sow farm with 450 farrowing crates. During a 6-month period, 3,615 litters were weaned with an average litter weaning weight of 101 lb at 19 d of age. During this 6-month period, 419 tons of lactation feed was delivered to the farm. Meticulous feed intake records were kept and scoops weighed periodically to ensure accurate scoop weights.

Another interesting aspect of this case study is that two farrowing rooms were converted from nurseries that had feed lines installed in the room. The feed lines were fitted with gestation feed drops over the farrowing crates. Multiple times per day farrowing house personnel would trip the drops and provide lactation feed for the rooms.

Average daily lactation feed intake was calculated from several hundred of the sow feed intake cards. Average daily feed intake was calculated to be 14.4 lb per day. Adjusted 21-day litter weaning weights were only 101 lb on this farm. Further calculations were made from the amount of milk energy output needed to support the observed litter gain and the amount of energy intake per day according to the 14.4 lb per day feed intake. These calculations indicated that the average sow should have been gaining approximately 50 lb during lactation. Visual appraisal of the weaned sows indicated that weight gain of sows during the lactation period was not occurring.

Therefore, lactation feed usage was calculated by two other methods. The first was based on number of crate days according to the following formula:

(Total Feed)/(Crates * Days) = (419 tons * 2000 lb)/(450 crates * 182 d) = 10.2 lb/d

The second method is based on the number of lactating days:

(Total Feed)/(Litters * Lactation Length) = (419 tons * 2000 lb)/(3615 * 19 d) = 12.2 lb/d

The first method should underestimate average lactation feed intake because of days that crates are empty or contain prefarrowed sows that are eating lactation feed. The second number overestimates lactation feed intake because the feed to prefarrowing sows is counted as feed fed to lactating sows. However, the true daily lactation feed intake has to be somewhere between 10.2 lb and 12.2 lb. This indicates that the feed intake on the cards is overestimating daily intake.

Also, average litter and pig weaning weight was examined in the modified rooms with the gestation feed drops and compared to the overall average. Litter weaning weight was 111 lb in the rooms with feed drops compared to the farm average of 101 lb. Average pig weight was 12.3 lb in the rooms with feed drops compared to 11.2 lb for the farm average. Comparison of the rooms with the feed drops to the farm averages indicates an energy deficiency due to low feed intake is limiting weaning weight.

This case study illustrates the major problems that often occur with sow feed intake cards. Sows were being fed according to a set pattern that limited consumption of many of the sows. The intake recorded on the cards also was assumed to be accurate, leading the producer to believe that feed intake was not the limiting factor in litter weaning weight.

What about inadequate nutrient levels in the lactation diet?

Certainly litter weaning weight can be reduced by limiting the level of lysine or other amino acids in the lactation diet. The lactation diet also has to be fortified with the proper levels of vitamins and minerals. For more information on diet formulation for gestating or lactating sows, we refer you to Tokach et al. (1997) or NRC (1998). Diet formulation used to be a major limitation for milk production and, thus, litter weaning weight. Most lactation and gestation diets used today are well fortified. The major nutritional limitation to milk production is lactation feed intake.

Practical method for maximizing lactation feed intake

Many different feeding methods will work to obtain maximum feed intake. The most important facet of any method is to ensure that the sow always has access to feed. The simplest method is—if the feeder is empty, put feed into it. However, many producers are concerned with detecting sows that go off feed. The following method is a simple procedure that can be taught with a minimum amount of training to ensure the early detection of sows that are off feed.

Lactating sows should be fed three or four times per day to ensure that feed is always available. We suggest using the procedure diagrammed in **Tables 6a** and **b** and outlined below to maximize sow feed intake:

- Sows are fed 0, 1, or 2 scoops at each of three feedings during the day. If the feeder has feed left from the previous meal, no feed will be added to the feeder. If a small amount of feed is left, one scoop will be added. If the feeder is empty, two scoops will be fed.
- The only exception is for day 0 to 2 after farrowing. During this time, the decision is to give 0 or 1 scoop at each meal. The sows should not receive 2 scoops at a single feeding during this period.

TABLE 6a: A suggested feeding procdure during lactation. Number of 4 lb scoops to feed at each feeding from day 0 to 2

	Feeding	
Feed in feeder	AM	PM
Empty	1	1
< 2 lb	0	0.5
> 2 lb	0	0

TABLE 6b: A suggested feeding procdure during lactation. Number of 4 lb scoops to feed at each feeding from day 2 to weaning

	Feeding		
Feed in feeder	AM	Noon	PM
Empty	2	2	2
< 2 lb	1	1	2
> 2 lb	0	0	1

Following is an example of the decision process at each feeding.

Morning feeding. All sows are fed one scoop (4 lb) if a small amount of feed is left in the feeder and two scoops if the feeder is empty.

Late morning feeding. A second feeding is done later in the morning or immediately after lunch using the same scheme (i.e., one scoop if a small amount of feed remains and two scoops if the feeder is empty). If no feed has been consumed since the morning feeding, the sow is then investigated to determine if she has a fever, retained pig, or other detectable reason for being off feed.

Evening feeding. A similar scheme is used for the evening feeding; however, some judgment will have to be used if there is some feed left in the feeder. The sows that have had good appetites throughout the day but some feed remaining should receive two scoops. Sows that appear to be reaching appetite receive one scoop. Again, if the feed has not been touched since the last feeding, the sow is checked to determine the reason.

Conclusion

Weaning weight variation can be reduced with management techniques like split weaning and split nursing. However, a much easier approach to reducing the num-

ber of lightweight pigs is to increase average weaning weight by increasing feed intake of the lactating sow. Fine tuning management with techniques, such as split weaning or split nursing, should be done after all steps are taken to maximize feed intake and, thus, litter weaning weight.

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