Feeder and Pen Design to Increase Efficiency

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▪ Introduction

Management decisions concerning feeders and pen design are not made on a frequent basis. However, during times of rapid expansion or a thorough review of an operation, such decisions can have a major impact on the efficiency of the business. Decisions concerning feeders and pen design affect both the capital cost and the operating costs of a swine farm. As with many capital items, we have relatively little information concerning the relative merits of the various alternatives. Research on such items is difficult and, consequently, costly. It is much easier to determine the relative merits of diet formulations or reproductive technologies than to set up a barn to compare different feeders or pen designs. Nevertheless, by combining information being generated around the world, we are finding answers to many of the questions asked by producers.

▪ Feeder Design

Not long ago the typical recommendation was that one feeder space could feed no more than 5 pigs. At the time that this recommendation was developed the approach to reducing feed wastage was to make it difficult for pigs to eat from a feeder. By slowing the rate of consumption, fewer pigs could eat from a feeder space. Two significant research projects on feeder design in the 1980's, in Scotland and the United States, along with the innovative approach of feeder manufacturers, have dramatically changed the way we design pig feeders and our recommendations for stocking rate. As a result, today's feeders generally provide protection to the pig while it is eating, in order to reduce aggression, and the feeder space accommodates the eating behaviour of the animal. Pigs eat more quickly due to easier access to the feed and less interference from other pigs, and consequently more pigs can be fed from a feeder space. The manufacturing industry has continued to develop new feeder designs, notably the wet/dry feeder and tube feeders. The swine production industry has simultaneously placed greater demands on the feeder industry by first

combining the grower and finisher phases, and more recently by moving to wean-to-finish systems. A wider range of body weight, now involving as much as a 14-fold increase, are being accommodated using the same feeder. It was to address some of these developments that we conducted a series of studies on grower/finisher feeders (Gonyou and Lou, 1998).

Eating Behaviour

Growing/finishing pigs generally consume between 10 and 20 meals per day. Smaller pigs eat more meals, and increasing the number of pigs eating from a feeder space will also reduce the number of meals. On older feeder designs it was not uncommon to find that pigs spent in excess of 120 min per day eating, while on newer feeders, which may feed 20 pigs from a single space, the total duration of eating is considerably less. Pigs will spend approximately 40% less time eating pellets as they would the same amount of feed in mash form.

The diurnal eating pattern of a pen of pigs usually consists of a peak in the morning and a second in late afternoon. The level of eating at midday is intermediate to the peak and nighttime levels. If pigs are kept in continuous light, the eating pattern is much less distinct with only a minor increase during the actual daytime period. As more and more pigs are fed from the same feeding space, first daytime feeding levels and then nighttime levels increase to the level of the morning and afternoon peaks.

Eating behaviour, particularly the total duration of eating in a day, is quite variable. However, it is the amount of feed consumed, rather than the time taken to consume it, that best determines the growth rate of the pig. Pigs have a remarkable ability to maintain feed intake levels even though their eating behaviour is curtailed by factors in their environment.

Single vs. Multiple Space Feeders

The improvements in feeder space design that have facilitated eating by the pig have increased the number of pigs that can eat from a single space. Rather than the earlier recommendations of 5 pigs per feeder space, we have producers regularly feeding 10-15 pigs per single space feeder. In our feeder project we fed 12 pigs from either single or multiple (2-4) space feeders. Our five single-space feeders included both dry and wet/dry models, as did the seven multiple-space feeders. We fed the pigs a mash diet, which would slow their eating speed.

Pigs fed from the single-space feeders consumed their feed faster than those fed from two-space feeders, and, as would be expected, the single-space feeders were occupied for a greater proportion of the day (Table 1). Despite the fact that pigs spent less time eating from single-space feeders, they maintained the same levels of feed intake and growth as did pigs on multiple-

space feeders. Under the conditions of this study, 12 pigs can be fed from a single-space feeder without detrimental effects on productivity.

Single-space feeders have a number of advantages over multiple-space feeders under certain conditions. Providing a single feeder space to a group of pigs forces them to eat from that space and to keep it clean and functional. Small groups of pigs fed from multiple –space feeders are more likely to foul or avoid using one of the spaces. There is more flexibility of placement of single-space feeders within a pen than for multiple-space feeders. When it is desirable, single space-feeders can be situated such that pigs stand along the fenceline while eating, thereby keeping the centre of the pen available for movement. This position also provides the pigs with additional protection while eating. To achieve the same effect, multiple-space feeders must be placed 'back-to-back' or be shared between pens.

Table 1. Feeding behaviour and growth rate of pigs fed from single or multiple-space feeders.

Item	Single-space feeder	Multiple-space feeder
Total duration of eating (min/day)	84.0	97.6
Occupancy rate of feeder (% of time)	71.5	50.3
Average daily feed intake (kg/day)	2.69	2.77
Average daily gain (gm/day)	885	905

Dry vs. Wet/Dry Feeders

Traditionally, we have had the options of providing our pigs with dry feed, or wet feeding in which we mix the feed with water. A third option, providing pigs the options of eating the feed dry or of adding water is now available in wet/dry feeders. Wet/dry feeders have become very prevalent in western Canada due to the presence of one of the principle manufacturers. We included six wet/dry models in our study and compared them with six dry feeders. Some have suggested that the appropriate comparison is to use a wet/dry feeder, with and without the water turned on. However, wet/dry feeders must keep the feed access point separate from the water in order to prevent wicking of the water into the feed storage area and blocking the feeder. The common means of achieving this separation; a dry feed shelf, paddles that drop the feed, or separate feed and water bowls, will affect eating behaviour and may prejudice the results to favour the wet/dry condition for which the feeder was designed.

We chose to compare feeders that were designed to be used dry, with feeders designed to be used wet/dry.

Pigs spent less time consuming their feed from wet/dry feeders than from dry feeders (Table 2). There was also less activity at the wet/dry feeders as pigs remained in the feeder for longer periods once they entered. They did not have to interrupt their meal in order to get a drink of water. Although the time spent in the feeders was reduced when water was available, feed intake was not reduced. In fact, feed intake increased approximately 5% on wet/dry feeders compared to dry feeders. Similarly, average daily gain increased 5% as well. Pigs on wet/dry feeders reached market weight nearly a week before those on dry feeders.

There are other advantages, and some disadvantages, to wet/dry feeders. Because pigs spend less time eating, more pigs can be fed from a single feeder space in a wet/dry feeder than in a dry feeder. Water use is reduced in a wet/dry feeder compared to a nipple drinker used in conjunction with a dry feeder. These estimates of reduced water range from 30-40%. Two disadvantages of wet/dry feeders relate to keeping them clean and functional. If the number of pigs in a pen is too few, as when most of the pigs have been marketed, the feeder may accumulate wet feed. In addition, if pigs access the dry feed with a wet snout, the feed access point may plug. Wet/dry feeders work best when they have enough pigs in the pen to keep the feeder occupied.

Table 2. Feeding behaviour and growth rate of pigs fed from dry and wet/dry feeders.

Item	Dry feeders	Wet/Dry feeders
Total duration of eating (min/day)	104.1	86.3
Frequency of entrances (#/day)	60.1	36.7
Average daily feed intake (kg/day)	2.66	2.82
Average daily gain (gm/day)	873	917

Feed Wastage

Estimates of feed spillage from feeders vary considerably, with values of 2 to 10% being cited frequently. We measured spillage from our feeders by collecting the feed that fell through the floor near the feeder. Our values ranged from 2 to 5.8%. Perhaps more importantly, we determined that pig size is a major determinant of level of spillage. Large pigs (80 kg) wasted only 2.4% of

the feed, compared to 4.4% for 40-kg pigs. This difference explains some of the variation seen among previous reports on feed wastage.

Knowing that small and large pigs wasted different proportions of feed, we attempted to determine how this feed was spilled. We videotaped the pigs and the area under the feeder. When we detected feed falling through the floor, we would examine the behaviour of the pig that was associated with the spillage. Spillage occurred while pigs were eating; as they backed out of the feeder; during fighting at the feeder; and when pigs stepped in and out of the feeder. Two of these behaviours, fighting and stepping in and out, were more frequently observed among small pigs than large.

Fighting occurred when two pigs would attempt to eat at the same time. In single-space feeders, or multiple-space feeders with well-defined eating spaces, the width of the feeding space must be wide enough for a market weight pig. Unfortunately, this is also the width of two 25-kg pigs. For the first few weeks two small pigs will attempt to eat together and often fight. It is important that feeder spaces do not exceed the width needed for a market pig or else fighting among small pigs will be extended.

We also examined the importance of feeder depth (lip to feed access) and lip height on the incidence of stepping in and out of the feeder. Lip height had little effect on whether or not pigs would step into the feeder. Depth of the feeder was far more important. Small pigs would step into the feeder if the depth was greater than 20 cm. Large pigs would step in if the depth exceeded 40 cm. A compromise needs to be struck that minimizes the period that pigs will step into the feeder, and yet provides sufficient space for large pigs to eat comfortably. We concluded that a depth of 25-30 cm is good for grower/finisher feeders.

Size of Pig

We have already identified several differences in the eating behaviour of 40 and 80-kg pigs. Small pigs spend more time eating, step into the feeder and fight more, and waste more feed than do large pigs. Consequently, feeder design and management is limited by the size of the smallest pig to use the feeder. The number of pigs to be fed per feeder hole should be determined by the eating behaviour of the pigs at the beginning of the feeding period. Fewer small pigs can be fed from a feeder space than can large pigs. The width of the feeder space needs to be minimized in order to avoid fighting and consequent feed wastage, yet must be sufficient for the largest pigs being fed. Similarly, the depth of the feeder should be the minimum possible to allow market weight pigs to eat, as greater depths will result in small pigs continuing to step in and waste feed longer into the feeding period.

In western Canada we have not yet moved to combining the nursery and grower/finisher phase of production, as is the trend in the U.S. Manufacturers

of wean-to-finish feeders recognize that the small pigs must stand in the feeder in order to eat. This behaviour will result in higher levels of wastage for the young pig. Wean-to-finish operations may feed pigs from 7 to 120 kg on the same feeder. Manufacturers should be examining significant design changes in order to accommodate such a range of pig sizes.

Pigs Per Feeder Space

Perhaps the most frequently asked question concerning feeders is, 'How many pigs can I feed from each feeder?' Unfortunately, the answer is not a simple one. Using the eating behaviour data from ten feeders on our study, I have estimated the number of pigs that would keep each feeder occupied for 80% of the time (Table 3). It should be emphasized that these are conservative estimates. Our data were collected while feeding mash feed. We would expect that pigs fed pellets would eat faster and more could eat from a feeder. Secondly, basing the estimate on 80% occupancy may be low. This was the highest occupancy observed in our study, but others have seen no decrease in performance at occupancy rates of 90%. Finally, the data was collected with only 12 pigs in a pen. When more pigs are placed in a pen they compensate by eating more quickly as well. Thus, even more pigs can probably be fed than predicted using the above data. Even so, the estimates are considerably higher than the traditional recommendation of five pigs per feeder hole. It should also be noted that there is considerable variation in estimates. It is important to know the characteristics of the feeder before predicting its stocking potential.

Table 3. Time spent eating by pigs and estimates of acceptable stocking rates for ten commercial feeders.

Feeder description	Total duration of eating (min/day per pig)	Estimated stocking rate (pigs/feeder)
Single-space, dry (1)	92	12
Single-space, dry (2)	98	11
Two-space, dry (1)	99	22
Two-space, dry (2)	101	22
Single-space, wet/dry (1)	73	15
Single-space, wet/dry (2)	75	15
Single-space, wet/dry (3)	81	14
Two-space, wet/dry (1)	79	28
Two-space, wet/dry (2)	98	22
Two-space,wet/dry (3)	110	20

Recent Developments

We included a 'tube' feeder in our study, but manufacturers have since devised a number of variations to this simple design. Early tube-feeders provided little protection to the pigs while they ate but some recent models have well defined feeder spaces. The original tube-feeders did not include a feed storage hopper and required frequent if not continuous filling. Most feeders now provide a storage hopper, or the option of having one. Many tube-feeders retain the simple design of feed being directly accessible from the tube, while others have included a valve or other access device to prevent wicking of water into the tube. With all of these modifications it is impossible to make a simple assessment of tube-feeders. Based on our study, intake and growth rate of the pigs on tube-feeders was equal to that of other multiple-space wet/dry feeders. The modifications are likely to change eating behaviour and the level of aggression around the feeder, and perhaps feed wastage, but are unlikely to improve intake or growth rate.

At least one manufacturer and another research group have suggested that providing contact between pens in the area of the feeder may improve intake and growth rate. That is, by allowing pigs to nose or see pigs from the neighbouring pen at the feeder, social facilitation of eating will occur. We recently examined both the behaviour and the performance of pigs when they either had or did not have contact with the adjacent pen through the wall and/or the feeder. When the feeder was open between the two pens and pigs could see and touch the neighbouring pig, eating was more synchronized between the pens. However, total duration of eating, feed intake and average daily gain did not differ from pens with no contact with the adjacent pigs. Eating behaviour was changed, but productivity was not.

▪ Pen Design

The three most common questions I receive concerning pen design are; how many pigs per pen, how much space per pig, and what layout should I use? All of these questions are interrelated and one cannot be properly answered without making assumptions about the other two. On an operation of 200 sows, weaning approximately 100 pigs per week, group size is limited. After split-sexing the pigs and making 2-3 divisions based on weight, group sizes are 16-25. At this point the decision on group size depends upon the type of feeder you wish to use. On larger units we have the potential of group sizes in excess of 100 pigs.

It is common on many farms to provide pigs with less space than they need for maximum growth. This is done in order to maximize the amount of pork produced per square metre. Nevertheless, we should be concerned if our

production practices are so stressful that growth is restricted. As we look for ways of improving productivity while maintaining the economic efficiency of low space allowances we must consider pen layout. Will some combination of feeder location and pen shape result in improved growth compared to traditional designs?

How Pigs Use Space

Pigs use space to perform the behaviours necessary to maintain life and, in the case of growing/finishing pigs, to grow. Pigs lie about the pen, eat, drink, eliminate, and move to the different locations used for these behaviours. We commonly think of space in terms of area, but not all area is used equally by the pig. Pigs prefer to lie and eliminate close to a wall. The center of a pen is used for traffic. Wall space or perimeter is at a premium within a pen. As pens are increased in size, the perimeter:area ratio decreases. Ten pigs, provided with 1 m^2 per pig, in a square pen each have 1.26 m of perimeter to lie against or eliminate next to. One hundred pigs, also with 1 m^2 per pig and in a square pen, have only 0.4 m of perimeter per pig. Perimeter is also increased as pen shape becomes more elongated rather than square.

In general, pigs prioritize their space into three levels. The eating area is determined by the location of the feeder. The sleeping area is then selected from the most comfortable area remaining. Any area not used for eating or sleeping becomes eligible for dunging. Drinking location is determined by drinker location and is usually superimposed on the dunging or eating areas. Clearly defining the most comfortable area in the pen will determine the sleeping, and hence the dunging, area of the pen.

How Much Space Do Pigs Require

It may seem a trivial point, but big pigs need more space than small pigs. Yet many recommendations will list the same amount of space for 60 and 120-kg pigs. What if you would like to keep pigs up to 75 kg in a grower facility? The typical grower recommendations would be too crowded, while the finishing recommendations would waste space. Space allowance should, in some way, be expressed in terms of body weight. I believe the best way to do this is to use the relationship between body weight and surface area of the pig. A pig's space needs can be expressed in terms of a proportion of its surface area, which needs to contact the floor when lying. To do this, we express the area allowance of a pig as the product of a constant k x BW.667. To test this concept we provided pigs with three levels of space, with k equal to 0.030, 0.039, and 0.048 (area is in m^2, weight is in kg). We maintained this space allowance as the pigs grew by adjusting the size of the pens every two weeks. During the first 4 weeks of the grow/finish period, using a constant of 0.030 reduced growth by 5% compared to the higher levels. The same was true for

the final 4 weeks of the study. The results indicate that space allowance should be expressed in the manner suggested (Gonyou and Stricklin, 1998).

The primary effects of space restriction are reduced feed intake and reduced rate of gain. If reduced intake were due to increased difficulty moving to the feeder and hence a restriction on eating time, we would expect a more concentrated diet to alleviate the effects of overcrowding. It does not. It would appear that overcrowding reduces the pigs' appetite, and hence reduces intake and growth rate.

There has been some data that suggests that pigs can compensate for a period of space restriction by improved growth in a subsequent period. We placed several groups of pigs in either crowded or adequate conditions at the beginning of the growing/finishing period. At 4-wk intervals we would move some groups from one condition to the other. Overcrowding always resulted in a reduction in growth rate, whether the pigs had been crowded before or not. Moving from crowded to un-crowded conditions resulted in an improvement in growth to that of other pigs in un-crowded conditions, but no compensatory growth occurred. We concluded that for every month a pig spends in crowded conditions during the growing/finishing period, there is a reduction in their overall average daily gain of approximately 16 g. Pigs that are crowded for the entire period have a 5% reduction in growth rate, which is consistent with previous studies.

The value of *k* used for fully slatted floors in the Code of Practice is 0.035, and represents a level at which average daily gain is near maximum. Reduction of space allowance to a *k* of 0.030 will reduce average daily gain by 5%.

Pen Size

Our research has shown that increasing group size from 3 to 15 pigs results in a reduction in feed intake and average daily gain (Gonyou and Stricklin, 1998). Over the same range of group sizes there is an increase in the complexity of the social hierarchy within the group. Very small groups have a stable social hierarchy that is associated with high levels of feed intake and growth. Until recently we have had little information about much larger social groups, and so our recommendations have been to use group sizes that are relatively small but which also allow efficient use of space in terms of alley area.

More recently we have seen examples of large groups of pigs, such as 100 or more pigs per pen. Compared to mid-sized groups of 20-40, these pigs have equal productivity and more efficient use of space as less area is used for alleys. Our limited amount of study of large groups indicates that individual pigs have preferred lying locations within the pen, but move about the entire area when active. This suggests that they are not avoiding other pigs within the

large group. We are continuing work on the social behaviour of pigs within large groups to determine the nature of their organization.

Pen Layout

As we understand the behaviour of pigs and the effects of features within the pen and group size we realize that no one pen design will suit all situations. For traditional sized groups, from 10 to 40 pigs, we would recommend rectangular pens with a length to width ratio of 1.5 to 2.5:1. The rectangular shape provides distinct microenvironments at each end of the pen and facilitates control of dunging. It is also easier to handle pigs in a rectangular pen for this group size as one person and a pig board can control the width. We would usually place the feeder in a corner or along the wall rather than in the centre of the pen in order to allow free movement from one end to the other. The centre can also be kept free by orienting the feeder so that pigs stand along the wall while eating, rather than protruding into the centre of the pen. For these small to medium sized groups, the ratio of perimeter to area is relatively high so pigs can usually sleep adjacent to a wall. Water should either be part of the feeder, or be placed in the preferred dunging area so that it does not wet the sleeping area.

We examined pens in which the feeder was either in a corner opposite the drinker and dunging area, or situated along the wall near the back of the pen. We used observations of real pigs as well as a computer simulation of pig movement in such pens. Two factors seemed to affect the behaviour of the pigs. As the distance between feeder and drinker increased, the pigs had to travel farther during each day. However, if the feeder and drinker were close together, there were more encounters among pigs during the day. Separation of resources within the pen would appear to have an advantage, but there is probably a limit to the distance that pigs should have to travel in a day. In our study there was no difference in feed intake or weight gain among the layouts we considered, so we can only speculate on the point at which distance becomes a problem.

As we move to much larger group sizes we need to reconsider feeder position in terms of distance travelled and use of the centre of the pen. In large pens the centre of the pen is not crowded with traffic and may be better used for feeding. Placing the feeders in the centre of the pen also minimizes the distance pigs have to travel to obtain feed. A central location for feeders allows pigs to use the entire perimeter for lying and dunging, but even then there is relatively little wall space per pig. A more complex design with additional ‘walls’ within the pen may provide better control of behaviour.

Several pen designs are now being used for large group sizes of pigs. Most of you will be familiar with hoop structures that house 150-200 pigs. Although feed and water are provided toward one end of the pen, the feeder is usually in

the centre of the barn so that pigs can encircle it. Farms using large group sizes in the U.S. have generally placed the feeders and drinkers in an 'island' in the centre of the pen. Often some additional penning is provided to provide additional lying space and to aid in sorting pigs. I have also seen the rectangular approach used with large groups by employing a 4-5:1 length:width ratio. Providing a slatted area at each end of the pen controls dunging. Feeders were placed along the walls, but this may not be the best design. I expect that all of these designs will undergo modification, as large groups become more common.

▪ Conclusions

Feeder and pen design, as well as management decisions such as group size, market weight, and type of feed, are interrelated. We shall see a variety of feeders and pen designs in use in different situations. Because pigs are so adaptable in their behaviour we can expect that many of these designs will work well. Feeder design features such as width and depth of feeding space should be determined by the size of pigs being fed. The number of pigs per feeding space is determined by the type of feed (mash or pellet) and type of delivery (dry or wet/dry). Resources within pens will shift from the perimeter to the centre of the pen as group size increases. However, we have much to learn about how large groups of pigs use space.

▪ References

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