RESOURCES TO MANAGE POPULATIONS TO IMPROVE PRODUCTION EFFICIENCY

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Introduction

The starting point for any discussion of production efficiency is a clear definition of the term which then allows the development of appropriate production targets and methods of measurement that can be used to monitor progress. Ideally, any definition should be simple and objective, and be based on criteria that can be easily measured under commercial conditions. In concept, defining production efficiency is relatively simple, however, in practice there are a number of components that can all be measured at different levels. Efficiency is normally defined as a ratio between inputs and outputs. Typically, in swine production we are interested in the efficiency of conversion of feed, because this represents the largest cost associated with producing pigs, and the ratio between feed intake and live weight output has been used as the index of feed efficiency, expressed as either unit of feed/unit of gain (generally called the feed conversion ratio), or unit of gain/unit of feed (gain:feed ratio). However, and as discussed by Dr. Cuaron in another paper at this meeting, there is increasing interest in moving further along the production chain when defining output, using carcass weight or even primal cut weights. Ultimately, we may move to use the weight of commercial cuts or products as the measure of output in the calculation of feed efficiency. In addition, we have typically measured the average feed efficiency for an entire population or group of pigs and this obviously overlooks any variability between either sub-populations or individual animals within the group.

Discussion of approaches to improve the efficiency of producing pigs often focusses on the input side of the equation, namely the feeding program. Although this is obviously important, substantial improvements in efficiency can also be obtained by increasing output and one of the best indexes of the economic efficiency of production of finished pigs is the total output from a given finishing facility, defined as the total weight of top value pigs produced, which is normally measured as the total weight per unit floor space (kg/m^2). This paper summarizes research carried out at the University of Illinois evaluating approaches to increasing the output from wean-to-finish facilities. One somewhat surprising result from this research is that increases in output can often be achieved with a similar or, in some instances, reduced feed input, thus, also increasing feed efficiency.

Variation and Compensation

Two important concepts that are fundamental to understanding approaches to managing populations of pigs to maximize output are variation within the population and compensatory growth.

Within-population Variation in Growth: One major cause of reduced output results from the variation in growth that is seen in growing pigs in commercial facilities. Variation in growth rates between pigs within a population results in variation in live weight within the population. Of particular significance is the lighter weight pigs in the population that often do not reach desired slaughter weights before facilities need to be emptied, consequently reducing total output. One of the management targets to increase facility output is to increase the growth rates and, therefore, weights of these animals.

Typical variation in weight within a population of growing pigs is illustrated in Figure 1 which is based on data from barrows in a wean-to-finish facility.

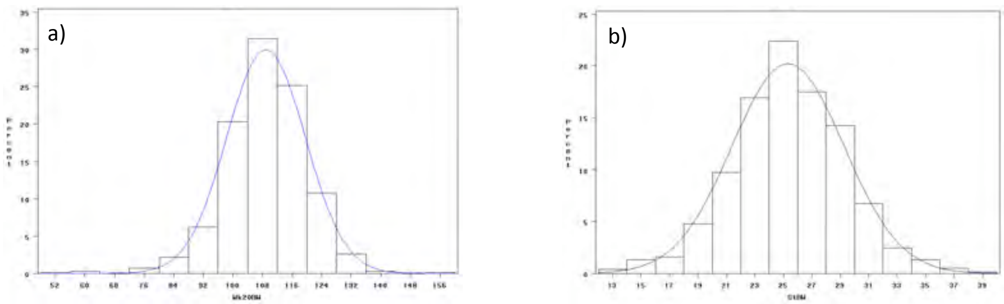


Figure 1. Distribution of live weight within a population of barrows at: a) Week 6 and b) Week 20 post-weaning.

The mean of the population of barrows at week 6 post-weaning (Figure 1a.) was 25.3 kg with a Standard Deviation (SD) of 3.95 kg, a Coefficient of Variation (CV) of 15.6%, and a range (±3 SD) of 13.5 to 37.2 kg (Figure 1). Equivalent values for week 20 post-weaning (Figure 1b) were: mean 108.9 kg, SD 10.67 kg, CV 9.8%, and range 76.9 to 140.9 kg. Interestingly, the CV of live weight of a population of pigs decreases as the population gets heavier. This is illustrated in Figure 2 which is based on a number of studies that we have carried out on commercial facilities. In this example, the CV of live weight decreased from ~ 17% at weaning to ~10% at ~110kg (Figure 2).

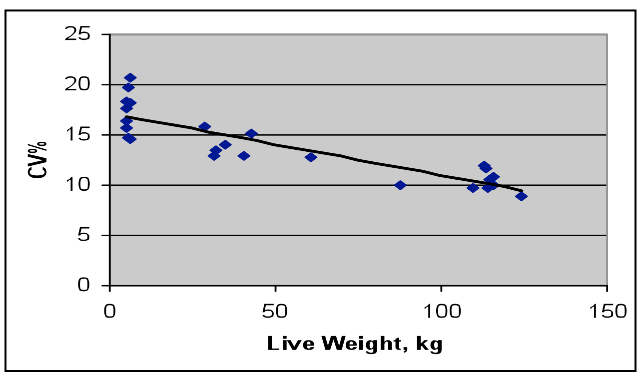


Figure 2. Changes in the CV of live weight within a population with increasing live weight.

Although the CV of weight decreases with increasing live weight, it is important to appreciate that the range in weights within the population actually increases (Table 1). At 25kg live weight, the CV was 16% with a range in weight of 25kg whilst at 110kg equivalent values were 10% and 66kg, respectively (Table 1).

Table 1. Relationship between live weight and CV and range of weights in the population.

Mean live weight, kg	CV, %	Lightest to heaviest weights, kg	Range, kg
25	16	13 to 37	24
50	14	29 to 71	42
70	12	45 to 95	50
110	10	77 to 143	66

There are a large number of potential causes of variation in growth rate between individual pigs within a population including differences between animals in factors such as genetic potential, gender, birth weight, and health status, and in the environment to which individual pigs are exposed.

Compensatory Growth: Following a period of restricted growth due to reduced feed supplies is followed by a period of accelerated growth when full feeding is resumed is referred to as "Compensatory Growth" (Lawrence and Fowler, 2002). Compensatory growth is not a novel concept and it has been exploited for many years in commercial production systems, particularly for ruminants. In forage-based systems that are common in many areas of the world, seasonal variation in the availability (quantity and quality) of feedstuffs results in periods of restricted growth during the winter or dry season followed by periods of compensatory growth when the quantity and quality of forages improves in the spring or wet season. However, compensatory growth has largely been ignored in pig production systems where it has generally been believed that the most efficient approach is to grow that animal as fast as possible from birth to slaughter. While this belief may well be true in terms of individual animal performance, it is certainly not the case for facility output where the exploitation of compensatory growth is central to maximizing output from a population of pigs. That the pig, in common with other animals, has tremendous potential to compensate for periods of restricted growth with periods of very rapid growth is beyond doubt. Interestingly, feed efficiency is generally high during the period of compensatory growth such that the feed efficiency for the overall growth period of pigs subjected to periods of restricted growth followed by compensation can as good as or better than animals reared under unrestricted conditions. This was most clearly illustrated by a classic study carried out in the UK in the 1960s by Dr. David Lister. In this study, pigs were fed at maintenance to keep them at a fixed live weight of ~10 kg for a period of 1 year and then were returned to full feeding. They eventually achieved the same body weight and a similar body composition as their sibs that had been reared on full feeding from weaning onwards. This incredible potential for compensatory gain can be exploited commercially to improve economic performance and we will discuss approaches that can be used to achieve this end later in this paper.

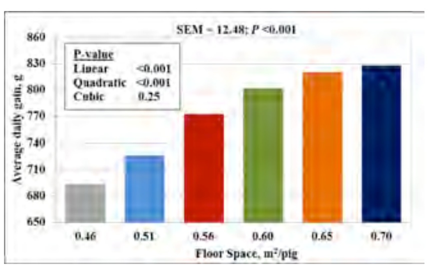
Managing Populations of Growing Pigs to Maximize Facility Output

Our research program, which for the last 15 years has largely been based on commercial wean-to-finish facilities, is focused on identifying management approaches to maximize output and the more important findings from this research are summarized in this paper.

Optimum Floor Space: One of the most important management decisions is the floor space at which the pigs are allowed, which in practice is the number of pigs to be placed in the building. There has been a substantial amount of research carried out in this area, mainly on research facilities with small group sizes, that has shown that keeping pigs at low floor spaces will reduce their growth rate. However, our research that has been carried out on commercial facilities has generally shown that the floor space below which growth performance is reduced is lower than would be predicted from historical research. This research has also shown that the floor space per pig that results in maximum facility output is generally below that for maximum growth rate and because of this most producers in the US will keep pigs at relatively low floor spaces. This is illustrated in Figure 3 where the results of a study carried in a commercial wean-to-finish facility are summarized. In this study, pigs were kept at floor spaces between 0.46 to 0.70 m2/pig from 45 and 120 kg live weight. Growth rate was decreased as floor space decreased (Figure 1a), with pigs kept at 0.46m^2/pig growing 16% slower than those kept at 0.70 m^2/pig. However, the total weight of pigs produced from a typical wean-to-finish facility (with 650 m^2 of total floor space) was 30% greater when pigs were housed at 0.46 compared to 0.70 m^2/pig.

Interestingly, although keeping pigs at low floor spaces will reduce average growth rates it appears to have little if any effect on variation in weight within a group of animals (Shull, 2010). This obviously suggests that whatever factor is responsible for reducing growth rate of crowded pigs has a relatively similar effect on all of the pigs in the group.

a)



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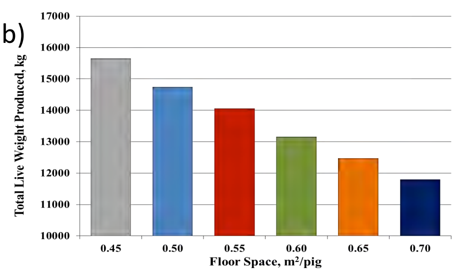

Figure 3. Effect of floor space in grow-finish on growth rate and total facility output: a) Average daily gain; b) Total live weight produced from a facility with total floor space of 650 m^2. 3.3 7.6 6.3

In the above example, floor space was kept constant throughout the grow-finish period. However, varying the floor space over the growth period can increase facility output. This is the case, for example, in wean-to-finish systems where the floor space is initially greatly underutilized if buildings are single-stocked (i.e., with the number of pigs that will be taken to slaughter weight). This has led to producers using “overstocking” of buildings at weaning with the extra pigs being moved to another facility after perhaps 8 to 12 weeks of overstocking. Obviously, the floor space per pig in the overstocked period is considerably reduced. We carried out a study to investigate the impact of reduced floor space in the early wean-to-finish period on subsequent and overall growth performance. In the nursery period (from weaning to 10 weeks post-weaning), pigs were housed at floor spaces of either 0.3 (Restricted) or 0.7 (Unrestricted) m^2/pig; subsequently from the end of the nursery period to slaughter weight all pigs had the same floor space (0.6 m^2/pig). The results of this study are illustrated in Figure 4, where growth performance is presented for the nursery period during which the floor space treatments were applied, the following period during which pigs had the same floor space, and the overall period from weaning to slaughter weight. The reduced floor space during the nursery period resulted in reduced growth rate and feed intake, with no effect on feed efficiency (Figure 4). However, during the grow-finish period pigs kept at the Restricted floor space in the nursery compensated for the reduced nursery performance, having greater growth rates, feed intake, and feed efficiency than those kept at the Unrestricted floor space. For the overall wean-to-finish period, there was no difference in growth performance between the nursery floor space treatments. We have seen similar results to these in a number of other similar studies and, obviously, increasing the number of pigs in the facility during the nursery period is one approach to increasing facility output if the system of production is designed to handle such an approach.

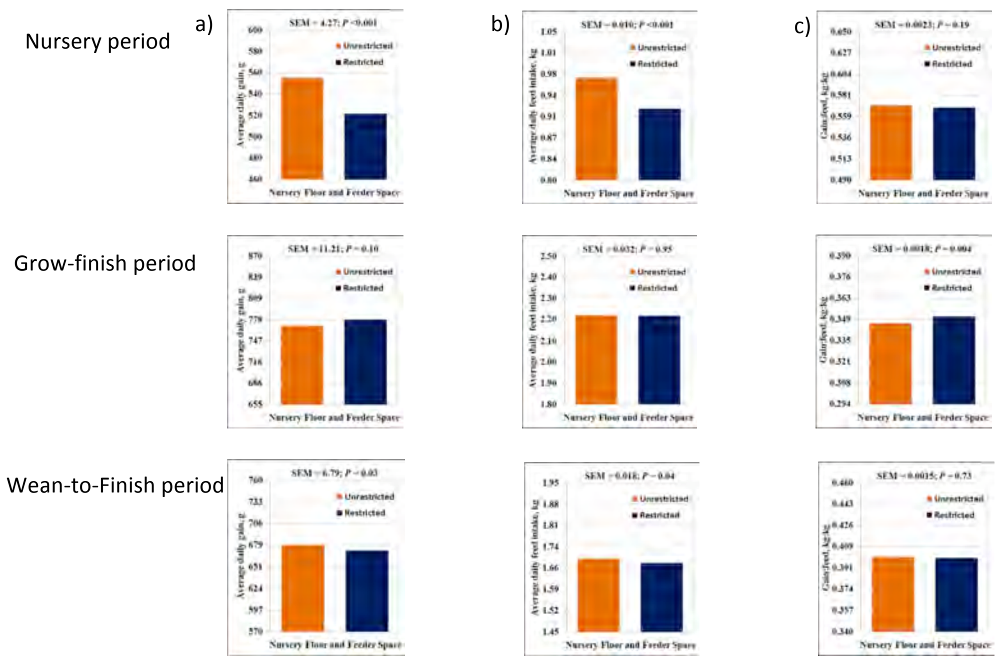

Figure 4. Effect of floor space in the nursery period on wean-to-finish growth performance a) Average daily gain; b) Average daily feed intake; c) Gain:feed ratio

Pig Removal Strategy: Another strategy to exploit compensatory growth to increase facility output and, also, reduce variation in weight of the pigs marketed from a population is to remove the heaviest pigs from the population when they reach the target live weight. This not only maximizes the proportion of the population in the target weight window but also results in increased growth performance of the pigs that remain in the pens. This is illustrated by the results of a number of studies carried out at the University of Illinois investigating the effects of removing a proportion of the pigs from the pen on the performance of the remaining animals which are summarized in Table 3 (DeDecker, 2006). In total, 13 studies were included in this summary and these differed in a number of important aspects such as the proportion of pigs removed, the timing of removal, and the time period post-removal over which performance was measured. However, these studies showed a relatively consistent and substantial improvement in growth performance of the pigs that remained in the pen after removal compared to leaving the pen intact (Table 3).

Table 3. Effect of removing pigs from a group on the performance of the remaining pigs (Summary of 13 studies; DeDecker, 2006).

	Response, %[1]		
	D 0[2] to 7	D 7 to end	Overall
ADG, %	+10.4	+12.3	+11.3
ADFI, %	+5.7	+5.5	+5.6
G:F	+6.5	+8.0	+7.2

[1]Difference in performance between pens with pigs removed (variable proportion of pigs removed) and control pens (no pigs removed).
[2] Day 0 = day that pigs were removed from the group

In subsequent pig removal studies we have shown that the increase in growth performance when pigs are removed from the pen results largely from the extra floor space that becomes available to the remaining animals. Consequently, the growth response in the pigs remaining in the pen after pig removal is likely to be greatest with pigs that were previously crowded and is likely to be minimal in un-crowded conditions.

Sorting Pigs Early in the Growth Period: One approach that has been proposed to reduce variation within a population of pigs is to form groups with a narrow weight range early in the growing period with the expectation that this reduced variation will be maintained through to harvest weight. Unfortunately, such an approach is not effective at reducing variation as illustrated by the results of a study carried out by Wolter et al. (2002) which are presented in Table 2. Groups of 54 pigs with light, average, or heavy weights were formed when the average weight of the population was ~30 kg. Obviously, the light and heavy groups had lower variation in weight when they were formed compared to the groups of average weight pigs (Table 2). However, when the pigs reached an average live weight of 112 kg there was no difference in CV between the different live weight treatment groups. The variation in weight in the light and heavy groups had actually increased during the study period whereas that for the average weight groups had actually decreased.

Table 2. Effect of sorting pigs by weight on subsequent performance (Wolter et al., 2002).

	Live weight after sorting		
	Average	Light	Heavy
Live weight, kg			
Start of study (after sorting)	31.1	28.6	34.2
End of study	112.0	112.8	112.3
Coefficient of variation of live weight, %			
Start (after sorting)	10.7	7.6	6.3
End	9.3	8.5	9.2

Mixing of Pigs: Maximizing the total output from a population of pigs is likely to involve the mixing of different sub-populations at some stage in the production process. For example, at the end of a period of overstocking of facilities as described above some of the pigs are moved to another facility where they are likely to be mixed. Mixing of unfamiliar pigs is associated with increased levels of aggression and, potentially, reduced growth performance. Luis Ochoa, a Mexican PhD student working at the University of Illinois, has carried out several studies to establish the effect of mixing of unfamiliar pigs on growth performance. In general, the results of his studies would suggest that immediately following mixing (i.e., the first 1 or 2 weeks) growth rate and feed intake of pigs is reduced, however, there is little effect of mixing on feed efficiency. Subsequent to this initial check in growth, the mixed pigs will compensate and grow faster than the unmixed contemporaries and, ultimately, the performance of mixed and unmixed pigs is similar. The impact of mixing on total output will depend on the length of time following mixing at which this is measured. If it is measured in the first 1 to 2 weeks following mixing then output will be reduced; if it is measured subsequent to this period then mixing will have little or no impact on overall growth performance or on total output.

Increasing Growth Rates in Late Finishing: Increasing the growth rate of pigs at any stage during the growing period should increase the numbers of pigs that reach the target live weight window before the building needs to be emptied, provided of course that the improved growth rates are maintained to harvest weight. The late finishing phase is most important in this regard as any improvement in growth is likely to be maintained to slaughter weight and, also, because there are some approaches that can be used in this period to increase growth rates and facility output. For example, feeding Ractopamine in late finishing is a proven approach to increase growth rate and will also reduce the number of light weight pigs in the population. Combining a technology such as Ractopamine with pig removal could boost the growth performance of the remaining pigs to an even greater extent and is likely to substantially increase the proportion of the lighter pigs reaching acceptable harvest weights. However, there has been limited research evaluating the optimum strategy for pig removal (e.g., the frequency and timing of removal and the proportion of pigs to remove) in combination with Ractopamine. In addition, immunological castration of entire male pigs using Improvest® is a technology that allows the producer to capture the advantages of producing entire males whilst eliminating the risk of boar taint in the meat. In addition, entire males treated with Improvest® show a dramatic increase in feed intake and growth rate after the second injection with the product which is generally given some 4 to 6 weeks prior to harvest. This response can be used to reduce the number of light weight pigs in the population, particularly if it is combined with approaches to increasing growth rates in late finishing previously discussed, including Ractopamine and pig removal strategy.

Conclusions

Maximizing facility output (defined as the total weight produced per m^2 of floor space) will generally result in maximum economic performance. To achieve this requires approaches to managing the entire population of pigs to minimize variation in weight within the population. Critical components include managing the floor space available to the pigs throughout the wean-to-finish period and exploiting compensatory growth, particularly of the lighter weight pigs in the population.

Literature

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