factsheet
Pork Information Gateway

Space Allocation Decisions for Nursery and Grow-Finish Facilities

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Introduction

Investment in nursery and grow-finish facilities represents the most capital-intensive portion of modern pork production systems. It also is the investment most likely to have the lowest asset turnover ratio as a measure of financial return to investment. Thus, the decision on how many pigs to stock a facility with has major economic impacts. Not only must a decision be made regarding the number of pigs to put into a facility each time it is stocked, during the construction of the facility decisions must be made regarding the number of pens per facility and hence, the number of pigs per pen.

Objectives

- Present data regarding the impact of space allocation on performance.
- Discuss the impact of various management factors on the response to space allocation.
- Examine the financial impact of the space allocation decision.

The Basic Decision

Stocking density, in terms of floor area, has traditionally been expressed as area per pig, or when a pen of known area is used, as pigs per pen. Under conventional management systems, pigs remain in the same pen for several weeks, and space allowance is based on the maximum space required during that time period. For pigs that are removed from the pen as a group, such as when pigs are moved from a nursery to a growing-finishing barn, the maximum space requirement occurs on the day all pigs leave the pen. For finishing pigs, the maximum space requirement usually occurs the day that the first pig from a pen is removed for market.

Results from numerous research trials [1, 2] make it clear that as nursery and growing-finishing pigs are provided less space per pig, feed intake decreases, with a decrease in daily gain. It is not clear whether a reduction in feed intake causes the decline in daily gain, or whether a decline in daily gain results in a reduction in daily feed intake. The impact on feed conversion efficiency is less predictable. Stocking density has not been known to have an effect on diet nutrient digestibility [3]. One suggested mechanism for the response is that when pigs are crowded, their potential for lean growth is decreased, resulting in a decrease in feed intake [4, 5].

In the past, space allocation recommendations were weight specific [6]. The challenge in these recommendations is that they were often considered as absolute values within a given weight range, rather than as a continuum of values relating to pig growth.

Space allowance can be expressed as an allometric relationship between body weight and body dimensions. The relationship between space allowance (A) and body weight (BW) can be expressed as $A=k \times BW^{.67}$ [7] where k represents a constant. A recent summary of research studies suggests that the maximum growth rate for the entire grow-finish period will be achieved at a coefficient (k) of 0.0336, when A is m^2/pig and BW is in kg and a coefficient of 0.2145 when A is in ft^2/pig and BW is in lb [2]. The coefficient (k) for fully slatted nurseries was 0.0333 when A is m^2/pig and BW is kg, a value not significantly different from the grow-finish value. For fully slatted facilities, each 3% decrease in space allocation resulted in a 1% reduction in daily gain and daily feed intake [2]. These researchers were unable to determine a statistical correlation between space allocation and feed conversion efficiency. Table 1 lists the space allocations in fully slatted facilities predicted to have no impact on daily gain and the space allocations predicted to reduce daily gain 5%.

Wt, lb	Adequate ft^2/pig	5% reduction in ADG
50	2.9	2.5
100	4.6	3.9
150	6.1	5.2
200	7.3	6.2
250	8.5	7.2
300	9.6	8.2

Table 1. Predicted adequacy of space allocation for fully slatted facilities

Space Allowance and Codes of Practice

The European Council [8] specifies space allowances for several weight ranges of pigs that approximate k values of 0.028 for grow-finish pigs when using metric units in the allometric equation to assess space. On the other hand, the Canadian Code of Practice recommends a metric k of 0.035 for pigs on fully slatted floors [9].

Current Production Density

Recent survey results suggest the average stocking density for finishing facilities in the US is 7.2 ft^2/pig, with a range of 6.8 to 8.0 ft^2/pig [10]. Results from this survey do not suggest any regional (Southeast versus Midwest) differences in stocking density, nor do they suggest any difference in density for full versus partial slats.

The impact of space allocation on carcass backfat and percentage lean have only been reported in a few trials [11, 12, 13, 14]. In all trials, the leanest carcasses and the carcasses with the smallest backfat depth were those in pigs given the lowest space allocation treatment even in trials with similar final weights for the various space allocation treatments [13, 14]. From the limited data available, it is not possible to predict the impact of space allocation on carcass traits, other than to state that the effect is a slight improvement in carcass lean and a slight decrease in carcass backfat depth as space is restricted with a resulting decrease in daily feed intake.

Pigs per Social Group

In general, pigs use their sense of smell to locate peers within a social group [15]. As long as the social group is limited to 20-25 pigs, pigs can rely on these olfactory clues and form stable social hierarchies [16]. When group sizes become larger than this, an unstable social grouping occurs. Unstable groups are characterized by 1-5 dominant pigs in the social group, 1-5 submissive pigs in the group, and the remainder unsure of their social ranking. This instability is demonstrated by frequent social disruptions (fighting), resulting in slight reductions in performance. Within the range of 5 to 30 pigs per pen, summaries of research suggest that for each additional pig within a pen, assuming adequate space allocation, daily gain decreases .004 lb/day during the grower phase and .003lb/day during the finisher phase [1].

Recently, the industry has begun using large pen facilities for wean-to-finish, nursery and finishing facilities. The evidence available to date suggests that housing newly weaned pigs in large groups (upwards of 100 pigs per pen) results in a depression in daily gain and feed intake for the first 6-8 weeks post-weaning [17]. However, there does not appear to be any negative long-term effect on performance when housing growing-finishing pigs in large groups when the group remains intact to slaughter [17, 18].

The above discussion centered on the independent effects of space allocation and number of pigs per pen. In production systems where pen size is fixed, space decisions are confounded with the number of pigs per pen. That is, as the number of pigs per pen increases and pen size remains the same, the space per pig decreases.

A key component of the impact of this confounding is the issue of 'free space'. Free space is defined as the space within a pen not directly occupied by a pig. Free space includes space necessary for such activities as dunging, drinking, eating, sleeping, and movement. As group sizes increase, the amount of total pen space devoted to dunging and movement areas doesn't increase in proportion. Thus, the effective space needed per pig may decrease with no change in expected performance [19]. On the other hand, there was no interaction between group size and space allocation when comparing group sizes of 18 and 108 pigs per pen [20].

	Management Option			
Input	A	B	C	D
Number of pens	40	40	40	40
Pen size (sqft)	190	190	190	190
Pigs/pen	25	23	27	27
Space/pig (sqft)	7.6	8.3	7.0	7.0
Initial weight, lb	52	52	52	52
Final weight, lb	260	260	260	260
ADG	1.70	1.75	1.65	1.65
Market period, d	21	21	21	27
Days to clean, d/turn	4	4	4	4
F/G	2.90	2.90	2.90	2.90
Vet/med, $/hd	$1.50	$1.50	$1.50	$1.66
Death loss, decimal %	3.00%	3.00%	3.00%	3.50%
Feeder pig price, $/hd	$52.00	$52.00	$52.00	$52.00
Net market price, $/cwt	$45.00	$44.90	$45.10	$45.10
Feed price, $/t	$140.00	$140.00	$140.00	$140.00
Contract fee, $/facility/yr	$36,000.00	$36,000.00	$36,000.00	$36,000.00
Total pigs placed/turn	1,000	920	1,080	1,080
Turns/year	2.67	2.76	2.57	2.54
Pigs purchased	2,667	2,518	2,804	2,746
Pigs sold	2,587	2,443	2,720	2,650
Income	$302,688.78	$285,138.48	$318,988.20	$310,712.37
Expenses				
Pigs	$138,689.02	$130,938.62	$145,833.18	$142,785.69
Feed	$108,392.40	$102,335.08	$113,975.92	$110,869.52
Vet/med	$4,000.64	$3,777.08	$4,206.73	$5,436.84
Contract fee, constant $	$36,000.00	$36,000.00	$36,000.00	$36,000.00
Total expenses	$287,082.06	273,050.78	300,015.83	295,092.05
Net	$15,606.72	$12,087.70	$18,972.38	$15,620.32
Difference versus A		($3,519.02)	$3,365.66	$13.60

Table 2. Economic modeling of the space allocation decision for fully slatted facilities

Interaction of Diet and Space Allocation

The most predictable response to decreased space allocation is a decrease in daily feed intake and daily gain. It would seem logical to explain the decrease in daily gain as due to a decrease in dietary nutrient intake as a result of the decrease in daily feed intake. That is, if feed intake is decreased, the intake of nutrients such as energy, amino acids, etc. is decreased, resulting in a slower rate of gain. A logical reaction to this would be to suggest that the decrease in daily gain can be alleviated by increasing the nutrient density of the diet.

However, research does not support this logic [11, 21, 22]. The addition of fat, lysine, soybean meal, or fat plus lysine to control diets had no effect on overcoming the depression in performance associated with space allocation reductions. Research results also suggest that pigs do not respond differently to growth promoting dietary antimicrobials when space is restricted [23, 24, 25]. Thus, it is not recommended that the nutrient composition of growing-finishing diets be modified when space allocation is restricted.

Interaction of Nursery and Grow-Finish Space Allocation

Research evidence suggests that the response to space allocation during the grow-finish phase may depend in part on whether the pigs are resorted into new social groups upon movement from the nursery facility [26]. Pigs which remain in the same social group (no remixing of pen mates) from weaning to slaughter don't react as negatively to a reduction in space allocation as pigs which are remixed upon a move from the nursery to the grower-finisher facility.

Research results suggest that the space allocation for pigs moved to growing-finishing facilities from nursery facilities may differ from that of wean-to-finish pigs who are in the same pen with the same pen mates from weaning to slaughter. In two recently reported wean-to-finish experiments, daily gain decreased 1% for each 7% decrease in space allocation [14] and 1% for each 4.5% decrease in space allocation [27]. Both of these reductions in daily gain are less than the prediction equations of Gonyou et al [2].

Interaction of Sex and Grow-Finish Space Allocation

There is no evidence to suggest that barrows and gilts respond differently to space allocation [12, 14]. Nor is there evidence that space restrictions during growth affect age at puberty or other reproductive traits of replacement gilts [28, 29].

Season Effect of Space Allocation

Given an opportunity, a pig can and will adapt to changing environmental temperatures. For example, as a part of its thermo-regulatory mechanism in a cold environment, the pig will attempt to make itself as small as possible and lay close to pen mates. In a hot environment, the pig will adopt cooling behaviors, including separation from pen mates and a more sprawled posture. These behavior modifications suggest adding 1-2 pigs per pen in winter and removing 1-2 pigs during summer heat are logical management strategies. However, issues related to the number of pigs flowing seasonally from farrowing facilities often limits implementation of this strategy.

	Barrows[a]		Gilts[a]	
Item Space (ft^2):	7	6	7	8
Initial pig weight, lb	50	50	49	49
Final pig weight, lb	256	255	252	255
Average daily gain, lb	1.88[b]	1.79[c]	1.72	1.78
Average daily feed, lb	5.98[d]	5.80[e]	5.48	5.52

Table 3. Effect of sex on the response to space allocation in fully slatted facilities[14]. [a]Terminal crossbred commercial genetics [b,c]$P < .05$ [d,e]$P < .075$

Space Allowance and Behavior

Crowding has been cited as a common cause for tail biting [30]. Two surveys of pork producers regarding tail biting and various management practices reported no association between stocking density and the incidence of tail biting [31, 32]. In contrast, stocking densities during the growing phase greater than 22.4 lb/ft^2 (4.5ft^2/100lb pig or 9.0ft^2/200lb pig) increased the risk of tail biting (odds ratio = 2.70) on 92 pig farms in England [33].

Crowding has not increased the variation in weight within a pen [11, 14, 26, 34]. It also does not change the amount of time pigs spend in lying or standing behaviors [35].

II. The Economic Decision

The Swine Welfare Assurance Program (SWAP[SM]) of the National Pork Board uses the recommendations of Fritschen and Muehling [6] as the basis for their assessment of swine welfare as related to space. While the goal of pork production systems is to provide pigs an environment that promotes rapid and efficient gain, the decision on appropriate space allocation must include consideration of the economic tradeoffs of best pig performance and increasing facility costs as more space is provided to support best pig performance [36].

Table 2 examines the economics of the space allocation decision in a 1,000 head finishing facility managed on an all-in/all-out basis. In column A, typical pig and financial performance is projected for a facility with 40 10'x19' pens stocked at 25 pigs/pen (1,000 head at 7.6ft^2/pig). The contract fee to cover labor, repairs, utilities, interest, depreciation, and facility insurance is $36/space/yr ($36,000/yr).

In column B, the number of pigs per pen is reduced from 25 to 23 (space increases to 8.3 ft^2/pig). Even though daily gain is projected to improve versus the projections in column A, net income is $3,519.02 less than column A. The improvements in performance aren't enough to offset the fixed expenses as estimated by the $36,000 per year contract payment.

In column C, the number of pigs per pen is increased to 27, versus 25 in column A (space per pig is decreased to 7.0 ft^2/pig). As a consequence, daily gain is projected to decrease. However, net price received also increased $.10/cwt liveweight due to leaner pigs as a result of the feed intake depression associated with space reductions. The net result is a $3,365.66 increase in net profit per year when compared to column A, even though individual pig performance was projected to decrease.

In column D, pig performance is predicted to be poorer than C. The attempt was to predict how much performance had to decrease due to the addition of two pigs per pen and still have a net profit similar to column A. In this comparison, the number of days in the market period, vet/med expense and death loss were all increased.

Feeding by Sex and the Space Decision

For many producers who feed barrows and gilts separately in smaller facilities (ie 400-600 head one-time capacity) with both sexes in the facility at the same time, marketing uniform truck-load lots (180-200 head) can be a struggle. Assuming the same sale weight for barrows and gilts, the barrows are typically ready for market 10-14 days sooner than littermate gilts. Many producers who sex feed in smaller facilities have few market access options since they can=t fill a truck-load and capture the economies of transport and market access. If there are several market options within 30-40 miles, this is a minor concern. However, if the nearby market options are limited, producers may be unable to afford the transportation costs associated with delivery of small loads to distant markets. If they choose to capture market access economics associated with direct plant delivery via semi-load lots, they often face discounts for sort loss due to variations in delivery weights.

Typical transport charges for semi-trailers are in the range of $2.25-2.50 per loaded mile. To deliver a truck-load of 200 market weight butchers weighing 250 pounds each to a packing plant 200 mile distant costs $450-500. This amounts to $.95/cwt live weight. Typically, country buying points in Iowa and Southern Minnesota offer producers prices which are $1/cwt or more below the corresponding plant-delivered bids. Thus the opportunity for $100 more income per 200 head of pigs if truck-load lots can be configured and delivered directly to the plant. For every 500 head sold, this is $250 increased income after expenses. Opportunities are greater if shorter distances are involved.

Currently, sex is not a consideration when decisions regarding pen space allocations are made. That is, both barrows and gilts are given the same space allocations within a facility. Research at the University of Nebraska [14] investigated the effects of altered space allocations on pig performance and carcass composition (Table 3) and supports the suggestion to vary the space allocation according to the sex in situations such as those described above.

When both barrows and gilts were given 7ft^2/pig, the gilts grew slower than the barrows. At a constant sale weight of 250 pounds, this represents 10 more days for the gilts to achieve the same slaughter weight as the barrows.

If the space allocation within the facility was shuffled so the gilts were given 8ft^2 and the barrows 6ft^2, both barrows and gilts grew at the same rate. These results support the recommendation of altering space allocations to manipulate barrow growth in order to better utilize facility space. A reassignment of pen space (more space for gilts and less space for barrows) resulted in a similar rate of live weight gain for both barrows and gilts.

Summary

The decision regarding space allocation pits the biology of the pig against the economics of production systems. Since each 3% reduction in space allocation for pigs in fully slatted facilities results in only a 1% reduction in daily gain and daily feed intake, producers have historically accepted a reduction in individual pig performance in order to maximize economic returns from investments in facilities. Based on the recommended codes of practice from the European Economic Community and Canada, there is no agreed upon standard for space allocation in the world community. In the future, considerations such as welfare codes and response of the market chain may change the space allocation decision.

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Information developed for the Pork Information Gateway, a project of the U.S. Pork Center of Excellence supported fully by USDA/Agricultural Research Service, USDA/Cooperative State Research, Education, and Extension Service, Pork Checkoff, NPPC, state pork associations from Iowa, Kentucky, Missouri, Mississippi, Tennessee, Pennsylvania, and Utah, and the Extension Services from several cooperating Land-Grant Institutions including Iowa State University, North Carolina State University, University of Minnesota, University of Illinois, University of Missouri, University of Nebraska, Purdue University, The Ohio State University, South Dakota State University, Kansas State University, Michigan State University, University of Wisconsin, Texas A & M University, Virginia Tech University, University of Tennessee, North Dakota State University, University of Georgia, University of Arkansas, and Colorado State University.