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GROUP SIZE AND FLOOR-SPACE ALLOWANCE AFFECT THE ECONOMIC PERFORMANCE OF A FOUR-WEEK NURSERY SYSTEM FOR WEANLING PIGS[1]

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ABSTRACT

The study objective was to compare the economic performance of nursery systems based on large (100 pigs) or small (20 pigs) group sizes and two floor-space allowances (adequate or reduced). A total of 1920 pigs were used. Pig performance data were from two trials carried out over a 4-wk period immediately post-weaning. The trials compared four treatment combinations (2 x 2

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factorial) of group size and floor-space allowance: 1) small group (20 pigs/pen) at a floor-space allowance for maximum growth (.17 m^2/pig) (SREQ); 2) small group (20 pigs/pen) at a reduced floor space (.15 m^2/pig) (SRED); 3) large group (100 pigs/pen) at a floor space for maximum growth (.17 m^2/pig) (LREQ); and 4) large group (100 pigs/pen) at a reduced floor space (.13 m^2/pig) (LRED). The economic analysis was based on a nursery building with 409 m^2 floor space and used economic data collected on U.S. farms from 1988 to 1998. Treatment results are presented in the following order: SREQ; SRED; LREQ; and LRED. Reduced floor-space designs had greater annual animal throughput (23,040; 26,880; 24,000; and 28,800 pigs/yr) and, therefore, lower fixed costs per pig sold ($0.21; $0.19; $0.20; and $0.17). However, pigs housed at reduced floor space were 2.7% lighter at the end of the nursery period than those given adequate floor space, and pigs in large pens were 4.3% lighter than pigs in small pens. Overall, total costs per pig sold (i.e. variable, fixed, and management costs) were marginally reduced by moving to reduced-floor-space or large-group designs ($34.91; $34.74; $34.70; and $34.56). However, because of the increased pig weights out of the nursery, the small group size treatments resulted in greater total returns per pig sold ($32.41; $31.44; $30.89; and $30.16). Consequently, returns over total costs per pig, which were negative, were greater for pigs reared in small groups at an adequate floor space (-$2.50; -$3.30; -$3.81; and -$4.40). A selling price of $2.07 per kg live weight was assumed in the current model, however, sensitivity analysis suggested that the break-even pig selling prices per kg live weight for each system were $2.23; $2.29; $2.33; and $2.38, respectively. Increases in pig growth rates of 2.4%, 4.8% and 6.5% above those observed in the current study would be required for nursery systems with the small group size at a reduced floor space, large group size at an adequate floor space, and large group size at an adequate floor space, respectively, to have the same returns as from small groups at an adequate floor space. Results of this study suggest that penning pigs in the large groups or at the reduced floor-space allowance negatively influenced pig performance such that economic returns were decreased.

KEYWORDS. Pig Housing, Economic Analysis, Space Allocation, Group Size.

INTRODUCTION

The construction and operation costs are considerable for modern pig facilities. Therefore, producers are continuously searching for ways to minimize these costs and, thereby, the total cost of pork production. This can be achieved through either minimizing facility costs and/or maximizing facility use. In this respect, optimizing the level and efficiency of production for the whole unit could conceivably have a greater influence on overall enterprise profitability than maximizing the performance of the individual animals.

Historically, two key factors in the design of pig housing systems have been the number of pigs per group (i.e. pigs/pen) and the floor space allowed per pig. Kornegay and Notter (1984), after summarizing data from several published research reports, determined the effects of floor-space allowance and group size on pig performance. Commonly used floor space and group size recommendations for pigs housed in commercial pig units (Fritcshen and Muehling, 1986) are similar to values obtained using prediction equations offered by Kornegay and Notter (1984). However, in the experiments upon which these recommended values are based, the pigs were kept in relatively small groups (6 to 16 pigs per pen). In commercial practice, pigs are typically housed in groups of 25 or more per pen, and some producers have recently developed systems based on even larger group sizes of 50, 100, or even 200 pigs per pen in an effort to lower equipment and labor costs. However, limited research data is available to evaluate the effect of large group sizes on pig performance.

Previous research was conducted by McGlone and Newby (1994) to evaluate the effect of group size and floor space on the use of space and pig performance in conventional production facilities. These authors employed time-lapse video recordings to detail movements of pigs (96 kg BW) kept in groups of 10, 20, or 40 pigs per pen with a constant floor-space allowance in order to determine the unoccupied or “free space” (i.e. the total floor space not occupied by a pig at any time). They found that “free space” increased as group size increased under constant floor-space allowance. In

a second study utilizing groups of 20 pigs per pen, these authors determined that removing all the "free space" had a significant detrimental effect on pig performance, but removing only half had no significant effect. Therefore, if large-group-size pen designs were used in commercial pig operations, it can be hypothesized that the total space per pig could be decreased without reducing growth rate. However, there is a paucity of data from which to evaluate the interaction between large group sizes and floor-space allowance on pig performance.

The objective of this research was to determine the effect of four nursery designs with different group size and floor-space allowance combinations, on the economic performance of a four-week system for weanling pigs.

MATERIALS AND METHODS

An economic model was constructed using a spreadsheet that integrated pig growth performance and variable pricing data to evaluate the relative performance of four different combinations of group size and floor-space allowance for a nursery system based on a building with 409 m^2 of floor space and a four-week production period. The animal performance data for this analysis originated from a controlled experiment designed to evaluate the effects of group size and floor-space allowance on pig performance (Wolter et al., 2000).

Production Experiment

An experiment was conducted to assess the effects of two group sizes (20 [small] or 100 [large] pigs per pen) and two floor-space allowances (calculated requirement [requirement] and calculated requirement less 50% of calculated "free space" [reduced]) on the performance of weanling pigs. The experiment was carried out in two trials, each using a randomized block design with a 2 × 2 factorial arrangement of treatments. Replicates within each trial were blocked by day of weaning. The research was carried out at the Burton Russell Swine Research Farm, United Feeds, Inc., Frankfort, IN.

Floor-space allowance was kept constant within treatment for the four-week study and was determined based on body weight (BW) using the formula: floor-space allowance (m^2) = $k \times BW^{.667}$, where BW is in kg and k is a constant (Petherick and Baxter, 1981). The value assumed for k was 0.030 (Edwards and Armsby, 1988; Gonyou and Stricklin, 1998). The BW assumed was 14 kg, which was the predicted pig weight at the end of wk 4. "Free space" was determined using the formula: $Y = 0.179 + 0.002092X$, where Y is "free space"/pig in m^2 and X is number of pigs per group which is the relationship developed by McGlone and Newby (1994) for pigs of 93 kg (BW) at .74 m^2 of floor space. Based on this equation, the floor-space allowance minus 50% of "free space" for groups of 20 and 100 pigs were equivalent to 85 and 74 %, respectively, of the estimated requirement (.74 m^2/pig) for pigs of this weight (93 kg). These percentages were applied to the required floor space allowance (i.e. .17 m^2/pig) for the weight of the nursery pigs used in the current study (i.e. 14 kg) to calculate the floor spaces for the reduced floor-space treatments. Space allowances were .17 m^2/pig for the required floor space treatment for both group sizes and .15 and .13 m^2/pig for the reduced floor space treatment for the small and large groups, respectively.

A total of 1920 pigs were weaned at 15 days of age (mean body weight = 5.3 ± .7 kg) and allotted to treatment at approximately 22 hour after weaning. Pigs were randomly allotted to treatment pens from outcome groups of 12 pigs formed on the basis of common gender and weight. Pigs were housed in an insulated, mechanically ventilated, curtain-sided nursery house with four rooms, and fully slotted, T cross-sectional profile, metal flooring. Each room accommodated one replicate of the trial. Pens were equipped with one nipple drinker/10 pigs and a four-space nursery feeder/20 pigs providing 4 cm of feeder-trough space/pig. Feeders were positioned in the center of the pen for all pen designs and were accessible from both sides. Water nipples were placed at equal (25.4 cm) intervals on one wall in each pen. The pen dimensions and features are illustrated in Fig. 1. Pigs were given ad-libitum access to a six-phase dietary regimen formulated to meet or exceed NRC (1998) nutrient requirements.

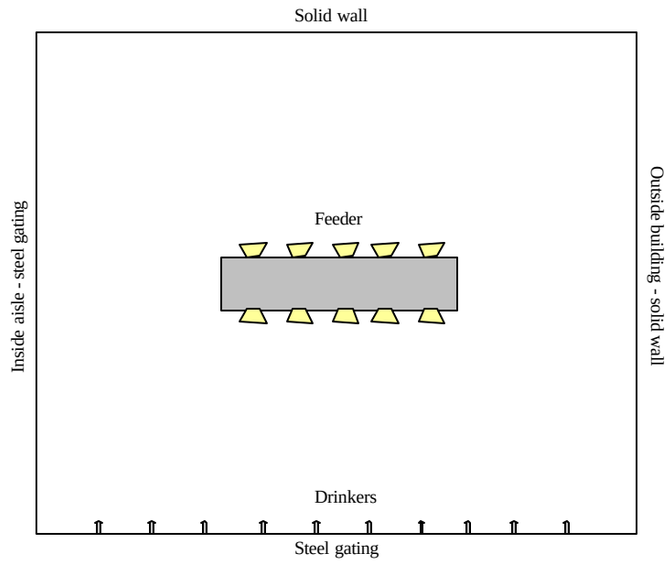
Pig performance data were analyzed as a randomized block design using the GLM procedure of SAS (SAS, SAS Institute, Cary, NC). Pen was considered the experimental unit. The model included effects of group size, space allowance, interaction of group size and space allowance, trial, and replicate nested within trial. Least squares means were evaluated using the STDERR options of SAS (1990) and are summarized in Table 1.

Table 1. Least squares means for the effect for nursery pen design on pig performance.

	Nursery Pen Design				
Group Size:	Large		Small		Avg SE
Floor Space Allowance:	Requirement	Reduced	Requirement	Reduced	
Performances measures					
Start weight (kg)	5.31	5.31	5.31	5.31	.006
End weight (kg)	14.92	14.57	15.66	15.19	.151
Feed:gain	1.37	1.39	1.33	1.41	.020
Mortality rate (%)	1	1	1	1	-

Economic Analysis

Performance data used in the model were from the previously described experiment (Table 1). The economic data used in constructing the model are presented in Table 2.



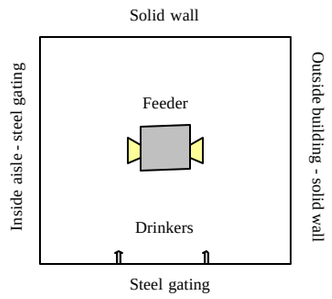


Figure 1. Plan view of pen designs for both group sizes of weanling pigs. Top figure, Large group design, dimensions (m, length × width) were 4.6 × 3.8 and 4.6 × 2.9, and 8.5 × 4.6 and 6.3 × 4.6 for the requirement and reduced floor-space allowance, and wks 1 - 4 and wks 5 - 9, respectively. The dimensions of the feeder were 2.05 × .406 m and it provided ten 20.3-cm-wide eating places on each side. Lower figure, Small group design, dimensions (m, length × width) were 1.9 × 1.8 and 1.8 × 1.7, and 4.2 × 1.8 and 3.6 × 1.8 for the requirement and reduced floor-space allowance, and wks 1 - 4 and wks 5 - 9, respectively. The dimensions of the feeder were .406 × .406 m and it provided two 20.3-cm-wide eating-places on each side.

The model fixed costs were based on a four-room, mechanically ventilated nursery building that was priced at $81,400 (D. Webel, Personal Communication). Equipment costs included the feeders and gating used for each pen design. Painted steel rod gating was valued at $27.89/linear m (K. Smith, Personal Communication). The feeders used in all pen designs were stainless steel and offered a dry, meal-form diet ad libitum. Pen designs used for small groups (20 pigs/pen) included one feeder positioned in the fenceline that provided 61 cm of trough space valued at $150.00/feeder. Designs used for large groups (100 pigs/pen) included two feeders that provided a total of 305 cm of trough space valued at $160.00/feeder (M. Dorris, Personal Communication). A depreciation period of 10 years were used for the building and equipment; therefore, a capital recovery was performed on the investment over this period assuming an 8% annual interest rate.

The analysis included cost of taxes and insurance on the investment. The value assessed for management of the unit was $1500/yr independent of system.

Variable costs included pig placement value in the nursery, feed, and miscellaneous cost (i.e. veterinary supplies, labor, utilities, etc.) associated with the production of weanling pigs (Table 2). The model was based on the use of segregated-early-weaned (SEW) pigs that weighed 5.31 kg on entry and were valued at $5.65/kg (Meyer and Lazarus, 1998). Diets were based on corn and soybean meal and were typical of those used in commercial operations during the nursery stage of production (D. Webel, Personal Communication). Ten year average pricing data (1989 - 1998) were used to estimate the diet costs (F.B.F.M., 1999). The estimates of miscellaneous costs were based on the results of a recording scheme operated on a large number of units in the Midwest by the Illinois Farm Business Farm Management Association (F.B.F.M., 1999).

Table 2. Model inputs for four pen designs in a pig nursery system.

	Nursery System Pen Design			
Group Size:	Large		Small	
Floor Space Allowance:	Requirement	Reduced	Requirement	Reduced
Revenue				
Price received for pigs ($/kg) [a]	2.07	2.07	2.07	2.07
Variable costs				
Price paid for pigs ($/kg) [a]	5.65	5.65	5.65	5.65
Feed prices				
Corn ($/kg) [a]	.08	.08	.08	.08
Supplement ($/kg) [b]	.58	.58	.58	.58
Miscellaneous ($/pig) [a]	1.53	1.53	1.53	1.53
Investment costs				
Building ($) [b]	81,400.00	81,400.00	81,400.00	81,400.00
Equipment				
Feeders ($) [c]	6,400.00	7,680.00	7,200.00	7,860.80
Penning costs ($) [d]	5,820.80	6,500.80	7,180.80	7,860.80
Other economic costs				
Management ($/yr)	1,500.00	1,500.00	1,500.00	1,500.00
Building and equipment life (yr)	10	10	10	10
Taxes (%)	.80	.80	.80	.80
Insurance (%)	.25	.25	.25	.25
Interest rate (%)	8.0	8.0	8.0	8.0

a Source: Illinois Farm Business Farm Management Association, Urbana, IL.
b Source: United Feeds Inc., Sheridan, IN.
c Source: GrowMaster Inc. Omaha, NE.
d Source: FarmWeld Inc. Teutopolis, IL.

Income to the pig unit was determined by multiplying the weight of the pigs at the end of the 4-wk nursery period by the market value. The market value was determined using 10-yr average pricing data for feeder pigs (22.5 kg BW) recorded by the Illinois Farm Business Farm Management Association (F.B.F.M., 1999) which was adjusted to value pigs at 15 kg BW using price adjustment factors for weight differences (-$1.53/hd for every kg under 20.4 kg BW and +$1.07/hd for every kg over 20.4 kg BW) developed by Lawrence and Schmidt (1994).

Sensitivity analyses were conducted to determine the break-even purchasing price, selling price and ending weight for the pigs for each design. Additional sensitivity analyses were used to determine the pig purchasing or selling price at which the economic advantage of one design was replaced by an alternative design. In those analyses only the purchasing price, selling price or ending weight of the pigs were changed, and all other variables were held constant.

RESULTS AND DISCUSSION

The results of the economic analysis for each system design are summarized in Table 3. The annual nursery capacity was 24,000, 28,800, 23,040, and 26,880 pigs for the large group size given required floor space, large group size given reduced floor space, small group size given required floor space, and the small group size given reduced floor space designs, respectively. Reducing the floor space allowance resulted in a 13% and 17% greater annual throughput (kg of pigs sold) for the small and large group sizes, respectively. However, the design utilizing the small group size given the required floor space resulted in the greatest pig growth performance which yielded the highest ending weight and consequently had the highest total returns per pig sold. This system had 3.0%, 5.0% and 7.5% higher total returns per pig sold than the small group size given a reduced floor space, the large group size given a required floor space, and the large group size given a reduced floor space, respectively.

The purchase price of the pigs for placement into the nursery accounted for over 85% of the total variable costs of production for all systems. The pig purchase cost per pig sold was equal for all four designs. Mortality rates were similar for the four designs, if any significant differences in mortality extend between these designs, the pig purchase cost per pig sold would have increased for systems with higher mortality. Feed costs per pig sold for each design increased with increases in pig weight at the end of the four-week nursery period, therefore, the small group size designs had higher total feed costs than large group size designs. Miscellaneous costs could also impact the economic performance of the designs evaluated. However, because feed and miscellaneous costs together account for less than 15% of the total variable cost their impact was less dramatic than the purchase price of the pigs. Overall, pigs housed in the large group size at the reduced floor-space allowance had the lowest feed consumption and growth performance during the four-week nursery period and therefore, this design had the lowest total variable costs per pig sold (Table 3); in contrast, the small group size given the required floor space design had the greatest total variable costs per pig sold (Table 3).

Building costs/pig sold were as much as 22% lower for the reduced floor-space allowance designs because these costs were spread across a higher total number of pigs produced (Table 3). Similarly, management costs per pig were marginally lower for the decreased floor space allowance designs. As a result of using fewer gates and feeders, the large group size designs had marginally lower equipment costs ($0.004/pig sold). The small group size at the required floor space design had the highest fixed costs/pig sold. However, total fixed cost represented no more than 0.5% of the total cost of production and the differences in fixed costs between system designs made a limited contribution to the differences in returns above fixed and variable costs (Table 3).

Table 3. Results of economic analyses for four pen designs in a pig nursery system.

	Nursery System Pen Design			
Group Size	Large		Small	
Floor Space Allowance	Requirement	Reduced	Requirement	Reduced
Annual capacity (hd)	24,000	28,800	23,040	26,880
Annual sales (kg)	354,499	415,420	357,198	404,224
Revenue ($/pig sold)				
Feeder pigs	30.89	30.16	32.41	31.44
Variable costs ($/pig sold)				
SEW pigs	30.30	30.30	30.30	30.30
Feed	2.56	2.46	2.76	2.62
Miscellaneous	1.55	1.55	1.55	1.55
Total	34.41	34.31	34.61	34.47
Fixed costs ($/pig sold)				
Buildings	0.17	0.14	0.18	0.16
Equipment	0.03	0.03	0.03	0.03
Total	0.20	0.17	0.21	0.19

Other economic costs ($/pig sold)				
Management	0.07	0.06	0.07	0.06
Total costs ($/pig sold)	34.70	34.56	34.91	34.74
Revenue ($/pig sold)				
Above variable costs	(3.52)	(4.15)	(2.20)	(3.03)
Above fixed and variable costs	(3.72)	(4.34)	(2.41)	(3.22)
Above all economic costs	(3.81)	(4.40)	(2.50)	(3.30)
Total annual revenue to the unit ($)				
Above variable costs	(84,103)	(118,895)	(50,341)	(81,255)
Above fixed and variable costs	(88,875)	(123,765)	(55,220)	(86,228)
Above All Economic Costs	(90,488)	(125,378)	(56,833)	(87,841)

Figures in parenthesis represent negative values.

Much of the economic data used in these analyses were based on a traditional eight-week feeder pig systems, however, the system evaluated in this paper had a shorter production cycle and generated pigs with lighter ending weights. The economic losses above variable costs, fixed and variable costs, and total economic costs per pig sold, as well as the total annual losses to the unit were lowest for the small group size given the required floor space pen design and highest for the large group size at the reduced floor space pen design (Table 3).

Results of the sensitivity analysis are presented in Table 4. Break-even analysis for the purchase and selling prices of the pig with respect to total economic costs favored the small group size given required floor space design (Table 4). However, the pig ending body weight that resulted in break-even was relatively similar for all designs, indicating fixed costs per pig had little impact on the economic performance of the system (Table 4).

Table 4. Results of economic sensitivity analyses of four pen designs for a pig nursery system.

	Nursery System Pen Design			
Group Size:	Large		Small	
Floor Space Allowance:	Requirement	Reduced	Requirement	Reduced
Prices and body weights yielding break-even				
Purchase price of pigs ($/kg)	4.95	4.85	5.19	5.05
Price received for pigs ($/kg)	2.33	2.38	2.23	2.29
Pig ending body weight (kg)	17.04	17.02	17.05	17.03
Prices required to exceed returns of the SREQ system				
Purchase price of pigs ($/kg)	—[a]	3.46	---	4.16
Price received for pigs ($/kg)	—[a]	3.25	---	2.73

[a] The returns from this system will not at practical levels exceed the returns of the SREQ system

The total annual returns above total economic costs favored the small and large group sizes at the reduced floor space over the small group size at the required floor space when the price received for pigs increased to $2.73/kg and $3.25/kg, respectively. However, data collected by the Illinois Farm Business Farm Management Association suggest that prices for feeder pigs of this magnitude have rarely been realized during the past decade in the United States (F.B.F.M., 1999). The economic performance of the system may also change when the purchase price of the pigs increases or decreases above traditional levels (Table 4). However, Meyer and Lazarus (1998) suggest that the U. S. pork industry only recently implemented a price reporting mechanism for SEW piglets, but found that SEW pigs are a unique product that have typically held a stable value. Finally, the economic performance of the system favors the small and large group sizes at the reduced floor space if the growth performance of the pigs in each of these designs is increased by 2.4% and 6.5%, respectively. However, when selling prices are more favorable, less dramatic

increases in performance would be required for the reduced floor space designs to have an economic advantage to the small group size at the require floor space design.

SUMMARY

Recently, pig producers have adapted systems based on penning weanling pigs in groups of over 100 animals (Vansickle, 1999). An advantage claimed for larger groups is lower facility or fixed costs per pig place resulting from both a reduced need for pen partitions and an increase in the number of pigs fed per building. The objectives of the current study were to quantify effects of and interactions between group size (20 versus 100 pigs) and space allowance on the economic performance of a pig nursery system. Results of the production experiment demonstrate negative effects on growth performance associated with the large groups and reduced floor space allowance. Furthermore, the results of the economic analysis suggest that the fixed costs associated with the production of weanling pigs make up a small portion of the total economic costs and do not greatly affect the total annual returns to the nursery system. When prices are untraditionally favorable, however, an economic advantage may be realized in a system using reduced floor-space allowances.

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