Effects of Increasing Stocking Density on Finishing Pig Performance[1]

M. L. Potter[2], S. S. Dritz[2], M. D. Tokach, J. M. DeRouchey, R. D. Goodband, and J. L. Nelssen

Summary

A total of 1,201 finishing pigs (initially 63 lb) were used in a 99-d growth trial to evaluate the effects of increasing stocking density on finishing pig growth performance. Single-sex pens of barrows and gilts were blocked to minimize variation due to gender and barn location. There were 12 pens per block with 3 replication pens per treatment within each block. Pens of pigs were randomly allotted to 1 of 4 treatments with 12 pens per treatment. Treatments were stocking pens with 22, 24, 26, or 28 pigs each, allowing 8.2, 7.5, 6.9, and 6.4 ft^2 per pig, respectively. Pens of pigs were weighed and feed intake was determined on d 0, 14, 28, 42, 56, 70, 84, and 99 to calculate ADG, ADFI, and F/G. Pigs were fed common diets throughout the trial. No adjustments were made at the pen level to account for space increases because of removed pigs.

Overall, as stocking density increased, ADG and ADFI decreased (linear; $P < 0.001$), but there were no differences (linear; $P = 0.99$) in F/G. These performance differences resulted in off-test (d 99) pig weights decreasing (linear, $P < 0.001$) as stocking density increased. These data indicate that in this commercial barn, finisher pig ADG and ADFI improved as the number of pigs in each pen was reduced. However, based on an economic model, income over feed and facility cost per pig placed was numerically optimized when pens were stocked with 24 pigs each, allowing 7.5 ft^2 of floor space per pig.

Key words: growth, space allowance, stocking density

Introduction

Recommendations for finishing pig stocking density vary from approximately 6.0 to 9.0 ft^2 per pig, depending on factors to be optimized. Pig performance is improved with more space per pig, while facility cost per pig, economic return, and overall efficiency are likely to be improved with less space allowed. Other factors, including pig flow and facility availability, also affect practicality of achieving an optimum stocking density. A report by the National Pork Board indicated that, on average, swine operations stock pens at approximately 7.2 ft^2 per pig (2005[3]). In the facilities used for this experiment, stocking 25 pigs per pen allowed 7.2 ft^2 per pig. Understanding the effects of different stocking densities on performance can aid pig flow decision-making and help producers maximize income by balancing fixed costs with effects on performance. The objective of this experiment was to determine the effects of different stocking densities (6.4, 6.9, 7.5, or 8.2 ft^2 per pig) on performance of finisher pigs.

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[2] Department of Diagnostic Medicine/Pathobiology, College of Veterinary Medicine, Kansas State University.

[3] Kliebenstein, J., M. Brumm, B. Buhr, and D. Holtkamp. 2005. Economic analysis of pig space: Comparison of production system impacts. pp. 1-38. National Pork Board (NPB #04-177).

Procedures

The Kansas State University (K-State) Institutional Animal Care and Use Committee approved procedures used in this study. This experiment was conducted in a standard, double-curtain-sided, research finishing barn in northeast Kansas. There was slatted concrete flooring throughout the barn. Pens were 10 × 18 ft and equipped with a single-sided dry, 3-hole, stainless steel feeder (AP-3WFS-QA; Automated Production Systems, Assumption, IL) and a dual swinging waterer (Trojan Plastic Waterswing; Trojan Specialty Products, Dodge City, KS), allowing pigs to have ad libitum access to feed and water. Each hole in the feeder was 14 inches long. The barn was equipped with an automated feeding system (FeedPro; Feedlogic Corp., Willmar, MN) to allow recording of feed delivery to individual pens.

A total of 1,201 pigs were used to determine the effects of increasing pen-stocking density of commercial finishing pigs. Pens were allotted to 1 of 4 stocking density treatments and gender assignment (barrow or gilt) to distribute treatments around the barn. Treatments were stocking pens with 22, 24, 26, or 28 pigs per pen, allowing 8.2, 7.5, 6.9, and 6.4 ft^2 per pig, respectively. A set of 12 pens constituted a generalized block to minimize variation due to gender and barn location. Although barrows and gilts were penned separately, gender was likely confounded with age: The 12 gilt pens contained pigs that may have been younger than the barrows in the remaining 36 pens.

Pens of pigs were double-stocked in a second barn on the research site before the trial began. At the start of the trial (d 0), pigs were moved from the second finisher barn to the trial barn. Within gender, multiple pens of pigs were allowed to mix within the alley of the second barn. After mixing, pigs were gate-cut by stocking density treatment into their trial pens. These procedures ensured that all trial pens had initial disruption of social order as well as a random assortment of pig weights. Pens of pigs were weighed and feed intake was determined on d 0 and every 2 wk thereafter until pigs were taken off test (d 99). Pigs were fed common diets throughout the trial. If a pig died or was removed because of illness or injury, no adjustment was made to the pen to account for the additional space per pig. For the overall trial, removed pigs by treatment (1.9%, 1.0%, 1.6%, and 1.5% for the 22, 24, 26, and 28 pigs per pen treatments, respectively) were within normal production criteria for this commercial system.

Data were analyzed as a generalized blocked design with stocking-density treatment as a fixed effect and block as a random effect using the GLIMMIX procedure in SAS (SAS Institute, Inc., Cary, NC). Pen was the experimental unit for an analysis. The effects of increasing stocking density on performance and economic response criteria were determined by linear and quadratic polynomial contrasts.

Results and Discussion

Stocking density did not affect (linear; $P \geq 0.20$) ADG, ADFI, or F/G within the first 14 d of this trial (Table 1). In all subsequent periods, ADFI decreased (linear, $P < 0.001$) as stocking density increased, which led to a decrease (linear, $P \leq 0.02$) in ADG in all periods except from d 56 to 70. Stocking density did not change feed efficiency except for a small linear improvement ($P = 0.02$), from d 56 to 70, as density increased.

Overall, as stocking density increased ADG and ADFI decreased (linear; $P < 0.001$), and F/G was not affected (linear; $P = 0.99$). On d 99, pig weights decreased (linear; $P < 0.001$) as stocking density increased, which resulted in a 13.2 lb increase in pig weight due to pens being stocked with 22 pigs compared to the pens loaded with 28 pigs. These data indicate that in this commercial barn, finisher pig ADG and ADFI was improved as stocking density was reduced.

The relationship between space allowed per pig (m^2 or ft^2) and weight in kg raised to the two-thirds power ($BW^{0.67}$) can be determined using a value defined as the *k*-value ($m^2 = k \times BW(kg)^{0.67}$) (Whittemore 1998[4]). After a review of published studies, Gonyou et al. (2006[5]) reported a range of *k*-values (range: 0.0335 to 0.0358 $m^2/BW^{0.67}$) below which feed intake was reduced for pigs on either fully or partially slatted floors. Thus, representative value of 0.035 $m^2/BW^{0.67}$ defines a critical limit below which feed intake is reduced due to inadequate space allowance per pig (Torrallardona and Roura, 2009[5]).

According to the *k*-value calculations (Table 2) for each stocking density and average pig weight from the present trial, the negative effects on feed intake should have started as pigs reached average body weights of 218.1, 191.5, 169.9, and 152.1 lb for the 22, 24, 26, and 28 pigs per pen treatments, respectively. These weight limits were not reached, and similarly feed intake should not have decreased until after d 70 for the 22 pigs-per-pen treatment, d 56 for the 24 pigs-per-pen treatment, and d 42 for both the 26 and 28 pigs-per-pen treatments. However, based on the feed consumption data recorded during this trial, after d 14, feed intake decreased linearly as stocking density increased.

The differences in trial performance compared with expected outcomes based on published responses may have been attributable to factors other than stocking density, which could have affected feed intake and subsequent growth rate. Potential influencing factors include feeder space or water access. Feeder space for the 22, 24, 26, and 28 pigs-per-pen treatment were as follows: 1.91, 1.75, 1.62, or 1.50 in. respectively, per pig. Though all pens were stocked at densities below manufacturer-recommended maximums for the feeder and waterer types, the feeder space was below that of other recommendations. It is unknown whether the amount of feeder space per pig or water access contributed to the negative effects on performance as the number of pigs per pen increased.

Regardless of potential other contributing factors, results of this trial indicate that growth rate and feed intake increased as stocking density per pen decreased. However, based on an economic model of these data (Table 3), income over feed and facility cost per pig placed was numerically highest (quadratic; $P = 0.64$) when pens were stocked with 24 pigs. Therefore, in this commercial barn the negative effects on performance from higher stocking and reduction of space per pig could not be overcome by throughput alone. Similarly, numbers and weight of pigs when stocked at 22 pigs per pen were low enough that even the improvements in ADG, compared with pigs from higher-stocked pens, could not overcome the increased facility cost per pig placed compared

[4] Whittemore, C. T. 1998. The science and practice of pig production. 2nd ed. Blackwell Science, Oxford; Malden, Mass.

[5] Torrallardona, D., and E. Roura. 2009. Voluntary feed intake in pigs. Wageningen Academic Publ, Wageningen.

to stocking at higher densities. Therefore, these results indicate that ADFI and ADG of pigs linearly improved as stocking density was reduced from 28 to 22 pigs; however, income over feed and facility cost appeared to be numerically optimized when pens were stocked at 24 pigs per pen, allowing 7.5 ft^2 of floor space per pig.

Table 1. Effect of stocking density on performance of commercial finishing pigs[1]

	Stocking density, pigs per pen[2]					Probability, $P <$	
Item	22	24	26	28	SEM	Linear	Quadratic
Pens, no.	12	12	12	12	---	---	---
d 0 to 14							
ADG, lb	2.07	2.08	2.05	2.04	0.065	0.20	0.82
ADFI, lb	3.56	3.57	3.54	3.53	0.132	0.59	0.77
F/G	1.71	1.72	1.73	1.73	0.019	0.45	0.86
d 14 to 28							
ADG, lb	1.94	1.83	1.77	1.77	0.065	<0.001	0.07
ADFI, lb	4.24	4.09	3.90	3.91	0.160	<0.001	0.20
F/G	2.18	2.24	2.21	2.22	0.024	0.37	0.24
d 28 to 42							
ADG, lb	2.32	2.27	2.26	2.20	0.062	<0.001	0.87
ADFI, lb	5.26	5.08	5.02	4.89	0.241	<0.001	0.65
F/G	2.26	2.23	2.22	2.22	0.053	0.13	0.52
d 42 to 56							
ADG, lb	2.10	2.06	2.03	1.95	0.107	0.008	0.66
ADFI, lb	5.91	5.75	5.68	5.53	0.289	<0.001	0.92
F/G	2.81	2.80	2.82	2.85	0.090	0.68	0.72
d 56 to 70							
ADG, lb	2.51	2.47	2.45	2.46	0.089	0.34	0.46
ADFI, lb	6.35	6.06	5.98	5.94	0.251	<0.001	0.07
F/G	2.54	2.46	2.44	2.42	0.075	0.02	0.49
d 70 to 84							
ADG, lb	2.10	2.03	2.04	1.95	0.066	0.02	0.79
ADFI, lb	6.64	6.34	6.27	6.24	0.248	<0.001	0.05
F/G	3.18	3.12	3.08	3.22	0.104	0.75	0.09
d 84 to 99							
ADG, lb	2.09	1.99	1.96	1.85	0.072	0.003	0.96
ADFI, lb	6.86	6.49	6.48	6.31	0.215	<0.001	0.25
F/G	3.28	3.30	3.34	3.45	0.157	0.16	0.59
d 0 to 99							
ADG, lb	2.16	2.10	2.08	2.03	0.050	<0.001	0.65
ADFI, lb	5.55	5.35	5.28	5.20	0.210	<0.001	0.12
F/G	2.56	2.54	2.54	2.56	0.045	0.99	0.24

continued

Table 1. Effect of stocking density on performance of commercial finishing pigs[1]

	Stocking density, pigs per pen[2]					Probability, $P <$	
Item	22	24	26	28	SEM	Linear	Quadratic
Weight, lb							
d 0	62.9	63.0	62.6	63.0	2.41	0.95	0.86
d 14	91.9	92.1	91.3	91.6	3.27	0.73	0.96
d 28	119.4	117.7	116.0	116.4	4.11	0.05	0.39
d 42	151.8	149.5	147.7	147.2	4.86	0.007	0.46
d 56	181.3	178.2	176.3	174.7	6.04	<0.001	0.58
d 70	216.6	212.7	210.6	209.1	6.88	<0.001	0.35
d 84	246.0	241.2	239.1	236.4	7.27	<0.001	0.43
d 99	277.4	271.0	268.6	264.2	7.14	<0.001	0.52

[1] A total of 36 barrow pens and 12 gilt pens with 22 to 28 pigs per pen were used in a 99-d growth trial.

[2] Stocking density treatments (12 pens per treatment: 3 gilt pens and 9 barrow pens) were 22, 24, 26, and 28 pigs per pen, providing approximately 8.2, 7.5, 6.9, and 6.4 ft^2 per pig, respectively.

Table 2. Determination of *k*-values for different stocking densities and pig weights[1]

	Stocking density, pigs per pen[2]				*k*-value[3,4]			
Item	22	24	26	28	22 pigs	24 pigs	26 pigs	28 pigs
Space per pig, ft[2]	8.18	7.50	6.92	6.43	---	---	---	---
BW when k = 0.035, lb[5]	218.1	191.5	169.9	152.1	---	---	---	---
Weight, lb								
d 0	62.9	63.0	62.6	63.0	0.080	0.074	0.068	0.063
d 14	91.9	92.1	91.3	91.6	0.062	0.057	0.053	0.049
d 28	119.4	117.7	116.0	116.4	0.052	0.049	0.045	0.042
d 42	151.8	149.5	147.7	147.2	0.045	0.041	0.038	0.036
d 56	181.3	178.2	176.3	174.7	0.040	0.037	**0.034**	**0.032**
d 70	216.6	212.7	210.6	209.1	0.035	**0.033**	**0.030**	**0.028**
d 84	246.0	241.2	239.1	236.4	**0.032**	**0.030**	**0.028**	**0.026**
d 99	277.4	271.0	268.6	264.2	**0.030**	**0.028**	**0.026**	**0.024**

[1] Average pig weight reported for each stocking density and weigh day.
[2] Stocking density treatments were 22, 24, 26, and 28 pigs per pen providing approximately 8.2, 7.5, 6.9, and 6.4 ft^2 per pig, respectively.
[3] *k*-Values calculated using a formula reported by Whittemore (1998): Space per pig (m^2) = $k \times BW (kg)^{0.67}$ or Space per pig (ft^2)/10.7639) = $k \times ((BW (lb)/2.2046)^{0.67}$.
[4] Bold type with shaded background indicate *k*-values below 0.035, the critical *k*-value for adequate feed intake (Torrallardona and Roura, 2009).
[5] Calculated body weight for each stocking density when k = 0.035, the critical *k*-value for adequate feed intake (Torrallardona and Roura, 2009).

Table 3. Economic impact of different stocking densities on pig performance[1]

	Stocking density, pigs per pen[2]					Probability, $P <$	
Item	22	24	26	28	SEM	Linear	Quadratic
Total weight[3]							
Pig weight produced, lb/pen	5985.4	6437.3	6890.5	7283.7	169.75	<0.001	0.65
Revenue[4]							
Pen revenue, $/pen	3292	3541	3790	4006	93.36	<0.001	0.65
Total feed consumption							
Feed usage, lb/pen	11,925	12,652	13,514	14331	505.5	<0.001	0.65
Costs							
Feed cost, $/pen[5]	954	1012	1081	1146	40.439	<0.001	0.65
Facility cost, $/pen[6]	272	272	272	272	---	---	---
Income over feed and facility cost							
IOFAFC, $/pen[7]	2065.75	2256.14	2436.40	2587.29	55.763	<0.001	0.51
IOFAFC, $/pig placed[8]	93.90	94.01	93.41	92.40	2.223	0.34	0.64

[1] A total of 1,201 pigs, initially 63 lb, were used in a 99-d trial with 22 to 28 pigs per pen and 12 pens per treatment.
[2] Stocking density treatments were 22, 24, 26, and 28 pigs per pen, providing approximately 8.2, 7.5, 6.9, and 6.4 ft2 per pig, respectively.
[3] Total weight produced; calculated as (initial weight × initial no. pigs per pen) + [(off-test weight × no. pigs per pen at off-test) - (initial weight × initial no. pigs per pen)]
[4] Based on live value of $55/cwt.
[5] Based on diet cost of $160/ton.
[6] Based on $0.11/pig/day × 25 pigs/pen × 99 days.
[7] Income over feed and facility cost (IOFAFC); calculated as (revenue - feed cost - facility cost).
[8] Income over feed and facility cost (IOFAFC) per pig placed; calculated as (revenue - feed cost - facility cost)/initial no. pigs placed.