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Characterizing Variation in Nursery Pig Growth Performance Based on Different Allotment Strategies

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Characterizing Variation in Nursery Pig Growth Performance Based on Different Allotment Strategies

Abstract

A total of 360 pigs (200 × 400, DNA; initially 13.8 ± 1.83 lb BW) were used in a 42-d nursery trial to evaluate multiple procedures to allot pigs to pens and pens to treatment in swine nursery research. At placement, pigs were randomly assigned to 1 of 3 different allotment strategies. For the first strategy (random), pigs were allotted to pens using a completely randomized design. For strategy 2 (body weight distribution), pigs were sorted by body weight into 1 of 5 groups. Pigs were then randomly assigned to pen so there was 1 pig from each weight group in each pen to ensure that distribution of body weights within pen was relatively consistent across pens. For strategy 3 (body weight group), pigs were sorted by body weight to create 3 body weight categories: light, medium, and heavy. Within each group, pigs were randomized to pen such that each pen consisted of pigs from a single body weight group (pens of light pigs, pens of medium pigs, pens of heavy pigs). There were 72 pens on test with 5 pigs per pen and 24 pens per allotment strategy. For all allotment strategies, once pigs were allotted to pens, pens were allotted to 1 of 2 environmental enrichment treatments for a concurrent trial. There were no allotment × enrichment treatment interactions ($P > 0.10$), so only effects of allotment strategy will be described herein. There were no statistical differences in ADG, ADFI, and F/G between allotment strategies at any point in the study or overall. When looking at the coefficient of variation (CV) for pig body weight within each pen, the random or body weight distribution allotment strategies remained relatively consistent over the course of the experiment. Pigs that were grouped by body weight had the lowest within-pen CV at allotment, with CV increasing over the course of the experiment but still being lower than the other two allotment strategies at the conclusion of the trial. For between-pen CV, pigs allotted using the body weight distribution or body weight grouping strategy had the lowest CV on d 0. Pigs allotted using the random strategy had the highest CVs for the entire trial, and pigs allotted using the body weight grouping strategy remained intermediate for the remainder of the trial. The CV of pig body weight within the population was approximately the same for all treatments at allotment. Between d 3 to 21, CV increased the most in pigs allotted using the random strategy, peaking at approximately d 21 and remaining higher than other allotment strategies at the end of the study. The CV for pigs allotted using the body weight distribution and grouping strategies were relatively consistent over the course of the study. Results were used to estimate the replication required with each allotment strategy to obtain significant differences with different percentage responses. The body weight distribution and body weight grouping allotment strategies would require the fewest replications for most response criteria tested. In conclusion, different allotment strategies did not influence average growth performance in any of the 3 phases during the nursery period. However, fewer replications would be required to find similar percentage responses when allotting pigs using the body weight distribution and body weight grouping techniques as compared to the other allotment strategy. When conducting nursery research with pen serving as the experimental unit, the data herein would support that a body weight distribution allotment strategy or body weight grouping strategy would result in the least pen-to-pen variation depending on response.

Keywords

allotment strategies, coefficient of variation, nursery pigs

Authors

Jenna J. Bromm, Mike D. Tokach, Jason C. Woodworth, Robert D. Goodband, Joel M. DeRouchey, and Jordan T. Gebhardt

Characterizing Variation in Nursery Pig Growth Performance Based on Different Allotment Strategies

Jenna J. Bromm, Mike D. Tokach, Jason C. Woodworth, Robert D. Goodband, Joel M. DeRouchey, and Jordan T. Gebhardt[1]

Summary

A total of 360 pigs (200 × 400, DNA; initially 13.8 ± 1.83 lb BW) were used in a 42-d nursery trial to evaluate multiple procedures to allot pigs to pens and pens to treatment in swine nursery research. At placement, pigs were randomly assigned to 1 of 3 different allotment strategies. For the first strategy (random), pigs were allotted to pens using a completely randomized design. For strategy 2 (body weight distribution), pigs were sorted by body weight into 1 of 5 groups. Pigs were then randomly assigned to pen so there was 1 pig from each weight group in each pen to ensure that distribution of body weights within pen was relatively consistent across pens. For strategy 3 (body weight group), pigs were sorted by body weight to create 3 body weight categories: light, medium, and heavy. Within each group, pigs were randomized to pen such that each pen consisted of pigs from a single body weight group (pens of light pigs, pens of medium pigs, pens of heavy pigs). There were 72 pens on test with 5 pigs per pen and 24 pens per allotment strategy. For all allotment strategies, once pigs were allotted to pens, pens were allotted to 1 of 2 environmental enrichment treatments for a concurrent trial. There were no allotment × enrichment treatment interactions ($P > 0.10$), so only effects of allotment strategy will be described herein. There were no statistical differences in ADG, ADFI, and F/G between allotment strategies at any point in the study or overall. When looking at the coefficient of variation (CV) for pig body weight within each pen, the random or body weight distribution allotment strategies remained relatively consistent over the course of the experiment. Pigs that were grouped by body weight had the lowest within-pen CV at allotment, with CV increasing over the course of the experiment but still being lower than the other two allotment strategies at the conclusion of the trial. For between-pen CV, pigs allotted using the body weight distribution or body weight grouping strategy had the lowest CV on d 0. Pigs allotted using the random strategy had the highest CVs for the entire trial, and pigs allotted using the body weight grouping strategy remained intermediate for the remainder of the trial. The CV of pig body weight within the population was approximately the same for all treatments at allotment. Between d 3 to 21, CV increased the most in pigs allotted using the random strategy, peaking at approximately d 21 and remaining higher than other allotment strategies at the end of the study. The CV for pigs allotted using the body weight distribution and grouping strategies were relatively consistent over the course

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of the study. Results were used to estimate the replication required with each allotment strategy to obtain significant differences with different percentage responses. The body weight distribution and body weight grouping allotment strategies would require the fewest replications for most response criteria tested. In conclusion, different allotment strategies did not influence average growth performance in any of the 3 phases during the nursery period. However, fewer replications would be required to find similar percentage responses when allotting pigs using the body weight distribution and body weight grouping techniques as compared to the other allotment strategy. When conducting nursery research with pen serving as the experimental unit, the data herein would support that a body weight distribution allotment strategy or body weight grouping strategy would result in the least pen-to-pen variation depending on response.

Introduction

Variability is a substantial factor to consider and minimize when determining the best approaches to allot animals to pens and experimental units to treatments in research trials. Previous research has shown that there is a strong correlation between weaning weight and growth performance, which can influence body weight variation in early stages of production. The stressors that are combined with the weaning process also influence growth performance and can increase body weight variability.[2] Past research has looked at the comparison of different experimental designs and how to interpret each design's results.[3] More research is needed to evaluate multiple approaches for allotment and subsequent statistical analysis with primary outcome measurements including within- and between-pen variability. Therefore, the objective of this study was to evaluate multiple procedures to allot pigs to pens in swine nursery research to characterize nursery pig body weight variability in a 42-d feeding trial.

Procedures

General

The Kansas State University Institutional of Animal Care and Use Committee approved the protocol used in this experiment. The study was conducted at the Kansas State University Segregated Early Weaning Research Facility in Manhattan, KS. Each pen contained a 4-hole, dry, self-feeder and a nipple waterer for *ad libitum* access to feed and water. Pens (4 × 4 ft) had metal tri-bar floors and allowed approximately 3.2 ft^2/pig.

Animal treatment and structure

A total of 360 barrows (200 × 400, DNA; initially 13.8 ± 1.83 lb BW) were used in a 42-d nursery trial across two barns. There were 72 pens on test with 5 pigs per pen and 24 pens per allotment strategy. Pigs were weaned at approximately 21 d of age. On d 0, pigs were individually weighed and then sorted in Excel by body weight from lightest to heaviest. Sequentially, each grouping of 3 pigs were randomized to one of three allotment strategies to ensure the underlying populations used in each allotment strategy were as similar as possible.

[2] Tolosa A. F., J. M. DeRouchey, M. D. Tokach, R. D. Goodband, J. C. Woodworth, J. T. Gebhardt, M. J. Ritter, and C. M. Pilcher. 2021. A meta-analysis to understand the relationship between pig body weight and variation from birth to market. Animals 11(7): 2088. doi:10.3390/ani11072088.

[3] Shelton, N. W., S. S. Dritz, M. D. Tokach, R. D. Goodband, J. L. Nelsen, J. M. DeRouchey, and L. W. Murray. 2011. Effects of experimental design and its role in interpretation of results. 2009. Kansas Experimental Station Research Reports: Issue 10.

For the first strategy (random), pigs were allotted to pens using a completely randomized design. For strategy 2 (body weight distribution), pigs were sorted by body weight and assigned to 1 of 5 body weight groups. Pigs were then randomly assigned to pen so there was 1 pig from each group in each pen to ensure that distribution of body weights within pen was relatively consistent across pens. For strategy 3 (body weight grouping), pigs were sorted by body weight to create 3 body weight groups: light, medium, and heavy. Within each group, pigs were randomized to pen such that each pen consisted of pigs from a single body weight group (pens of light pigs, pens of medium pigs, pens of heavy pigs).

Once pigs were allotted to pens, pens were allotted to 1 of 2 environmental enrichment treatments for a concurrent trial. The first treatment contained no environmental enrichment. For the second treatment, environmental enrichment, in the form of a rope, was secured to the feeder in each pen from d 0 to 10.[4]

Pigs were individually weighed on d 0 and 3 to determine initial change in body weight. Pigs were then individually weighed on d 10, 14, 21, and 42 to determine ADG and coefficient of body weight variation (CV). Feeders were weighed daily from d 0 to 14 to determine initial feed intake and feed disappearance over time. Following d 14, feed disappearance was measured on d 21 to determine ADFI and F/G.

Diet preparation

Pigs were fed common, corn-soybean meal-based diets from d 0 to 42. All 3 phases were manufactured at Hubbard Feeds (Beloit, KS). Phase 1 was fed in pellet form, and phases 2 and 3 were fed in meal form.

Sample size

Sample size was calculated by 2 times ($Z\ \alpha/2$ minus $Z\beta$) squared times standard deviation squared, all divided by (u_1 minus u_2) squared. $Z\ \alpha/2$ (1.96) represented the Z score of σ, when σ was 0.25. $Z\beta$ (-0.84) represented the Z score of β, when β was 0.20. Values were reported as number of pens per treatment group to detect a statistically significant difference between treatments of indicated magnitude. Values reported within body weight grouping strategy are values for numbers of pens total within each treatment group, not number of pens within each body weight group.

Statistical analysis

Growth performance data were analyzed using the lme4 package of R (Version 4.0.0, R Foundation for Statistical Computing, Vienna, Austria) with pen considered the experimental unit. Allotment strategy was included in the model as a fixed effect to test the effect of strategy on growth performance outcomes. Additionally, a second statistical model was fit using the pens of pigs allotted by using the body weight grouping strategy to test the effect of strategy, body weight group (light, medium, heavy), and the associated interaction on growth performance outcomes. Differences were considered significant at $P \leq 0.05$ and marginally significant at $0.05 < P \leq 0.10$. Additionally, models were fit to test the effect of environmental enrichment within each of the allotment strategies. Following model fit, the SEM was used to back-calculate the model-fit

[4] Bromm, J. B., M. D. Tokach, J. C. Woodworth, R. D. Goodband, J. M. DeRouchey, and J. T. Gebhardt. 2022. Evaluation of environmental enrichment on feed intake and growth performance of weanling pigs. In progress.

standard deviation. These standard deviation estimates were used to calculate sample size necessary to detect various differences between two treatments using the equation described by Dohoo et al. (2009)[5] using an α of 0.05 and β of 0.20.

Results and Discussion

There was no statistical difference in average BW, ADG, ADFI, or F/G between allotment strategies at any point in the study (Table 1). Within the body weight grouping strategy, there was no body weight group × treatment interaction.

When considering how allotment strategy affects replications needed for improvement in growth performance responses, pigs allotted using the body weight grouping strategy required the least number of replications per group for a 1 to 5% improvement for d 21 and 42 BW (Table 2). However, as the percentage of improvement increases, the number of replications per group needed to see that improvement become more similar across the different strategies. Therefore, the needed number of replications per group for a 5% improvement in d 42 BW are relatively similar (Figure 4). Pigs allotted using the body weight distribution strategy also required the least number of replications per group for a 1 to 5% improvement in ADG, ADFI, and F/G from d 0 to 21 (Table 2). However, pigs allotted using the body weight grouping strategy required the least number of replications per group for a 1 to 5% improvement in ADG from d 0 to 42.

Looking at CV for pig body weight within each pen, the random and body weight distribution allotment strategies had approximately 14% CV on d 0 and remained relatively consistent over the course of the experiment (Figure 1). Pigs that were grouped by body weight had the lowest CV of 5.7% on d 0. The CV of the body weight grouping strategy increased over the course of the experiment and was 9.6% on d 42 but was still lower than the other 2 allotment strategies at that time point (11.7% and 12.9%, body weight distribution, and random, respectively).

When looking at CV for the mean body weight between pens, at allotment, pigs allotted with the body weight distribution or body weight grouping strategies had the lowest CV of 1.7%, with pigs allotted using the random strategy having the highest CV (12.1%; Figure 2). Pigs allotted using the body weight distribution strategy slightly increased from d 0 to 10, but then remained relatively constant, and had the lowest CV of 4.8% on d 42. The CV for the body weight grouping strategy increased from d 0 to 10, and then decreased over the rest of the trial with a CV of 5.0% on d 42. Pigs allotted using the random strategy had the highest CV for the duration of the trial and had a CV of 6.4% at the end of the trial.

When considering the population CV of pigs within each strategy, there was an initial CV for pig body weight between 13.0 and 14.0%, regardless of allotment strategy (Figure 3). Between d 3 and 21, CV increased the most in pigs allotted using the random strategy and peaked at approximately 17% on d 21. From d 21 to 42, CV for pigs allotted using the random strategy decreased to 13.6%. The CV for pigs allotted using the body weight distribution strategy slightly increased after d 3 peaking at 14.2% on d 14, then decreased to have a CV of 12.0% on d 42. Pigs allotted using the body weight grouping strategy had relatively consistent CV over the course of the study and the CV was 12.5% on d 42 at the conclusion of the study.

[5] Dohoo, I. R., W. Martin, and H. Stryhn. 2009. Veterinary Epidemiologic Research. AVC Inc.

In conclusion, different allotment strategies did not influence average growth performance in any of the 3 phases during the nursery period. However, fewer replications would be required to find similar percentage responses when allotting pigs using the body weight distribution and body weight grouping techniques as compared to the other allotment strategy. When conducting nursery research with pen serving as the experimental unit, the data herein would support that a body weight distribution allotment strategy or body weight grouping strategy would result in the least pen-to-pen variation depending on response.

Table 1. Evaluation of different allotment strategies on growth performance of nursery pigs[1]

Item	Random[2]	Body weight distribution[3]	Body weight grouping[4]	SEM	*P* =
BW, lb					
d 0	13.7	13.7	13.7	0.258	0.997
d 3	13.1	13.1	13.1	0.212	0.989
d 10	16.0	16.2	16.0	0.509	0.828
d 14	18.9	19.0	18.9	0.499	0.941
d 21	25.8	26.2	26.1	0.813	0.775
d 42	53.8	55.4	54.6	0.905	0.309
d 0 to 10 (Phase 1)					
ADG, lb	0.24	0.26	0.25	0.026	0.672
ADFI, lb	0.23	0.24	0.25	0.017	0.789
F/G	0.91	0.96	1.04	0.194	0.438
d 10 to 21 (Phase 2)					
ADG, lb	0.89	0.90	0.90	0.036	0.835
ADFI, lb	1.25	1.26	1.27	0.028	0.829
F/G	1.42	1.41	1.42	0.041	0.996
d 0 to 21					
ADG, lb	0.57	0.59	0.59	0.030	0.657
ADFI, lb	0.68	0.69	0.69	0.012	0.711
F/G	1.22	1.17	1.19	0.059	0.590
d 21 to 42 (Phase 3)					
ADG, lb	1.35	1.39	1.35	0.021	0.298
d 0 to 42 (Overall)					
ADG, lb	0.96	0.99	0.97	0.020	0.315

[1]A total of 360 barrows (DNA 200 × 400; initial BW 13.7 ± 1.83 lb) were used in a 42-d experiment with 5 pigs per pen and 24 replications per allotment strategy.
[2]Pigs were allotted to pens in a completely randomized design.
[3]Pigs were sorted by body weight into five groups in Excel. Within each body weight group, pigs were randomized to pen such that each pen consisted of 1 random pig from each body weight group to ensure that distribution of body weights within pen was relatively consistent across pens.
[4]Pigs were sorted into three groups by body weight in Excel (light, medium, heavy). Within each body weight group, pigs were randomized to pen such that each pen consisted of pigs from a single body weight group (pens of light pigs, pens of medium pigs, pens of heavy pigs).

Table 2. Effects of allotment strategy on sample size per group required to detect statistically significant percent improvement in response[1]

	Improvement in response, %				
Item	1%	2%	3%	4%	5%
BW					
d 21					
Random[2]	2,891	723	322	181	116
Body weight distribution[3]	981	246	109	62	40
Body weight grouping[4]	952	238	106	60	39
d 42					
Random[2]	942	236	105	59	38
Body weight distribution[3]	561	141	63	36	23
Body weight grouping[4]	437	110	49	28	18
ADG (d 0 to 21)					
Random[2]	7,905	1,977	879	495	317
Body weight distribution[3]	3,588	897	399	225	144
Body weight grouping[4]	3,622	906	403	227	145
ADFI (d 0 to 21)					
Random[2]	4,143	1,036	461	259	166
Body weight distribution[3]	2,671	668	297	167	107
Body weight grouping[4]	3,059	765	340	192	123
F/G (d 0 to 21)					
Random[2]	1,107	227	123	70	45
Body weight distribution[3]	529	133	59	34	22
Body weight grouping[4]	1,289	323	144	81	52
ADG (d 0 to 42)					
Random[2]	941	236	105	59	38
Body weight distribution[3]	1,385	347	154	87	56
Body weight grouping[4]	857	215	96	54	35

[1]A total of 360 barrows (DNA 200 × 400; initial BW 13.7 ± 1.83 lb) were used in a 42-d experiment with 5 pigs per pen and 24 replications per allotment strategy. Sample size calculations assume α of 0.05 with 80% power. Values reported as number of pens per treatment to detect a statistically significant difference between treatments of indicated magnitude. Values reported within body weight grouping strategy are values for numbers of pens total within each treatment group, not number of pens within each body weight group.
[2]Pigs were allotted to pens in a completely randomized manner.
[3]Pigs were sorted by body weight into five groups in Excel. Within each body weight group, pigs were randomized to pen such that each pen consisted of 1 random pig from each body weight group to ensure that distribution of body weights within pen was relatively consistent across pens.
[4]Pigs were sorted into three groups by body weight in Excel (light, medium, heavy). Within each body weight group, pigs were randomized to pen such that each pen consisted of pigs from a single body weight group (pens of light pigs, pens of medium pigs, pens of heavy pigs).

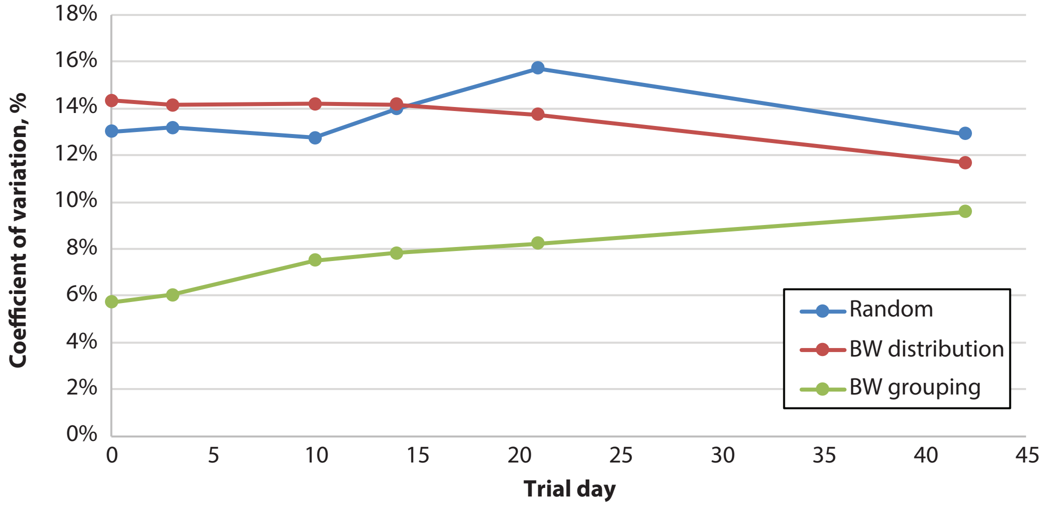

Figure 1. Coefficient of variation of body weight within pen (within-pen coefficient of variation) over time by randomization strategy. Calculated by dividing standard deviation of pig weight within pen by the average weight of pigs within pen. For the first strategy (random), pigs were allotted to pens in a completely randomized design. For the second strategy (body weight distribution), pigs were sorted by body weight into five groups in Excel. Within each body weight group, pigs were randomized to pen such that each pen consisted of 1 random pig from each body weight group to ensure that distribution of body weights within pen was relatively consistent across pens. For the third strategy (body weight grouping), pigs were sorted into three groups by body weight in Excel (light, medium, heavy). Within each body weight group, pigs were randomized to pen such that each pen consisted of pigs from a single body weight group (pens of light pigs, pens of medium pigs, pens of heavy pigs).

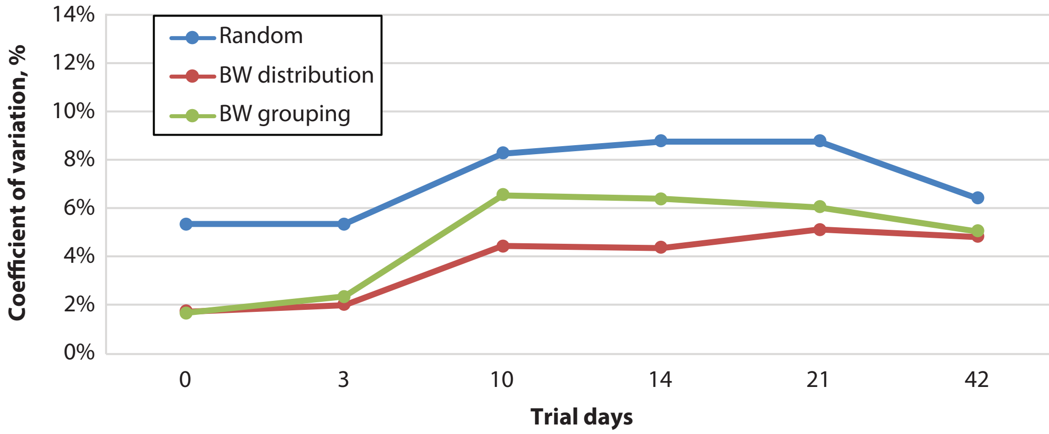

Figure 2. Coefficient of variation of pen mean body weight (between-pen coefficient of variation) over time by randomization strategy. Calculated by dividing standard deviation of pen mean body weight by the average of pen mean body weight. For the first strategy (random), pigs were allotted to pens in a completely randomized design. For the second strategy (body weight distribution), pigs were sorted by body weight into five groups in Excel. Within each body weight group, pigs were randomized to pen such that each pen consisted of 1 random pig from each body weight group to ensure that distribution of body weights within pen was relatively consistent across pens. For the third strategy (body weight grouping), pigs were sorted into three groups by body weight in Excel (light, medium, heavy). Within each body weight group, pigs were randomized to pen such that each pen consisted of pigs from a single body weight group (pens of light pigs, pens of medium pigs, pens of heavy pigs).

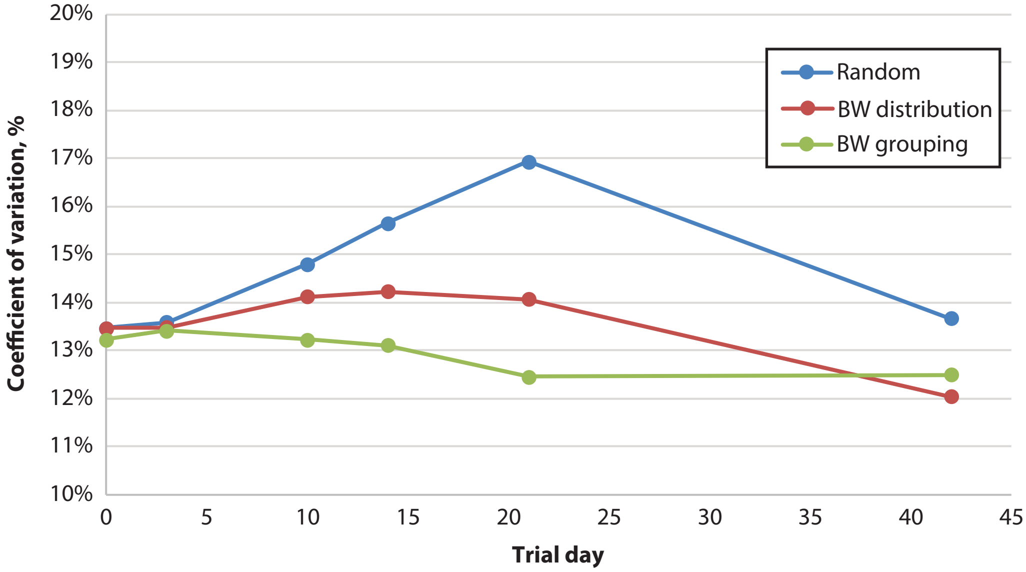

Figure 3. Coefficient of variation of pig body weight (population coefficient of variation) over time by randomization strategy. Calculated by dividing standard deviation of body weight of all pigs within randomization strategy by mean body weight of all pigs within randomization strategy. For the first strategy (random), pigs were allotted to pens in a completely randomized design. For the second strategy (body weight distribution), pigs were sorted by body weight into five groups in Excel. Within each body weight group, pigs were randomized to pen such that each pen consisted of 1 random pig from each body weight group to ensure that distribution of body weights within pen was relatively consistent across pens. For the third strategy (body weight grouping), pigs were sorted into three groups by body weight in Excel (light, medium, heavy). Within each body weight group, pigs were randomized to pen such that each pen consisted of pigs from a single body weight group (pens of light pigs, pens of medium pigs, pens of heavy pigs).

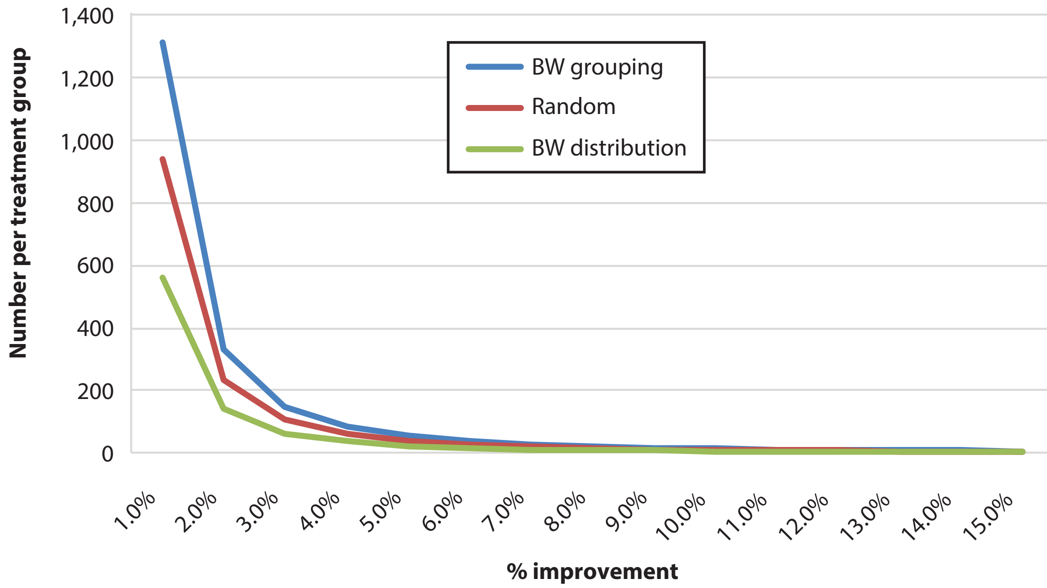

Figure 4. Replications needed per group for an improvement in final BW for each group. Values reported as number of pens per treatment group to detect a statistically significant difference between treatments of indicated magnitude. Values reported within body weight grouping strategy are values for numbers of pens total within each treatment group, not number of pens within each body weight group. For the first strategy (random), pigs were allotted to pens in a completely randomized design. For the second strategy (body weight distribution), pigs were sorted by body weight into five groups in Excel. Within each body weight group, pigs were randomized to pen such that each pen consisted of 1 random pig from each body weight group to ensure that distribution of body weights within pen was relatively consistent across pens. For the third strategy (body weight grouping), pigs were sorted into three groups by body weight in Excel (light, medium, heavy). Within each body weight group, pigs were randomized to pen such that each pen consisted of pigs from a single body weight group (pens of light pigs, pens of medium pigs, pens of heavy pigs).