Effects of frequent out-of-feed events on growth performance of nursery and grow-finish pigs[1]

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ABSTRACT: Two experiments were conducted to evaluate effects of out-of-feed events on nursery and grow-finish pig performance. An out-of-feed event is a period of time that pigs do not have access to feed as a result of late feed delivery or bridging in bulk bins, feed lines, or feeders. In these studies, we created an out-of-feed event by removing the feeders from pens or preventing access to the feeder. In Exp. 1, 190 pigs (initially 6.4 ± 1.6 kg and 21 ± 3 d of age) were used in a 35-d growth study. Treatments involved a 20-h feed withdrawal for 1, 2, or 3 randomly selected times or a control treatment where feeders were never withdrawn. Feeders were withdrawn on d 11 for pigs with 1 out-of-feed event, d 8 and 23 for pigs with 2 out-of-feed events, and d 9, 14, and 20 for pigs with 3 out-of-feed events. There was a treatment ($P < 0.06$) effect only during weeks in which an out-of-feed event occurred. Growth rate was lower ($P < 0.05$) for pigs with 1 out-of-feed event (d 11) compared with control in the d 8 to 14 period. During the same period, those pigs with the first of 2 (d 8) or 3 (d 9) out-of-feed events had intermediate ADG. In the d 15 to 21 period, only pigs with the second and third of 3 out-of-feed events (d 15 and 20) had lower growth performance compared with control pigs, whereas growth performance was similar to the control for those with 1 or 2 out-of-feed events. Pigs with 3 out-of-feed events had greater ADG and G:F ($P < 0.05$) compared with the other 3 treatments for the d 22 to 28 period. For the overall study (d 0 to 35), there were no differences ($P > 0.86$) in growth performance among pigs with 0, 1, 2, or 3 out-of-feed events. In Exp. 2, 479 pigs (initially 41.6 ± 4 kg) were used in an 85-d growth study. Treatments involved feed withdrawal (20 h) weekly for the duration of the study; feed withdrawn weekly from d 45 to 85; or a control treatment where pigs had access to feed for the duration of the experiment. Feed withdrawal occurred on a randomly selected day with the exception of Saturday, Sunday, or a day before a weigh day (usually a Thursday every other week). From d 0 to 45, 46 to 85, and the overall d 0 to 85 period, there were no differences ($P > 0.12$) in ADG, ADFI, G:F, or average final BW among treatments. Results suggest that out-of-feed events of 20 h or less have no long-term detrimental effects on growth performance in nursery or grow-finish pigs.

Key words: feed availability, feed management, pig

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INTRODUCTION

Out-of-feed events refer to periods when pigs do not have feed access due to delayed feed delivery or feed bridging in bulk bins, feed lines, or feeders. These events could lead to decreased growth rates and increased incidence of gastric ulcers, ileitis, or hemorrhagic bowel syndrome (Brumm et al., 2005). Previous research on effects of out-of-feed events is limited compared with feed restriction. Brumm and Colgan (2005) and Brumm et al. (2006) simulated out-of-feed events by preventing access to feed for 20-h periods (from noon to 0800). Brumm and Colgan (2005) used treatments of 0, 1, 2, or 3 feed removals every 2 wk and found no differences in growth performance. Brumm et al. (2006) simulated out-of-feed events by removing feeders on randomly selected days and found decreased ADG and ADFI for grow-finish pigs during the first period (d 0 to 53) and in the overall period (d 0 to 109). However, from d 53 to 109, there were no differences in growth performance. Therefore, most of the decreased growth performance found in the overall study was due to decreased ADG and ADFI in the first 8 wk.

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Previous research concerning feed restriction without total feed removal has focused on the compensatory gain effect in grow-finish pigs. Compensatory gain is defined as accelerated growth to recover from a period of feed restriction (Hornick et al., 2000). Pigs experience compensatory gain following restricted feed intake (Prince et al., 1983; Stamataris et al., 1991; Lovatto et al., 2006) or restricted protein allowance (de Greef et al., 1992; Whang et al., 2003). Currently, it is not clear if pigs experiencing a complete feed withdrawal will have compensatory gain similar to pigs that have had some type of feed restriction. Therefore, the objective of these experiments was to evaluate the effect of random out-of-feed events in nursery and grow-finish phases on growth performance.

MATERIALS AND METHODS

The experimental protocols used in these studies were approved by the Kansas State University Institutional Animal Care and Use Committee.

Experiment 1

A total of 192 weanling barrows and gilts (line L337 × C1050, PIC, Franklin, KY), with an initial BW of 6.4 ± 1.6 kg and 21 ± 3 d of age, were used in a 35-d growth study. Treatments involved a control, where pigs had continual access to feed, or 1, 2, or 3 out-of-feed events over the entire study. Out-of-feed events were done by removing feeders from the pens for 20 h (1200 to 0800 the following morning). The out-of-feed events occurred on d 11 for the 1; d 8 and 23 for the 2; and d 9, 14, and 20 for the 3 out-of-feed events groups, respectively. Withdrawal days were chosen at random, with the exclusion of the first week after the pigs were weaned to allow for acclimation to the nursery.

This experiment was conducted at the Kansas State University Swine Teaching and Research center in an environmentally controlled nursery. The facility contains pens (1.22 × 1.52 m) that provide 0.11 m of feeder space/pig, each with 1 nipple waterer and 1 stainless-steel feeder. The temperature was 32°C for the first 7 d and was lowered approximately 2°C each week for the remainder of the experiment. Each pen contained 6 pigs (3 barrows and 3 gilts), and there were 8 replications (pens) per treatment.

A standard 4-phase, nursery feeding regimen was used, with phases 1 and 2 consisting of pelleted diets and phases 3 and 4 consisting of diets in mash form (Tokach et al., 1997). The diets were corn-soybean meal-based with supplemental vitamins and minerals. Diets 1, 2, and 3 contained specialty protein sources such as spray-dried animal plasma, select menhaden fish meal, and spray dried blood meal. Amounts of these specialty ingredients decreased with each progressing diet. Diet 4 did not contain any specialty protein sources. Diets were formulated to meet or exceed NRC (1988) requirement estimates on an as-fed basis. The diets were fed on a feed budget beginning with 0.45 kg/pig of a 1.56% true ileal digestible (**TID**) Lys diet, and increasing to 1 kg/pig of a 1.51% TID Lys diet, 2 kg/pig of a 1.35% TID Lys diet, and lastly, approximately 20 kg of a 1.20% TID Lys diet fed until the end of the experiment (d 35). Pigs and feeders were weighed on d 0, 7, 14, 21, 28, and 35 to determine the response criteria of ADG, ADFI, and G:F.

Experiment 2

In Exp. 2, 479 pigs (initially 41.6 kg; line L337 × C1050, PIC) were used in an 85-d growth study. Treatments involved a control with no out-of-feed events for the duration of the study, out-of-feed events occurring each week for the duration of the experiment, and out-of-feed events occurring each week beginning on d 45 of the study. Out-of-feed events were simulated by placing wooden enclosures in front of the feeders to prevent access to the feeder for 20 h (1200 to 0800 the following morning). Feed withdrawal occurred on a randomly selected day each week, with the exception of Saturday, Sunday, or the day before a weigh day, which was usually on a Thursday.

The experiment was conducted at a commercial, research finishing barn in southern Minnesota. The facility contains pens (2.44 × 5.49 m) that provide 0.67 m^2 per pig, each with a cup waterer and 4-hole feeder. The barn temperature began at 21°C and was gradually reduced to 18°C by the end of the finishing period. Each pen contained 19 or 20 pigs, with 8 replications (4 barrow and 4 gilt pens) per treatment. Pens had adjustable gating to provide the same space allowance for the pen that initially contained 19 pigs or pens that had pigs that died. Seven pigs died during the course of the study, and they were all from different pens. Three dead pigs were from the control group with access to feed for the entire period; 2 pigs were from each of the other 2 groups.

Pigs were fed based on a feed budget, with the first 3 phases allocated 68 kg/pig, and the fourth phase fed until they reached market BW (123 kg, d 85). The diets were corn-soybean meal-based with supplemental vitamins and minerals. Diets were formulated to meet or exceed NRC (1998) requirement estimates on an as-fed basis. Diets contained 6% choice white grease (as-fed) and were formulated to contain 1.09, 0.95, 0.83, and 0.76% TID Lys, on an as-fed basis, respectively. Pigs were weighed and feed measurements were recorded on d 0, 16, 29, 45, 59, 73, and 85 to determine ADG, ADFI, and G:F.

Statistical Analysis

Data from both experiments were analyzed by ANOVA using the MIXED procedure (SAS Inst. Inc., Cary,

Table 1. Effects of feeder withdrawal on nursery pig performance (Exp. 1)[1]

		Feeder withdrawal on day[2]				
Item	None	11	8 and 23	9, 14, and 20	SE	*P*-value
d 1 to 7						
ADG, g	159	182	180	179	13.1	0.42
ADFI, g	142	149	148	158	9.6	0.42
G:F	1.127	1.220	1.223	1.120	0.051	0.32
d 8 to 14						
ADG, g	435[a]	386[b]	408[ab]	401[ab]	29.2	0.06
ADFI, g	462[a]	418[b]	424[b]	420[b]	23.1	0.07
G:F	0.945	0.929	0.967	0.959	0.030	0.79
d 15 to 21						
ADG, g	470[a]	487[a]	495[a]	240[b]	22.1	0.01
ADFI, g	671[a]	709[a]	688[a]	574[b]	21.7	0.02
G:F	0.707[a]	0.687[a]	0.723[a]	0.422[b]	0.028	0.01
d 22 to 28						
ADG, g	667[a]	623[a]	618[a]	840[b]	31.1	0.01
ADFI, g	947	912	921	1,012	23.6	0.35
G:F	0.711[a]	0.685[a]	0.671[a]	0.837[b]	0.022	0.01
d 29 to 35						
ADG, g	731	756	775	780	41.3	0.15
ADFI, g	1,142	1,158	1,188	1,156	36.8	0.68
G:F	0.641	0.653	0.656	0.676	0.014	0.23
d 0 to 35						
ADG, g	492	487	495	488	14.7	0.94
ADFI, g	673	669	674	664	31.9	0.96
G:F	0.733	0.727	0.736	0.735	0.008	0.86
BW, kg						
d 0	6.36	6.36	6.35	6.35	0.29	0.47
d 35	23.56	23.36	23.64	23.39	0.72	0.94

[a,b]Means in the same row with different superscripts differ ($P < 0.05$).
[1]A total of 192 pigs with an initial BW of 6.4 kg were used, with 8 replications per treatment.
[2]Feeder withdrawal was for 20 h on the indicated day, with feeders removed at 1200 and replaced at 0800 the next day.

NC). Data were analyzed as a randomized complete block design, with pen as the experimental unit. Pigs from both experiments were blocked based on initial BW and initial BW within sex in Exp. 2. The statistical model included the fixed effect of treatment and the random effect of block. In addition, for Exp. 2 the effects of sex and the sex × treatment interaction were included in the initial model as fixed effects. Due to the lack of a sex × treatment interaction, this term was dropped from the final model. All means reported are least squares means. The means were compared using least significant difference tests ($P < 0.05$), and the comparison of means was protected by significant *F*-tests ($P < 0.05$).

RESULTS AND DISCUSSION

In Exp. 1, there was a treatment ($P < 0.06$) effect only during weeks in which an out-of-feed event occurred (Table 1). The first out-of-feed event for the 3 treatment groups occurred during the d 8 to 14 period of the study. During this period, ADG and ADFI were decreased ($P < 0.07$) for pigs with an out-of-feed event on d 11 (1 out-of-feed event) compared with control pigs. Pigs with an out-of-feed event on d 8 or 9 (2 and 3 out-of-feed events, respectively) were intermediate and not different from the control. From d 15 to 21, pigs previously with an out-of-feed event during d 8 to 14 (1 and 2 out-of-feed events, respectively) had similar ADG, ADFI, and G:F compared with the control pigs. This response, however, was not seen for pigs with out of feed event in d 11 and 8. The out-of-feed event resulted in decreased ADG for the week it occurred; however, pigs compensated the following week. This may suggest that the BW loss in a 20-h out-of-feed event in the nursery is primarily due to lost contents from the gastrointestinal tract, not from tissue loss. Pigs with 3 out-of-feed events had the third out-of-feed event on d 20, which was 20 h immediately before they were weighed. Thus, ADG, ADFI, and G:F were poorer ($P < 0.05$) than pigs on all other treatments. These pigs had 2 out of feed events in the previous week (d 7 to 14, d 9 and 14), which means an additional stress. From d 22 to 28, pigs with the out-of-feed event on d 20 had increased ($P < 0.05$) ADG and G:F compared with the other treatment groups. Despite having feed withdrawn on d 23, pigs with 2 out-of-feed events had similar ($P < 0.05$) ADG, ADFI, and G:F as control pigs or those with only 1 previous out-of-feed event. From d 29 to 35 there were no out-of-feed events. During this

Table 2. Effects of feeder withdrawal on finishing pig performance (Exp. 2)[1]

Item	Weekly feed removal period[2] None	d 0 to 85	d 46 to 85	SE	*P*-value
d 0 to 45					
ADG, g	954	929	946	11.8	0.34
ADFI, g	2,343	2,339	2,324	26.4	0.86
G:F	0.408	0.397	0.408	0.010	0.21
d 46 to 85					
ADG, g	971	995	1,004	12.0	0.16
ADFI, g	3,051	3,141	3,083	31.5	0.15
G:F	0.319	0.318	0.326	0.003	0.14
d 0 to 85					
ADG, g	962	960	973	10.1	0.64
ADFI, g	2,674	2,717	2,679	25.6	0.46
G:F	0.360	0.354	0.364	0.003	0.12
BW, kg					
d 0	41.4	41.5	41.9	0.70	0.87
d 45	84.3	83.3	84.6	1.00	0.64
d 86	123.1	123.0	124.6	1.24	0.59

[1]A total of 479 pigs with an initial BW of 41.6 kg were used, with 8 replications per treatment.

[2]Feed removal was done by blocking access to the feeder with a wooden enclosure. Feed removal was randomly assigned once weekly, beginning on Monday, Tuesday, Thursday, or Friday from 1200 until 0800 the next day.

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period as well as the overall period (d 0 to 35), there were no differences ($P > 0.15$) among the 4 treatment groups. In Exp. 2, from d 0 to 45, 46 to 85, or the overall period, there were no differences ($P > 0.12$) in ADG, ADFI, G:F, or final BW among treatments (Table 2). This could be because natural feed consumption is low and water intake is high during the hours we removed the feeders (Brumm, 2006).

The only other studies that document effects of out-of-feed events on grow-finish pigs were completed by Brumm and Colgan (2005) and Brumm et al. (2006). Brumm and Colgan (2005) used treatments of 0, 1, 2, or 3 removal periods for every 2-wk period for similar removal hours to those used in our studies. The results were similar to ours with reductions in growth performance during the period of removal, but no differences were observed in growth performance over the overall d 0 to 42 period. However, Brumm et al. (2006) observed different results because they found that weekly out-of-feed events reduced ADG and ADFI as a result of poorer growth in the first half of their study (23 to 68 kg). The authors suggested that pigs adjust to repeated out-of-feed events by changing their feed intake pattern. In the current study, withholding feed had no effect on grow-finish pig performance. The contrasting results among our study and Brumm and Colgan (2005) with results of Brumm et al. (2006) are surprising but not easily explained. Our results indicate that withdrawing feeders during a time of low feed intake (1200 to 0800) allowed pigs to easily compensate for a 20-h feed withdrawal.

Because there are only 2 published research studies analyzing effects of random out-of-feed events, there is minimal research with which to compare our results. Other research also focused on compensatory gain as defined by accelerated growth to recover from a period of feed restriction (Hornick et al., 2000). Pigs experience compensatory gain when they are previously restricted to a lower feed allowance ranging from 95 to 50% of the control pig intake (Cole et al., 1968; Prince et al., 1983; Stamataris et al., 1991). Similarly, when pigs are previously restricted to a lower protein allowance than control pigs, compensatory gain is also experienced (de Greef et al., 1992; Whang et al., 2003; Lovatto et al., 2006). Chiba et al. (1999) tested effects of dietary restrictions on growth performance and compensatory gain. Through feeding Lys levels based on digestible energy, they found a compensatory gain effect in lean tissue growth because pigs fed restricted diets had greater lean accretion rate. However, it is not yet clear if feed restriction and feed removal have the same effect on pig growth performance. Although a compensatory gain effect was observed in Exp. 1, the mode of feed restriction by removing feeders is different than the previous research of restricting feed allowance or protein.

In summary, nursery and grow-finish pigs quickly compensated to random out-of-feed events. Although growth performance may have been reduced for the period with an out-of-feed event, the following week the pig compensated. Out-of-feed events of up to 20 h did not affect overall growth performance of pigs.

LITERATURE CITED

Brumm, M. 2006. Patterns of drinking water use in pork production facilities. Nebraska Swine Report. Ext. Publ. EC06-219:10–13. Univ. Nebraska, Lincoln.

Brumm, M., and S. Colgan. 2005. Impact of repeated out-of-feed events on growing pig performance. J. Anim. Sci. 83(Suppl. 2):38. (Abstr.)

Brumm, M., S. Colgan, and K. Bruns. 2006. Impact of weekly random out-of-feed events and particle size on grow-finish pig performance. J. Anim. Sci. 84(Suppl. 2):115–116. (Abstr.)

Brumm, M., B. Richert, J. Merchant-Forde, and R. Merchant-Forde. 2005. Out-of-feed events in grow-finish pigs: Causes and consequences. Nebraska Swine Report. Ext. Publ. EC05-219:9–11. Univ. Nebraska, Lincoln.

Chiba, L. I., H. W. Ivey, K. A. Cummins, and B. E. Gamble. 1999. Growth performance and carcass traits of pigs subjected to marginal dietary restrictions during the grower phase. J. Anim. Sci. 77:1769–1776.

Cole, D. J. A., J. E. Duckworth, and W. Holmes. 1968. Factors affecting voluntary feed intake in pigs. Anim. Prod. 10:345–357.

de Greef, K. H., B. Kemp, and M. W. A. Verstegen. 1992. Performance and body composition of fattening pigs of two strains during protein deficiency and subsequent realimentation. Livest. Prod. Sci. 30:141–153.

Hornick, J. L., C. Van Eenaeme, O. Gerard, I. Dufrasne, and L. Istasse. 2000. Mechanisms of reduced and compensatory growth. Domest. Anim. Endocrinol. 19:121–132.

Lovatto, P. A., D. Sauvant, J. Noblet, S. Dubois, and J. van Milgen. 2006. Effects of feed restriction and subsequent refeeding on energy utilization in growing pigs. J. Anim. Sci. 84:3329–3336.

NRC. 1998. Nutrient Requirements of Swine, 10th rev. ed. Natl. Acad. Press, Washington, DC.

Prince, T. J., S. B. Jungst, and D. L. Kuhlers. 1983. Compensatory responses to short-term feed restriction during the growing period in swine. J. Anim. Sci. 56:846–852.

Stamataris, C., I. Kyriazakis, and G. C. Emmans. 1991. The performance and body composition of young pigs following a period of growth retardation by food restriction. Anim. Prod. 53:373–381.

Tokach, M. D., S. S. Dritz, R. D. Goodband, and J. L. Nelssen. 1997. Starter pig Recommendations. Kansas State Swine Nutrition Guide. Ext. Publ. MF2299:4–7. Kansas State Univ., Manhattan.

Whang, K. Y., S. W. Kim, S. M. Donovan, F. K. McKeith, and R. A. Easter. 2003. Effects of protein deprivation on subsequent growth performance, gain of body components, and protein requirements in growing pigs. J. Anim. Sci. 81:705–716.