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Effects of mat feeding on the growth performance, removal, and mortality of pigs after weaning

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Abstract

Four experiments were conducted to determine the effect of mat feeding strategy on the growth performance, removal, and mortality of pigs after weaning. In exp. 1, 1,392 weanling pigs (initially 7.0 kg; approximately 24 d of age) were randomly allotted to 1 of 2 mat feeding treatments (mat feed vs. no mat feed). Overall, mat fed pigs had a tendency for improved ADG ($P = 0.065$) and G:F ($P = 0.060$) compared to pigs not offered mat feed. Mat fed pigs had fewer removals ($P = 0.013$) compared to pigs not offered mat feed. In exp. 2, 2,912 weanling pigs (initially 5.5 kg; approximately 21 d of age) were randomly allotted to 1 of 2 mat feeding treatments (mat feed vs. no mat feed). Overall, no differences in growth performance were observed. However, mat fed pigs had decreased ($P < 0.026$) final body weights compared to pigs not offered mat feed. This may be related to removal rates as mat fed pigs had fewer removals ($P = 0.026$). In exp. 3, 3,264 weanling pigs (initially 5.5 kg; approximately 21 d of age) were randomly allotted to 1 of 4 treatments in a 2 × 2 factorial with main effects of diet form (pellet or crumble) and mat feeding (mat feed vs. no mat feed). No interactions between diet form and mat feeding were observed. No differences were observed in overall growth performance for the main effect of mat feeding. Pigs offered pelleted feed had decreased overall ADFI (feed disappearance from the feeder and feed placed on the mat; $P = 0.013$) and improved G:F ($P < 0.001$) compared to pigs offered crumble feed. No differences were observed in removals or mortalities for the main effect of mat feeding or diet form. In exp. 4, 3,227 weanling pigs (initially 5.1 kg; approximately 21 d of age) were randomly allotted to 1 of 3 treatments consisting of mat feeding small (3.2 mm) pellets, mat feeding large (12.7 mm) pellets, or no mat feeding. Overall, no differences were observed in ADG or G:F. Mat fed pigs had increased ADFI ($P < 0.001$) compared to pigs not offered mat feed. Given the shorter duration of this experiment, the extra feed provided with mat feeding had a greater impact on overall feed usage than exp. 1, 2, and 3. No differences were observed in removals or mortalities. When combining the removal and mortality data for the four experiments, mat fed pigs had fewer removals ($P = 0.002$) compared to pigs not offered mat feed. In summary, mat feeding may encourage earlier feeding behavior, therefore reducing the removal rate of pigs post-weaning.

Lay Summary

Prior to domestication, weaning was a slow process in which young pigs develop new feeding behaviors as they transition from an all milk-based diet to solid feed. However, in modern commercial production, weaning is an abrupt event marked by a multitude of stressors that often interfere with the development of feeding behaviors. This leads to low feed intake and body weight gain immediately post-weaning. For this reason, management strategies, such as mat feeding, have become increasingly important to elicit the natural feeding behavior of pigs at weaning. Mat feeding is accomplished by applying a small amount of feed onto the floor mats of nursery or wean-to-finish pens to introduce weaned pigs to solid feed. Because limited data are available on mat feeding, a series of experiments were conducted to determine the effect of different mat feeding strategies on the growth performance, removal, and mortality of pigs after weaning. Overall, mat feeding had limited effects on the growth performance of pigs; however, mat feeding strategies may encourage the development of feeding behaviors, therefore eliciting early feed intake, and reducing the removal rate of pigs after weaning.

Key words: growth performance, mat feeding, survivability, pellet size, nursery pig, weaning

Abbreviations: ADG, average daily gain; ADFI, average daily feed intake; G:F, gain-to-feed ratio

Introduction

Prior to domestication, weaning was a slow process in which young pigs develop new feeding behaviors as they transition from an all milk-based diet to solid feed (Brooks and Tsourgiannis, 2003). The development of these new feeding behaviors over time corresponds with gastrointestinal, immune, and nervous system maturation (Moeser et al., 2017). Consequently, in modern commercial production, weaning is a single, abrupt event marked by a multitude of external and internal stressors. For newly weaned pigs, this can result in low feed intake and body weight gain immediately post-weaning (Bruininx et al., 2001), which can have significant effects

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on the pig's health status and gastrointestinal system development (Moeser et al., 2017). Therefore, management strategies have become increasingly important to elicit the natural feeding behavior of pigs at weaning. Mat feeding is a strategy in which a small amount of feed is applied onto the floor mats of nursery or wean-to-finish pens immediately after weaning. This feeding strategy is commonly practiced to introduce newly weaned pigs to solid feed by increasing feed accessibility. Similar to suckling, it has also been suggested that mat feeding may help stimulate group feeding behavior, therefore encouraging earlier feed intake after weaning and leading to reduced removal and mortality rates. However, limited research data are available to validate mat feeding protocols and understand their potential benefits. Therefore, the objective of these experiments was to determine the effect of different mat feeding strategies on the growth performance, removal, and mortality of pigs post-weaning.

Materials and Methods

The Kansas State University Institutional Animal Care and Use Committee approved the protocols used in these experiments. Experiment 1 was conducted in October at a commercial research facility in northeast Kansas. Each pen (3.0 × 5.5 m) was equipped with a single-sided dry, 3-hole, stainless steel feeder, and a dual swinging waterer to allow for ad libitum access to feed and water. Likewise, each pen was equipped with a brooder to provide supplemental heat post-weaning. Experiments 2, 3, and 4 were conducted from October to May at a commercial research facility in southeast Minnesota. Each pen (1.8 × 3.4 m) was equipped with a 5-hole stainless steel feeder and cup waterer to allow for ad libitum access to feed and water. No supplemental heat post-weaning was provided. Both sites used an automated feeding system (FeedPro; Feedlogic Corp., Willmar, MN) to measure and record daily feed additions to individual pens.

Experiment 1

A total of 1,392 weanling pigs (PIC, Hendersonville, TN; initially 7.0 kg) were used in a 27-d experiment. All pigs were weaned at approximately 24 d of age and transported approximately 1 h to the nursery facility. Upon arrival, pigs were randomized to pens based on sex and then weighed. Pens of pigs were blocked by source farm with each block consisting of 2 barrow and 2 gilt pens, and then randomly allotted to 1 of 2 mat feeding treatments (mat feeding vs. no mat feeding). There were 58 pigs per pen and 12 replications per treatment. Pens of pigs assigned to the mat feeding treatment group were provided approximately 500 g of pelleted feed, three times daily for 6 d post-placement (except for 1 pen which was fed on the mat for only 5 d before the mat disintegrated), for a total of 9.0 kg of feed per pen (155 g per pig). Mat feed was removed from the back of feeders in pens assigned to the mat feeding treatment group and spread across a 1.2 × 2.4 m biodegradable mat.

All pigs were provided the same diets which were fed in three different phases (Menegat et al., 2019) according to standard farm protocol. The phase 1 diet was provided at 1.36 kg per head and contained corn, soybean meal, and specialty protein and lactose sources such as spray dried animal plasma, dried whey, and fish meal. The phase 2 diet was provided at 5.90 kg per head, and it contained lower levels of dried whey and fish meal than the phase 1 diet. The phase 3 diet was corn and soybean meal-based and contained no specialty protein or lactose sources. It was formulated for an average pig weight range of 11.3–22.7 kg and was fed until the end of the experiment. Phase 1 diets were in pellet form and phase 2 and 3 diets were in meal form.

Pens of pigs were weighed and feed disappearance measured on days 11 and 27 post-weaning to determine ADG, ADFI, and G:F. Average daily feed intake represents feed disappearance from the feeder and feed placed on the mat for mat feeding. Removals and mortalities were recorded throughout the trial; however, mortality was not tracked on pigs after they were removed from the study. Pigs were removed based on animal caretaker discretion for welfare considerations (lameness, sick, or unthrifty) during daily observations.

Experiment 2

A total of 2,912 pigs [PIC sow × Duroc sire (PIC 800 or DNA 600), initially 5.5 kg], were used in a 37-d growth trial. All pigs were weaned at approximately 21 d of age and transported 2.5 h to the nursery facility. Upon arrival to the nursery, pigs were randomized to 1 of 96 pens (48 feeders). There was one pen of barrows and one pen of gilts per feeder. Thus, feeder (two pens) was the experimental unit. Feeders were then blocked by group (date of placement) and randomly allotted to 1 of 2 treatments with 60 to 64 pigs per feeder and 24 feeders per treatment. Treatments consisted of mat feeding vs. no mat feeding. Pens of pigs assigned to the mat feeding treatment group were provided one scoop of feed three times daily for 10 d post-placement. Mat feed was provided from a cart (not from the feeder) and the amount of feed applied was used to calculate total feed disappearance. Approximately 318 g of pelleted feed was provided at each feeding, totaling 9.5 kg of feed per feeder (divided amongst 2 pens; 148 to 158 g per pig). A single piece of Dura-Tuff solid flooring (46 × 61 cm; Southwest Agri-Plastics, Inc., Addison, TX) was installed directly into the plastic floor of nursery pens and used as the mat for mat feeding in this experiment.

Like exp. 1, nursery diets were fed in 3 different phases (Menegat et al., 2019) according to standard farm protocol. The phase 1 diet was provided at 1.8 kg per head and contained spray dried whey and enzymatically treated soybean meal. The phase 2 diet was provided at 5.4 kg per head and phase 3 was provided at 15.9 kg per head. Phase 1 diets were in pellet form and phase 2 and 3 diets were in meal form.

Pens of pigs were weighed and feed disappearance measured every 7 to 14 d to determine ADG, ADFI, and G:F. Like Exp. 1, ADFI represents feed disappearance from the feeder and feed placed on the mat for mat feeding. Removals and mortalities were recorded throughout the trial; however, mortality was not tracked on pigs after they were removed from the study. Pigs were removed based on animal caretaker discretion for welfare considerations (lameness, sick, or unthrifty) during daily observations.

Experiment 3

A total of 3,264 pigs (initially 5.5 kg) were used in a 37-d growth trial. The same genetic composition, weaning age, transportation duration, and allotment procedures were used as in exp. 2. Treatment structure differed such that feeders were randomly allotted to 1 of 4 treatments with 68 pigs per feeder and 12 feeders per treatment. Treatments were arranged in a 2 × 2 factorial with main effects of diet form [pellet (3.2 mm) or crumble] and mat feeding (mat feeding vs. no mat feeding). Crumble diets were manufactured by

processing the pelleted diet through a roller mill, which creates a mixture of mash and smaller pellets compared with strictly pelleted diets (Turner, 2014). Pens of pigs assigned to the mat feeding treatment group were provided one scoop of feed three times daily for 10 d post-placement. Like exp. 2, mat feed was provided from a cart (not from the feeder) and used to calculate total feed disappearance. An equal volume of pelleted and crumble feed was mat fed rather than an equal weight, resulting in approximately 318 g of pelleted or 372 g of crumble feed provided at each feeding, totaling 9.5 or 11.2 kg of feed per feeder (divided amongst 2 pens; 140 or 165 g per pig). A single piece of Dura-Tuff solid flooring (46 × 61 cm; Southwest Agri-Plastics, Inc., Addison, TX) was installed directly into the plastic floor of nursery pens and used as the mat for mat feeding in this experiment.

Diet composition and feed budgets were the same as in exp. 2. Diet form for phases 1 and 2 was based on pen treatment assignment where phase 1 diets were either in pellet or crumble form, phase 2 diets were either in meal or crumble form, and phase 3 diets were in meal form. Diet composition was the same regardless of feed form, and data were collected in a similar fashion to exp. 2.

Experiment 4

A total of 3,227 pigs (initially 5.1 kg) were used in a 14-d growth trial. The same genetic composition, weaning age, transportation duration, and allotment procedures were used as in exp. 2. Treatment structure differed such that feeders were randomly allotted to 1 of 3 treatments with 63–70 pigs per feeder and 16 feeders per treatment. Treatments consisted of mat feeding small (3.2 mm) pellets, mat feeding large (12.7 mm) pellets, or no mat feeding. Pens of pigs assigned to the mat feeding treatment group were provided two scoops of feed three times daily for 10 d post-placement. Like exp. 2, mat feed was provided from a cart (not from the feeder) and used to calculate total feed disappearance. Approximately 726 g of pelleted feed was provided at each feeding, totaling 21.8 kg of feed per feeder (divided amongst 2 pens; 311–346 g per pig). Two pieces of Dura-Tuff solid flooring (92 × 122 cm; Southwest Agri-Plastics, Inc., Addison, TX) were installed directly into the plastic floor of nursery pens. Providing mat feed on two pieces of solid flooring rather than one, as in the previous experiments, created a greater surface area for increased feed allowance.

Diet composition and feed budgets were the same as in exp. 2; however, only phase 1 diets in pellet form were fed because the trial ended on d 14 due to an outbreak of porcine respiratory and reproductive syndrome virus. Diet composition was the same regardless of feed form and pellet size, and data were collected in a similar fashion to exp. 2.

Data analysis

All data were analyzed on a closeout basis, such that pig removal weights were not used in the calculation for ADG but days prior to removal (pig days) were [(ending pen weight – starting pen weight) ÷ pig days]. Thus, removals and mortalities were assumed to be dependent on treatment.

For each experiment, data were analyzed as a randomized complete block design using the GLIMMIX procedure of SAS version 9.4 (SAS Institute, Inc., Cary, NC) with pen (exp. 1) or feeder (exp. 2, 3, and 4) as the experimental unit and treatment as a fixed effect. In exp. 1, source farm was considered a random effect. In exp. 2, 3, and 4, pig group (date of placement) was considered a random effect. A binomial model was used to determine removal and mortality rates for each experiment. Following individual analysis, data from all four experiments were combined and a binomial model was used to determine the overall effect of mat feeding on nursery pig removal and mortality rates. For the combined data, the main effect of mat feeding was used as a fixed effect and experiment as a random effect. All results were considered significant at $P \leq 0.05$ and a tendency at $0.05 \leq P \leq 0.10$.

Results

Experiment 1

From day 0 to 11 post-weaning, no differences ($P > 0.10$) in ADG, ADFI, or G:F (Table 1) were observed for the effect of mat feeding. Likewise, no differences in ADG or ADFI were observed from days 11 to 27; however, a tendency for improved G:F ($P = 0.084$) was observed for pigs that received mat feed compared to pigs that did not receive mat feed. Overall (days 0–27), mat fed pigs had a tendency for improved ADG ($P = 0.065$) and G:F ($P = 0.060$) compared to those not offered mat feed. No differences ($P > 0.10$) in ADFI were observed. Mat fed pigs had fewer removals ($P = 0.013$) compared to pigs not offered mat feed, but no differences ($P > 0.10$) in mortality were observed.

Table 1. Effect of mat feeding on the growth performance, removal, and mortality of pigs after weaning (exp. 1)[1]

	Mat feeding[2]		SEM	*P* =
	No	Yes		
Body weight, kg				
day 0	7.0	7.0	0.12	0.846
day 11	9.0	8.9	0.18	0.574
day 27	15.7	15.7	0.23	0.986
days 0–11				
ADG, g	114	136	11.4	0.145
ADFI, g[3]	208	211	7.9	0.641
G:F, g/kg	545	641	46.4	0.161
days 11–27				
ADG, g	410	418	5.7	0.264
ADFI, g	563	552	10.6	0.477
G:F, g/kg	730	758	11.1	0.084
days 0–27				
ADG, g	284	301	7.4	0.065
ADFI, g	413	410	8.5	0.801
G:F, g/kg	691	733	15.1	0.060
Removals, %	9.1	5.3	1.20	0.013
Mortality, %	0.3	0.5	0.29	0.654
Total, %[4]	9.5	5.9	1.20	0.023

[1] A total of 1,392 mixed sex pigs were used with 58 pigs per pen and 12 replicates per treatment.
[2] Treatment consisted of mat feeding vs. no mat feeding. Pens of pigs assigned to the mat feeding group were provided a scoop of feed from the back of the feeder (500 g) on a biodegradable mat three times daily for 6 d post-placement.
[3] Average daily feed intake represents feed disappearance from the feeder and feed placed on the mat for mat feeding. A total of 1,500 g of pelleted feed was applied to mat fed pens daily.
[4] Total = removals + mortality.

Experiment 2

From day 0 to 10 post-weaning, no differences ($P > 0.10$) were observed in ADG or G:F (Table 2); however, mat fed pigs had increased ADFI ($P < 0.001$) compared to pigs that did not receive mat feed. These results are likely in response to mat feed wastage. In contrast, from days 10 to 17, mat fed pigs had decreased ADFI ($P = 0.010$) and improved G:F ($P = 0.048$) compared to pigs not offered mat feed, with no differences ($P > 0.10$) in ADG. From days 17 to 39, mat fed pigs had decreased ADG ($P = 0.002$) and ADFI ($P = 0.028$) compared to pigs not offered mat feed, with no differences ($P > 0.10$) in G:F. Overall (days 0–39), no differences ($P > 0.10$) in growth performance were observed. However, mat fed pigs had decreased final body weights ($P < 0.026$) compared to pigs not offered mat feed, which may be related to removal rates. Mat fed pigs had fewer removals ($P = 0.026$) compared to pigs not offered mat feed, suggesting a greater percentage of light weight pigs remained on the mat-fed treatment. No differences ($P > 0.10$) in mortality were observed.

Table 2. Effect of mat feeding on the growth performance, removal, and mortality of pigs after weaning (exp. 2)[1]

	Mat feeding[2]			
	No	Yes	SEM	*P* =
Body weight, kg				
day 0	5.5	5.5	0.30	0.795
day 10	7.3	7.3	0.44	0.476
day 17	9.6	9.4	0.55	0.107
day 39	19.6	19.2	0.84	0.026
days 0–10				
ADG, g	139	144	19.0	0.442
ADFI, g[3]	168	181	8.9	<0.001
G:F, g/kg	812	790	87.4	0.492
days 10–17				
ADG, g	296	296	20.7	0.999
ADFI, g	455	434	12.5	0.010
G:F, g/kg	649	681	32.8	0.048
days 17–39				
ADG, g	468	457	14.3	0.002
ADFI, g	717	700	52.0	0.028
G:F, g/kg	661	661	36.1	0.999
days 0–39				
ADG, g	344	341	15.5	0.433
ADFI, g[3]	515	508	33.2	0.161
G:F, g/kg	672	676	29.4	0.456
Removals, %	5.6	3.8	1.93	0.026
Mortality, %	1.1	0.8	0.27	0.588
Total, %[4]	6.7	4.7	2.12	0.019

[1] A total of 2,912 mixed sex pigs were used with 60–64 pigs per feeder (2 pens) and 24 replicates per treatment.
[2] Treatment consisted of mat feeding vs. no mat feeding. Pens of pigs assigned to the mat feeding group were provided a scoop of feed from a feed cart (318 g) on a single 46 × 61 cm piece of DuraTuff solid flooring three times daily for 10 d post-placement.
[3] Average daily feed intake represents feed disappearance from the feeder and feed placed on the mat for mat feeding. A total of 954 g of pelleted feed was applied to mat fed pens daily.
[4] Total = removals + mortality.

Experiment 3

No significant interactions ($P > 0.10$) between diet form and mat feeding were observed; hence, only the main effects are provided in Table 3. From days 0 to 7 post-weaning, for the main effect of mat feeding, no differences ($P > 0.10$) were observed in ADG or G:F. However, mat fed pigs had increased ADFI ($P = 0.010$) compared to pigs that did not receive mat feed. From days 7 to 14, mat fed pigs had a tendency for improved ADG ($P = 0.097$) compared to pigs not offered mat feed, but no differences ($P > 0.10$) in ADFI or G:F were observed. A significant response was observed in ADG ($P = 0.020$) from days 14 to 21, with mat fed pigs having decreased gain compared to pigs not offered mat feed. No differences ($P > 0.10$) in ADFI were observed, thus a tendency for poorer G:F ($P = 0.068$) was observed for mat fed pigs. From days 21 to 28, no differences ($P > 0.10$) in ADG or ADFI were observed; however, mat fed pigs had improved G:F ($P = 0.005$) compared to pigs not offered mat feed. From days 28 to 35, mat fed pigs had decreased ADG ($P = 0.049$) compared to pigs not offered mat feed, with no differences ($P > 0.10$) observed in ADFI or G:F. Overall (days 0–35), no differences ($P > 0.10$) were observed in growth performance for the main effect of mat feeding. Although not statistically significant, a numeric difference was observed for total removals and mortalities, with mat fed pigs having 0.5 percentage points fewer removals and mortalities compared to pigs not offered mat feed.

From days 0 to 7, for the main effect of diet form, pigs that received pelleted feed had improved ADG ($P = 0.001$) and G:F ($P = 0.007$) compared to pigs that received crumble feed, with no differences ($P > 0.10$) observed in ADFI. From days 7 to 14, pigs that received pelleted feed had improved ADG ($P = 0.033$) and G:F ($P < 0.001$). This was driven by decreased ADFI ($P < 0.001$) compared to pigs that received crumble feed. From days 14 to 21, no differences ($P > 0.10$) in ADG were observed; however, pigs that received pelleted feed had decreased ADFI ($P < 0.001$) and improved G:F ($P < 0.001$) compared to pigs that received crumble feed. From days 21 to 35, no differences ($P > 0.10$) in growth performance were observed. Overall (days 0–35), no differences ($P > 0.10$) in ADG were observed for the main effect of diet form. However, pigs that received pelleted feed in the first two phases had decreased overall ADFI ($P = 0.013$) and improved G:F ($P < 0.001$) compared to pigs that received crumble feed. No differences ($P > 0.10$) were observed in removals or mortalities.

Experiment 4

From days 0 to 7 post-weaning, ADG and G:F were negative for all treatments (Table 4). Because data were analyzed on a closeout basis, poor performance in the first period was driven by high removal rates that mat feeding and pellet size were not able to overcome. Despite no differences ($P > 0.10$) in ADG and G:F, mat fed pigs, regardless of pellet size, had improved ADFI ($P < 0.001$) in the first period compared to pigs not offered mat feed. This response is likely a result of mat feed wastage, rather than improved feed intake. From days 7 to 14, mat fed pigs continued to have increased ADFI ($P < 0.020$) compared to pigs not offered mat feed. Mat fed pigs also had a tendency for improved ADG ($P = 0.085$). No differences ($P > 0.10$) were observed in G:F. Overall (days 0–14), no differences ($P > 0.10$) were observed in ADG or

Table 3. Main effect of diet form and mat feeding on post-weaning growth performance, removal, and mortality rates (exp. 3)[1]

Item	Diet form		SEM	*P* =	Mat feeding		SEM	*P* =
	Pellet	Crumble			No	Yes		
Body weight, kg								
day 0	5.5	5.5	0.05	0.968	5.5	5.5	0.05	0.905
day 7	6.3	6.1	0.22	0.004	6.2	6.2	0.22	0.703
day 14	8.3	8.0	0.11	< 0.001	8.1	8.2	0.11	0.648
day 21	10.5	10.2	0.20	< 0.001	10.4	10.4	0.20	0.746
day 28	13.4	13.1	0.26	0.004	13.2	13.3	0.26	0.704
day 35	17.1	17.0	0.46	0.157	17.1	17.0	0.46	0.871
days 0–7								
ADG, g	107	82	21.4	0.001	92	97	21.4	0.473
ADFI, g[3]	111	104	15.0	0.107	102	113	15.0	0.010
G:F, g/kg	960	753	124.0	0.007	865	848	124.0	0.819
days 7–14								
ADG, g	232	217	6.9	0.033	219	230	6.9	0.097
ADFI, g[3]	349	367	8.2	< 0.001	355	361	8.2	0.190
G:F, g/kg	665	593	12.1	< 0.001	618	639	12.1	0.228
days 14–21								
ADG, g	309	310	10.0	0.876	316	304	10.0	0.020
ADFI, g	454	477	13.5	< 0.001	469	462	13.5	0.227
G:F, g/kg	682	650	14.5	< 0.001	674	659	14.5	0.068
days 21–28								
ADG, g	401	403	28.5	0.809	397	407	28.5	0.153
ADFI, g	588	596	19.2	0.272	596	588	19.2	0.272
G:F, g/kg	682	676	33.9	0.490	665	692	33.9	0.005
days 28–35								
ADG, g	526	537	39.3	0.173	540	523	39.3	0.049
ADFI, g	780	794	39.5	0.162	792	783	39.5	0.332
G:F, g/kg	672	676	27.0	0.713	681	667	27.0	0.162
days 0–35								
ADG, g	311	306	15.1	0.121	309	309	15.1	0.983
ADFI, g[3]	450	461	18.7	0.013	456	456	18.7	0.855
G:F, g/kg	691	663	8.8	< 0.001	676	678	8.8	0.787
Removals, %	6.7	7.1	1.46	0.627	7.2	6.6	1.47	0.527
Mortality, %	0.7	0.5	0.22	0.468	0.5	0.6	0.21	0.731
Total, %[4]	7.4	7.7	1.34	0.774	7.8	7.3	1.35	0.571

[1]A total of 3,264 mixed sex pigs were used with 68 pigs per feeder (2 pens) and 12 replicates per treatment.
[2]Treatment consisted of a 2 × 2 factorial design with main effect of diet forms (pellet vs. crumble) and mat feeding (mat feeding vs. no mat feeding). Pens of pigs assigned to the mat feeding group were provided a scoop of feed from a feed cart (318 g pellet or 372 g crumble) on a single 46 × 61 cm piece of DuraTuff solid flooring three times daily for 10 d post-placement.
[3]Average daily feed intake represents feed disappearance from the feeder and feed placed on the mat for mat feeding. A total of 954 g of pelleted feed or 1,116 g of crumble feed was applied to mat fed pens daily.
[4]Total = removals + mortality.

G:F. However, mat fed pigs had increased ADFI ($P < 0.001$), regardless of pellet size, compared to pigs not offered mat feed. Given the shorter duration of this experiment, the extra feed provided with mat feeding had a greater impact on overall feed usage than was found in exps. 1, 2, and 3. Although not statistically significant ($P > 0.10$), numeric differences were observed in the total removals and mortalities for mat fed pigs compared to those not offered mat feed. Mat feeding small pellets numerically reduced the total removal rate by 2.1 percentage points compared to pigs that did not receive mat feed and 1.2 percentage points compared to mat feeding large pellets.

Experiments 1, 2, 3, and 4

When combining the removal and mortality data for the four experiments, mat fed pigs had fewer removals ($P = 0.002$) compared to pigs that did not receive mat feed (Table 5). No evidence for differences ($P = 0.50$) in mortality were observed.

Discussion

The combination of stressors that occur at weaning often result in compromised intestinal structure and function (Kelly et al., 1991; McCracken et al., 1999; Moeser et al., 2006; Wijtten et al., 2011; Moeser, 2017), which has been shown

Table 4. Effect of mat feeding and pellet size on post-weaning growth performance, removal, and mortality rates (exp. 4)[1]

	Mat feeding[2]				*P* =
	Control	3.2 mm pellet	12.7 mm pellet	SEM	
Body weight, kg					
day 0	5.1	5.2	5.1	0.09	0.822
day 7	5.5	5.5	5.5	0.14	0.623
day 14	6.8	7.0	6.9	0.26	0.313
days 0–7					
ADG, g	−9.5	−7.4	−6.7	17.44	0.950
ADFI, g[3]	85[b]	117[a]	121[a]	7.3	< 0.001
G:F, g/kg	−154	−88	−86	182.7	0.736
days 7–14					
ADG, g	140	168	176	18.3	0.085
ADFI, g[3]	264[b]	287[a]	294[a]	24.5	0.022
G:F, g/kg	531	567	605	48.9	0.453
days 0–14					
ADG, g	58	73	75	16.7	0.186
ADFI, g[3]	166[b]	194[a]	200[a]	17.4	< 0.001
G:F, g/kg	348	354	366	70.7	0.933
Removals, %	14.1	11.8	13.1	2.22	0.267
Mortality, %	0.09	0.28	0.19	0.162	0.720
Total, %[4]	14.2	12.1	13.3	2.19	0.329

[1]A total of 3,227 mixed sex pigs were used with 63–70 pigs per feeder (2 pens) and 16 replicates per treatment. Trial was cut short due to PRRS outbreak.
[2]Treatment consisted of mat feeding small (3.2 mm) pellets, mat feeding large (12.7 mm) pellets, or no mat feeding. Pens of pigs assigned to the mat feeding group were provided two scoops of feed from a feed cart (726 g) on two 46 × 61 cm pieces of DuraTuff solid flooring three times daily for 10 d post-placement.
[3]Average daily feed intake represents feed disappearance from the feeder and feed placed on the mat for mat feeding. A total of 2,178 g of pelleted feed was applied to mat fed pens daily.
[4]Total = removals + mortality.
[a,b,c]Means lacking common superscript differ by $P < 0.05$.

Table 5. Overall effect of mat feeding on the removal and mortality rate of pigs post-weaning (exps. 1–4 combined)[1]

	Mat feeding[2]			*P* =
	No	Yes	SEM	
Removals, %	8.6	7.0	1.83	0.002
Mortality, %	0.5	0.5	0.18	0.960
Total, %[3]	9.3	7.7	1.69	0.003

[1] A total of 10,795 mixed sex pigs were used with 58–70 pigs per experimental unit and 12 (exp. 1), 24 (exp. 2), 12 (exp. 3), or 16 (exp. 4) replications per treatment.
[2] In exps. 1 and 2, treatments consisted mat feeding vs. no mat feeding. In exp. 3, treatments were arranged in a 2 × 2 factorial with main effects of diet form (pellet or crumble) and mat feeding (mat feeding vs. no mat feeding). In exp. 4, treatments consisted of mat feeding small (3.2 mm) pellets, mat feeding large (12.7 mm) pellets, and no mat feeding. In exp. 1, mat feeding was provided 3 times per day for 6 d post-placement. In exps. 2–4, mat feed was provided 3 times per day for 10 d post-placement.
[3] Total = removals + mortality.

to suppress the pigs innate immune system (McLamb et al., 2013) . Data by Pohl et al. (2017) have also shown that intestinal barrier defects and alterations in immune activity because of weaning can persist into later life. In practice, this may lead to poorer lifetime performance. However, research is needed to understand the potential growth implications of stress post-weaning. Furthermore, chronic or re-occurring stressors have also been linked to a hyperactive gut-brain axis in humans (Kelly et al., 2015), resulting in increased anxiety. If applicable to pigs, this could potentially influence or further delay the pigs' decision to search out and begin consuming feed after weaning, particularly if they have not previously been exposed to solid feed.

Short-term feed deprivation (24–72 h) has been shown to alter the endocrine response of weanling pigs, affecting their ability to regulate neuroendocrine hormones associated with feed intake homeostasis (Salfen et al., 2003). While the eating activity of newly weaned pigs increases over the first 3 d post-weaning (Corrigan, 2000), intake in the first 24-h is often less than 100 g (Bruininx et al., 2001). Consequently, there remains a portion of pigs that do not consume feed until 40-h post-weaning (Bruininx et al., 2001). Hence, strategies to minimize stress and improve feed intake after weaning have become increasingly important. Among the available strategies commonly used, mat feeding is thought to stimulate the development of natural feeding behaviors, such as foraging, leading to greater feed consumption.

Mat feeding has been shown to increase the eating behavior of pigs in the first 24-h after weaning (Corrigan, 2000). This may explain the decreased removal rates observed in the experiments reported herein. In agreement, Corrigan et al. (2000) also showed that mat feeding (supplemented feed placed on mat and in feed trough) for 4 d post-weaning decreased morbidity over the first 3 weeks after weaning compared to trough feeding (supplemented feed placed in feed trough only). However, mat fed pigs spent more time eating at the mat and less time eating at the feeder compared to pigs that were not provided mat feed (Corrigan et al., 2000). It may be possible that mat feeding for extended durations (> 3 d) distracts pigs from consuming feed at the feeder. Nonetheless, the 4–10 d difference in mat feeding durations between the experiments reported herein and by Corrigan et al. (2000), consistently resulted in decreased removal rates. Furthermore, with no peer reviewed data available on different mat feeding durations, the optimal duration in which mat feed should be provided cannot be concluded. However, mat feeding for more days will likely increase feed wastage, thus duration should be considered in future experiments.

Similar to the results herein, previous reports by Corrigan et al. (2000) showed that mat feeding had no effect on the ADG of nursery pigs, regardless if gruel or dry pellets were used as the source of mat feed. Corrigan et al. (2000) also observed increased feed disappearance, which commonly resulted in poorer feed efficiency. Hence, the results of these studies indicate that the value of mat feeding is not in improved growth performance, but rather in reduced removal and mortality rates. This response may be less related to mat feeding and more closely related to caretaker activity in the pen. In the process of mat feeding, animal caretakers enter pens and interact with pigs' multiple times a day, therefore, encouraging pigs to get up more frequently.

Although there are limited published data on the effect of crumble diets in pigs post-weaning, the improved feed efficiency observed in exp. 3 when pigs were provided pelleted diets agrees with previous literature (De Jong et al., 2014; Nemechek et al., 2015; Ulens et al., 2015). Crumble diets are typically manufactured

by crumbling pelleted diets, which has the potential to create a disproportionate blend of pellets and mash, therefore making it easier for pigs to sort through the diet. This may explain the poorer feed efficiency response observed in pigs fed crumble diets compared to pellets. Data on pellet quality indicates that minimizing the percentage of fines in pelleted diets is necessary to achieve improved feed efficiency (Nemechek et al., 2015). In addition to diet form and pellet quality, research shows that young pigs prefer pellets with a larger diameter (12 mm) compared to smaller pellets (2 mm; van den Brand et al., 2014). However, it appears that improvements in ADG and feed intake post-weaning are observed only when pigs are exposed to large, pelleted creep feed prior to weaning, rather than post-weaning (van den Brand et al., 2014; Craig et al., 2021). This is likely a result of increased creep feed intake pre-weaning. This also may explain why there was no response to pellet size in exp. 4, indicating that pellet size is more crucial when creep feeding rather than in nursery starter diets.

In summary, mat feeding had limited effects on the growth performance of pigs; however, mat feeding strategies may encourage natural feeding behaviors, therefore eliciting early feed intake and reducing the removal rate of pigs post-weaning. It is important to note that mat feeding will likely increase feed wastage so care should be taken to determine the appropriate duration of mat feeding and should largely be driven by pig need (i.e. age and health status). Lastly, the results of exp. 3 indicate that pelleted feed helps improve the feed efficiency of weanling pigs compared to crumble feed. However, it appears that both feed forms can be mat fed and have the same outcome on pig removal and mortality rates.

Supplementary Data

Supplementary data are available at *Journal of Animal Science* online.

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Conflict of Interest Statement

The authors declare no conflict of interest.

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