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Growth performance of segregated early-weaned versus conventionally weaned pigs through finishing

Steven D. Drum, DVM, MS; Roger D. Walker, PhD; William E. Marsh, PhD; Martha M. Mellencamp, PhD; Vickie L. King, PhD

Summary

Objective: To measure growth performance differences between segregated early-weaned (SEW) and conventionally weaned (CW) littermates to slaughter, and to investigate the effects of immunostimulation from vaccination on SEW pigs compared to CW pigs.

Methods: One hundred ninety-two pigs from 24 litters were systematically assigned to either a segregated early-weaning treatment (SEW) or a conventional-weaning treatment (CW). All pigs were weighed at birth and injected intramuscularly (IM) with 0.5 mL oxytetracycline at 200 mg per mL, and on day 10 with 1.0 mL oxytetracycline at 200 mg per mL. SEW pigs were weaned at 10 days of age and moved to an offsite nursery. CW pigs were cross-fostered to maintain litter sizes, weaned at 24 days of age, and moved to a similar onsite nursery. Pigs in both the SEW and CW pens were allocated either to a vaccination treatment (VAC) or a control treatment (CON). VAC pigs were given four injections of commercially prepared inactivated, adjuvented cattle vaccines on days 37 and 51; CON pigs received sterile saline injections on the same days. Pigs were weighed and feed disappearance recorded on a weekly basis through the nursery phase (day 56). On day 56, pigs were moved to a research finishing facility where SEW and CW pigs were housed in separate but identical finishing facilities. All feed disappearance throughout the finishing phase was recorded and pigs were weighed on days 100, 129, and at slaughter.

Results: At the end of the nursery phase, SEW pigs were heavier than CW pigs ($P<.0001$). During the last 4 weeks of the nursery phase, SEW pigs had a higher average daily gain (ADG) than CW pigs ($P<.0001$). However, ADG was lower in SEW pigs compared to CW pigs during the weeks of vaccination ($P<.0001$), and a higher feed:gain (F:G) ratio was observed during the first week of vaccination ($P=.0022$). In the finisher, we observed no effect of vaccination ($P>.43$) or weaning treatment on ADG. Feed:gain ratios for the last 4 weeks of the nursery were lower in SEW pigs than in CW pigs ($P<.05$), and there were no differences in F:G in the finisher ($P>.40$). There was no detectable difference in adjusted days-to-109 kg for SEW and CW males ($P=.9893$), while CW females had lower adjusted days-to-109 kg than SEW ($P=.0067$).

Implications: Our data indicate that SEW pigs weigh more at the end of the nursery phase, but did not maintain that advantage through finishing. Vaccination momentarily slows growth of SEW nursery pigs, but the effect disappears in finishing.

Keywords: swine, segregated early weaning, vaccination, finishing

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Attempts to improve nursery pig performance using medication, early weaning, and isolation strategies alone or in combination are now widespread in the United States swine industry.[1-4] Medicated early weaning (MEW), modified medicated early weaning (MMEW), and segregated early weaning (SEW) have each been observed to improve health and performance in the nursery production phase.[5,6] However, because it is difficult to keep SEW pigs in finishing facilities segregated from but identical to those of CW pigs, there is little published information to compare the performance of SEW and CW pigs throughout the entire growth phase from weaning to slaughter. Segregated early-weaned pigs may contract diseases from CW pigs and suffer more disease than CW pigs, thereby confounding performance differences.[7]

In addition to early-weaning technologies, other disease control methods are necessary in some herds. Perhaps easiest to implement is vaccination. Vaccination, however, comes at a price in terms of labor, materials, and possible lost production from immunostimulation.[8] In order to maximize profits, it is important to know the least-cost disease control method for each herd. Different herds may opt for different methods of control depending on circumstances. For producers contemplating management changes, having estimates of the costs and benefits for each outcome will facilitate decision making.

The objective of the present study was to follow SEW and CW littermates through similar nurseries and identical finishing facilities to investigate growth parameters from weaning to market, and to investigate the effects of immunostimulation on these pigs. This preliminary study was intended to develop protocols to guide the design and conduct of statistically more powerful larger-scale trials in the future.

SDD: 609 South Cleveland, Remsen, Iowa 51050, E-mail: drum@nwidt.com; RDW, WEM, MMM, VLK: University of Minnesota

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Materials and methods

Preweaning procedure

Thirty-one litters from the research herd at the University of Minnesota Southern Experiment Station were used in this study. The genetics of this herd were Yorkshire x Landrace sows mated to Duroc boars. Pigs were chosen from 24 litters that farrowed within 4 days of each other. Consequently, pig ages stated in this paper are days of age +/- 2 days. At birth (day 0), all piglets were individually identified, weighed, and injected intramuscularly (IM) with oxytetracycline (0.5 mL of 200 mg per mL) (Figure 1). Cross-fostering and other standard management practices were implemented and pig movements were recorded.

Pigs were weighed on day 7 and randomly allocated to

- () segregated early weaning (SEW; n=96) or
- () conventional weaning (CW; n=96)

treatment groups by weight, litter, and sex. Within each litter, barrows and gilts were weighed separately and were allotted to SEW or CW treatments based on decreasing day-7 weights. After weighing, all pigs were returned to their nursing litters.

Pigs were weighed again on day 10 and received a second IM injection of oxytetracycline (1 mL at 200 mg per mL). Pigs in the SEW groups were weaned on day 10 and transported 0.5 miles (0.8 km) to the SEW isolation nursery. The remaining (CW) nursing pigs were cross-fostered to maintain prior litter sizes. Consequently, some of the sows were weaned.

SEW pigs in the isolation nursery and nursing CW pigs were weighed on day 14 and day 21. CW pigs (n=96) were also weighed on day 24 and moved into the CW onsite nursery immediately post weighing.

Vaccination

To assess the effects of immune stimulation on growth performance of SEW pigs, one-half of the SEW group and one-half of the CW group were each assigned to a vaccination (VAC) treatment; the other half of each group served as controls (CON).

Pigs were randomly allocated to pens based on sex and day-35 weights such that each treatment group had nearly equal average pen weights and numbers of barrows and gilts. Vaccinations were given on days 37 and 51. CON pigs were handled similarly and injected with sterile saline on days 37 and 51.

VAC pigs were injected with commercially available cattle vaccines (Table 1). Cattle vaccines were used because:

- () inactivated (killed) vaccines prevent the possibility of microbial shedding that may occur with modified-live vaccines;
- () cattle vaccines do not induce protection against swine pathogens; thus, performance degradation from immune stimulation would not be confounded by protection from swine diseases;
- () commercially available vaccines would simulate antigenic and endotoxin challenges swine routinely face when vaccinated with commercial vaccines.

Phase I: Nursery

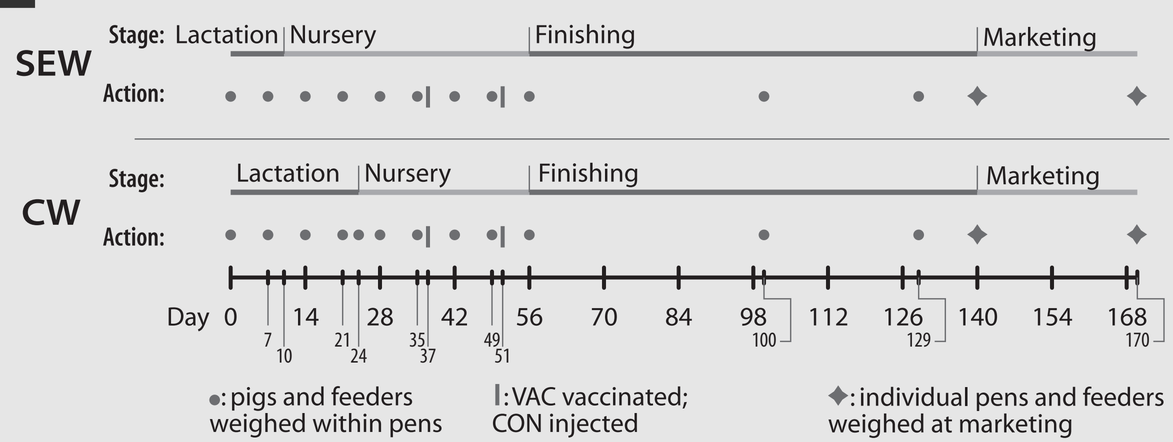
Procedure

SEW pigs were housed in a two-room Double L(TM) portable nursery owned by the Minnesota Pork Producers Association (MPPA). Each room contained 10 pens. Six pigs per pen were housed in 4 x 4 ft (1.2 x 1.2 m) pens. Pigs were allowed 2.6 ft^2 (0.24 m^2) per pig. Flooring was slotted plastic, and equipped with four-hole conventional stainless-steel fenceline feeders. Pigs were systematically assigned to pens based on weight. Care was taken to ensure that no more than two littermates were assigned to each pen.

CW pigs were housed in the onsite nursery. This nursery is a free-standing structure adjacent to breeding, farrowing, and finisher buildings. Eight pigs were placed in each of the 12 pens, allowing 2.5 ft^2 (0.23 m^2) per pig, which approximated the space allowance of SEW pigs. Flooring was vinyl-covered expanded metal. Pens were equipped with six-hole conventional fenceline stainless-steel feeders. Pigs were assigned to pens in this nursery in a similar manner as the SEW group pigs, based on day-24 weights.

Labor for the onsite nursery was provided by personnel who also had responsibilities for other stages of swine production. Biosecurity mea-

Figure 1



Study timeline

Table 1

Vaccination regimen

Vaccine	Composition
Triangle® 3V5L (Fort Dodge Labs)	Inactivated, killed adjuvanted infectious bovine rhinotracheitis, bovine virus diarrhea, parainfluenza virus, *Campylobacter fetus, Leptospira canicola, L. grippotyphosa, L. hardjo, L. icterohaemorrhagiae*
Somnu Shield™ (Grand Labs)	Killed adjuvenated *Hemophilus somnus*
Fermicon® CD/T (BioCeutic)	Killed adjuvenated *Clostridium perfringens* types C and D
Scourguard 3® (K) (Pfizer)	Inactivated, killed adjuvenated *Escherichia coli*, bovine rotavirus, and bovine coronavirus

sures were not instituted for the onsite nursery. In the SEW nursery, separate labor was used without any other pig care responsibilities in order to maintain biosecurity.

Nutrition

All pigs were placed on a commercial four-phase nursery diet regimen (Nutrena feed division, Cargill, New Richland, Minnesota) (Table 2). Pigs were fed the four-phase diets based on average pen weights. Pigs were switched to the next diet phase as the average pen weight approached the weight break recommended by the manufacturer. Phase 1 and 2 diets contained apramycin (150 g per ton) and phase 3 and 4 diets contained carbadox at 50 g per ton. Because some CW pigs began their nursery period on the phase-3 diet, a small amount of the phase-3 diet contained apramycin at 150 g per ton to ensure that all pigs received the medication.

Weight

All pigs were weighed individually at weekly intervals throughout the nursery stage. Feed was weighed when it was placed in the feeders, and the feeders were weighed weekly at the same time as the pigs in order to accurately determine weekly feed disappearance. The weight of pigs that died or were removed (n=8) were recorded as well as the weights of the penmates and feeder.

Table 2

Nursery diet

Phase	Reccommended weight kg(l.)	% Crude protein	% Lysine	Diet type
1	<5.5 (<12)	23.0	1.75	Complex
2	5.5–6.8 (12–15)	23.0	1.55	Complex
3	7.3–11.4 (16–25)	21.0	1.30	Simple
4	11.8 (26) to exit	19.0	1.20	Simple

Phase II: Finishing

Procedure

Capacity in the finishing facilities differed from that of the nurseries. Therefore, on day 57, 80 pigs from each of the SEW and CW groups from Phase I of the trial were randomly selected and moved to the finishing facility at the MPPA Swine Test Station (New Ulm, Minnesota). Both SEW and CW group pigs were blocked on vaccination subset status and assigned to pens systematically by sex and by day-56 weight to ensure that beginning pig weights were uniform within pens. SEW and CW pigs were transported in separate clean, disinfected trailers on the same day.

SEW and CW pigs were housed separately in identical rooms of the finishing facility. This building is H-shaped, with the main sections running north to south. Each wing has two rooms, and a large storage room interconnects the two wings at the midpoint. SEW pigs were housed in the northwest room of the facility and the CW pigs in the northeast room, so that SEW pigs were upwind according to the prevailing winter wind direction. The storage room connecting the two wings was sealed from the inside with heavy-gauge plastic sheeting to eliminate direct air flow between wings.

Phase II pigs were placed four to a pen in 20 pens in this finishing facility. Pens were 5 x 11 ft (1.5 x 3.4 m), allowing 13.75 ft^2 (1.3 m^2) per pig. The concrete flooring was bedded with wood shavings. Manure was scraped manually from the pens and removed from the building by a mechanical gutter cleaner. Each pen contained identical single-hole feeders. Not all feeders had lids, so care was taken to ensure gilt pens had feeders with lids to prevent them from accidentally fouling the feed.

The station manager began each day in the SEW wing, and then went to care for the CW pigs. He did not return to the SEW wing until after showering and changing clothes. Separate sets of foot baths, boots, and coveralls were maintained in each wing for the respective groups. Investigators followed the same protocol when visiting the unit to take measurements and record data.

Nutrition

Barrows and gilts were fed a separate-sex, four-phase commercial pelleted corn/soy finishing regimen (Cargill) (Table 3). Diet phases were switched as the average pen weight approximated the recommended starting weight for the next phase. All bags of feed were individually weighed and marked prior to use, and the weight was recorded when rations were placed in individual pen feeders. All pigs, feeders, and contents were individually weighed on day 97 and day 125 to determine feed disappearance. Pigs, feeders, and feeder contents were also weighed on days when diet phases were switched in each pen.

Table 3

Finishing diet

Bodyweight (kg [lb])		% Crude	
Barrows	Gilts	protein	% Lysine
22.7–45.4 (50–100)	22.7–56.7 (50–125)	16.35	1.03
45.4–68.0 (100–150)	56.7–79.4 (125–175)	15.04	0.88
68.0–90.7 (150–200)	79.4–102.4 (175–225)	13.63	0.79
90.7–108.0 (200–240)	79.4–108.9 (225–240)	12.86	0.69

Statistical analysis

All data except days-to-109 kg (240 lb) were analyzed using repeated-measures ANOVA with the GLM procedure (SAS, Cary, North Carolina). Days-to-109 kg was analyzed using an ANOVA. The experimental unit for all variables was the pen--pigs were weighed individually but averaged for analysis. The treatment design was a 2 x 2 x 2 factorial. Contrasts were used to make comparisons of interest (VAC versus CON, SEW versus CW, SEWVAC versus SEWCON, SEWVAC versus CWVAC, and CWCON versus CWVAC).

Average daily gain (ADG) and feed:gain (F:G) were analyzed for only the last 4 weeks of the nursery phase to avoid the potentially confounding variables among treatment groups (i.e., different weaning day, different diet, cross-fostering, etc.), which prevented valid comparison during the first 28 days.

Results

SEW versus CW

Pig weights

SEW pigs were significantly heavier than CW pigs throughout the nursery period (*P*=.0023), with individual differences observed on days 35, 42, 49, and 56 (*P*<.01) (Figure 2). On day 56, SEW pigs were 17% heavier than CW pigs (*P*<.0001). A significant linear interaction between SEW and time was observed (P<.0001).

At the beginning of the finishing phase, Phase II SEW pigs weighed more than Phase II CW pigs (*P*<.0003). However, the weight advantage of SEW over CW pigs was significantly diminished by day 100 (*P*=.0974) and had vanished by day 129. As expected, males grew faster than females throughout the finishing phase (*P*<.05).

Average daily gain

Although during the last 4 weeks of the nursery period, the ADG of SEW pigs was significantly higher than that of CW pigs (*P*<.0001), we observed no difference in ADG between SEW and CW pigs throughout the finisher phase (Figure 3).

Feed:gain ratio

During the last 4 weeks of the nursery period, SEW pigs required less feed per unit gain than CW pigs (1.50 versus 1.67, respectively; *P*<.05) (Figure 4). Throughout the finishing period, however, there were no significant differences in F:G between SEW and CW pigs (*P*>.40).

Days-to-109 kg

As expected, barrows reached 109 kg (240 lb) earlier than gilts (*P*=.0001). SEW and CW males showed no significant difference in time to reach 109 kg (*P*=.9893). However, days-to-109 kg was significantly longer for SEW females than for their CW counterparts (*P*=.0067) (Figure 5). About 40% of the SEW and CW gilts reached 109 kg at the same time. These were the faster-growing gilts that attained 109 kg at or before 150 days of age. After 150 days of age, the growth rates of the SEW and CW gilts diverged, resulting in the SEW gilts reaching 109 kg significantly later than the CW gilts.

VAC versus CON

Pig weights

Vaccinations administered on days 37 and 51 had no effect on weight of SEW or CW pigs (*P*>.24). Vaccinations, given in the nursery phase, did not significantly affect body weight during the finishing period (*P*>.43), nor were any treatment x vaccination interactions detected during the finishing phase (*P*>.40).

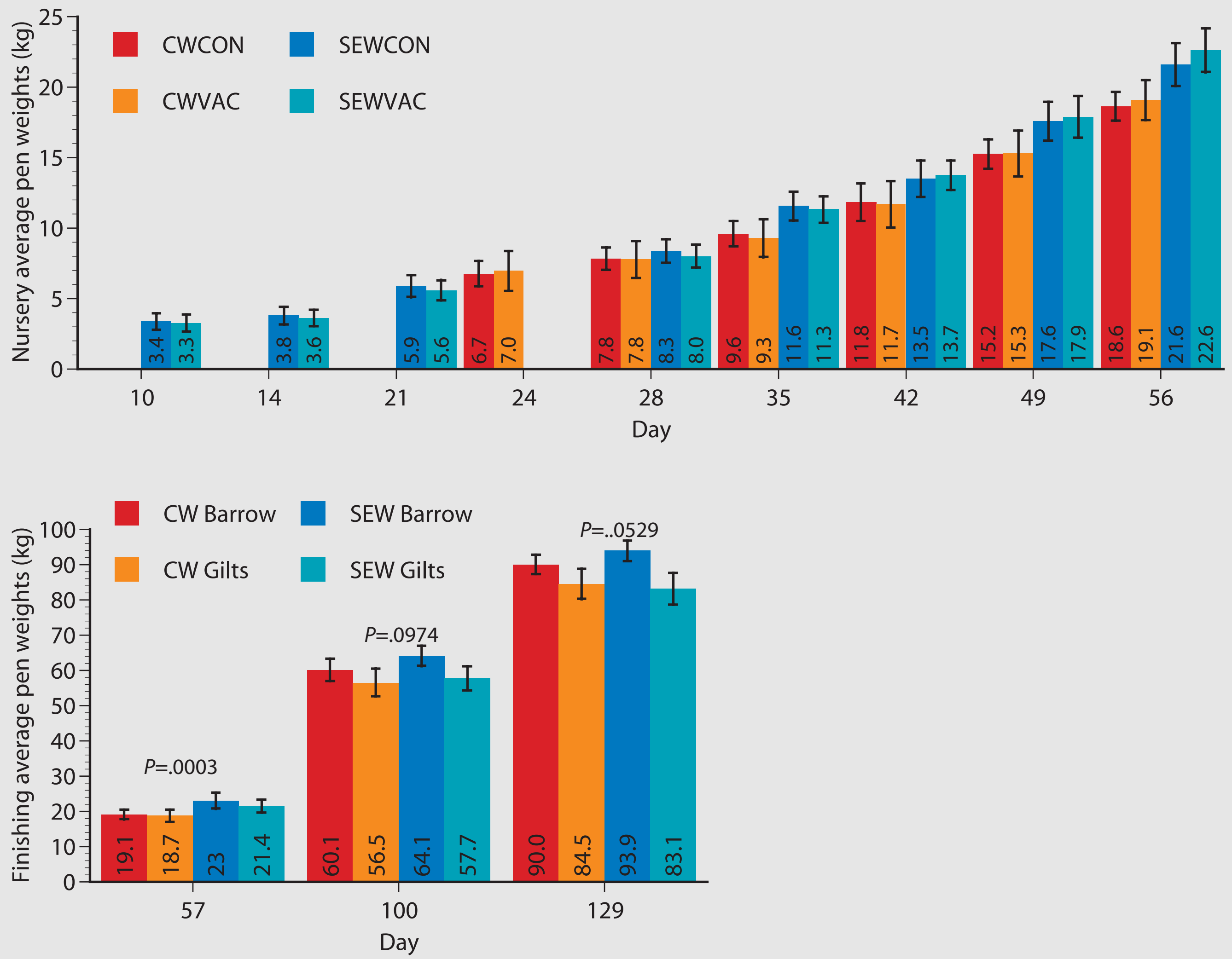
Average daily gain

Vaccination did not affect ADG for CW pigs, as shown by lack of differences in ADG of CWVAC and CWCON pigs in weeks 6-8 (*P*>.16). However, ADG was significantly reduced in SEWVAC pigs during the week of the initial vaccination (week 6) compared to SEWCON pigs (*P*<.01) (Figure 3). After the initial vaccination in week 6, SEWVAC pigs had significantly reduced ADG compared with CWVAC (*P*<.0001); ADG of the SEWVAC pigs recovered to the values for SEWCON pigs within 1 week (days 42-49, *P*>.12). A second reduction in ADG was observed in SEWVAC pigs after the day-51 booster (*P*=.0098) compared to SEWCON pigs. Throughout the finisher phase, we observed no effect of vaccination (*P*>.39) on growth performance, and no interactions of vaccination with other treatments (*P*>.42).

Feed:gain ratio

Averaged over the last 4 weeks of the nursery period, vaccination did not influence F:G in SEW or CW pigs (*P*>.25). However, vaccinated

Figure 2



Comparison of mean weights between CW and SEW pigs

SEW pigs needed more feed per unit of gain than nonvaccinated SEW pigs during the week after the first vaccination (day 37) (*P*=.0022) (Figure 4). Throughout the finishing period, vaccination had no effect on F:G.

Days-to-240 lb

Vaccination had no effect on the number of days to 109 kg.

Discussion

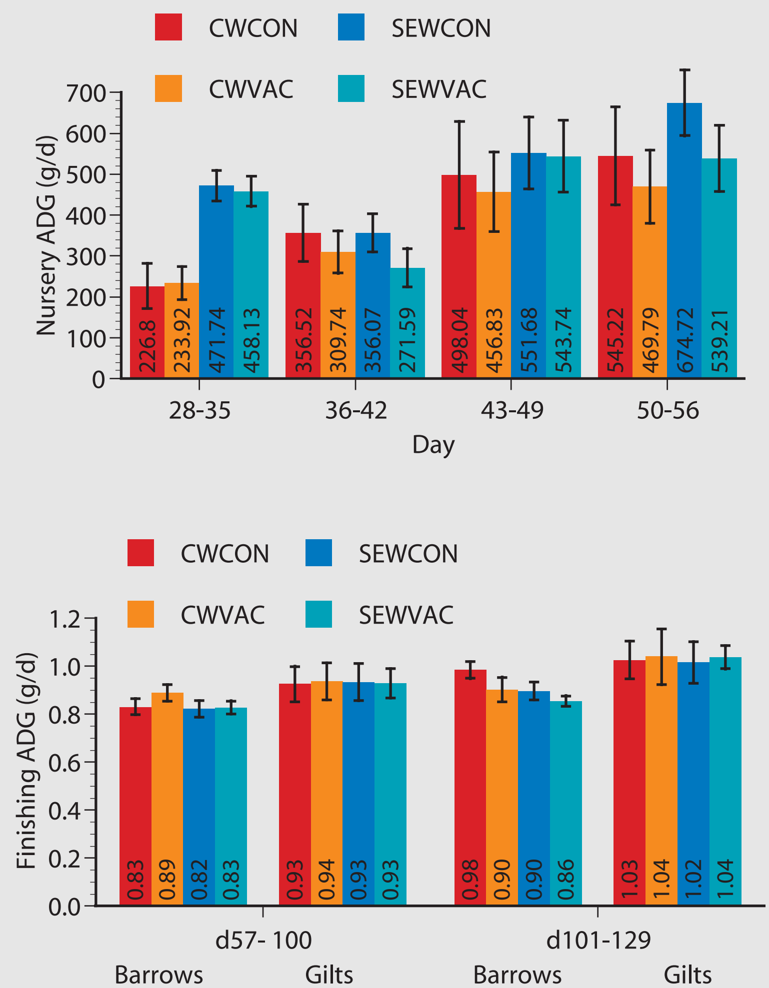
The finisher phase of the trial allowed us to segregate both SEW and CW pigs, so that the SEW pigs were reared on three sites with segregation in the nursery and grow-finish units and the CW pigs were reared on two-sites with segregation in the grow-finish unit only. Thus, our comparison of grow-finish performance can be characterized as a comparison of a three-site system to a two-site system with the nursery and sow units on one site and the grow-finish unit on the other. Unfortunately, the capacity of the finisher site only allowed one replication in time, so the data presented here represent only a single replication; thus, limited conclusions can be drawn from the observations made in this study. Our observations can, however, suggest future research directions.

The day-56 difference in weight between the SEW and CW pigs is consistent with results obtained in previous SEW studies conducted within this research facility.[7] In these studies, SEW pigs were observed to have a 15%-20% growth advantage over CW pigs in the nursery production phase.

It is not clear why the SEW gilts in our study reached 109 kg (240 lb) later than CW gilts. Since SEW and CW barrows reached 109 kg at a similar rate, we would expect the gilts to do the same. Because only one replicate was included in the present study, it is not possible to draw any conclusions about this unexpected finding.

It appears that vaccination temporarily retarded growth in the SEW pigs, but they recovered and no effect of vaccination was evident in the grow-finish phase of the trial; thus the setback in weight gain in the

Figure 3



Comparison of average daily gain between CW and SEW pigs

vaccinated pigs appears to have been a short-term effect. In previous experiments with pigs and other species, it has been shown that antigenic challenge and subsequent cytokine production slows growth.[9,10] Cytokine production and the associated immunological changes in the metabolism in response to vaccination are energy-intensive processes; thus, the slower growth we observed during immunologic challenge was not unexpected.

The preliminary observations we made in this study suggest that the benefits of SEW observable during the nursery phase may disappear during the finishing phase. It also suggests that vaccination, which can be costly in terms of expense and labor, may not result in a lasting detriment to growth performance. Although further research is required to adequately test these hypotheses, if a herd is in relatively good health, our study raises the possibility that strict segregation in the grow-finish phase may be all that is needed to assure good growth performance from birth to market.

Implications

- () SEW-like performance was achieved by segregation of CW pigs only in the finisher phase.
- () For pork producers considering changing their swine operation to a three-site system, segregation of the finisher unit and strict adherence to isolation procedures should be the first step, and may be all that is needed to improve growth performance.

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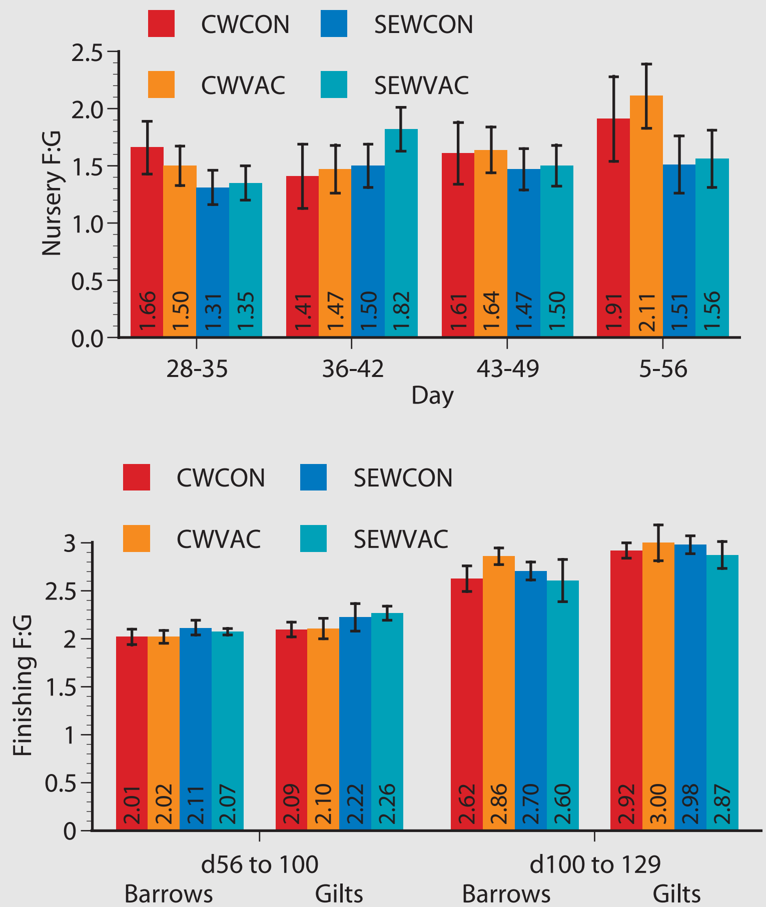
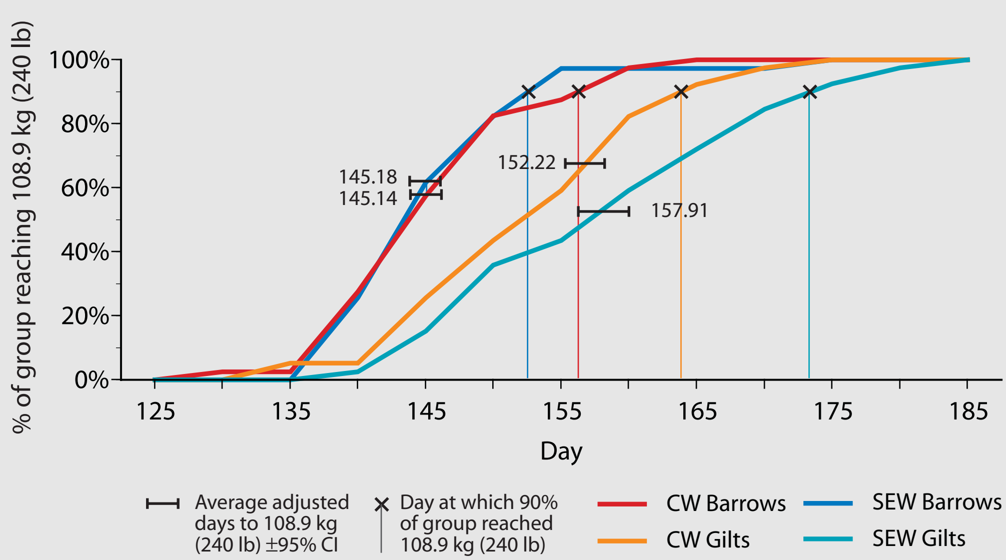
Figure 4



Comparison of feed:gain between CW and SEW pigs

Figure 5



Comparison of average adjusted days-to-109-kg (240 lb) for CW and SEW pigs

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