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ABSTRACT

Two hundred and sixteen pigs were weaned at 14 or 21 d of age to determine the effect of weaning age and commingling after the nursery phase on growth and behavior of pigs in a wean-to-finish facility. Pigs were divided into older and younger age groups and allotted 12 pigs/pen with nine replications of each group. At the end of the nursery phase (d 34 after weaning), one-half of the pigs in each group were removed and commingled for the grower/finisher phase and the other half remained in their original pens. Beginning at weaning (d 0), pigs were monitored via camera surveillance following weaning, commingling, and on d 65 after weaning. While in the nursery phase, older pigs had greater gain and feed intake than younger pigs, however, younger pigs were more efficient throughout the nursery phase than older pigs. Toward the end of the grower/finisher period, younger pigs had greater gain, feed intake, and gain:feed than older pigs and reached a common weight 4 d sooner. Younger pigs spent more time standing or moving during the nursery phase than older pigs. Immediately following commingling, the younger, unmixed pigs spent more time feeding. However on d 65 after weaning, the older, commingled pigs and younger, unmixed pigs spent more time feeding than older, unmixed pigs and younger, commingled pigs. In conclusion, younger pigs grew slower than older pigs during the nursery phase; however, younger pigs gained more during the finishing period. Additionally, weaning age and commingling influenced feeding behavior during the grower/finisher period.

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MEET THE STUDENT-AUTHOR

Sarah C. Arthur

I am a 2001 graduate of Springdale High School where I was active in National Future Farmers of America. I raised and showed all types of livestock, including sheep, chickens, horses, and rabbits, for local and state-level competitions. With my experience in livestock production, I began my undergraduate career at the University of Arkansas in fall 2001 and began to pursue my degree in the Department of Agricultural and Extension Education, studying agricultural education and communication. At that time, I began working at the Swine Research Facility in Savoy and in the Swine Nutrition Laboratory for Dr. Charles Maxwell in the Department of Animal Science. While working in the Department of Animal Science, I have worked on several swine nutrition and immunology research trials and gained valuable skills such as cell culture techniques and immunological assay procedures. In 2002, I applied for a Dale Bumpers Undergraduate Research Grant and later that year I began working on this project. With the help of Dr. Maxwell and Dr. Jason Apple I have developed an interest in this field of study and plan on pursing a career in the swine industry upon graduating in fall 2005.

INTRODUCTION

Pigs produced in conventional intensively managed swine production systems are routinely weaned as early as 21 d of age and as early as 10 to 14 d of age in off-site segregated early weaning systems. The industry average weaning age is about 17 d. Although there are no restrictions on weaning age in the U. S., the practice of weaning at an age earlier than 21 d is discouraged in some countries and prohibited in others. Recent studies have shown that early-weaning and removal of pigs to an isolated site for rearing can reduce the potential for disease transfer from the dam. Pigs reared in isolation after weaning have been reported to have reduced immunological stress (Johnson, 1997), resulting in a substantial improvement in growth and efficiency of feed utilization compared with those reared in conventional farrow-to-finish systems (Williams et al., 1997). Similarly, commingling pigs following the nursery phase is a common management practice in the swine industry, and imposes an additional social stress upon the young pig. The advent of wean-to-finish facilities has potentially alleviated commingling after the nursery phase. However, the wasted space of placing weanling pigs in pens with space allowances for market hogs has led to the practice of double-stocking pens at weaning and later moving half of the pigs to another pen (DeDecker et al., 2002), again introducing a commingling stress.

Many food-service companies have come under scrutiny from animal-rights and animal-welfare organizations over the humane care and use of the meat animals from which their products are derived. However, it is inherently difficult to measure an animal's well-being in a manner consistent with quantitative science. Stress is typically measured by evaluating changing levels of serum cortisol as an indicator of activation of the hypothalamic-pituitary-adrenal axis in response to a defined stressor (Dantzer and Mormede, 1983). Although cortisol levels have consistently been reported to elevate in response to stress, the very act of obtaining the blood sample intrinsically alters cortisol response (McGlone et al., 1993). It has been suggested that immunological evaluations such as the neutrophil:lymphocyte ratio in the blood may be a more reliable measure of stress than is cortisol concentration (Gross and Siegel, 1983; Stull et al., 1999).

It is imperative that industry decisions in this country are based on studies determining the well-being and

health effects as well as effects on pig performance. Data to support production systems, such as wean-to-finish practices, are lacking, and the effect of these systems on pig well-being has not been evaluated. The objective of this study was to determine the impact of age at weaning and of rearing pigs in the same pen in an all-in-all-out/wean-to-finish facility versus commingling pigs after the nursery phase.

MATERIALS AND METHODS

A group of gilts farrowing over a 10 d period produced 30 litters, which were weaned when the average age was approximately 17 d of age. Pigs were divided into equal age groups representing the older (21 d of age) and younger (14 d of age) group of pigs (108 pigs in each group). On the day of weaning, the pigs were divided based on weight within age groups and randomly allocated to pens in a double-stocked wean-to-finish facility, with a total of nine replications of each age group for the nursery study. At the completion of the nursery phase one-half of the pigs in each age category were removed from the double-stocked pens and re-randomized based on weight and commingled for the growing-finishing component of the study. One-half of the pigs remained in original wean-to-finish pens. This arrangement of treatments permitted evaluation of the effects of weaning age in pigs double-stocked in a wean-to-finish facility as well as effects of post-nursery commingling on well-being and performance.

On the day of weaning, the pigs were moved from the farrowing room and distributed to their assigned pen. Pigs were offered ad libitum access to a Phase I nursery diet for 14 d after weaning and a Phase II diet for an additional 20 d. At the completion of the nursery period, the pigs were started on the growing-finishing study. Pigs were fed a four-phase diet with transition from starter to grower I, from grower I to grower II, and from grower II to finisher occurring when the mean weight of each block reached 45, 68, and 90 kg. All diets met or exceeded NRC (1998) requirements for all nutrients and were formulated to simulate diets typical of those used in the swine industry. The study was terminated when the lightest block reached an average weight of 104 kg.

Beginning at weaning, after pigs had been allotted to their respective pens, pigs in four pens/treatment were monitored with mounted camera surveillance equipment for 24 hours to observe initial behaviors following weaning. Time-lapse videos were viewed at a later date in 2-h increments (one AM hour and one PM hour), and the following behaviors were recorded: 1) acts of aggression (head-to-head and head-to-tail body knocks, tail-biting, ear-chewing, pushing and aggressive circling); 2) feeding; 3) drinking; 4) lying; 5) moving; and 6) belly nosing. The duration of time spent by each pig engaged in these behaviors was recorded and percentages of time were calculated based on the 2-h observation. This was replicated on days 7, 14, and 27 post-weaning. Monitoring was continued on day 35 (after commingling at the end of nursery phase), 38, 44 and 65 of the growing-finishing period. Plasma samples were obtained on days 0, 2, 7, 13, 27, 37, 42, and 56 to measure lymphocyte:neutrophil ratio.

Pigs were weighed as each block reached the projected weight for each phase. Feed disappearance from each pen self-feeder was calculated as the difference between feed added and feed weighed back for each period. Gain:feed ratios for each period were calculated.

Performance and behavioral data were analyzed as a 2 X 2 factorial with two weaning ages and two post-nursery management systems, with pen as the experimental unit. Neutrophil:lymphocyte and behavioural data were analyzed using the PROC MIXED analysis of SAS. Growth performance data were analyzed using GLM procedures of SAS (1988).

RESULTS AND DISCUSSION

During the nursery phase of the experiment, pigs weaned at 21 d of age had greater ($P < 0.01$) average daily gain and average daily feed intake during Phase 1, Phase 2, and in the overall nursery period than did pigs weaned at 14 d of age (Table 1). Pigs weaned at 14 d of age were more efficient ($P < 0.01$) than pigs weaned at 21 d of age during Phase 2 of the nursery and throughout the overall nursery period (Phases 1-2), (Table 1). At the beginning of the experiment, body weight was greater ($P < 0.01$) when pigs were weaned at 21 d of age compared to pigs weaned at 14 d of age, and as expected, the older pigs continued to be heavier ($P < 0.01$) throughout the nursery period; however, the difference in body weight increased from 2.15 kg at the initiation of the experiment to approximately 6.50 kg at the end of the nursery period.

During the growing/finishing phase of the experiment, ADG, ADFI, and gain:feed did not differ between pigs weaned at 21 d of age or those weaned at 14 d of age during Starter, Grower I, or Finisher phases (Table 2). However, during the Grower II, pigs weaned at 14 d of age had greater ($P < 0.05$) ADG, ADFI, and gain:feed; and greater ($P < 0.01$) ADG and gain:feed in the overall growing/finishing period than did pigs weaned at 21 d of age. The removal and commingling of one-half of the pigs from each pen at the end of the nursery period and re-sorting for the growing/finishing phase of the experiment did not affect ADG, ADFI, gain:feed, or pig body

weight. However, ADFI decreased during Phase 3 ($P < 0.05$) when pigs weaned at 21 d of age were mixed and re-sorted compared to those that remained in original pens, whereas there was no difference in ADFI of pigs weaned at 14 d of age regardless of whether they were commingled or remained in their original pens (interaction, $P = 0.08$; Fig. 1). Mixing and re-sorting pigs following the nursery phase of the study had no effect on the number of days required for pigs to reach a common market weight of 104 kg. However, age of pigs at weaning did impact days-to-market, such that pigs weaned at 14 d of age reached a common weight of 104 kg four days sooner than pigs weaned at 21 d ($P < 0.05$; Fig. 2). There was no effect of weaning age or mixing after the nursery phase on the neutrophil:lymphocyte ratio on any of the sampling day (data not shown).

The lower growth rate during the nursery period of pigs weaned at 14 d of age compared to older pigs conflicts with data from other studies that report either an improvement in ADG of early-weaned (10 d) pigs compared to late-weaned (30 d) pigs (Hohenshell et al., 2000), or no effect of weaning age on rate of the growth in the overall nursery period (Dritz et al., 1996). To our knowledge, this is the first experiment to report that early-weaned pigs overcame a deficit in body weight at the end of the nursery period to reach a common market weight in fewer days than pigs weaned at 21 d of age. Others have reported no effect of weaning age when evaluating overall gain from birth to market weight (Hohenshell et al., 2000) and no difference in BW when comparing early- and late-weaned pigs at a common age (Dritz et al., 1996).

Pigs weaned at 21 d of age spent a greater ($P < 0.05$) percentage of time lying down on the day of weaning (day ,0 post-weaning) than pigs weaned at 14 d of age. Although the percentage of time spent standing or moving did not differ between pigs of different weaning ages on any observation day during the nursery period, pigs weaned at 14 d of age spent a greater ($P < 0.05$) percentage of time standing or moving during the overall nursery phase than pigs weaned at 21 d of age (Table 3). Although there were no differences in the percentage of time that pigs weaned at either age were engaged in aggressive behavior on any of the sampling d, the frequency of aggressive behavior was greater ($P < 0.05$) at weaning (day 0) than on any other observation d. During the growing/finishing period, the effect of weaning age and post-nursery commingling on feeding behavior was dependent upon the day of observation (weaning age x mixing x date interaction, $P < 0.05$; Fig. 3). During the growing/finishing period, pigs that were weaned at 14 d of age and remained unmixed after the nursery period spent a greater ($P < 0.05$) percentage of time engaged in feeding activity than 21 d-old pigs that were mixed, or mixed pigs regardless of weaning age. The percentage of time spent feeding did not differ among pigs of either weaning age or post-nursery mixing treatment on d 38 or d 44 post-weaning; however, on d 65 post-weaning, pigs that were weaned at 21 d of age and mixed and pigs weaned at 14 d and unmixed exhibited a greater ($P < 0.05$) proportion of time engaged in feeding behavior than pigs in the other two treatments.

It is difficult to determine why the younger pigs performed poorly during the nursery phase in this study. Behavioral observations indicated that younger pigs spent less time lying down on the day of weaning and more time standing or walking during the overall nursery phase, suggesting that younger pigs were less apt to settle into their new environment than older pigs. This nervousness or curiosity toward the new environment may have contributed to the lower weight gains observed in young pigs in the nursery phase.

The results of this study show that management conditions perceived as stressors, in this case weaning and commingling pigs after the nursery period, do influence behavior, and there is no indication from the results of this study that neutrophil:lymphocyte ratio is quantitative measure of immune or behavioral well-being in pigs. In the present study, neutrophil-to-lymphocyte ratios were similar among pigs regardless of weaning age or mixing treatment. To further compound the difficulty in measuring immune response or behavior as indicators of welfare, there were very few differences in behavioral responses between pigs weaned at different ages or between pigs mixed after the nursery phase and those that remained unmixed, and immune responses were inconsistent depending upon the age of the pig at weaning. Whereas the results of this study raise interesting questions about the effect of management environments and stressors on subsequent performance and health of pigs weaned at varying ages, no measure of growth performance, immunity, or behavior was found to conclusively measure a pig's welfare in response to wean-to-finish management schemes.

In conclusion, the results of this study indicate that weaning age affects growth performance in a wean-to-finish facility as well as behavioral and immunological responses to weaning and commingling after the nursery phase. Weaning pigs at an early age results in a less immunologically developed pig compared to pigs weaned later, and this may contribute to the benefits of early weaning with respect to an overall improvement in gain and days to a common weight. However, management strategies should be further explored to optimize these benefits without the detrimental effects on health, as observed during the nursery period in this study.

ACKNOWLEDGMENTS

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Table 1. Average daily gain (ADG), average daily feed intake (ADFI), and gain:feed of pigs in response to weaning age during the nursery period.

	Weaning age, d			
Variable	14	21	SE	P-value
ADG, (g)				
Phase 1	262	383	15.3	<0.001
Phase 2	487	612	14.7	<0.001
Phase 1-2	397	521	13.9	<0.001
ADFI, (g)				
Phase 1	273	410	15.9	<0.001
Phase 2	617	876	29.1	<0.001
Phase 1-2	474	689	24.1	<0.001
Gain:feed				
Phase 1	0.92	0.94	0.01	0.095
Phase 2	0.77	0.70	0.01	0.001
Phase 1-2	0.81	0.76	0.01	0.001
Weight, (kg)				
Initial	4.52	6.67	0.26	<0.001
Phase 1	8.17	12.06	0.45	<0.001
Phase 2	18.39	24.92	0.72	<0.001

Table 2. Average daily gain, average daily feed intake, and gain:feed of pigs in response to weaning age during the grower/finishing period.

	Weaning age, d			
Variable	14	21	SE	P-value
ADG, (kg)				
Starter	0.76	0.77	0.02	0.593
Grower I	1.01	0.98	0.02	0.258
Grower II	1.04	0.86	0.02	<0.001
Finisher	0.88	0.86	0.04	0.719
Overall	0.91	0.87	0.01	0.005
ADFI, (kg)				
Starter	1.56	1.61	0.03	0.199
Grower I	2.43	2.30	0.05	0.075
Grower II	2.76	2.59	0.06	0.040
Finisher	3.03	2.88	0.08	0.190
Overall	2.26	2.30	0.04	0.509
Gain:feed				
Starter	0.49	0.48	0.01	0.396
Grower I	0.42	0.43	0.01	0.360
Grower II	0.38	0.33	0.01	0.003
Finisher	0.29	0.30	0.01	0.757
Overall	0.40	0.38	0.01	0.003

Table 3. Summary of behavioral data (presented as percentage of time engaged in each respective behavior) collected during the overall nursery phase from pigs weaned at either 14 or 21 d of age.

	Age at weaning, d			
Observation, %	14	21	SE	P=
Lying	36.1	46.1	4.00	0.130
Standing/moving	30.1	22.6	2.23	0.054
Drinking	1.7	2.5	0.47	0.255
Feeding	11.2	9.1	1.69	0.399
Aggression	2.9	2.1	0.61	0.387

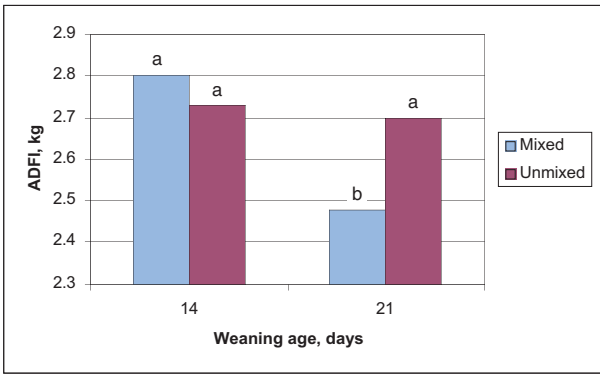

Fig. 1. Effect of mixing and age at weaning on average daily feed intake of pigs (ADFI) during Grower II of the growing/finishing period (interaction, P = 0.08; a,b P< 0.05).

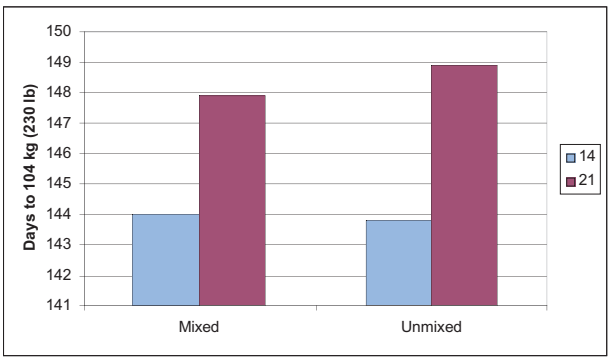

Fig. 2. Effect of mixing and age at weaning on the number of d for pigs to reach 230 lb. Effect of weaning age; P < 0.05.

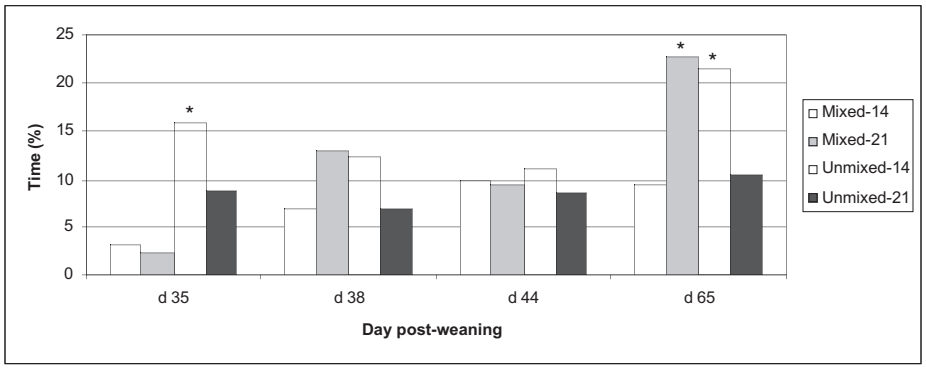

Fig. 3. Percentage of time spent engaged in feeding behavior during the growing/finishing phase by pigs weaned at either 14 or 21 d of age and either subjected to mixing and re-sorting following the nursery phase or remaining in original pens (weaning age x mixing x date interaction, $P < 0.05$). Bars with an asterisk differ from other bars without asterisks within d post-weaning ($P < 0.05$).