GROWTH AND MICROBIOLOGY OF NONMEDICATED, SEGREGATED, EARLY-WEANED PIGS[1]

S. S. Dritz, M. M. Chengappa[2], J. L. Nelssen, M. D. Tokach, R. D. Goodband, and M. W. Vorhies[3]

Summary

Seventy pigs, 7 to 10 d of age, were randomly selected by litter of origin from a commercial farm in Northeast Kansas to compare the growth and microbiology of nonmedicated, segregated, early-weaned pigs to controls raised at the farm of origin. After weaning, both groups were fed a similar nutritional programs consisting of dry diets. No antimicrobial drugs were administered to the pigs except for a feed grade antimicrobial (carbadox) from weaning to 50 lb. Pigs were monitored for 12 weeks. Individual pigs weights, nasal swabs, and serum samples were collected on d 0 and then every 14 d thereafter for a total of 7 collections. Four pigs were necropsied at the initiation of the study (d 0). In addition, four pigs were randomly selected at each collection period from each group for necropsy and collection of tissues for bacterial culture. The segregated early-weaned pigs were able to reach an accelerated phase of growth before the controls. On d 14, 28, 42, 56, and 70 of the experiment, segregated early-weaned pigs were 21, 82, 90, 54, and 52% heavier than control pigs, respectively. A low percentage of pigs were infected with *Pasteurella multocida* at 7 to 10 d of age, which corresponds to d 0 of the experiment. The principal time of transmission of *P. multocida* infection was in the immediate post-weaning period. The rate of isolation of *P. multocida* then declined from d 14 to d 84 of the experiment in both groups of non-medicated pigs. This response must be kept in mind when evaluating the efficacy of antibiotic protocols. Appropriate non-medicated controls must also be evaluated. The maximum difference in rate of isolation of *P. multocida* from nasal swabs and tissues between the early and control groups occurred on d 28 and d 42 of the experiment. This corresponds to the two collection days when segregated early-weaned pigs were 82% and 90% heavier than control pigs raised on-site. The only *Pasteurella multocida* isolates capable of producing toxin were detected on d 14 in the control group. *Pasteurella multocida* toxin has also been shown to have deleterious effects on systemic organs and immune response. The rates of *Bordetella bronchiseptica* isolation were similar between control and segregated early-weaned groups. However, *B. bronchiseptica* isolates were recovered from any tissues of any pigs necropsied. Antibiotic regimens targeted at this organism would appear unwarranted in a commercial production setting. *Haemophilus parasuis* and *Streptococcus suis* were present in both groups of pigs at 7 to 10 d of age. However, as indicated by the excellent growth performance achieved in the presence of *H. parasuis* colonization of the nasal cavity, elimination of this organism probably is not necessary to achieve excellent growth

---

[1]Appreciation is expressed to Jacque Staats, Barb Kelly, John Kramer, and the employees of J-Six Farms for technical assistance.

[2]Department of Pathology and Microbiology.

[3]Department of Veterinary Diagnostic Investigations.

levels. More studies need to be undertaken to understand the mode of transmission and epidemiology of *Streptococcus suis* infection. *Mycoplasma hyopneumoniae* apparently was eliminated without medication by moving pigs to an isolated site. *Mycoplasma hyopneumoniae* could be detected only in the control group. Data from this experiment also suggest that weaning pigs at 14 to 17 d could prevent vertical transmission of *Actinobacillus pleuropneumonia*. The growth and microbiology of nonmedicated, segregated, early-weaned pigs must be considered when developing cost-effective and efficacious medication protocols for application of segregated early weaning in the commercial swine industry.

(Key Words: Pigs, Growth, Microbiology.)

Introduction

Early weaning in disease elimination procedures is becoming a common practice in the commercial swine industry. These procedures have evolved from research conducted in the 1950's on the elimination of enzootic pneumonia. Modifications of these procedures were reported in the 1980's. They consisted of farrowing the sows in isolation and medicating them prefarrowing and during lactation. Piglets were also medicated preweaning and postweaning. This procedure has become known as medicated early weaning. The original program was successful for disease elimination but increased levels of postweaning mortality (approximately 13%) occurred and were attributed to postweaning scour. Nutritional programs for the young pig now include highly palatable and highly digestible ingredients, which have greatly decreased the incidence of postweaning diarrhea. Medicated early-weaning has been further modified for application of early-weaning disease elimination on a commercial scale. The procedures have become known as modified, medicated, early weaning; isowean^{R}; or multiple-site production. However, these procedures typically employ the use of antibiotics administered to the sow and off-spring. Decreasing medication costs to a minimum will be necessary for the large-scale implementation of early-weaning, disease elimination procedures. Thus, our objective was to evaluate the growth and microbiology of nonmedicated, segregated, early-weaned pigs. Further understanding of growth and microbiology will aid in the development of cost-effective management procedures.

Procedures

Seventy pigs, 7 to 10 d of age, were randomly selected by litter of origin from a commercial farm in northeast Kansas. Thirty-two pigs were early-weaned at 7 to 10 d of age and transported to isolation nurseries at the Kansas State University College of Veterinary Medicine for the duration of the 84 d experiment. Thirty-four litter mates were weaned conventionally on-site at 14 to 17 d of age. They served as the control group. Four pigs were necropsied at the initiation of the study on d 0. All facilities were environmentally controlled, and pigs had ad libitum access to feed and water after weaning. After weaning, both groups were fed a similar nutritional programs consisting of dry diets. No antimicrobial drugs were administered to the pigs except for a feed grade antimicrobial (carbadox) from weaning to 50 lb. The farm was known to be infected with *Mycoplasma hyopneumoniae*, *Bordetella bronchiseptica*, toxigenic *Pasteurella multocida*, *Haemophilus parasuis*, *Streptococcus suis*, and *Actinobacillus pleuropneumonia*. Sows and gilts received no parenteral or feed-grade antibiotics prefarrowing or during lactation.

Pigs were monitored for 12 weeks. Individual pig weights, nasal swabs, and serum samples were collected on d 0 and then every 14 d thereafter for a total of 7 collections. The first collection for both groups was at the time of weaning for the segregated early-weaned group (d 0). In addition, four pigs were randomly selected at each collection period from each group for necropsy and collection of tissues for bacterial culture. Tissues cultured from the

eight pigs were: tonsil, lung, liver, spleen, brain, meningeal swabs, intestine, and mesenteric lymph node.

Nasal swabs and tissue specimens were cultured aerobically for bacteria. Because virtually all samples contained a large number of *Streptococcus* spp. per nasal sample, 10% of colonies were randomly selected and biochemically characterized to species. *Pasteurella multocida* and *Bordetella bronchiseptica* were assayed for the production of dermal necrotic toxin. All pigs necropsied were examined for the presence *Mycoplasma hyopneumoniae* using a fluorescent antibody technique. Lung tissue from all pigs negative by fluorescent antibody testing was cultured for the presence of *M. hyopneumoniae*. Serum from all pigs was evaluated for the presence of antibodies to *M. hyopneumoniae* and *Actinobacillus pleuropneumonia*.

Results and Discussion

Growth Performance. The segregated early-weaned pigs were able to reach the accelerated phase of the growth curve before the controls (Figure 1). On d 14, 28, 42, 56, and 70 of the experiment, segregated early-weaned pigs were 21, 82, 90, 54, and 52% heavier than control pigs, respectively. The growth curve of animals is sigmoidal in shape and can be divided into four phases: lag, accelerated, linear, and maturity. Accelerated growth occurs when the rate of increased growth is non-linear. Part of the advantage of early weaning may be due to segregated early-weaned pigs reaching the accelerated growth phase sooner than control pigs. These growth data illustrate that pigs have a tremendous biologic potential for growth that is not being realized in many commercial production systems.

Bacteriology Culture Studies. A low percentage of pigs was infected with *Pasteurella multocida* at 7 to 10 d of age (Table 1). This would be advantageous for developing a medication regimen for the elimination of this organism. The principal time of transmission of *P. multocida* infection is the immediate postweaning period. This is indicated by the rate of nasal swab isolation rising from 6% to 22% in the segregated early-weaned pigs and from 0% to 50% in the control group. Day 14 of the experiment was d 14 postweaning for the segregated early-weaned group and d 7 postweaning for the farm-raised controls. The increased rate of transmission postweaning could be explained by three factors: 1) increase in pig density postweaning, 2) decreased immune response capability immediately postweaning, and 3) commingling of piglets during transport to the nursery. The rate of isolation of *P. multocida* declined from d 14 to d 84 of the experiment in both groups of nonmedicated pigs. This response must be kept in mind when evaluating the efficacy of antibiotic protocols. Appropriate nonmedicated controls also must be evaluated. The cost to benefit ratio of antibiotics for the elimination of *P. multocida* needs to be evaluated further.

The maximum difference in rate of isolation of *P. multocida* from nasal swabs and tissues between the early and control groups occurred on d 28 and d 42 of the experiment. This corresponds to the two collection days when segregated early-weaned pigs were 82% and 90% heavier than control pigs raised on-site. Research in poultry suggests that stimulation of the immune system in growing chicks causes decreased feed intake and nutrient utilization. The immune stimulation is thought to occur by exposure of the immune system of nonpathogenic organisms from the animal's environment. Because *P. multocida* was the only microorganism consistently isolated from systemic organs, this bacterium may play a key role as a cause of continual nonpathogenic stimulation of the immune system. The only *Pasteurella multocida* isolates capable of producing toxin were detected on d 14 in the control group. *P. multocida* toxin also has been shown to have deleterious effects on systemic organs and immune response. Isolation of the toxigenic strains from the d 14 collection

corresponds to when the segregated early-weaned pigs were 82% heavier than the control pigs. Toxin production may be a key influence on the growth of pigs in the nursery period.

Isolation of *Bordetella bronchiseptica* increased in the d 56, 70, and 84 nasal swab samples in both the early-weaned and control pigs (Table 2). No *B. bronchiseptica* isolates were recovered from any tissues of any pigs necropsied. The rates of *B. bronchiseptica* isolation were similar between control and segregated early-weaned groups. *Bordetella bronchiseptica* organisms were not isolated until d 56 of the experiment. These results would indicate that off-spring receive adequate maternal immunity until they develop an innate resistance to this organism. With little colonization by *B. bronchiseptica,* very few toxigenic *P. multocida* organisms were able to colonize. Thus, the organisms were subsequently eliminated from the nasal passage. This could explain why no toxigenic *P. multocida* organisms were detected after the d 14 collection and few clinical signs of rhinitis were present. *Bordetella bronchiseptica* infection does not seem to cause systemic infection or have a negative influence on growth performance when pigs are infected at this age. Therefore, elimination of this organism would have little impact on growth performance. Current control strategies should concentrate on stimulation and transfer of maternal immunity. Antibiotic regimens targeted at this organism would appear unwarranted in a commercial production setting.

Haemophilus parasuis was isolated from 78% and 47% of the early-weaned and control pigs, respectively, on d 0 (Table 3). The rates decreased to 31% and 9%, respectively, on d 14 of the experiment and then rose to 80% and 74% for the early-weaned and control pigs on d 56 of the experiment. No *H. parasuis* isolates were recovered from any tissues of any pigs necropsied. The high rate of *H. parasuis* isolation from the nasal passage indicates that maternal transfer of immunity had little affect on the colonization of this organism. It is well known that *H. parasuis* can cause mortality in an immunologically naive herd. The absence of clinical disease in the presence of infection of very young pigs indicates that these pigs had transfer of maternal immunity. However, as indicated by the excellent growth performance achieved in the presence of *H. parasuis* colonization of the nasal cavity, elimination of this organism probably is not necessary. Because this organism can cause severe disease in immunologically naive populations, elimination of this organism may be desirable.

Streptococcus suis was present in many of the isolates from 7- to 10-d-old of age pigs. Several serotypes were isolated with no consistent pattern. No clinical signs of systemic *S. suis* infection were noted in the segregated early-weaned or control pigs. The data from this experiment indicate that *S. suis* is present in a large percentage of 7- to 10-d-old pigs. More studies need to be undertaken to understand the mode of transmission and epidemiology of *S. suis* infection.

***Mycoplasma hyopneumoniae* Culture and Serology**. *Mycoplasma hyopneumoniae* apparently was eliminated without medication by moving pigs to an isolated site. *Mycoplasma hyopneumoniae* could be detected only in the control group. One pig from each control necropsy group in the d 42, 70, and 84 collections was positive for the presence of *M. hyopneumoniae* by fluorescent antibody testing; however, all pigs in the early group were negative for its presence by the same procedure. *Mycoplasma hyopneumoniae* was not detected in any of the samples cultured. Further indication of *M. hyopneumoniae* elimination is provided by the serologic results (Table 4). On d 14 one pig had a titer to *Mycoplasma hyopneumoniae* greater than 0.2; however, the titer from this pig had decreased to less than 0.2 on d 28. Three pigs on d 28 had titers greater than 0.2. These three titers were all higher than on the previous collection at d 14. The serologic results indicate

that a small proportion of pigs in the control group were sero-converting and show a slow spread of infection.

***Actinobacillus pleuropneumonia* Serology**. No pigs had rising titers for the duration of the experiment. This indicates that neither sero conversion nor transmission of infection was taking place. The proportion of titers greater than 6000 decreased from d 0 to 42 at the same rate in both groups (Table 5). No samples were detected from d 42 to the end of the experiment, with titers greater than 6000. High levels of antibody specific for *A. pleuropneumonia* were detected in both groups of pigs on d 0. One hundred percent of pigs in both groups had titers greater than 6000. Serology results suggest very good maternal transfer of antibody to *A. pleuropneumonia*. These data suggest that, in the presence of high maternal immunity, weaning pigs at 14 to 17 d could prevent vertical transmission of *A. pleuropneumonia*.

In conclusion, the pig's potential for growth is not being achieved in many present production systems. Possible explanations for the growth response in early-weaning programs are: 1) segregated early-weaned pigs reaching the accelerated growth phase sooner, 2) absence of deleterious effects of pathogenic microorganism infection, or 3) decreased feed intake and altered nutrient partitioning because of nonpathogenic stimulation of the immune system. The growth and microbiology of nonmedicated, segregated, early-weaned pigs must be considered when developing cost-effective and efficacious medication protocols for application of segregated early weaning in the commercial swine industry.

Table 1. Recovery of *Pasteurella multocida* from Nasal Swab and Tissue Specimens

	Day						
Sample	0	14	28	42	56	70	84
Nasal Swabs							
Early-Weaned							
Type A	-	3	1	1	-	-	-
Type D	-	3	-	-	-	1	-
Nontypeable	2	1	-	-	-	-	-
Total	6% (2/32)[a]	22% (7/32)	4% (1/28)	4% (1/24)	0% (0/20)	6% (1/16)	0% (0/12)
Control							
Type A	-	2	12	11	4	3	2
Type D	-	14[b]	2	-	-	-	1
Nontypeable	-	1	-	-	-	-	-
Total	0% (0/28)	50% (17/34)	47% (14/30)	42% (11/26)	21% (4/19)	19% (3/16)	23% (3/13)
Necropsy Tissues[c]							
Early-Weaned							
Type A	NA[d]	-	1	1	2	1	-
Type D	NA	-	-	1	-	-	-
Nontypeable	NA	1	-	-	-	-	-
Total	NA	1	1	2	2	1	-
Control							
Type A	NA	1	1	3	4	4	4
Type D	NA	3	3	1	1	-	-
Nontypeable	NA	1	2	-	-	-	-
Total	NA	5	6	4	5	4	4

[a]Percentage (number nasal swabs positive / total number of nasal swabs).
[b]Three isolates positive for the production of toxin.
[c]Each number represents the total number of positive tissues for the total of four pigs. Tissues cultured were: tonsil, lung, liver, spleen, brain, and meningeal swab.
[d]No *Pasteurella multocida* were isolated from the four pigs necropsied on d 0.

Table 2. Recovery of *Bordetella bronchiseptica* from Nasal Swabs

	Day						
Group	0	14	28	42	56	70	84
Early-Weaned	0% (0/32)[a]	0% (0/32)	0% (0/28)	0% (0/24)	25% (5/20)	38% (5/16)	25% (3/12)
Control	0% (0/28)	0% (0/34)	10% (3/30)	0% (0/26)	11% (2/19)	31% (6/16)	54% (7/13)

[a]Percentage (number nasal swabs positive / total number of nasal swabs).

Table 3. Recovery of *Haemophilus parasuis* from Nasal Swabs[a]

	Day						
Group	0	14	28	42	56	70	84
Early-Weaned	78% (25/32)[b]	31% (10/32)	64% (18/28)	75% (18/24)	80% (16/20)	56% (9/16)	50% (6/12)
Control	47% (16/28)	9% (3/34)	30% (9/30)	42% (11/26)	74% (16/19)	31% (5/16)	46% (6/13)

[a]No Haemophilus parasuis were found in any necropsy tissues.
[b]Percentage (number nasal swabs positive / total number of nasal swabs).

Table 4. Serology Results for *Mycoplasma hyopneumoniae*

	Week						
Group	0	2	4	6	8	10	12
Early-Weaned	26%[a] (7/34)[b]	6% (2/31)	4% (1/28)	0% (0/23)	0% (0/18)	0% (0/16)	0% (0/9)
Control	26% (9/34)	3% (1/34)	11% (3/27)	8% (2/25)	5% (1/19)	7% (1/15)	7% (7/14)

[a]Percentage of samples with an absorbance > 0.2.
[b](number of samples > 0.2 / total number of samples).

Table 5. Serology Results for *Actinobacillus pleuropneumonia*

	Week						
Group	0	2	4	6	8	10	12
Early-Weaned	100% (30/32)[a]	94%[a] (30/32)	46% (13/28)	0% (0/24)	0% (0/18)	0% (0/16)	0% (0/11)
Control	100% (34/34)	91% (31/34)	61% (14/26)	0% (0/25)	0% (0/17)	0% (0/16)	0% (0/15)

[a]Percentage (number of serum samples >6000 / total number of serum samples).

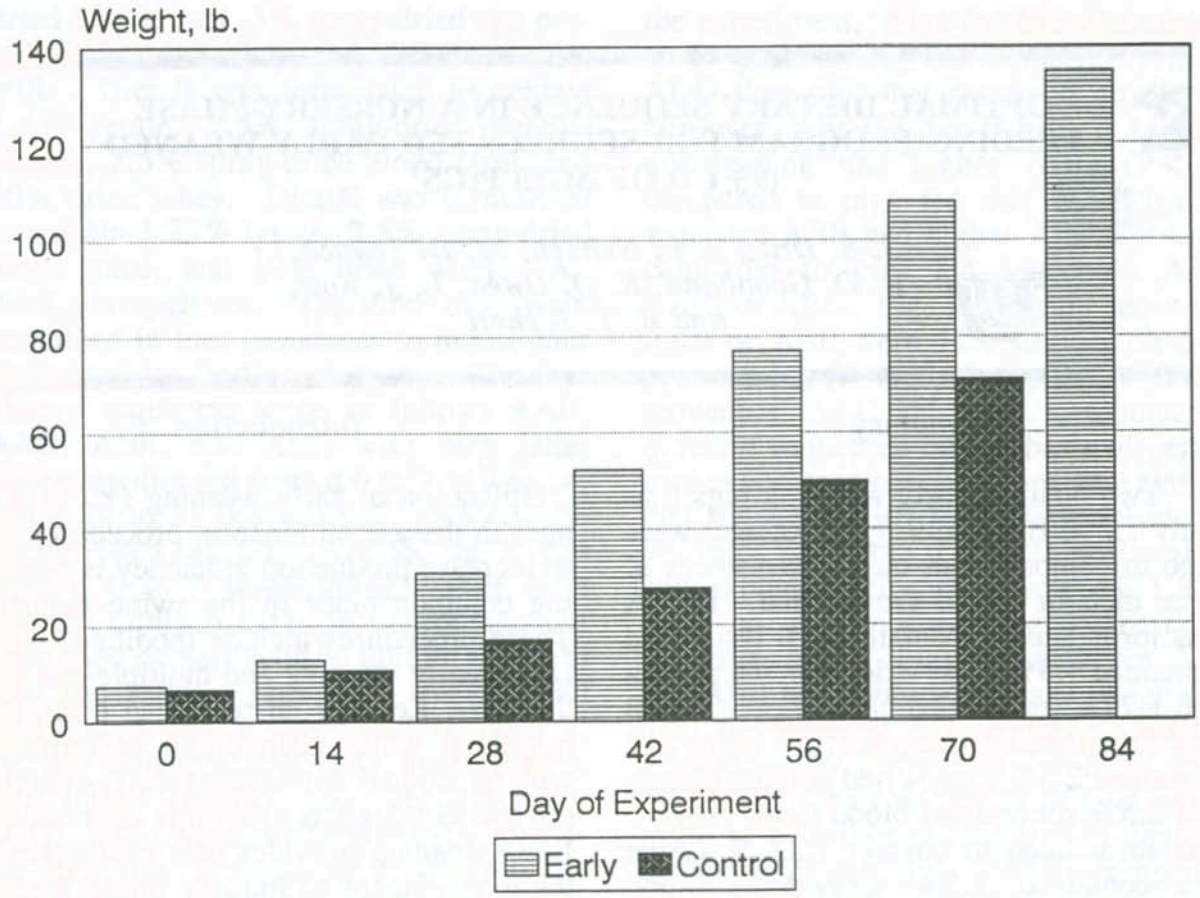

Figure 1. Weights of Segregated Early-Weaned Pigs and Farm Raised Controls

Site Preparation of the New KSU Segregated, Early-Weaning Facility.