ORIGINAL RESEARCH

Ration-induced diarrhea in grower pigs

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Summary *— An epidemiologic investigation in a boar test station indicated that the morbidity rate due to diarrhea was higher when the pigs were fed a 21% crude protein ration (morbidity rate = 28.5 ± 16) than when they were fed a 17% CP ration (morbidity rate = 5.6 ± 4) (P < 0.05). No causative pathogenic organism was identified. The spread of the diarrhea within the barn was sporadic. Pigs fed the higher CP ration had a lower average daily gain (0.85 kg versus 0.92 kg) and a higher feed conversion (2.47 versus 2.36) than the pigs fed the lower protein rations (P < 0.0001). Feed trials were conducted on feeder pigs to compare the 21% protein ration used in the boar test station to a 16% protein ration. Higher morbidity rates due to diarrhea were associated with the high protein ration (88.6% versus 10.6%) (P < 0.01). It was concluded that the pelleted corn and soybean-based 21% CP ration was a necessary cause of the diarrhea.*

As the genotype of the domestic pig improves, more protein will be required to allow these pigs to express their full potential for growth (Campbell RG, 1992, Proc Minn Swine Conf for Veterinarians, p. 299-306).[1-3] Managers at a boar test station were concerned that the level of protein in the ration (17%) was limiting the pigs' growth performance. In January 1991 they changed the ration to a pelleted 21% protein ration to include 328 kg of 47% soybean meal and 0.2 kg L-lysine HCl per 1,000 kg (Tables 1-2). They observed an increase in morbidity rate due to diarrhea and on April 1, 1991 the high-protein ration was replaced with a pelleted 18.5% crude protein (CP) ration.

This investigation will describe the rise of morbidity rates due to clinical diarrhea at the boar test station during the period when pigs were being fed 21% CP rations and our attempt to isolate a pathogenic organism from the affected pigs. The productivity of boars fed rations with the three levels of CP was compared. Field trials were then conducted to determine whether exposure to the feed, the environment or the feces of the affected pigs could induce diarrhea in naive feeder pigs.

Methods

Observational study:

The boar test station had four wings, each containing 64 pens holding two pigs per pen. During the study there were between 86 and 120 pigs per wing. The pens had concrete floors that were bedded with shavings. Each wing had a separate ventilation system. The temperature within the wings varied between 75° F and 65° F, depending on the size of the pigs. The daily temperature fluctuated up to 5° F within a wing. The unit was stocked with 25-kg (± 3) pigs from multiple sources. The pigs remained in the unit for 3.5 months, and one wing was restocked every month.

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Table 1. — Formulation of the corn and soybean-based and wheat-based ration, in kg.

	Affected unit			Wheat diet	Control diet
	10/90-12/90	1/91-3/91	4/91-6/91		
Corn	531.0	405.3	473.6	—	636.5
Soybean 48%	—	—	—	—	170.0
Soybean 47%	210.0	328.0	250.0	—	—
Soybean 46%	—	—	—	331.5	—
Wheat	—	—	—	400.0	80.0
Barley	200.0	—	200.0	190.0	80.0
Fat	—	—	5.0	13.0	—
Lignosol	12.0	12.5	12.5	12.5	—
Salt	5.0	5.0	5.0	5.0	5.0
Limestone	15.0	14.0	14.0	15.0	10.0
Dical	17.0	25.0	26.0	23.0	15.0
L-Lysine HCL	0.4	0.2	2.5	—	—
DL-Methionine	—	—	0.4	—	—
Threonine	—	—	0.8	—	—
Vit/Mineral	10.0	10.0	10.0	10.0	3.5

Table 2. — Composition of the corn and soybean rations used in the affected unit and of the wheat-based diet used in a similar unit (values are percentages).

	Affected unit: Corn diet			
	10/90-12/90	1/91- 3/91	4/91- 6/91	Wheat diet
Protein	17.00	21.18	18.42	22.47
Lysine	0.90	0.98	1.16	0.99
Methionine	0.29	0.26	0.27	0.25
Meth-Cys	0.61	0.55	0.52	0.58
Threonine	0.69	0.61	0.60	0.59
Tryptophan	0.21	0.22	0.18	0.24
Total Phos	0.71	0.92	0.91	0.91
Sodium	0.20	0.20	0.20	0.20
Calcium	0.94	1.05	1.05	1.06
Dig. Energy in kilocalories/kg (kJ/kg)	3202.00 (13448.4)	3269.84 (13733.3)	3273.00 (13746.6)	3265.40 (13714.7)

The barn staff observed the swine twice daily for clinical signs of diarrhea, i.e.:

- fresh manure adhered to the perineal region;
- observation of loose feces during defecation; or
- loose feces on the pen floor.

The staff recorded all cases of diarrhea in a logbook and referenced them to the pig's tattoo or pen number. We calculated the morbidity rate due to diarrhea as the number of affected pens per wing during a 3-month period. Affected pens were included only once in the numerator. Pens refilled during the 3-month period were considered new pens. The date of onset of diarrhea was plotted for each pen and the data was examined visually for trends indicating a spread of infection. We identified the location of affected pens and used a Chi-square test to determine whether pigs adjacent to affected pigs were more likely to have diarrhea than pigs separated from affected pigs. We used a student t-test to compare the morbidity rate during January, February, and March to that between October through December and April through June.

The average daily gain and the number of days it took the pig to attain 100 kg body weight were measured on each boar. The feed : gain ratio was calculated by pen. The productivity of the boars that completed testing between February 1991 and May 1991 was compared to those that completed testing from October 1990 through January 1991 and June 1991 through October 1991. These productivity parameters were analyzed with a student t-test.

In January and February, 34 untreated pigs with diarrhea were examined for pathogenic organisms. A complete postmortem was conducted on three pigs, rectal swabs were taken from seven, and fecal samples were taken from 24 pigs. From these samples, attempts were made to isolate or observe *Salmonella* spp., *Campylobacter* spp., *Serpulina hyodysenteriae, Escherichia coli,* transmissible gastroenteritis (TGE) virus, and intestinal parasites. All pigs that died at the boar test station were submitted for a complete autopsy.

Field trials

Rations

The low-protein ration was formulated to contain 16% CP and the high-protein ration was formulated to contain 21% CP (Table 1). Analyses of composite samples of each ration indicated that the low-protein ration contained 17% CP and the high-protein ration contained 23% CP. Both rations were pelleted corn and soybean-based rations that contained no medication. The pigs were fed ad libitum. The final weights of the pigs were not recorded and feed intake was not measured.

Animals

Four groups of 15 kg (± 2) pigs were involved in this investigation. All pigs came from a closed herd originally derived by Caesarean section and known to be free of *S. hyodysenteriae.* The pigs in the first three groups were housed in isolation rooms that were cleaned, disinfected, and left empty for 1 week between groups. Each room held one fully slatted pen raised 2 feet from the floor. The rooms were environmentally controlled and kept at approximately 75° F with a fluctuation of 2° F per 24 hours. I observed the pigs twice a day, 6 days per week for a period of 2 weeks. The criteria for clinical diarrhea were:

- fresh manure adhered to the perineal region; or
- the observation of diarrhea during defecation.

I marked affected pigs with a wax marker to avoid counting the same animal twice. Although I was not blinded to the treatment and control groups and the diagnosis of diarrhea was subjective, if the case was questionable, I did not include the pig in the morbidity rate. If there was doubt about the diagnosis, the pig was considered normal.

Experiment 1

Five pigs were fed approximately 3,000 mL of manure from clinically affected untreated pigs from the boar test station

and were observed for 14 days for clinical signs of diarrhea. These pigs were fed the low-protein ration for the first 14 days and then the high-protein ration for the subsequent 14 days.

Ten pigs were fed the low-protein ration for the first 14 days and then the high-protein ration for 14 subsequent days, and were not challenged with manure.

All pigs from Experiment 1 were submitted for postmortem examination, whether or not they had diarrhea.

Experiment 2

Thirty-six pigs were randomly assigned to one of three rooms and one of two treatments. Three groups were housed on raised decks and fed the high-protein ration. The other three groups were fed the low-protein ration and were housed on the floor under the decks. The lower-tier pigs thus had exposure to the manure of the pigs fed the high-protein ration but did not have access to their feed. A student t-test was used to test for a difference in morbidity rate between the upper-tier and lower-tier pigs. Nine of the upper-tier pigs with diarrhea were examined at postmortem for evidence of infection with *Salmonella* spp., *Campylobacter* spp., *S. hyodysenteria, E. coli,* TGE virus, *Yersinia* spp., enterobacters, and intestinal parasites.

Experiment 3

Eight pigs were sent to the boar test station and housed in four pens, two pigs per pen. They were randomly assigned to a pen, and thus were interspersed among the pigs in the unit. They were managed in the same manner as the boars except they were fed the low-protein ration. They were observed for clinical evidence of diarrhea for 6 weeks.

Results

Observational study

The morbidity rate due to diarrhea was 4% (± 3) during October, November and December 1990 and was 28% (± 16) for January, February and March 1991 (Fig 1). It fell to 6% (± 4) for April, May and June 1991. The diarrhea was typically a grey/green color, and ranged from a pasty to a watery consistency. Although the pigs were not treated, the feces returned to a normal consistency within 3-4 days. A recurrence of diarrhea was observed in 25% of the affected pens. We could detect no pen-to-pen transmission of the diarrhea ($P > 0.05$).

No pathogenic organisms were identified from the fecal samples or rectal swabs taken from the boar test station. At postmortem one pig of three examined had ingesta adhered to the spiral colon, indicative of erosive or ulcerative colitis, and small focal ulcerations of the cecum. Another pig had swollen mesenteric lymph nodes and moderate numbers of *Balantidium coli* in the colon. The third pig had no abnormal findings.

Productivity at the boar test station was also affected by the ration change. The average daily gain was 0.85 kg on the high CP ration compared to 0.92 on the low CP rations ($P < 0.0001$) (Fig 2). It took the boars on the high-protein ration 5 days more (156 days) to reach 100 kg body weight than the boars on the low-protein rations (151 days) ($P < 0.0001$). Three percent of the boars on the high-protein ration did not reach 100 kg within 3.5 months compared to 0.4% on the low-protein ration ($P < 0.05$). The feed : gain ratio was higher on the high-protein ration (2.47) than on the low-protein ration (2.36, $P < 0.0001$) (Fig 2).

Field trials

Experiment 1

During the 28 days of observation, the pigs in experiment 1 did not have diarrhea on the low-protein ration but did have diarrhea on the high-protein ration (Fig 3), whether or not they were fed manure from affected pigs. The morbidity rate due to diarrhea was 60% in the treatment group 40% in the control group (Fig 4).

No abnormal lesions were observed in any of the Experiment 1 pigs.

Experiment 2

In experiment 2, the morbidity rate due to diarrhea was higher in the pigs fed the high-protein ration (88% ± 3.2) than the pigs fed the low-protein ration (11% ± 3.2) ($P < 0.01$) (Fig 4).

Nine pigs from experiment 2 were submitted for postmortem examination. Postmortem findings included moderate,

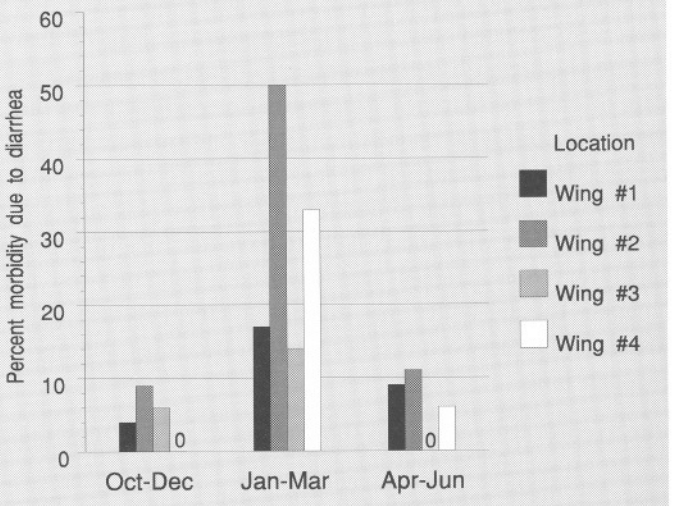

Fig 1. — Morbidity rate due to diarrhea by 3-month time period in the boar test station..

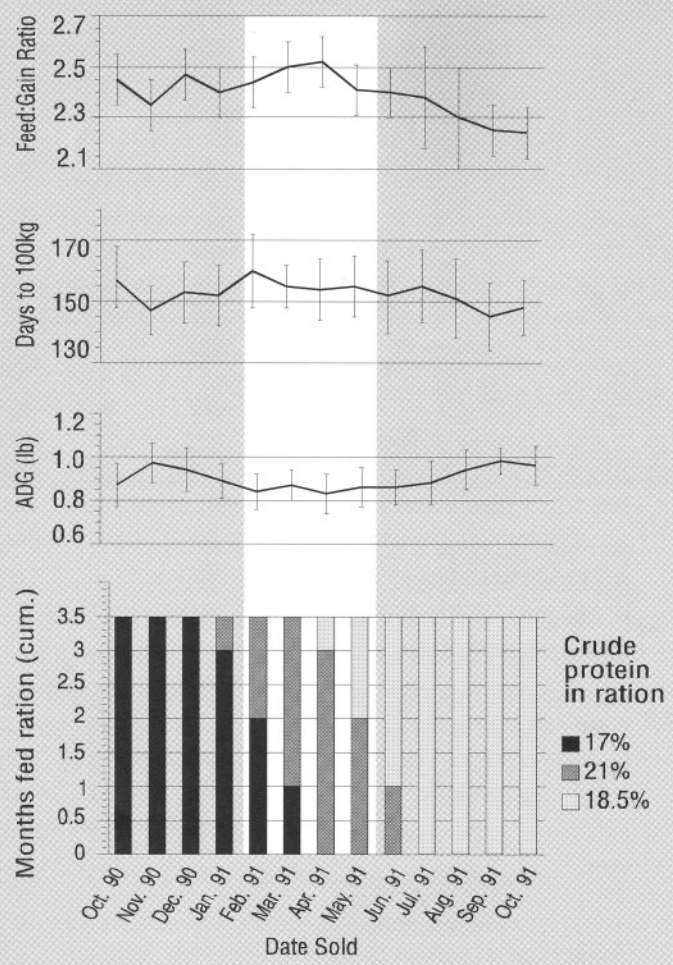

Fig 2. — Productivity and rations of the boars that completed testing between October 1990 and October 1991. The white band highlights data for the period February to May, 1991.

patchy thickening of the wall of the jejunum, shortened villi of the duodenal and jejunal mucosa, eosinophils in the lamina propria of the small intestine, mononuclear infiltrate of the lamina propria of the spiral colon and swollen mesenteric lymph nodes.

In one pig, *Campylobacter* spp. were found in the ileum in large numbers. Large numbers of *C. jejuni* were isolated from the colon of another pig. Spirochetes were seen in moderate numbers in the colon of one pig but were not identified as *S. hyodysenteria.* No pathogenic bacteria were seen or isolated from any of the other boars. A causative organism could not be isolated from the manure or the rectal swabs of the scouring pigs.

Experiment 3

None of the pigs that were sent to the boar test station and fed the low-protein ration had diarrhea (Figs 3–4).

Discussion

Postweaning diarrhea in pigs can be caused by a number of pathogens, including *Salmonella* spp., *S. hyodysenteria, E. coli,* rotavirus, TGE virus, *Trichuris suis,* and *Ascaris suum.*[4] It can also be the result of gastric ulcers,[5] low weaning weights; variable weaning weights (Skirrow SZ, Mercy AR, Buddle JR, Madec, 1992, Proc. IPVS 551); or diet.[6-9]

Because the clinical diarrhea was not transmitted to the groups of pigs exposed to the environment or the manure of affected pigs from the boar test station, and because diarrhea occurred in the trial pigs that were housed in disinfected, isolator rooms, we assume that the primary cause of the diarrhea was not an infectious agent.

Pigs fed the high-protein ration had higher morbidity rates due to diarrhea than those fed low-protein rations. ($P < 0.05$). Three other boar test stations changed their pelleted rations from 17% CP to 21% CP at the same time as the test station that participated in this observational study. The pigs in one of these other three units, which used a corn-soybean ration, experienced a similar increase in the morbidity rate due to diarrhea. The other two units, which used a pelleted wheat-based ration (Tables 1 and 2), did not experience an increase in morbidity rate due to diarrhea with the ration change, probably because less soybean meal is needed to achieve similar CP levels in wheat-based rations.

Other researchers have found that rations with high levels of soybean contributed to diarrhea.[4,6-8] Rations containing between 22% CP and 27% CP caused more diarrhea than rations with 15%-19% CP.[3,7]

The productivity of the boars on the higher CP ration was lower than those on the low-protein ration. It was not determined whether the decreased productivity was associated with the diarrhea. Other studies have shown a higher average daily gain with 22% CP to 27% CP rations compared to 15% CP to 18% CP rations.[3,7] They reported no difference in the feed : gain ratios between rations.

Enzymes in the pig intestine partially digest feed prior to microbial degradation.[4] If pigs are fed rations that contain nutrients the enzyme system cannot digest, the nutrients will be available in the large intestine. These nutrients may cause a change in the balance and the number of bacteria in the hind gut, resulting in symptoms of looseness or diarrhea.[4] This dysbacteriosis may explain the large numbers of *Campylobacter* spp., and *Balantidium* found in the affected pigs.

Soybean products can induce a net excess of secretion in the small intestine similar to that caused by enterotoxigenic strains of *E.coli*.[6,8] The higher level of soybean in the ration may have induced this increase in the secretion : absorption ratio.[6,8] Although the mechanism of this reaction is unknown, it is unlikely to be an allergenic response because the effect decreases the longer the pig is exposed to the ration.[8]

Another explanation for the diarrhea may be the use of pelleted feed. Nonspecific colitis has been associated with the use of pelleted rations.[4] This diarrhea can be prevented by feeding the same ration as a mash.

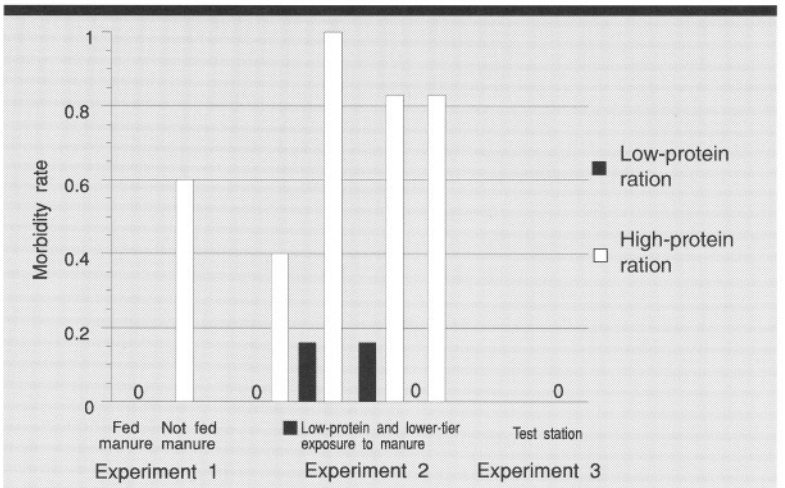

Fig 4. — Morbidity rate due to diarrhea in the feeding trial pigs.

Although the interactions between environment, disease and nutritional factors with respect to diarrhea in grower pigs are unresolved,[4] some risk factors have been identified. Stocking density, environmental conditions such as high temperature variations and cold stress,[6] and pig weight are associated with postweaning diarrhea (Skirrow SZ, Mercy AR, Buddle JR, Madec, 1992, Proc. IPVS 551). In the affected boar test station, the stocking density and temperature variation were within normal limits but the variation in the weights of pigs entering the barn and the mixed source of pigs may have been component causes of the diarrhea.

Because morbidity rates at the boar test station and in the field trial were lower in groups fed the lower protein rations, we conclude that the pelleted corn and soybean, 21% CP ration was a necessary cause of the diarrhea. As the genetic capacity for muscle growth in the pig is enhanced, we must increase the level of lysine in the ration and carefully balance the essential amino acids to enable the pig to grow to its maximum capacity. However, we must be aware that marginal excesses of dietary lysine may depress growth rate (Campbell RG, 1992, Proc Minn Swine Conf for Veterinarians, p. 299-306), and that excess soybean in the ration may increase the risk of diarrhea.

Diet-induced diarrhea can be avoided by feeding a mash rather than a pelleted feed. The present study suggests, however, that decreasing the amount of soybean in a pelleted ration while maintaining an adequate level of lysine and a balance of other essential amino acids may also be necessary.

Acknowledgements

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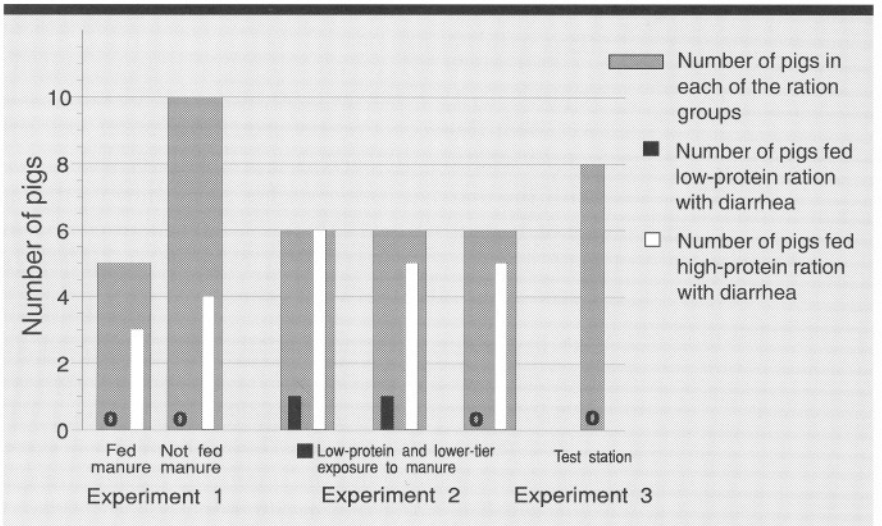

Fig 3. — Morbidity due to diarrhea in the feeding trial pigs

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