THE EFFECT OF TRANSPORTATION STRESS AND FEED WITHDRAWAL ON THE
SHEDDING OF SALMONELLA TYPHIMURIUM BY SWINE

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Of the food borne pathogens, the United States Department of Agriculture has identified
Salmonella to receive its highest priority (Davies, P., 1997). The consumption of pork products
contaminated with Salmonella is a frequent cause of disease. Bryan (Bryan, 1988), for example,
demonstrated, for example, that 11% of Salmonella outbreaks were associated with the
consumption of pork, while Bean and Griffin (1990) have described numerous outbreaks where
pork was identified as the source of contamination. S. typhimurium is one of the leading causes of
salmonellosis in man and is the second most commonly isolated serotype from swine (Hargrett-
Bean, Pavia, and Tauxe, 1988). Animals exposed to Salmonella generally become persistently
colonized for the remainder of their lives and can serve as reservoirs to contaminate other animals
and food products. In a study by Wood, et al (1989), it was shown that animals challenged with
S. typhimurium continued to shed S. typhimurium until they reached market weight 28 weeks
later. In that study, carrier animals were identified because they persistently shed low levels of
the challenge organism.

Current data is consistent with the hypothesis that pigs are infected early in life and
become persistently infected. Stresses, particularly those associated with shipping, are believed
to increase the shedding of Salmonella by carrier animals. While most of this belief stems from
anecdotal evidence, in 1970 Williams and Newell 1970 showed that shipment of pigs led to
altered (increased) shedding patterns of Salmonella. Thus, as a result of shipping, carrier animals
begin to shed higher levels of Salmonella that may be spread within the herd during shipment, at
packing plants, and during the processing to finished products. We hypothesize that the number of
Salmonella shed by carrier animals on the farm remains low because the immune system
suppresses bacterial proliferation. The stress associated with shipment of pigs leads to
suppression of the immune system and this in turn leads to uncontrolled growth of Salmonella.
In addition, our preliminary data suggests that feed withdrawal prior to shipment to slaughter
plants also may be an important factor leading to shedding of Salmonella (Isaacson,
unpublished). The work described in this manuscript was designed to test these hypotheses.

MATERIALS AND METHODS

Fifty-six pigs were obtained and after weaning (4-5 weeks of age) each was challenged
orally with 1 ml of S. typhimurium strain 798 containing 2 x 108 viable cells. The strain used was
resistant to nalidixic acid. Four weeks post challenge the pigs were re-challenged with the same
number of organisms. For the first month fecal samples were obtained from each pig on a weekly
basis and after the first month, on a monthly basis. When the pigs reached an average weight of
240 pounds, they were divided into four groups. Pigs in groups 1 and 2 were allowed access to
feed for the 24 hour period prior to slaughter while pigs in groups 3 and 4 were taken off feed.
Pigs in groups 2 and 4 were transported by truck-trailer for 167 miles (approximately four hours
in duration) and slaughtered, while the pigs in groups 1 and 3 were slaughtered without
transporting. Contents from the intestinal tract at the ileocecal junction were collected from each

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animal.

One gram samples of feces or ileocecal contents were added to 10 ml tetrathionate broth, mixed, and four serial 1:10 dilutions were prepared into four additional tubes containing 10 ml tetrathionate broth. All tubes were incubated 24 hours at 37°C. One ml from each tube was added to 10 ml of Rappaport medium, incubated 24 hours at 37°C, and then plated on brilliant green plates. After another 24 hour incubation period (37°C) red colonies from the brilliant green plates were picked and plated on LB agar containing nalidixic acid (50 μg/ml) to confirm that the colonies were the nalidixic acid resistant challenge organism. The relative concentration of challenge *S. typhimurium* per sample was defined as the highest log10 dilution yielding growth.

RESULTS

All 56 pigs in this experiment were challenged with the nalidixic acid resistant *S. typhimurium* strain 798 to ensure that all pigs had been exposed to *Salmonella*. As expected, all animals were shedding the challenge organism one week after being challenged. The mean log10 concentration was 3.35 per gram of feces one week post challenge. There was a steady decrease in the concentration of challenge organism in feces from the subsequent samples. After the re-challenge, the concentration of challenge organism in feces increased and then subsequently fell. One week prior to slaughter only one pig was shedding the challenge organism in feces and the log10 concentration for that pig was 1.

To determine whether any of the treatments affected the presence of challenge organism in the intestinal tract, contents from the ileocecal junction were collected and cultured. Ileocecal contents were used instead of feces because after feed withdrawal and transporting, fecal samples could not be collected from a large number of the pigs. The culture results are shown in Table 1. Only 3 of 14 pigs in group 1 (on feed and no transport) were positive for *S. typhimurium* while 11/14 pigs in

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<th>No transport (#positive/total)</th>
<th>Transport (#positive/total)</th>
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<tr>
<td>Feed</td>
<td>3/14</td>
<td>11/14</td>
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<tr>
<td>Feed withheld</td>
<td>7/14</td>
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Table 1. Presence of *S. typhimurium* in ileocecal contents after feed withdrawal and/or transport

Of group 2 (on feed and transported) were positive. The difference between these groups was statistically significant (*p*=0.023). The mean concentration of challenge organism in samples from each group did not differ ranging from log10 2.3-2.6.

DISCUSSION

The objective of this study initially was to determine whether transportation related stress increased the risk that a pig would shed *Salmonella* in feces (or intestinal contents). In our preliminary experiments, there was evidence that suggested that feed withdrawal also might be a stressor that increased shedding of *Salmonella*. To test these two possibilities, a two by two matrix study was designed. Four groups of pigs were employed: feed, no transport; feed,
transport; no feed, transport; and no feed, no transport. To insure that all pigs had an equal opportunity to be persistent carriers, all were challenged with a nalidixic acid resistant strain of S. typhimurium that is known to persistently colonize pigs. Twenty-four hours before slaughter, the pigs were randomized into four equal groups of 14 and treated as described. As expected, pigs that remained on feed and not transported had the lowest incidence of S. typhimurium in ileocecal contents (3/14). The highest incidence (11/14) was in pigs that were transported and remained on feed. The two other groups had an intermediate incidence. We had expected that the pigs that were subjected to feed withdrawal and transported would have experienced the greatest degree of stress and would have had the highest number of S. typhimurium positive samples. However, this was not the case. Our interpretation of these results is that transportation related stress does contribute to increased shedding of Salmonella. This is consistent with the study of Williams and Newell (1970). It is interesting that when assessed as a single variable, feed withdrawal also appeared to increase the incidence of S. typhimurium shedding. However, when feed withdrawal was combined with transportation, the effects were not additive and shedding did not increase further. This suggests that feed withdrawal may actually reduce the incidence of Salmonella shedding when combined with transportation (5/14 pigs compared to 11/14 pigs). Thus, the practice of feed withdrawal prior to shipment of pigs to market, which was developed to reduce the amount of feces in the gut at slaughter, also may actually reduce the incidence of pigs that are actively shedding Salmonella.

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REFERENCES


