SUBCLINICAL SALMONELLA INFECTION IN DANISH FINISHING PIG HERDS: 
THE EFFECT OF SALMONELLA CONTAMINATED FEED

Stege H.\textsuperscript{ab}, Christensen J.\textsuperscript{a}, Baggesen D.L.\textsuperscript{a}, Nielsen J.P.\textsuperscript{a}

As part of the integrated salmonella programme in the pig production, feed produced in Danish feed mills is examined for salmonella after heat treatment. The results of the bacteriological examination have shown that the prevalence of salmonella in the finished feed products has been < 0.1% (Annual Report on Zoonoses in Denmark, 1996). Since feed may be contaminated during transport, storage or in the feeding systems at the farms, and only the concentrate part of home-mixed feed is being heat treated and examined, the actual occurrence of salmonella in the feed when fed to the pigs is unknown. The aim of this study was to determine the prevalence of salmonella in feed at the outlets in the pens, to establish whether certain feeding systems or types of feed were more likely to be contaminated and to assess the possible association between salmonella detected in feed and salmonella infection of pig herds.

MATERIALS AND METHODS

The study comprised 96 randomly selected herds (low sero-prevalence) and 39 herds randomly selected among herds with a high sero-prevalence in the salmonella surveillance programme in Danish slaughter pig herds (Mousing et al. 1997; Nielsen et al. 1997). From each herd, 10 pens were examined by: (1) a pooled pen sample (5x5 g faeces), (2) a feed sample (50 g feed), and (3) 5 blood samples. All samples were forwarded to the Danish Veterinary Laboratory and examined by culturing or in the mix-ELISA (Nielsen et al. 1995). The data included the results of bacteriological testing of pen and feed samples, stated as salmonella serotype or negative, and the result of the serological testing, stated as OD\% (optical density).

Pen and blood samples were included to examine the salmonella status of the herds and to confirm that the 96 randomly selected herds had a low sero-prevalence, and the 39 high sero-prevalence herds were still high prevalence herds.

Herds were considered bacteriologically positive if salmonella was isolated from one or more pen or feed sample(s). Salmonella sero-types were categorized as either 'S. Typhimurium' (Tm) or 'non-S. Typhimurium' (non-Tm).

The feed samples were collected from the cribs, and precautions were taken in order to avoid contamination from the environment; if wet feeding was used, the system was turned on, and the samples were collected in the 'mid-flow' from the tube. If dry feeding was used, the crib was wiped clean, and feed was poured from the dispenser and collected immediately.

Information regarding types of feed and feeding systems was collected. For analyses, the feeding systems were divided into 7 groups, consisting of different combinations of the factors; ad libitum/restricted, home-mixed/purchased, pelleted/non-pelleted, and wet/dry feed. One combination did not allow sampling without faecal contamination (ad libitum, purchased, pelleted, and dry feeding), and therefore all bacteriological results from this type of system are

\textsuperscript{a} Danish Veterinary Laboratory, 27 Bülowsvej, DK-1790 Copenhagen V, Denmark
\textsuperscript{b} Royal Veterinary and Agricultural University, Department of Animal Science and Animal Health, Division of Ethology and Health, 13 Bülowsvej, DK-1870 Frederiksberg C, Denmark
presented, but were excluded from statistical analyses.

RESULTS

Prevalence: The results from the testing of pen and blood samples confirmed that the 96 randomly selected herds had a low sero-prevalence, and the 39 high sero-prevalence herds still had a high sero-prevalence at the time of the visit. The results of the bacteriological examination of feed samples are shown in table 1. Among the 96 randomly selected herds, 14 different salmonella sero-types (non-Tm) were isolated from feed samples from 25 herds (26%). In these herds the proportion of positive samples ranged from 0.1 -1.0 with a mode of 0.1. In 8 herds more than one salmonella serotype was isolated.

In the group of high prevalence herds salmonella (non-Tm) was isolated from one feed sample (2.6%). S. Typhimurium was only isolated from feed when the feeding system did not allow sampling without faecal contamination, and exclusively from herds where S. Typhimurium was isolated from pen samples as well. These results were therefore excluded before statistical analyses.

Table 1. Prevalence of salmonella, detected in feed samples, collected from 135 Danish finishing herds

<table>
<thead>
<tr>
<th></th>
<th>96 randomly selected herds</th>
<th>39 high prevalence herds</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Tm</td>
<td>25 (26%)</td>
<td>1 (2.6%)</td>
<td>26 (19%)</td>
</tr>
<tr>
<td>Tm</td>
<td>1 (1%)</td>
<td>7 (18%)</td>
<td>8 (5.9%)</td>
</tr>
<tr>
<td>Total</td>
<td>26 (27.1%)</td>
<td>8 (20.5%)</td>
<td>34 (25.2%)</td>
</tr>
</tbody>
</table>

Influence of different feeding systems on salmonella occurrence in feed: Calculation of $\chi^2$ or Fishers Exact tests and corresponding p-values was based upon the data in table 2 (2x6 table). The calculations were repeated for the two groups of herds separately and the groups combined. All p-values were > 0.1, indicating that the occurrence of salmonella in feed samples was not significantly related to the type of feeding system. However, the distribution of feeding systems differed in the two groups, since the combination (ad libitum, purchased, pelleted, dry feed) was far more common in the group of high prevalence herds.

Table 2. Distribution of herds with salmonella positive feed samples, using different feeding systems. 135 Danish finishing herds

<table>
<thead>
<tr>
<th></th>
<th>Randomly selected herds</th>
<th>High prevalence herds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Feed negative</td>
<td>Feed positive</td>
</tr>
<tr>
<td>Ad libitum, home-mixed, non-pelleted, dry</td>
<td>27</td>
<td>8</td>
</tr>
<tr>
<td>Ad libitum, purchased, non-pelleted, dry</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>(Ad libitum, purchased, pelleted, dry)</td>
<td>19</td>
<td>4</td>
</tr>
<tr>
<td>Restricted, home-mixed, non-pelleted, dry</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Restricted, home-mixed, non-pelleted, wet</td>
<td>7</td>
<td>4</td>
</tr>
</tbody>
</table>
Restricted, purchased, pelleted, dry  4  3  4  0
Other combinations            6  2  2  0

Total                     70  26  31  8

¹ Excluded before statistical analyses.

Association between salmonella detected in feed and salmonella infection in pig herds: When comparing the two groups of herds and excluding all results that could be caused by faecal contamination, the occurrence of salmonella in feed differed between the groups. Among 73 randomly selected herds, the number of herds with one or more positive feed sample(s) was 22, among 17 high sero-prevalence herds, the number of herds with one or more positive feed sample(s) was 1.

The OR_{non-Tm in feed} for randomly selected herds was 6.9 with p = 0.061 (Fishers exact 2-tail).

DISCUSSION

The occurrence of non-S. Typhimurium in feed, demonstrated in this study, is considerably higher than the prevalence of salmonella in finished feed products after heat treatment. An explanation could be that the sample site in this study was the cribs, hence included possible contamination of feed during transport, storage or in the feeding systems at the farms, and that all components of home-mixed feed were included as well. To establish when contamination of feed may occur needs further studies.

This study suggests that the occurrence of salmonella in feed is not associated with the feeding system as such, since all combinations were equally likely to be infected.

When comparing groups of herds with low and high sero-prevalence, the occurrence of non-S. Typhimurium in feed was associated with low sero-prevalence herds. A possible explanation could be that pigs exposed to non-S. Typhimurium in feed are somehow protected against infection with S. Typhimurium, maybe by means of a local immune response, and that infection with S. Typhimurium is more likely to initiate a high serological response in pigs than infection with non-S. Typhimurium. Alternatively, the occurrence of salmonella in feed may be related to another protective factor, not included in the analyses presented here. Further investigation is needed in order to explain this result.

REFERENCES


**SUMMARY**

The study comprised 96 randomly selected herds and 39 high sero-prevalence herds. Among the randomly selected herds, 14 different salmonella sero-types (non-S. Typhimurium) were isolated from feed samples from 25 herds (26%). In these herds the proportion of positive samples ranged from 0.1-1.0 with a mode of 0.1. In 8 herds more than one salmonella serotype was isolated. In the group of high prevalence herds salmonella (non-S. Typhimurium) was isolated from one feed sample (2.6%). The occurrence of salmonella in feed samples was not significantly related to the type of feeding system.

When comparing groups of herds with low and high sero-prevalence, the occurrence of non-S. Typhimurium in feed differed considerably. The occurrence of salmonella in feed (non-S. Typhimurium) was in this study associated with low sero-prevalence.