Prevalence of *Salmonella* in fattening pigs – risk factors and spread

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Abstract

The objective of this study was to analyse herd-level factors increasing the risk of *Salmonella* infections in fattening pigs. Therefore, 1836 blood samples from 32 fattening farms in Northern Germany were examined for *Salmonella* antibodies, considering the management and hygienic conditions on the respective farms. This additional information was collected by questionnaires. Nearly 14% of all blood samples were classified as *Salmonella*-positive and only five farms were free from *Salmonella*. A logistic regression model showed that the application of antibiotics increased the Odds Ratio (OR) by the factor of 5.21 compared to untreated pigs. In addition, a partly slatted floor raised the prevalence of *Salmonella* as well as an insufficient usage of overalls for visitors or the lack of feed tube cleaning (OR circa 2). Regarding the proximity to other swine herds, it was shown that a distance of at least 2 km decreased the chance of a positive *Salmonella* result (OR = 0.27).

This study clearly supported the benefit of hygienic measures for the reduction of *Salmonella* in pigs.

Introduction

With 40,000 to 50,000 human illnesses every year (RKI, 2007; 2008; 2009) *Salmonella* still represents a major health problem in Germany. Especially pork was identified as source of infection, as shown by an outbreak in illnesses in the year 2005, traced back to the consumption of unboiled pork and a following infection with *Salmonella BovisMorbigicans* (BfR, 2005).

*Salmonella* prevalence on German fattening farms is very heterogeneous, as shown by first results of the 2007 established *Salmonella*-Monitoring in pork (Münster, 2009). Therefore, the question of the involvement of management or husbandry factors and preventive hygiene measures is of great importance to find the reasons for these differences in *Salmonella* prevalence. The aim of this study was to evaluate the most important risk factors associated with pigs tested seropositive for *Salmonella*.

Material and methods

Before plausibility check, the data consisted of blood samples from 1949 animals of 34 conventional fattening farms in Northern Germany. Each animal was tested only once. The numbers of examined animals differed between the farms. The calculation of Noordhuizen et al. (1997) was used to ensure that the sampling enables the estimation of *Salmonella* prevalence at herd-level. The pig sampling was randomised and included all fattening houses. Furthermore, data about husbandry, management and hygiene were collected by questionnaires. This survey was carried out at stable-level because of the possible housing differences between stables of one farm. Some of the survey-issues were not considered in the analysis of possible risk factors because of unilateral answers. Furthermore, two fattening farms were not considered in the further evaluations because of basically different production systems. After plausibility check, the upgraded dataset consisted of 1836 blood samples from 59 stables of 32 fattening farms. Following 19 factors were recorded:
- Number of fattening pigs
- Permanent pig producer(s) or varying supplier(s)
- Kind of partitions between pens
- Application of antibiotics
- Fully slatted floor or partly slatted floor
- Cadaver pick-up from yard or street
- Proximity to other swine herds (less than 2 km)
- Overalls for visitors
- Changing room
- Separation of diseased pigs
- Birds or rodents in the stable
- Cleaning of feed tube
- Cleaning of walls
- Cleaning of boots
- Pets access to stable
- Feeding system
- Kind of feed
- Origin of feed (farm output or bought)
- Acidification of feed

Due to the fact that the number of included fattening farms was still small not all of the listed factors were considered for analysis. The number of effects was reduced and the SAS Procedure PROC LOGISTIC (SAS 9.1) was applied. The SELECTION=STEPWISE option adds an effect to the model and might remove it or any other factor from the model in the next step. The selection process ends when none of the effects meet the specified level for the inclusion or exclusion in the model or when same effect is included and then removed in the next step (SAS Institute Inc, 2004). Finally the following model was used:

$$\log \left( \frac{E(Y_{ijkmno})}{1 - E(Y_{ijkmno})} \right) = \beta_0 + PP_i + AA_j + F_k + PS_l + OV_m + CF_n + BR_o$$

- $Y_{ijkmno}$ = Testing result of the blood sample (positive/negative)
- $PP_i$ = Partition between pens with $i = 1$ (closed partition), 2 (latticed partition)
- $AA_j$ = Application of antibiotics with $j = 1$ (yes), 2 (no)
- $F_k$ = Floor with $k = 1$ (fully slatted floor), 2 (partly slatted floor)
- $PS_l$ = Proximity to other swine herds (< 2 km) with $l = 1$ (yes), 2 (no)
- $OV_m$ = Overalls for visitors with $m = 1$ (yes), 2 (no)
- $CF_n$ = Cleaning feed tube with $n = 1$ (regularly), 2 (sometimes), 3 (never)
- $BR_o$ = Birds and rodent in the stable with $o = 1$ (less rodents and no birds), 2 (increased rodents as well as birds in the stable)

All combinations of effects were checked by using the Phi-Coefficient and Cramer’s V to assure that there are no correlations between them. No couple of variables showed such a correlation and all effects remained in the model.

**Results**

Every seventh blood sample was tested *Salmonella* positive. With regard to the stable and farm-level nearly 60% of all stables and more than 80% of the fattening farms had at least one positive sample. Nevertheless, only two farms were classified in QS-Category III (herd-level prevalence > 40%), which is the only class demanding for *Salmonella* reducing activities. The estimation of the logistic regression showed that all selected effects had a significant impact on the *Salmonella* prevalence. Nagelkerke’s $R^2$ reached a value of nearly 20 %, meaning that the model could explain almost one fifth of the variance in *Salmonella* prevalence. The Odds Ratio of an antibiotic treated pig tested *Salmonella* positive was five times higher than for an untreated pig (Table 1). Furthermore, the
proximity to other swine herds increased the chance of getting a positive sample. However, a fully slatted floor, overalls for visitors and the -even irregular- cleaning of the feed tube reduced the chance for a positive tested pig. Furthermore, the results showed that a latticed partition between pens and the increasing number of rodents and birds in the stable decreased the chance for a positive result, too.

Table 1: Stable-level factors associated with seropositivity for *Salmonella*

<table>
<thead>
<tr>
<th>Effect</th>
<th>Odds Ratio</th>
<th>95% confidence limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application of antibiotics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>yes vs. no</td>
<td>5.21 /1</td>
<td>3.51 - 7.73</td>
</tr>
<tr>
<td>Floor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>fully slatted floor vs. partly slatted floor</td>
<td>0.51 /1</td>
<td>0.35 - 0.74</td>
</tr>
<tr>
<td>Proximity to other swine herds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>yes vs. no</td>
<td>3.76 /1</td>
<td>2.47 - 5.73</td>
</tr>
<tr>
<td>Overalls for visitors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>yes vs. no</td>
<td>0.54 /1</td>
<td>0.38 - 0.77</td>
</tr>
<tr>
<td>Cleaning feed tube</td>
<td></td>
<td></td>
</tr>
<tr>
<td>regularly vs. sometimes</td>
<td>1.14 /1</td>
<td>0.75 - 1.74</td>
</tr>
<tr>
<td>regularly vs. never</td>
<td>0.40 /1</td>
<td>0.27 - 0.63</td>
</tr>
<tr>
<td>sometimes vs. never</td>
<td>0.35 /1</td>
<td>0.24 - 0.51</td>
</tr>
<tr>
<td>Birds and rodent in the stable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>less rodents no birds vs. increased rodents and birds</td>
<td>3.04 /1</td>
<td>2.02 - 4.56</td>
</tr>
<tr>
<td>Partition between pens</td>
<td></td>
<td></td>
</tr>
<tr>
<td>latticed partition vs. closed partition</td>
<td>0.56 /1</td>
<td>0.40 - 0.79</td>
</tr>
</tbody>
</table>

Discussion

In accordance with van der Wolf et al. (2001) this study showed an association between the use of antibiotics and an increasing *Salmonella* prevalence. This might be related to the negative impact of antibiotic application on the physiological gut flora, enabling *Salmonella* to colonise the intestines without antagonists. However, antibiotics are mainly administered on fattening farms with existing hygienic problems, and therefore, cause and effect could be inverse.

The *Salmonella* reducing effect of a fully slatted floor is most probably associated with fewer faeces remaining on the floor. Several other studies described similar results, for example Davies et al. (1997), Nollet et al. (2004) or Vonnahme et al. (2008). Latter analysed data of gilts and did not approve a significant correlation between *Salmonella* prevalence and cleaning the feed tube, rodents and birds in the stable, application of antibiotics or the proximity to other swine herds.

Moreover, the results suggested that a partition enabling contact from pen to pen reduced the chance for a positive blood sample as well as the occurrence of rodents and birds in the barn, which could not be explained logically and might be related to hitherto unknown factors. In case of pen partitions, even closed pen partitions enable the pigs to have at least snout contact with their neighbours. Furthermore, the importance of snout by snout infection is minor (Schwarz, 1999). The subjective perception of pest infestation could be one reason for the bias in the data set resulting in the Odds Ratios for rodents and birds in the barns. Furthermore, the fact that only two farms had a *Salmonella* prevalence exceeding 40% complicated the analysis of risk factors.

Conclusions

The examined dataset considered 32 fattening farms. Although the small number of farms, the analysis clearly showed that especially hygienic aspects like cleaning the feed tube, overalls for visitors and as little faeces contact as possible provide prospects to reduce *Salmonella* infections in pigs.
References


