RESULTS FROM A STUDY OF THE EFFECT OF ENHANCED CLEANING AND DISINFECTION ON SALMONELLA PREVALENCE IN FINISHER PIG BUILDINGS

Francesca Martelli¹, Mark Lambert², Becky Gosling¹, Rebecca Callaby², Rob Davies¹, Richard Piers Smith³

¹Department of Bacteriology and Food Safety, Animal and Plant Health Agency (APHA) – Weybridge, Woodham Lane, New Haw, Addlestone, Surrey KT15 3NB. UK
²National Wildlife Management Centre, APHA - Sand Hutton, York, YO41 1LZ UK
³Department of Epidemiological Sciences, APHA – Weybridge, Woodham Lane, New Haw, Addlestone, Surrey KT15 3NB. UK
Corresponding author: Richard Piers Smith, Richard.P.Smith@apha.gsi.gov.uk

Introduction

Salmonella is the second most commonly reported zoonotic gastrointestinal pathogen in the European Union [1]. Although the majority of foodborne outbreaks have been linked to the consumption of eggs and egg products (44.0%), a substantial proportion originate from pork and pork products (9.3%) [1]. Biosecurity measures correctly implemented on farm are important to reducing Salmonella carriage in live pigs and consequently the number of Salmonella contaminated carcasses entering the food chain. Cleaning and disinfection (C&D) of pig pens is considered an essential part of any successful on-farm Salmonella control regimen [2,3]. Environmental Salmonella contamination increases the risk of Salmonella shedding in newly introduced batches of pigs [4]. The ability of disinfectants to eliminate Salmonella is influenced by the type of disinfectant chosen and its concentration, and may be severely compromised by the presence of organic matter [5,6]. Different types of disinfectant are commercially available, such as quaternary ammonium compounds (QAC) products containing glutaraldehyde or formaldehyde, peroxy or peracetic acid based compounds, iodine based compounds or chlorocresols. Their effectiveness against Salmonella varies greatly, as demonstrated in several in vitro and on farm studies [5,6,7]. Currently, disinfectants intended for veterinary use may be assessed for efficacy using methods which do not use the matrices commonly found on farms, and therefore the efficacy of a disinfectant in field conditions can be overestimated. Within this study, a C&D regimen consisting of disinfectants of known efficacy and following a rigorous standardised procedure was compared to farmers’ routine C&D procedures on Salmonella contaminated pig holdings in the UK. The effectiveness of C&D procedures was evaluated by the reduction in Total Bacterial count (TBC), Enterobacteriaceae and Salmonella contamination.

Method

Ten farms were enrolled, all of which produced finished bacon pigs; operated the study buildings using an all-in/all-out programme; and had a previous pen faecal prevalence of Salmonella of over 20%. In each of the farms, two buildings housing finishing pigs at the same stage, with similar size and management practices, were selected. One building was randomly assigned as the intervention building, and the other building served as control. Four sampling visits were carried out to each of the study farms. The first visit (pre-C&D) was carried out when the first batch of pigs was
close to slaughter. The second visit (post-C&D) was carried out when the buildings had been cleaned and disinfected and were still empty. The third visit was carried out 2 to 3 weeks after the second batch of pigs had been housed in the study buildings (post-restocking). The fourth visit was carried out when the second batch of pigs was close (2 to 3 weeks) to slaughter. At each visit, one pooled faecal sample was collected for each 50 pigs housed in a pen. Furthermore, 10 individual faecal samples were collected from the floor in up to 6 randomly selected pens for each building. At the second visit (post-C&D), feeders, drinkers and floors of the empty buildings were swabbed with hand-held gauze swabs. All intervention buildings were cleaned and disinfected by trained contractors, according to a protocol comprising a series of steps (removal of faeces, foaming, washing, disinfecting and cleaning portable equipment). All intervention buildings were disinfected using GPC8 (Evans Vanodine International Plc, Preston, UK) at Defra-approved concentration (1:35 ratio) and boot dips were refilled with FAM30 1:90 (Evans Vanodine). The procedures and products used in the control buildings were those usually employed by the farmer, and therefore differed from farm-to-farm. The association between building type (intervention or control) and the shedding of *Salmonella* by pigs was assessed using generalised linear mixed models (GLMM) in R version 3.2.4 using the lme4 package. Sample type and age group of pigs sampled, season and whether the sample came from an intervention building or a control, were included in the model as *a priori* variables. The farmer C&D practices were recorded and a forwards stepwise selection process was used to identify variables that were significantly associated with *Salmonella* prevalence. When analysing the Enterobacteriaceae and total bacterial counts, statistical analyses were carried out with STATA® software (StataCorp, Texas, USA). The model tested both Enterobacteriaceae and TBC counts as two separate outcomes, and included the farm identifier as a random effect to account for the non-independence of samples from the same farm.

**Results**

*Salmonella* was isolated from all buildings at the pre-C&D visit, apart from the control buildings in farms 222C and 225C. At the post-C&D visit, *Salmonella* was isolated only in farm 228C in the intervention building, and in farms 221C, 229C and 230C in the control buildings. At the post-restocking visit, *Salmonella* was isolated from all buildings in all farms, except for the intervention building in farm 225C. At the pre-slaughter visit, *Salmonella* was isolated from all buildings in all farms, except for farm 222C. The samples from intervention buildings were significantly less likely to be positive for *Salmonella* than the control buildings after C&D and at the pre-slaughter visit (both *p*=0.004) (Figure 1). However, there was no difference in the likelihood of samples from the intervention and control buildings being positive for *Salmonella* at the post-restocking visit (*p*=0.119).
Figure 1. Plot showing the interaction effect of intervention and visit type on the predicted probability of a sample being positive for *Salmonella* (with 95% confidence interval error bars). Samples used in this analysis were: a) the pre-C&D and post-C&D visits only; b) the pre-C&D and post-restocking visits only; c) the pre-C&D and pre-slaughter visits only.

TBC counts were significantly lower in intervention buildings in samples from floors, drinkers and feeders (p<0.001) after C&D but only in drinker samples (p=0.003) for Enterobacteriaceae (Figure 2).

Figure 2. Mean Enterobacteriaceae (A) and total bacterial counts (B) in intervention (case) and control buildings from samples from floors, feeders and drinkers on 10 farms.

The results of the multivariable analysis assessing the farmer’s methods of C&D showed how thorough cleaning and disinfection of ledges, beams, vents and ceilings and allowing 3-10 days downtime between batches was an effective measure to reduce the likelihood of residual *Salmonella* contamination. Leaving pens empty for longer period (2-3 weeks) appeared to be a significant risk and this may reflect a less intensive management system on these farms. Leaving a pen to dry after cleaning for 3-4 days was a risk factor when compared to 1-2 days. Other significant risk factors included changing feed between visits, coughing present in the pigs, the use of treatments between visits, whereas improvements to wildlife control and harbourage was identified as a significant protective factor. These individual factors appeared to explain the difference between the results from the intervention and control buildings and may highlight the key differences between the cleaning protocols.
Salmonella contamination was observed post-C&D in the control buildings of four farms. Three of these farms used glutaraldehyde and QAC products, but at a dilution rate (1:200) which was far higher than the recommended dilution (1:49). Over-diluting disinfectants is a common reason for disinfection failure [2]. The fourth control farm with residual post C&D contamination used an iodine-based disinfectant. In this farm, the disinfectant was used at a lower dilution rate (1:50) than the recommended rate (1:90). However, iodine-based compounds have been demonstrated to be less effective than aldehydes, especially in the presence of organic matter. This was confirmed in this study by the results of the multivariable analysis that showed that the iodine-based product used on this farm was significantly more likely to result in residual Salmonella contamination. Whilst there was no difference in the Salmonella prevalence between intervention and control buildings at the post-restocking visit, a significant difference was observed at the pre-slaughter visit, where pigs housed in the intervention buildings had a significantly lower prevalence. Samples collected during the summer were more likely to be positive for Salmonella and the highest Salmonella prevalence is observed on farms in these summer months, and this can be attributed to the fact that the higher temperature represents a stress factor for the pigs and it can result in higher shedding rates [8].

Conclusion

The study found that buildings that were cleaned by the intervention method, using Defra recommended concentrations, were more likely to be Salmonella free post-C&D and this reduced the probability of samples from them being positive pre-slaughter, which demonstrates the effectiveness of appropriate disinfection programmes aimed at eliminating Salmonella. The study also highlighted key risk and protective C&D procedures that can influence the likelihood of Salmonella contamination. Due to the high prevalence of infection in replacement breeding and weaned pigs, elimination of Salmonella from pig holdings is unlikely to be possible in most countries. C&D is a useful measure to reduce the proportion of infected pigs prior to slaughter, but is only one of many combinations of measures needed to minimise Salmonella contamination of pig meat. Abstract adapted from Martelli et al [9], where further details of the study are presented.

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References


