Modelling Salmonella spread within a pig farm under three biosecurity strategies

Amandine Lurette, Catherine C. Belloc, Suzanne Touzeau, Thierry Hoch, Henri H. Seegers, Christine Fourichon

Modelling *Salmonella* spread within a pig farm under three biosecurity strategies

Lurette, A. [1] **, Belloc, C.** [1] **, Touzeau, S.** [2] **, Hoch, T.** [1] **, Seegers, H.** [1] **and Fourichon, C.** [1]
[1]Unit of Animal Health Management, Veterinary School – INRA, Nantes, France; [2]Unit of Applied Mathematics and Computer Science, Jouy-en-Josas, France.

Abstract

Pork products contribute to human cases of salmonellosis. The *Salmonella* contamination level of pigs at slaughter age is a critical point in the contamination of the human food chain. The aim of this study was to estimate the number of shedder and carrier pigs at slaughter age under three biosecurity strategies. A stochastic mathematical model was hence developed to simulate the pig population dynamics and the pathogen transmission within a farrow-to-finish herd in which the batch farrowing system was set. We considered, both, the biological variability and the producers' management that can alter the contact structure and thus, the transmission of *Salmonella*. The proportion of pigs at slaughter age either carrying or shedding *Salmonella* was almost twice higher when batch mixing occurred. Our modelling approach allowed us to investigate the magnitude of the effects of biosecurity strategies.

Introduction

The *Salmonella* contamination level of pigs at slaughter age is a critical point in the contamination of the human food chain. Our aim was to estimate by simulation the influence of within farm biosecurity strategies on the prevalence of shedder and carrier pigs at slaughter age.

Material and Methods

We developed a stochastic mathematical model to simulate the pig population dynamics (Fig.1) and the *Salmonella* transmission within a farrow-to-finish herd. In this herd, the farrowing batch system was set. To model the infection of *Salmonella* in sows and pigs, three states were distinguished: susceptible state, shedder state, and carrier state. *Salmonella* transmission between pigs depended on contamination of pen floor which was influenced by the prevalence of shedders in the pen. Input parameter values for *Salmonella* transmission were estimations from literature (Beloeil, 2003; Fravalo, 2003; Kranker, 2003; Nielsen, 1995).

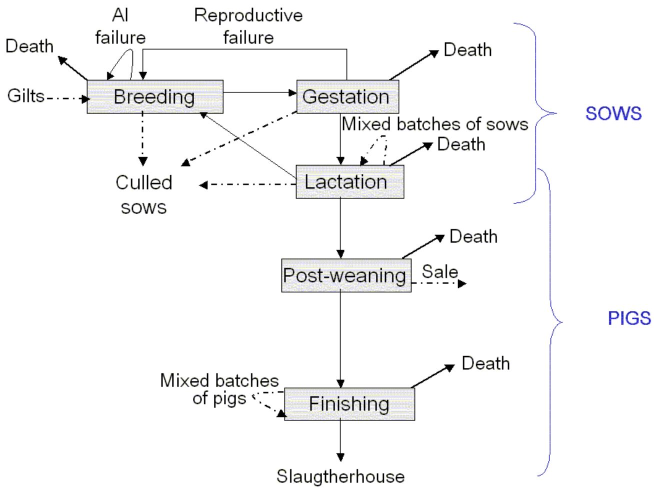

Figure 1. Simplified flow diagram of the farrow-to-finish herd production system.
→ flows linked to demographic processes
-·-→ flows controlled by producer.

We modelled variability of pig reproduction and growth and of producers' management that can influence the size of batches. Groups of slaughtered pigs were issued from several batches depending on their weight.

For an effective control of *Salmonella* transmission within a farrow-to-finish herd, biosecurity interventions simulated here were prevention of batch mixing while raising pigs and implementation of cleaning and drying period between consecutive batches. We tested three biosecurity strategies: (i) strict all-in/all-out (AI/AO), (ii) all-in/all-out with suppression of the

Proceedings of the 11th International Symposium on Veterinary Epidemiology and Economics, 2006
Available at www.sciquest.org.nz

drying period between batches (NDP), and (iii) possible batch mixing and suppression of the drying period between batches (BM). Under the BM strategy, we calculated the frequency of batch mixing during finishing, that was the number of batch mixed per total number of batches produced. We assumed a herd marketing groups of 105 pigs every two weeks on average. We aimed at comparing biosecurity strategies in a situation of endemic infection. Therefore, to initialise the model, simulation were ran after the introduction of a shedder gilt until an equilibrium was reached. Afterwards, we estimated the influence of the three biosecurity strategies on two model outputs: (a) the average number of batches in a slaughtered group, (b) the prevalence of shedder and carrier pigs at slaughter age. One hundred simulations were performed for each biosecurity strategy over a 300-week period.

Results

The frequency of batch mixing during finishing was 40% (±SD=3.2) for the BM strategy. The number of batches in a group at slaughter differed significantly under the three biosecurity strategies (P<0.01) (Tab.1).

Table 1. Proportion of groups of pigs at slaughter per number of batches under the three biosecurity strategies.

Biosecurity strategy	Number of batches 1	2	3	>3
AI/AO	0.18	0.34	0.30	0.18
NDP	0.21	0.35	0.27	0.17
BM	0.15	0.20	0.31	0.34

The introduction of a shedder gilt at the beginning of the simulation led to an average prevalence of 20% of shedder and carrier sows in the herd under the AI/AO strategy after around 50 weeks. When we changed the biosecurity strategy at 130 weeks, the prevalence of shedder and carrier pigs at slaughter varied between the three strategies tested around 20 weeks later (Fig. 1).

Prevalence of shedders and carriers at slaughter differed significantly (0.53±0.01. 0.45±0.02 and 0.27±0.04 for BM, NDP and AI/AO, respectively) (prevalence ± SD, p<0.001).

Discussion

Allowing contact between batches and reducing drying period increased the *Salmonella* transmission within the herd. When pigs from two batches were mixed, the number of shedders and carriers at slaughter age was almost twice higher than under AI/AO strategy.

Our modelling approach allowed to investigate the magnitude of the effects of biosecurity strategies. We used a simple epidemiological model. Transmission parameters must be precised. Indeed, published parameters were obtained from experiments which were not always performed in realistic herd conditions and varied highly depending on authors. Moreover, environmental transmission parameters are not documented. Sensitivity analysis on parameter values has to be done.

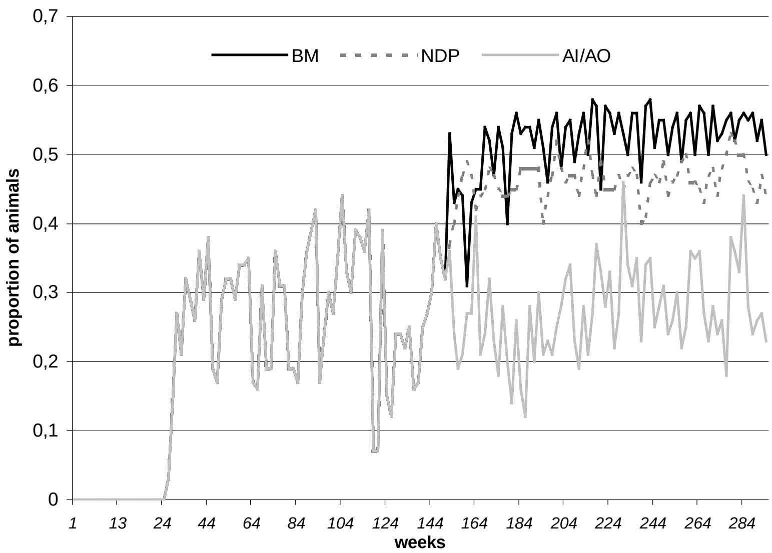

Figure 2. Prevalence of shedder and carrier pigs at slaughter over 300 weeks under AI/AO, NDP and BM biosecurity strategies (average over 100 simulations).

Previously published models described *Salmonella* transmission assuming homogeneous pig populations and considered only the growing and the finishing periods (Ivanek, 2004; van der Gaag, 2004). Our model studied the influence of both biological variability (such as growth heterogeneity) and producers' decisions on the population dynamics and structure. The contact structure plays a major role in pathogen transmission in a farrow-to-finish herd.

References

Beloeil P.A., Chauvin C., Proux K., Rose N., Queguiner S., Eveno E., Houdayer C., Rose V., Fravalo P., Madec F. (2003). Longitudinal serological responses to *Salmonella enterica* of growing pigs in subclinically infected herd. *Prev. Vet. Med.*, 60, 207-226.

Fravalo P., Cariolet R., Proux K., Salvat G. (2003). Le portage asymptomatique de *Salmonella enterica* par les porcs : résultats issus de la constitution d'un modèle en conditions expérimentales. *Journées de la recherche porcine*, 35, 393-400.

Ivanek, R., Snary, E.L., Cook, A.J., Grohn, Y.T. (2004). A mathematical model for the transmission of *Salmonella* Typhimurium within a grower-finisher herd in Great Britain. *J. Food Protect.*, 11, 2403-2409.

Kranker S., Alban L., Boes J., Dahl J. (2003). Longitudinal study of *Salmonella enterica* serotype Typhimurium infection in three Danish farrow-to-finish swine herds. *Journal of Clinical Microbiology*, 41, 2282-2288.

Nielsen B., Baggesen D., Bager F., Haugegaard J., Lind P. (1995). The serological response to *Salmonella* serovars Typhimurium and Infantis in experimentally infected pigs. The time course followed with an indirect anti-LPS ELISA and bacteriological examinations. *Veterinary Microbiology*, 47, 205-218.

van der Gaag , M.A., Vos, F., Saatkamp, H.W., van Boven, M., van Beek, P. and Huirne, R.B.M. (2004). A sate-transition simulation model for the spread of *Salmonella* in the pork supply chain. *European Journal of Operational Research*, 3, 782-798.