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Short communication

Salmonella in fattening pigs in Reunion Island: Herd prevalence and risk factors for infection

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ABSTRACT

Our objective was to identify the risk factors for *Salmonella* infection in fattening pigs in Reunion Island. Sixty pig farms were studied from April to August 2008 on the whole island. A questionnaire was submitted to the farmers, and samples of fresh faeces and gauze socks were taken to assess the *Salmonella* status of each herd. 40% of the herds tested positive for *Salmonella* spp. The most prevalent serovars were *S.* Typhimurium and *S.* Derby. The risk of *Salmonella* infection for the fattening pigs was increased when there was no disinfection at the farrowing stage (OR = 5.2), when large numbers of cockroaches were present on the premises (OR = 5.5) and when these facilities were not resistant to feral birds (OR = 4.5). The risk for *Salmonella* infection of the herd was decreased when the number of visits from technical personnel was limited (<1 per month) (OR = 0.38), when castration of piglets was done after 1 week of age (OR = 0.38) and when the all-in all-out system was respected (OR = 0.13).

1. Introduction

Salmonellosis is a widespread foodborne zoonosis in many countries (Wegener and Baggesen, 1996; Lo Fo Wong et al., 2002). Besides eggs and poultry, pork and pork products are recognized as one of the major sources of human salmonellosis (D'Aoust, 1994). To prevent contamination of pig carcasses, it is essential to control *Salmonella* infection along the food-production chain (Mead, 1993). Because numerous routes of contamination exist during the growth period, rearing conditions at the farm are important for controlling *Salmonella* (Bailey et al., 2001).

Furthermore, antimicrobial resistant *Salmonella* has become a worldwide problem (Agustin et al., 2005). Monitoring of antimicrobial susceptibility is important to limit the risk of transfer of resistant *Salmonella* to humans. In this context, the European Union has decided to toughen the national control programmes in the pig industry over the next few years (EU-regulation 2160/2003).

Reunion Island is a tropical island located in the Indian Ocean and is an overseas territory of France and an outermost region of the European Union. Reunion is therefore subject to European regulations. Pork production is locally consumed; 9000 tons per year are produced locally, equivalent to 50% of total pork consumption, the other 50% is imported frozen pork from France. Most of the farmers are farrow-to-finish pig producers (of a total population of 190 pig farmers); they belong to a small-scale commercial rearing system in which fatteners, boars, gestating sows, and sows with their litters are kept in separated pens. These pig farms are family-run, single-site and usually located on the same property as the owner's house. The pig breeds come usually from a synthetic line (Large White, Landrace and Pietrain) produced locally. No live pigs have been imported into Reunion since 1978. Follow-

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ing the enforcement of EU regulations, pig producers in Reunion Island have decided to modernise their own system in order to prevent *Salmonella* contamination of pork and pork products.

Thus, the first purpose of this study was to estimate the herd prevalence of *Salmonella* infection in fattening pigs and their serovar distribution. The second objective was to assess the association of specific farm characteristics and managerial practices with the *Salmonella* status at the end of the fattening period.

2. Material and methods

2.1. Study sample

Our study was carried out from April to August 2008 and included 60 farrow-to-finish pig farms in Reunion Island (20 farms in the south east, 12 in the south west, 14 in the north east and 14 in the north west). Thirty of them were pig producers only; 30 were pig and poultry producers. These herds were randomly selected from the 150 producers in the Pig Producers Co-operative (CPPR). Before we started the survey, we visited the farmers to explain the aim of the study. Subsequently, farm selection was based on the owner's willingness to cooperate. Only three producers declined.

2.2. Data collection

Each farm was visited once, at the end of the fattening period, 15 days before slaughtering. Data relating to farm and housing characteristics, piglets, management of sick and dead pigs, control of rodents and other domestic animals, feeding and watering practices during the farrowing, weaning and fattening stages, farm staff and visitors, cleaning and disinfection procedures were collected by means of a questionnaire submitted to each farmer (available upon request in a French version). A team of two professional investigators (including one veterinarian and one veterinary technician) from the laboratory administered the 30 min questionnaire. This questionnaire was pre-tested in a preliminary study carried out in 5 farms. The final questionnaire contained 80 questions and 75% were close-ended questions. One batch of contemporary growing pigs housed in the same fattening room was investigated for each farm in the study. The bacteriological *Salmonella* status of the farm was assessed by performing fresh faecal sampling directly using sterile pairs of gauze socks (Sodibox, La Forêt-Fouesnant, France). The socks consisted of an elastic cotton tube pulled over the investigator's overboots. Two pairs of socks were used per pen in order to cover the whole surface. Fresh faecal samples and the soiled pair of socks were placed in a sterile plastic bag using a sterile glove and transported to the laboratory within 4–6 h after sampling. 12 pooled samples of five fresh faeces were taken; this number of samples should detect an infected herd with a prevalence of >5% with 95% confidence, given that the sensitivity of the test is 100% (Martin and Meek, 1987).

2.3. Salmonella isolation and identification

Salmonella isolation and identification were carried out as described in Cardinale et al. (2004).

2.4. Definition of the outcome variable

The unit of observation was the herd. A herd was declared infected by *S. enterica* subsp. *enterica* if at least one pooled sample taken from the house, at the end of the fattening period, tested positive. The outcome variable was thus dichotomous (infected herd versus non-infected herd).

2.5. Definition of explanatory variables

All variables were categorical (Table 1). These variables were selected from a preliminary phase designed to lower the chance of results being affected by multicollinearity in the dataset (Dohoo et al., 1996). All bivariate relationships between risk factors were checked (χ^2). For bivariate relationships evidencing strong statistical association and biological plausibility, only one of the two variables of interest (the one most related to the outcome variable) was chosen.

2.6. Statistical procedure

A two-stage procedure was used to assess the relationship between explanatory variables and *Salmonella* status of the flock. In the first stage, a univariable analysis was performed to relate *Salmonella* infection of the flock to each explanatory variable. Only factors associated (Pearson χ^2-test, $P < 0.25$) with *Salmonella* infection of the flock were offered to a full model for multivariable analysis (Mickey and Greenlands, 1989). The second stage involved a logistic multiple-regression model (Hosmer and Lemeshow, 2000). The contribution of each factor to the model was tested with a likelihood-ratio χ^2 through a forward stepwise procedure. At the same time, the simpler models were compared to the full model using the Akaike information criterion (Akaike, 1974). This process was continued automatically until a model was obtained with all factors significant at $P < 0.10$ (two-sided). Interactions were not tested (because of the small sample sizes).

3. Results

Of the 60 herds studied, 40% tested positive for *Salmonella*. From the 780 samples cultured, 98 isolates (12.6% positive) were obtained. The most prevalent serovars were *S.* Typhimurium (20% of herds), *S.* Derby (12%), *S.* Weltevreden (3%), *S.* SI 4, 12: I – (3%), and *S.* Livingstone (2%). After variable selection the logistic multiple-regression model indicated that the risk of herd *Salmonella* infection was increased with the presence of cockroaches (OR = 5.52, 90% CI: 1.48–20.54), no disinfection at the farrowing stage (OR = 5.2, 3.9–71.1), and the lack of bird proof houses (OR = 4.52, 1.73–28), and decreased with an all-in all-out system (OR = 0.13, 0.03–0.52), greater than