Eradication of *Salmonella* Yoruba in an integrated pig herd

**Eradikation von *Salmonella* Yoruba aus einer integrierten Schweineherde**

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**Summary:**
An integrated SPF herd with 320 sows was found infected with *Salmonella* Yoruba during an annual control among sows, aiming to verify freedom from *Salmonella* infections. It is believed that the infection was introduced to the herd by purchase of feed. The herd performed an age segregated rearing system. Sows and piglets were reared at a central farm, while growers (25-100 kg body weight) were reared at sub-estates. The growers were free from the infection, and as a consequence a specially designed eradication program was designed.
Farrowing and weaning were defined as periods of risk for sows and piglets, respectively. Consequently sows were isolated and individually tested for presence of *Salmonella* one week before and one week after farrowing. The offspring were tested one week post weaning. To verify freedom from disease among piglets they were also tested another time before transfer to the uninfected sub-estates. Piglets with undefined status regarding *Salmonella* were denoted animals at risk and not transferred to the sub-estates. Instead they were transferred to a third estate, rented to house pigs at risk. The program was successful. It allowed full production during performance, and the herd was declared free from *S. Yoruba* seven and a half months after the initial diagnosis.

**Keywords:** Immunity, farrowing, weaning, feed, age segregation

**Introduction**
Sweden has a long history of controlling *Salmonella*. A massive outbreak of *Salmonella* Typhimurium infections in humans 1953 affected almost 9 000 persons and caused the death of 90 (Lundbeck et al., 1955). This forced new governmental regulations and control programs were initiated. The overall aim of the Swedish *Salmonella* control program is to ensure that food of animal origin is free of *Salmonella*. Any finding of *Salmonella*, irrespective of subspecies, in feed,
animals, food of animal origin or humans is compulsory notifiable. If *Salmonella* is found in food it is by law considered unfit for human consumption (Food Act. SFS (1971), 511). Whenever *Salmonella* is found, actions to eliminate the infection are undertaken and investigations are made to clarify the source of infection. Animals delivered for slaughter shall be free from *Salmonella* infections. Herds found infected are put under restrictions, which are not lifted until the bacteria is considered eradicated.

Sweden has achieved a good control of *Salmonella*, despite the industrialisation of animal production. In swine, as well as in cattle and poultry the prevalence of *Salmonella* infection is less than 1 % (Anonymous, 2001). Surveillances are made in animal feed, live animals, carcasses, cutting plants and food, comprising a large number of analysed samples per year. A low incidence of *Salmonella* was confirmed (Thornberg and Engvall, 2001). A total of 3388 samples from products and environments in five Swedish pig slaughterhouses were all culture negative for *Salmonella*.

In live pigs, faecal samples are collected annually from all nucleus and multiplier herds and from a large number of piglet producing herds. The number of salmonella infected herds has decreased steadily since the 70-ties and during the last 15 years less than five infected herds per year have been detected (Engvall et al., 1999; Anonymous, 2001).

**Material and methods**

**Herd description**

The herd was a nucleus herd within the Swedish SPF system (Wallgren and Vallgårda, 1993) with 320 pure bred Yorkshire sows. No animal had been introduced since establishment, and entrance was denied to any person whom had been in contact with conventional pigs for the last 48 hours.

The herd produced breeding animals and performed an age segregated rearing system from birth to mating/slaughter. Batches of 36 sows farrowed every second week in previously emptied and cleaned units at the central farm (A). Piglets were weaned at the age of 5 weeks. They were transferred to previously emptied and disinfected weaning units, still at A, and remained there until the age of 10-11 weeks. The growers (25-100 kg) were reared at two sub-estates (B) located 10 km from A (Figure 1). Selected gilts returned to A to be mated, whereas other pigs were slaughtered when reaching market weight.
Initial diagnosis of *Salmonella* Yoruba and initial status
In August 2000, *S.* Yoruba was demonstrated in sows through the annual surveillance program aiming to verify freedom from infection. Faecal samples were collected from 50 sows. They were pooled five and five before cultivation. *Salmonella* Yoruba was demonstrated by cultivation in two out of the ten mixed samples (Table 1). The herd was apparently healthy. Diarrhoea had not been recorded, neither in sows nor in growing animals. Following the initial diagnose, the growers at B were found free from *Salmonella*, whereas A was found truly contaminated. All positive individuals were removed from the herd.

Possible sources of infection
The high level of biosecurity maintained at the herd, made introduction of the infection to the herd via animals or visitors less likely. Consequently, contaminated feed was considered to be the most probable source of infection, and precautions aimed to verify this theory were undertaken.

Definition of freedom from infection
Pigs were considered free from infection when tested twice with negative result. However, to be considered as not at risk they had to be housed only with pigs free from infection and in units previously not infected (or emptied, cleaned and disinfected).

Design of the eradication program and monitoring
An eradication program was constructed based on the herd size, the SPF status and the well-organised management system. The aim was to certify freedom from infection and at the same time minimise control costs and production losses. As the growing pigs at B were declared free from *Salmonella*, these animals could be slaughtered without any precautions, provided that no pigs at risk were introduced. To maintain the health status at B a third estate (C) was rented. Piglets at risk included all young pigs present at A before initiating the program. They were transferred to C at the weight of 25 kg, reared to market weight there and not allowed re-entrance to A (Figure 1). Pigs at C were tested for presence of *S. yoruba* before slaughter, and if found they were sanitary slaughtered.

The first step of the program focused on sows. The period around farrowing was denoted as *locus minori*. The transfer of immunoglobulins to the udder during the last month of pregnancy decreases the immunity of sows, as least with respect to *Mycoplasma hyopneumoniae* (Wallgren et al., 1998).
The second step of the program focused on litters to sows declared free from infection. The *locus minori* was defined to occur one week post weaning. At weaning the diet is abruptly switched from milk to cereals. The switched diet and other stressors disrupt the intestinal flora, leading to a less diversification of that flora (Kuhn, 1993; Katouli et al., 1997). Thereby the colonisation by internal or external pathogenic microbes will be facilitated. Finally, the immune systems of piglets aged 6 weeks is poorly developed (Wallgren et al., 1998), and the immune response is further depressed due to the stress from the weaning (Bailey et al., 1992; Hessing et al., 1998; Watrang et al., 1998).

The aim was to ensure that no *Salmonella* shedding sow was introduced to the emptied and disinfected farrowing facilities. In this context the comparably long time required to ensure freedom from *Salmonella* at cultivation (5 days) constituted a practical problem. Faecal samples were collected from sows one week before transfer to the farrowing unit (around 10 days before expected farrowing), and any positive sow was culled. However, the transfer of Ig to the udder continues also during the last week of pregnancy (Wallgren et al., 1998), making the sows even more vulnerable at farrowing. Therefore another specimen was collected from sow and floor in the farrowing pens. These samples were collected two weeks after the initial sampling, thereby matching the management system with farrowings every second week. If *Salmonella* was found sow and offspring were immediately culled, the pen was whitewashed and left vacant until the unit was emptied. The dunging area of the pens were covered by slatted floor, so faecal contamination of neighbour pens could be avoided. Still, the remaining batch was to be considered as pigs at risk, and either retested or transferred to C. To certify freedom from *Salmonella* in the offspring piglets were tested one week post weaning and one week before transfer to the sub-estates earlier declared free from *S. Yoruba* (B). If *Salmonella* was detected in the weaning unit the entire litter was culled and the pen whitewashed. Further, the entire batch was considered at risk and transferred to C. Contact between sows with unknown status regarding *Salmonella* and sows and gilts confirmed free from the infection was avoided.

**Cleaning and disinfection**

To be able to perform careful cleaning and disinfection efforts were made to create some space in the rearing system. One group of sows were culled to make it possible to get the farrowing units successively empty for three weeks. Also one batch of infected weaners was removed. This facilitated cleaning and disinfection of the herd, which was made gradually as the units were emptied. Only pigs certified free from infection were introduced to cleaned units.
Surroundings and manure handling
Liquid manure was treated with 25 - 30 kg Ca(OH)\textsubscript{2} per m\textsuperscript{3}. Also solid manure was treated with Ca(OH)\textsubscript{2} and left aside at least 6 months before spread out. Soil close to buildings was covered by Ca(OH)\textsubscript{2}, or if judged heavily contaminated, removed.

Results

Animals
The initial diagnose and the results of the subsequent samplings before initiating the program are shown in Table 1. Within the program, all sows were individually tested for presence of \textit{Salmonella} one week before and one week after farrowing. Further, all litters were tested one week post weaning and before transfer to B. \textit{Salmonella} was never detected in any of these samples. Consequently, no culling beyond those made at the initial diagnose had to take place. After five months all sows had been tested and the whole establishment had successively been thoroughly cleaned and disinfected. Finally, following two negative faecal samplings, representing all animals at A and collected at one months interval, the herd was officially declared free from \textit{S. Yoruba} in March 2001.

Pigs at risk, i.e. piglets present at A when the diagnose was made, were moved to C. These animals were controlled for presence of \textit{Salmonella} when reaching market weight. \textit{Salmonella} Yoruba was demonstrated in one batch.

Feed
The herd had changed feed manufacturer in April 2000. \textit{Salmonella} Yoruba had been isolated from primary products at the feed mill in January 2000. The strains isolated at the herd and at the mill could not be differentiated by pulse field gel electrophoreses.

Discussion

\textit{Salmonella} is largely spread and may cause considerable damage to man and animals. The true incidence of infected individuals may be obstructed, as the bacteria is intermittently shed by the host (Jones and Hall, 1975). However, if combating the disease at a population level it is important to identify all infected individuals. We therefore aimed to collect samples from individuals at times when pigs were most expected to shed the bacteria. The strategy included collection of faecal samples from sows around farrowing and from piglets one week post
weaning, corresponding to times of decreased immune capacity, and presumably to an increased chance to demonstrate the bacteria.

The yield in the pig branch is the meat generated, and farms tend to become larger in modern agriculture. The animals grow fast, the mean age is low and dams continuously give birth to new sensitive stock. In small herds it is easy to collect samples and eliminate infected animals, or just eliminate the herd. Herds sized as in the present study do however demand other strategies. A continuous monitoring and removal of infected pigs without any other precaution must be considered less likely to be successful, not the least due to the continuous introduction and reshuffling of a large number of naive animals. Moreover, the cost for removing infected pigs would be very high, and so would stamping out. The present model allows almost full production during the effectuation; only offspring to infected sows will be lost. Further, the precautions required at abattoirs will be reduced as the status of the pigs is known before pigs are slaughtered. Thus, the resources spent on diagnosing Salmonella in living pigs will pay off by a reduced need for sanitary slaughter processes and Salmonella cultivations at the abattoir.

When assessing possible source of infection, the biosecurity program of the herd must be taken into account as well as the serotype involved. Thus, it was concluded that the infection most probably was introduced by purchase of contaminated feed. Salmonella Yoruba had in fact been isolated from raw products at a mill delivering feed to the herd. As the herd only had purchased food from that mill since April, it was probably infected quite recently.

The absence of S. Yoruba among growers when the infection was diagnosed may appear odd. However, as sows were proven infected, sow feed could be suspected as a source of infection.

S. Yoruba was diagnosed at A in August. At that time, pigs present at B were born in May or earlier. If S. Yoruba was introduced by sow feed after April 2000, no infected piglets had probably yet been transported to B. Instead possibly infected piglets were transferred to C as decided by the program. Indeed, S. Yoruba was later demonstrated among pigs reared to market weight at C.

The study highlights the importance of rearing pigs with different health status separated from each other. As B was proven free from S. Yoruba the circumstances allowed us to rear pigs at risk at another estate. Certainly, a contamination also of the growing units should probably be expected at outbreaks of salmonellosis. However, this would not interfere with the strategy chosen. In such cases, Salmonella free pigs would be reared at an extra unit, while pigs at risk are reared
in the ordinary facilities. As pigs at risk are slaughtered, the ordinary facilities will be emptied, cleaned and disinfected. Thereafter the management can return to normal. It must be established that a strategy like this demands extra facilities during the effectuation to render it possible to differentiate healthy individuals from individuals at risk. Otherwise the risk to contaminate healthy pigs must be considered too large, and an eradication attempt ought to be avoided.

References


Figure 1
A schematic view of the herd. Pigs were produced at the central farm (A) and the sub-estates (B) prior to the disease. During the eradication program pigs at risk were reared to market weight at a rented estate (C).

B  The Sub-Estates

Growing units (n=3)

Slaughter

Growing units (n=3)

Gilts, Selected

A  The Central Farm

Weaning units (n=3)

Farrowing units (n=3)

sows

Dry sow units (n=6)

Mature gilt units (n=3)

C  The Rented estate

Growing units (n=2)

Slaughter
Table 1
Faecal samples analysed for presence of *Salmonella* before designing the eradication program

<table>
<thead>
<tr>
<th>Date</th>
<th>Category</th>
<th>Number of individual samples</th>
<th>Number of pooled samples*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>total</td>
<td>positive</td>
</tr>
<tr>
<td>00-08-05</td>
<td>Sows</td>
<td></td>
<td></td>
</tr>
<tr>
<td>00-08-17</td>
<td>Sows with piglets</td>
<td>94</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Dry sows and gilts</td>
<td>45</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Weaned piglets</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manure</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>00-08-22</td>
<td>Growers at B</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manure at B</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>00-09-05</td>
<td>Sows with piglets</td>
<td>105</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Dry sows and gilts</td>
<td>125</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Weaned piglets</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manure</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>00-09-13</td>
<td>Growers at B</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The pooled samples differed between categories. Roughly, they represented 5-10 sows, 20 weaners or 4 pens of growers.