**SALMONELLA SEROTYPE DISTRIBUTION IN DANISH SWINE HERDS AND PORK 1998 - 2004**

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**Abstract** The serotype distribution in the Danish swine population and in pork has been remarkable stable during the period 1998-2004. S. Typhimurium remains the predominant serotype in the entire swine population and in pork. S. Derby is increasing in prevalence in herds and in pork. S. Infantis, which was highly prevalent in Danish pork 10 years ago, has reached a low and stable level in herds and in pork. An unexplained increase in rough salmonella isolated from carcasses has taken place during the entire study period. The original antibody ELISA for serological monitoring of herds can still be used without adjustments.

**Introduction** The mandatory Danish *Salmonella* Control Program in swine has been in place since 1995, and operates at all stages of the production chain (Mousing *et al.* 1997, Nielsen *et al.* 2001). Bacteriological examinations for *Salmonella* are carried out at four different places in the program; seropositive breeder and multiplier herds, seropositive finisher herds and sow herds producing weaners for seropositive finisher herds, and at the daily *Salmonella* monitoring of carcasses at slaughterhouses. The program gives a unique ability to follow the development in serotype distribution in the entire swine production chain over many years.

When the program started 10 years ago little was know about fluctuations of *Salmonella* serotypes over time in the Danish swine production. One of the preconditions for the serological monitoring of the Danish swine herds was knowledge to the distribution of serotypes. If the serotype distribution was stable, the same ELISA could be used over years without adjustments. However, if the serotype distribution changed significantly over time it was imperative to adjust the ELISA to maintain an acceptable high sensitivity.

Another important aspect of the bacteriological monitoring is the ability to follow an introduction of a serotype at a certain point in the production chain and its possible spread up and down the production chain. Finally, it is very important to have solid surveillance data in order to estimate the number of pork related human salmonellosis.

The present study describes the development in *Salmonella* serotypes from 1998 to 2004.

**Materials and Methods** Results from the bacteriological monitoring of seropositive breeder and multiplier herds, seropositive finisher herds and sow herds producing weaners for seropositive finisher herds were collected from the national data base The Zoonoses Register, owned by the Danish Ministry of Family and Consumer Affairs. Additionally, data from the *Salmonella* monitoring of carcasses at the slaughterhouses were obtained from the database of the Danish Bacon and Meat Council. Data were collected from 1998 to 2004.

Each month, all breeder and multiplier herds are blood sampled and examined for *Salmonella* antibodies. Based on the level of antibodies, a *Salmonella* index is calculated. If the index exceeds 5, pen fecal samples must be taken and examined for the presence of *Salmonella*.

All finishing herds producing >200 finishers per year are tested for *Salmonella* antibodies. Based on the number of seropositive samples the herds are assigned into level 1, 2 and 3 on a monthly bases, where level 2 and 3 are moderate to highly *salmonella* infected herds. Level 2 and 3 herds must have pen fecal samples taken and examined for *Salmonella*. Finally, if a sow herd has sold weaners to a level 2 or 3 finisher herd, pen fecal samples must be taken and examined for the presence of *Salmonella* (Nielsen *et al.* 2001). From 1998 to 2002, this was carried out by bacteriological examination of 20 pen fecal samples randomly selected from the different pens in the herd. Since February 2003, the 20 pen samples have been pooled 4 by 4 and analyzed as 5 cultures. Only one *Salmonella* isolate from a herd sampling is serotyped since February 2003 (Enøe *et al.* 2002).

From 1993 to 2000 the monitoring of pork was conducted by bacteriological examination of different pork cuts. Approximately 28,000 pork cuts were tested on an annual basis. A new method of *Salmonella* testing on carcasses was introduced on 1 January 2001. At each slaughterhouse, five randomly selected carcasses per slaughter day are swabbed at three defined areas.
(the hind leg near the tail, the sternum, and the jowl. The three areas are swabbed with the same gauze pad, and the pads from the five carcasses sampled on the same day are analyzed as one pooled sample. The swabbing areas were originally defined by USDA, USA. This method is twice as sensitive as the one previously used. (Sørensen et al. 2001). Approximately 36,000 carcasses are examined annually.

All Salmonella were serotyped using the Kaufmann-White scheme at the Danish Institute for Food and Veterinary Research in Copenhagen.

Results S. Typhimurium is the predominant serotype in the entire production chain from 1998 to 2004 and shows a remarkable stability, figure 1. S. Derby and S. Infantis are the second and third most prevalent serotypes followed by several low prevalent serotypes.

The proportion of S. Typhimurium isolates from positive breeder, multiplier and sow herds are nearly constant over the entire observation period and vary between 50-60%. In Salmonella positive finisher herds, S. Typhimurium constituted 80% of the isolates in 1998 and has subsequently declined slowly and steady every year reaching 70% in 2004. A similar trend was observed in pork where S. Typhimurium slowly has declined from 58% in 1999 to 40% in 2004.

S. Derby has a different development over the observation period, as this serotype has increased in prevalence in all herd categories as well as in pork, figure 2. Starting at 6 - 12% in herds in 1998 and reaching 19% in 2004 this serotype is apparently successfully spreading in the Danish swine population. In pork, a similar increase has been observed with 6% in 1998 to 19% in 2004.

S. Infantis has a nearly constant prevalence over the years; 10% of the Salmonella isolates in breeder, multiplier and sow herds but only 4% in finisher herds. In pork the prevalence was 30% in 1998 but declined rapidly to 7% in 2000, and has since then varied between 5 - 8%.

Beside the three mentioned predominant serotypes many exotic types are found in low numbers every year. The number of detected serotypes is highly dependent on the type of herds. In breeder and multiplier herds, 5 - 6 serotypes are consistently detected. In contrast to this low and stable situation, sow and finisher herds have an extensive number of serotypes. In sow herds, 31 serotypes were detected in 1999, peaking in 2000 with 42 serotypes followed by a steady decline to 25 in 2002. Subsequently, the number of serotypes increased to 32 in 2004. In finisher herds the diversity also peaked in 1999 with 42 different serotypes, followed by a steady yearly decline to 23 serotypes in 2003, again followed by an increase to 31 types in 2004.

In pork, 8 - 14 serotypes were identified when different pork cuttings were examined from 1998-2000. Approximately 15 serotypes were detected every year from 2001 to 2004 by culture of carcass swabs. The high serotype diversity in finisher herds was not reflected in pork.

Rough isolates were rarely detected in pen fecal samples from herds (<5%), but from pork an increasing proportion of rough Salmonella isolates were found over the observation period. Rough Salmonella isolates are defined as isolates missing the LPS layer in the surface making them non-serotypable. In 1998, 11% of the pork isolates were characterized as rough, increasing slowly to 14% in 2000 by culture of different pork cuttings. When the new carcass swab monitoring was implemented in 2001, 12% of the isolates were rough. Since then a steady increase in rough isolates have been observed every year reaching 19% in 2004.

The proportion of culture positive herds assigned to pen fecal sampling is highly dependent on the category of herd. Breeder, multiplier and finisher herds are examined by pen fecal samples due to high levels of Salmonella antibodies in the swine. In these herds, 65 - 71% of the examined herds were cultures posi-
tive in 1999-2001. However, from 2002 to 2004 a decreasing proportion of herds were found culture positive reaching a minimum of 55 - 57% in 2004. Less variation have been observed in sow herds where 46% of the examined herds were culture positive in 1998, decreasing to 40% in 1999 and 2000. The proportion of positive sow herds peaked in 2001 with 49%, and slowly but steadily declined year by year to 41% in 2004.

**Discussion** During the last 10 years, the Danish *Salmonella* Control Program for swine has included the entire production chain. The *Salmonella* prevalence in finisher herds has been reduced from 23% in 1993 to 11% in 1999 (Anon. 1998) and the prevalence in pork has declined from calculated 7% in 1993 to 1.3% in 2004 measured by the swab method. Despite this, a remarkable stable occurrence of serotypes has been observed from 1998 to 2004.

*S. Typhimurium* remains at a nearly unchanged level in sow herds of 50% of all isolates in contrast to 70 - 80% in finisher herds. This most likely reflects that finisher herds are monitored serologically using an ELISA method with a high sensitivity to *S. Typhimurium*. When moderate and highly seropositive herds subsequently become assigned to pen fecal sampling, *S. Typhimurium* will constitute a high proportion of the isolated serotypes. The proportion of *S. Typhimurium* in pork most likely shows the true proportion in the finisher population, as this monitoring method is equal sensitive to all serotypes.

*S. Derby* appears to increase in prevalence in all categories of herds and in pork. This increase has so far not been reflected in the number of pork related *S. Derby* cases, which remain very low at 15 human cases in 2004. *S. Infantis*, which was a dominant serotype and the cause of a major Danish pork related human salmonellosis outbreak in 1993, has decline to a constant low prevalence in herds and not at least in pork. There have been no specific initiatives against *S. Infantis*.

The significant different numbers of serotypes in the different herd categories and in pork may be due to several reasons. It may be argued, that the very few detected serotypes in breeder and multiplier herds is a result of a very high external biosecurity, preventing infectious agent from entering these herds. In contrast to this, sow herds and finisher herds have a less strict biosecurity system, and trade frequently pigs with other herds. The lower number of serotypes in pork may be explained due to the fact, that only the more frequently appearing types have a good chance to become detected in the monitoring system. Many of the exotic serotypes in sow and finisher herds are only detected 1-3 times annually; these serotypes are unlikely to become detected in the carcasses surveillance due to the low prevalence.

The authors don't know the cause of the continuous increase in rough isolates from pork. It may be speculated; that more and more *Salmonella* becomes rough on the carcasses as the survival conditions for *Salmonella* on the carcass surface becomes increasingly difficult due to increased hygienic slaughter procedures.

Not all moderate to highly seropositive herds are found culture positive after 20 pen fecal samples have been examined, as 30-40% of these herds turn out to be culture negative. This was a major surprise in the beginning of the Danish *Salmonella* Control plan. Today, it is known that *salmonella* infection may be highly clustered in swine herds at pen or section level. Even 20 pens are sampled *Salmonella* might not be identified. Additionally, pigs don’t excrete *Salmonella* continuously. When a herd is assigned to pen fecal sampling it may take 2 weeks before the sampling is done.

![Figure 2. Distribution of *S. Derby* in culture positive swine samples in Denmark 1998 – 2004](image-url)
The assignment is due to antibodies detected in finishers at slaughter over the last couple of months. Consequently, the pen fecal sampling may take place 1-2 months after the infection peaked in the herd, with a corresponding lower chance of detecting *Salmonella* bacteria in feces.

**Conclusions** Overall, the serotype distribution in the Danish swine population has been remarkable stable during the period 1998 – 2004, and the original antibody ELISA for serological monitoring of herds can still be used without adjustments. *S. Typhimurium* remains to be the predominant serotype in the entire swine population and in pork. *S. Derby* is increasing in prevalence in herds and in pork. *S. Infantis*, which was highly prevalent in Danish pork 10 years ago, has reached a stable and low level in herds and in pork. An unexplained increase in rough *Salmonella* isolated from carcasses has taken place during the entire study period from 1998 – 2004.

**References**


Sørensen, L.L., H. Wachmann, J. Dahl, B. Nielsen. 2001. The new Danish *Salmonella* surveillance on fresh pig carcasses based on pooled swab samples including compatibility with levels of the former system; *Salinpork* 2001. 2.-5. Sept., Leipzig, Germany: p 30-32