SURVEILLANCE OF INFECTIOUS DISEASES IN ANIMALS AND HUMANS IN SWEDEN 2020

Chapter excerpt -
Salmonellosis

SVA NATIONAL VETERINARY INSTITUTE
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Cover: Juvenile mink in hand. Photo: Elina Kähkönen

Reporting guidelines: Reporting guidelines were introduced in 2018 for those chapters related to purely animal pathogens. The guidelines build on experiences from several EU projects, and have been validated by a team of international experts in animal health surveillance. The aim is to develop these guidelines further in collaboration within the global surveillance community and they have therefore been made available in the form of a wiki on the collaborative platform GitHub (https://github.com/SVA-SE/AHSURED/wiki). Feel free to contribute!

Layout: The production of this report continues to be accomplished using a primarily open-source toolset. The method allows the source text, produced by authors, to be edited independently of the template for the layout which can be modified and reused for future reports. Specifically, the chapter texts, tables and captions are authored in Microsoft Word and then converted using pandoc and R to the LaTeX typesetting language. Most figures and maps are produced using the R software for statistical computing and the LaTeX library pgfplots. Development for 2020 has further improved the importing of content from Excel files to automatically build figures in the pgfplots LaTeX library. The tool is available as an R-package on GitHub (https://github.com/SVA-SE/mill/). The report generation R-package and process was designed by Thomas Rosendal, Wiktor Gustafsson and Stefan Widgren. In 2020, final typsetting was done primarily by Wiktor Gustafsson with contributions from the report authors.

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Salmonellosis

BACKGROUND

Salmonellosis is one of the most important bacterial zoonoses. The genus is divided into two species: *S. enterica* and *S. bongori*. Most *Salmonella* belong to *S. enterica* subspecies *enterica*. More than 2500 different serovars belonging to this subspecies have been described. *Salmonella* can infect a multitude of animal species, including humans. Humans are infected by contaminated food products of various types, through contact with infected animals, via person-to-person transmission or via a contaminated environment.

A severe domestic outbreak of *S.* Typhimurium in 1953 with more than 9000 cases prompted the need for a control programme for *Salmonella* in Sweden. Since then, the strategy for control has been to prevent *Salmonella* in all parts of the production chain, from feed to food of animal origin. When Sweden joined the European Union in 1995, the Swedish *Salmonella* control programme was accepted. Sweden obtained additional guarantees for live animals, meat, and eggs from countries with a non-equivalent *Salmonella* status to be tested for the presence of *Salmonella* before entering the Swedish market. The control programme constitutes an important safeguard to Swedish public health.

In recent years, a total of 2000–3000 human cases of salmonellosis have been reported annually to the Public Health Agency of Sweden. A majority (60–80%) of these cases were infected abroad. During the last decade, the number of cases infected abroad has decreased, whereas the domestic incidence has remained stable. Yet, the proportion of domestic infections in Sweden is low compared to many other countries. The source of the verified outbreaks is often imported food. The contribution to the human disease burden from domestic food-producing animals is low. In 2020, the COVID-19 pandemic has resulted in both a record low incidence of salmonellosis and a record high proportion of domestic infections.

DISEASE

Animals

Infected animals are often asymptomatic. However, *Salmonella* can cause clinical illness with diarrhoea, abortions, and fever, and even lead to death. In Sweden, clinical signs are frequently seen in cattle, horses, cats and dogs, whereas infected poultry are most commonly asymptomatic.

Humans

Salmonella infects the gastrointestinal tract and causes an acute gastrointestinal illness. The symptoms can range from asymptomatic and mild to severe. The incubation period is typically between 1 and 3 days but can vary from 6 hours to 10 days. Most patients recover from the illness spontaneously but sequelae such as reactive arthritis occur in approximately 1–15% of the patients. Excretion of the pathogen normally lasts for four to six weeks but prolonged asymptomatic excretion occurs. In rare but severe cases the infection can spread via the bloodstream to organs outside the gastrointestinal tract.

LEGISLATION

Feed

Control of animal feed is an integrated and essential part of the control programme for *Salmonella* in primary production. The feed business operator is responsible for producing *Salmonella*-free feed. Poultry feed must be heat treated according to the legislation. A major part of cattle and pig commercial feed is also heat-treated. The production of feed is supervised by the Swedish Board of Agriculture which carries out announced and unannounced inspections at feed mills and pet food producers. The control of *Salmonella* in feed is regulated in national legislation (SJVFS 2018:33) as well as in an EU regulation (Commission Regulation (EU) No142/2011).

Animals

Investigation is required upon clinical suspicion of salmonellosis and any finding of *Salmonella*, regardless of serovar, is notifiable. Action is taken to eliminate the infection or contamination except in cases of findings of *S. diarizonae* serovar 61:(k):1,5(7) in sheep. Vaccination is not used in Sweden. The *Salmonella* control programme is governed by the Swedish Act on Zoonoses (SFS 1999:658) and its regulations. The aim of the programme is that animals sent for slaughter and animal products should be free from *Salmonella*.

Food

Any finding of *Salmonella* in food is notifiable and a contaminated food product is considered unfit for human consumption. However, there is one exception, which is *S. diarizonae* serovar 61:(k):1,5(7) in sheep meat, as this serovar is not considered to be of public health importance (LIVFS 2005:20).

Laboratories analysing samples taken by authorities are obliged to send isolates of *Salmonella* from positive food samples to the National Reference Laboratory for serotyping (LIVFS 2005:21).

Humans

Salmonellosis in humans is notifiable according to the Communicable Disease Act (SFS 2004:168 with amendments, SFS 2013:634). Laboratory confirmed cases include cases with samples that are only positive by PCR i.e. where no isolate has been obtained.

MEASURES IN CASE OF FINDINGS OF SALMONELLA

Isolates

All suspected isolates of *Salmonella* from non-human sources are sent to the National Veterinary Institute for confirmation, serotyping, resistance testing, and further typing.

Index cases are defined as the first isolate of *Salmonella* in a holding of pigs, cattle, goats, sheep, horses or a poultry flock during the period of restriction measures. For companion animals, index cases are defined as the first isolate of *Salmonella* from a companion animal in a household or a kennel of a specific species during a calendar year. For wild animals, the index case is defined as the first isolate from a wild animal species in a municipality or a locality during a calendar year. Index isolates from index cases as well as other index isolates (other serovars from the holding or the companion animal, findings of *Salmonella* at post-mortem or in a lymph node but not confirmed in a holding and *S. diarizonae* serovar 61:(k):1,5(7) in sheep) are resistance tested. From cats and passerine birds, however, a subset of isolates is resistance tested and typed. In addition, one isolate per holding from holdings under restrictions are resistance tested. Isolates of *S.* Typhimurium are further typed by MLVA. From 2020 onwards selected isolates of all serovars from food and animal sources are characterized by whole genome sequencing.

All isolates of *Salmonella* from domestic human cases are sent to the Public Health Agency of Sweden for typing using whole genome sequencing (WGS). A subset of isolates from travel-associated cases are also typed. Both serotype and resistance markers are identified from the sequence data. Clustering of isolates is also done to identify outbreaks and for source tracing.

Feed

Findings of *Salmonella* in intra-community traded or imported feed materials and compound feeds are reported in the Rapid Alert System for Food and Feed (RASFF) (https://ec.europa.eu/food/safety/rasff_en). Measures are always taken when *Salmonella* is detected in feed samples. *Salmonella* positive feed materials are usually treated with organic acids. After acid treatment the feed material must be re-tested negative before use in feed production. Finished feed containing *Salmonella* must be withdrawn from the market. Extended sampling and cleaning are done in the production line if *Salmonella* is detected in the weekly surveillance. If *Salmonella* is found before heat treatment, the contaminated part of the production line is thoroughly cleaned and disinfected, usually by dry cleaning, followed by disinfection. If *Salmonella* is found after heat treatment, the production will be stopped, and the feed mill must be thoroughly cleaned and disinfected. Environmental sampling must show negative results before production is resumed.

Animals

If *Salmonella* is suspected in an animal, a veterinarian is obligated to take samples and implement measures to prevent further transmission. When *Salmonella* is detected, the laboratory must notify the Swedish Board of Agriculture and the County Administrative Board. When detected in a food-producing animal, the County Veterinary Officer informs the official veterinarian at the abattoir involved.

When *Salmonella* is confirmed on a farm, the holding is put under restrictions (except in cases of finding of *S. diarizonae* serovar 61:(k):1,5(7) in sheep), an epidemiological investigation is performed and a plan to eradicate *Salmonella* from the holding is defined. Animal movements to and from the holding are stopped.

All *Salmonella* positive poultry flocks are euthanised irrespective of serovar. The poultry house involved, and all possible contaminated areas are thoroughly cleaned and disinfected. Before introduction of new birds, all environmental samples must be negative for *Salmonella*.

In pigs and cattle, a combination of partial herd depopulation and hygienic measures controlled by repeated sampling is usually practiced. Cattle herds under restrictions for *Salmonella* are monitored by a combination of serological and bacteriological testing. Hygienic measures can include reducing the number of animals, control of animal feed and manure management on the farm and reduction of *Salmonella* contamination in the environment by cleaning and disinfection. Animals from restricted herds may be slaughtered after sampling with negative results. The restrictions are lifted when the cleaning and disinfection have been completed and *Salmonella* cannot be detected by culture from whole-herd sampling at two occasions performed four weeks apart.

If *Salmonella* is detected in companion animals, advice on hygienic measures to prevent further spread to other animals or humans is given to the owners. If *Salmonella* is detected in horses, the stables and/or the paddocks at risk are put under restrictions and follow up investigations are performed on the premises.

Food

Products released on the market will be withdrawn and contaminated products will be destroyed or sent for special treatment to eliminate the *Salmonella* bacteria, except for *Salmonella diarizonae* serovar 61:(k):1,5(7) in sheep meat.

Findings in imported consignments are reported in the RASFF system and the consignments will be returned to the country of origin, destroyed, or sent for special treatment as applicable. RASFF is also used for informing about contaminated Swedish food products released on the EU market or within Sweden.

In food enterprises where *Salmonella* has been detected, appropriate follow-up measures will be applied, such as careful cleaning and disinfection and environmental sampling.

SURVEILLANCE

Feed

In the control programme for feed, the emphasis is on control of feed raw materials, the heat treatment process, and preventive measures to avoid recontamination of heat-treated feed. Suspected feed-borne infections are also investigated (Figure 17).

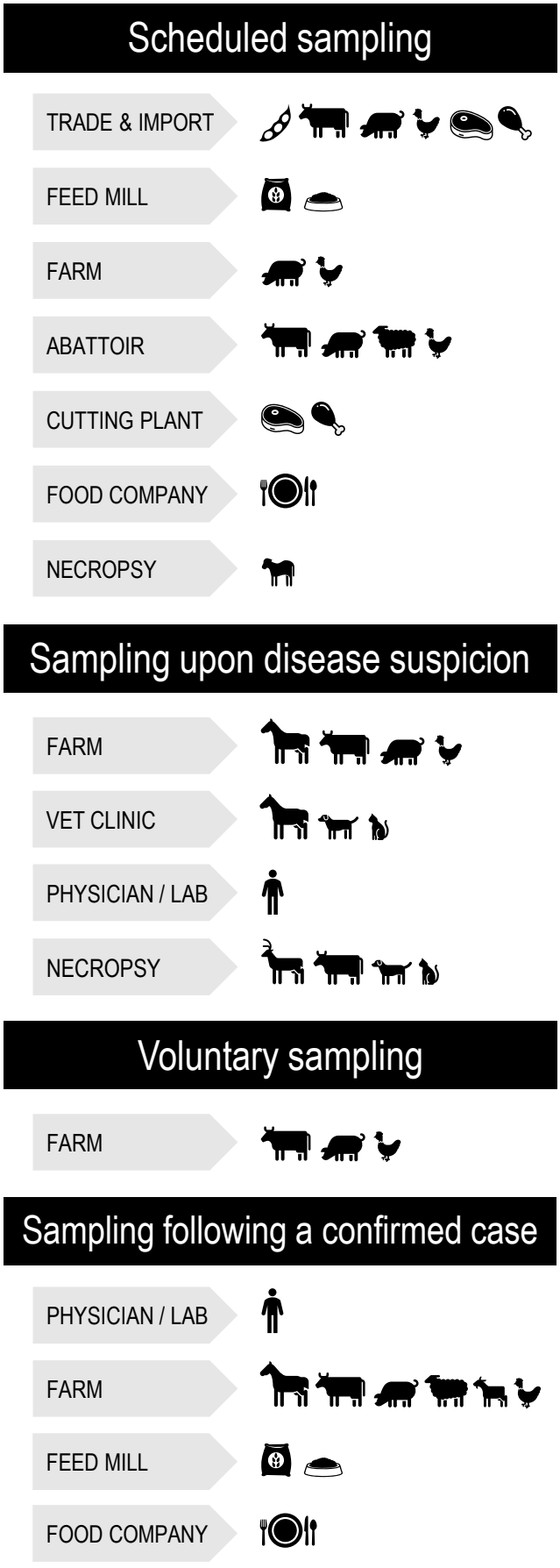

Figure 17: An illustration of the Swedish surveillance of *Salmonella* in feed, food, animals and humans. Infographic by Arianna Comin.

Surveillance of intra-community traded and imported compound feed and feed raw materials

Raw feed materials are the most important risk factor in feed production. In the domestic legislation, feed materials are classified according to the empirical risk of being contaminated, and high-risk feed materials must test negative for *Salmonella* contamination before being used in feed production. All consignments of intra-community traded or imported compound feed for cattle, pigs, poultry and reindeer and feed materials classified as a risk must be sampled and tested for *Salmonella*. The sampling plan is designed to detect a *Salmonella* contamination in 5% of the batch with 95% probability.

Surveillance of feed mills

The purpose of the surveillance is to ensure the absence of *Salmonella* in the production lines as well as in the feed mill environment. A safety management system is applied in the processing line according to HACCP (Hazard Analysis and Critical Control Points). The management system covers several specific GMP (Good Manufacturing Practices) requirements, according to the Swedish legislation. A minimum of five samples from feed mills that manufacture compound feedstuffs for poultry and a minimum of two samples from those manufacturing compound feedstuffs for other food-producing animals must be collected in the processing line on a weekly basis. These samples are analysed at the National Veterinary Institute (using the latest version of EN-ISO 6579-1) and any finding of *Salmonella* is reported to the Swedish Board of Agriculture. The feed manufacturers also take additional samples from the processing line and the feed mill environment as part of their own process quality control.

Pet food and dog chews

Sampling is performed by the feed business operators as part of their feed safety management system. Consignments of pet food and dog chews imported from third countries are sampled according to a sampling plan at the border inspection. The sampling plan is defined based on a risk assessment.

Animals

In all animal samples except for those taken within the control programme at abattoirs, detection of *Salmonella* is performed using the latest version of the EN-ISO 6579-1 method or a method validated against it. Measurement of antibodies against *Salmonella* in blood or milk samples of cattle is performed using commercial ELISA tests PrioCHECK® Salmonella Ab bovine ELISA and PrioCHECK® Salmonella Ab bovine Dublin.

Poultry

The programme comprises a compulsory part and a voluntary part. The purpose of the compulsory programme is to ensure that poultry sent for slaughter and meat products are free from *Salmonella*. All poultry species are included in the compulsory part, which sets the rules for mandatory sampling (Figure 17).

Compulsory programme

All breeding flocks with more than 250 birds are tested (Table 17). Grandparents of *Gallus gallus* broilers are imported as day-old chicks. Laying hens, turkeys, geese, and ducks are imported as parents. Samples consist of sock samples (free range systems) or faecal samples (cage systems) taken from all parts of the building or the department where the bird flock is kept. From rearing flocks, two pairs of sock samples are taken and pooled into one whereas five pairs pooled into two are taken from the breeding flocks in production.

All holdings that sell eggs for consumption are sampled (Table 17). All poultry flocks that have more than 500 birds, irrespective of species, must be tested. In practice, all poultry flocks are tested prior to slaughter and the results must be available before slaughter. According to the harmonised legislation, sampling needs to be performed within 3 weeks prior to slaughter.

The poultry producers pay the costs for laboratory analyses and the visits to the farms. Only accredited laboratories are allowed to perform the analyses. County Veterinary Officers supervise the poultry control programme regionally. The laboratory sends the test results to the County Veterinary Officer on a quarterly basis. According to regulations, the County Veterinary Officer must send a report on the test results of all poultry holdings to the Swedish Board of Agriculture once a year.

Voluntary programme

The aims of the voluntary programmes are to prevent introduction of *Salmonella* into the poultry holding and minimise the risk of spread of the infection to animals and humans. The voluntary programmes have been in place for more than 40 years.

All broiler and turkey producers belonging to the Swedish Poultry Meat Association are affiliated to the voluntary programme which represents approximately 99% of slaughtered broilers and 91% of turkeys. This voluntary preventive programme includes hygiene and biosecurity measures and a high standard for poultry house construction, such as biosecurity barriers between the clean and unclean parts. Purchases of animals may only occur from holdings affiliated to the voluntary programme and only heat-treated feed is allowed. The poultry houses must be cleaned and disinfected before introduction of a new flock. The poultry producer needs to make an application to be accepted into the voluntary programme and a veterinarian inspects the holding at least once a year.

The Swedish Egg Association is responsible for the voluntary programme of the egg line (laying hens, pullets, breeders). The voluntary programme of the egg line resembles that of the meat line. However, a voluntary programme is also available for holdings with outdoor access. Producers affiliated to the voluntary programmes of egg line receive higher financial compensation in case of a finding of *Salmonella*.

Cattle and pig herds

This programme includes a compulsory and a voluntary component (Figure 17).

Compulsory programme

The aim of the programme is to ensure a low prevalence of *Salmonella* in cattle and pig herds. The compulsory part consists of annual faecal sampling from breeding pig herds and gilt-producing herds and biannual sampling from sow pools. In cattle, *Salmonella* testing is performed in all calves <12 months of age that are submitted for necropsy. *Salmonella* testing is also performed in conjunction with necropsies if an infection is suspected based on macroscopic findings. All imported animals are also tested and on clinical suspicion, any herd or single animal should be tested for *Salmonella*.

Voluntary programme

The voluntary programme is a preventive biosecurity programme aiming at decreasing the risk of introduction of *Salmonella* and other infections. Holdings affiliated to the programme receive higher compensation in case of positive findings. In addition, affiliated holdings are entitled to apply for a commercial *Salmonella* insurance. Most breeding herds and many of the large dairy herds are affiliated to this programme.

In addition, there is a “Safe Trade” programme, including testing for *Salmonella* antibodies in bulk milk samples collected four times a year. All herds with test-positive results in this programme are offered veterinary consultations aiming at improved internal biosecurity to control and eradicate any *Salmonella* infection from the herd.

Salmonella screening in dairy herds

In 2020, regional bulk milk screenings were performed on the islands of Gotland and Öland in April and October, and in the county of Östergötland in October. Gotland and Öland were the regions with the highest proportion of test positive herds in the national screening in 2019, and herds in Östergötland were included due to new findings of *Salmonella* Dublin in this region. All samples were analysed with PrioCHECK® Salmonella Ab bovine ELISA (O antigens 1, 4, 5, 12 and 1, 9, 12). Samples with a PP-value higher than twenty (PP>20) in this first test were also analysed with PrioCHECK® Salmonella Ab bovine Dublin ELISA (JV Dnr 6.2.18-14893/2019).

Other animals

Animals are tested for *Salmonella* on clinical suspicion or as part of trace-back investigations (Figure 17). Wild animals necropsied at the National Veterinary Institute are also tested for *Salmonella* on suspicion (see chapter ”Post mortem examinations in wildlife” on page 139).

Surveillance of *Salmonella* in wild boar was initiated during 2020 following the detection of *S.* Choleraesuis in a breeding herd of domestic swine. This serovar had been absent from domestic swine in Sweden for a period of more than 40 years. Samples from wild boar found dead and reported to the National Veterinary Institute from all of Sweden and a subset of apparently healthy shot wild boar from the counties of Skåne and Södermanland were analysed for *Salmonella* according to ISO 6579:1. Suspected isolates of

Table 17: Sampling scheme of poultry for *Salmonella*.

Category of poultry	Sampling frequency	Sample type	Sampling before slaughter	Official veterinarian
Breeders in rearing	1 d, 4 weeks, 2 weeks prior to rearing or moving	2 pairs of sock samples	Within 3 weeks before slaughter	Once a year
Breeders in production	every 2nd week	5 pairs of sock samples	Within 3 weeks before slaughter	3 times during production
Layers in rearing	2 weeks prior to moving	2 pairs of sock samples or 2 faecal samples of 75 g	Within 3 weeks before slaughter	Once a year
Layers in production	every 15th week (start at 22–26 weeks)	2 pairs of sock samples or 2 faecal samples of 75 g	Within 3 weeks before slaughter	Once a year
Poultry for meat production (all species)		2 pairs of sock samples or 2 faecal samples of 75 g	Within 3 weeks before slaughter	Once a year

S. Choleraesuis were whole genome sequenced for confirmation and further typing. The surveillance activity is ongoing.

Food

Control of *Salmonella* is an important part of in-house quality control programmes in many food enterprises in Sweden (Figure 17). All findings must be reported to the competent authority.

Between 500 and 1000 samples per year are tested as part of official sampling by local authorities at food enterprises, other than slaughterhouses and cutting plants. These samples are analysed mainly using NMKL (nr 71:1999) or a method validated against the NMKL method.

Isolates of *Salmonella* from samples of food taken by authorities are always sent for serotyping at the National Reference Laboratory for *Salmonella* (see Legislation). Although there are no legal requirements, laboratories most often also send isolates for confirmation from samples taken by food business operators. Serotyping and in some cases whole genome sequencing of these isolates is funded by the Swedish Board of Agriculture, provided that the food business operator agrees that the results are made available to the national authorities. Data from 2007 and onwards are stored in a database at the National Veterinary Institute.

Surveillance at slaughterhouses and cutting plants

According to the Swedish *Salmonella* control programme, samples from intestinal lymph nodes and swabs from carcasses are taken from cattle and swine and neck skin samples are taken from slaughtered poultry. Sampling at each slaughterhouse is proportional to the annual slaughter volume. The total number of samples taken is calculated to detect a prevalence of 0.1% with 95% confidence level in cattle, pig, and poultry carcasses at a national level. Altogether, approximately 21 000 samples from cattle, adult pigs, fattening pigs, and poultry are collected at abattoirs annually.

At red meat cutting plants, approximately 5000 samples are taken annually from meat residues. Similarly, approximately 1000 samples are taken in poultry meat cutting plants.

The samples within the control programme are analysed by commercial laboratories using the current edition of the NMKL (nr 71:1999) method, except for approximately 700 samples analysed by a method validated against the NMKL method. Up to 10 samples are allowed to be pooled into a pooled sample. If *Salmonella* is detected in the pool the samples included in the pool are analysed separately.

Food business operators are obliged to take swab samples from carcasses of sheep, goats, and horses at slaughterhouses for analyses of *Salmonella,* according to the regulation (EG) 2073/2005 on microbiological criteria for foodstuffs. The results of these analyses are not yet collected by the competent authority. In Sweden, the corresponding requirements of swab sampling of carcasses of cattle and pigs and sampling of neck skins of poultry carcasses are replaced by the sampling within the *Salmonella* control programme.

Humans

Surveillance in humans is based on identification of the disease by a treating physician and/or by laboratory diagnosis (i.e. passive surveillance) (Figure 17). Both treating physicians and laboratories are obligated to report to the regional and national level to enable further analyses and adequate intervention measures. *Salmonella* spp. is part of the microbial surveillance programme at the Public Health Agency of Sweden and domestic isolates are whole genome sequenced for serovar determination, assessment of diversity and cluster detection. The long-term goal is to use the data to evaluate efforts to lower the level of domestic incidence of *Salmonella* infection.

RESULTS

Feed

Fifteen major feed mills produce approximately 95% of the feed for food-producing animals. In the weekly surveillance of feed mills, 7359 samples were analysed for *Salmonella;* 14 of these samples (0.2%) were positive. Seven serovars were detected; *S.* Typhimurium was the most common (n=5) (Table 18).

In addition, *Salmonella* was detected in 18 out of 1906 analysed batches from feed materials of vegetable origin. The most common serovar was *S.* Jerusalem (n=6). *Salmonella* was detected in 2 out of 1583 batches from feed materials of animal origin and from pet food.

Table 18: Serovars of *Salmonella* isolated within feed control in 2020.

Serotype	Feed material of animal origin[A]	Pet food	Feed material of oil seed origin[B]	Feed material of cereal grain origin	Other plants[C]	Process control feed mills	Process control rapeseed crushing plant
S. Derby	-	1	-	-	-	-	-
S. Dublin	-	1	-	-	-	-	-
S. Düsseldorf	-	-	-	-	-	1	-
S. Lexington	-	-	-	-	-	1	-
S. Mbandaka	-	-	4	-	-	2	-
S. Muenster	-	-	1	-	-	-	-
S. Saintpaul	-	-	-	-	-	1	-
S. Senftenberg	1	-	2	-	-	1	-
S. Tennessee	-	-	3	-	-	1	-
S. Typhimurium	-	1	3	-	-	19	-
S. Vejle	-	-	-	-	-	1	-
S. enterica sp. *diarizonae* (IIIb)	-	-	-	-	-	3	-
S. enterica sp. *enterica*	-	-	2	-	-	3	-
Not typed	-	-	1	-	-	-	-
Total	**1**	**3**	**16**	**0**	**0**	**33**	**0**
Number of samples	1222	195	1037	576	41	7394	822

[A]Meat and bone meal, animal fat, fish meal, greaves, protein meal, meat meal, milk products, egg products, poultry offal meal and animal by-products.
[B]Derived from palm kernel, rape seed, soya bean, linseed, and sunflower seed.
[C]Peas, algae, leaves (dried), beans, lignin, herbs (dried), and berries.

Sweden notified four findings of *Salmonella* in feed materials and pet food during 2020. All of these concerned intra-community traded or imported feed materials. Three of them had vegetable origin and the fourth one was of animal origin.

Animals

Poultry

Salmonella was not detected in any of the 4147 broiler flocks tested in routine sampling before slaughter (Table 19 and Figure 18). *Salmonella* was detected in 7 of the 646 flocks of layers tested. *Salmonella* was not detected in any breeding flocks, neither in any samples of commercially raised turkey flocks, quails, or ostriches. *Salmonella* was detected in one small-scale flock with laying hens, ducks and geese. As the poultry registries maintained by the Swedish Board of Agriculture are not sufficiently updated and a unique flock identification is lacking, the figures on the number of flocks within the programme and the number of flocks not sufficiently sampled, can only be considered estimates. It is estimated that approximately 20% of the poultry holdings lack an annual official sampling.

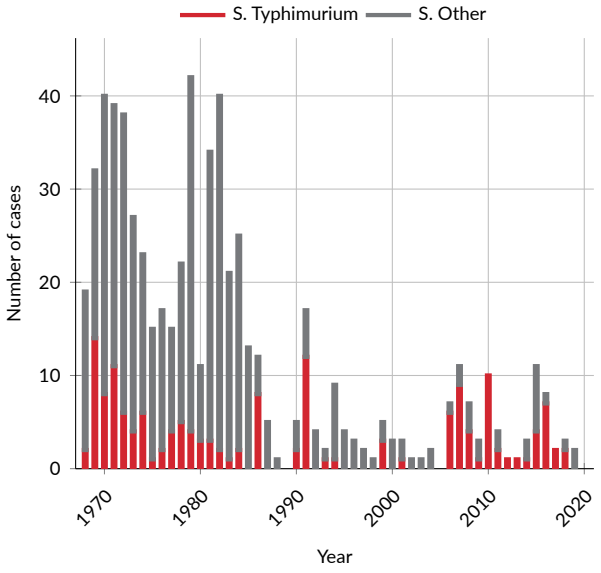

Figure 18: Annual notifications of *Salmonella* in broiler holdings during 1968–2020, breeding flocks included.

Table 19: Results from the *Salmonella* control programme in poultry flocks in 2020. The figures on the flocks tested are estimates due to the deficiencies in the Swedish poultry registries and the lack of a unique flock identification.

Animal species	Production type	Production stage	No. flocks tested	No. positives	Percentage	Serovar
Gallus gallus	Meat production	Adult Grand Parent	20	0	0.00%	-
Gallus gallus	Meat production	Adult Parent	139	0	0.00%	-
Gallus gallus	Meat production	Production	4147	0	0.00%	-
Turkeys	Meat production	Adult Parent	4	0	0.00%	-
Turkeys	Meat production	Production	159	0	0.00%	-
Gallus gallus	Egg production	Adult Parent	14	0	0.00%	-
Gallus gallus	Egg production	Production	646	7	1.08%	*S.* Typhimurium (n=7)
Geese	Meat production	Production	7	0	0.00%	-
Ducks	Meat production	Production	8	1	12.50%	*S.* Enteritidis

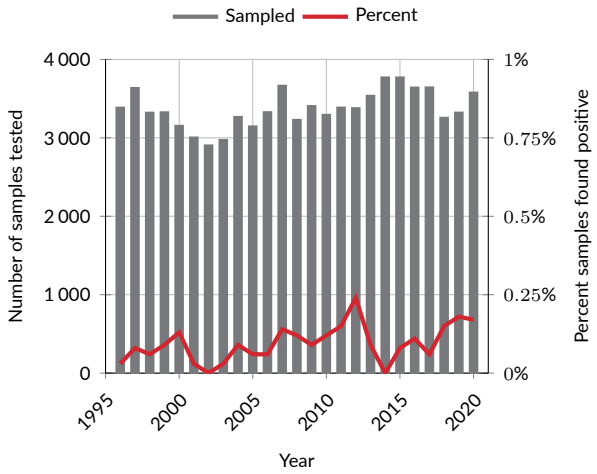

Figure 19: Samples tested (bars — left axis) and percentage of *Salmonella* found (line — right axis) in lymph node samples from **cattle.**

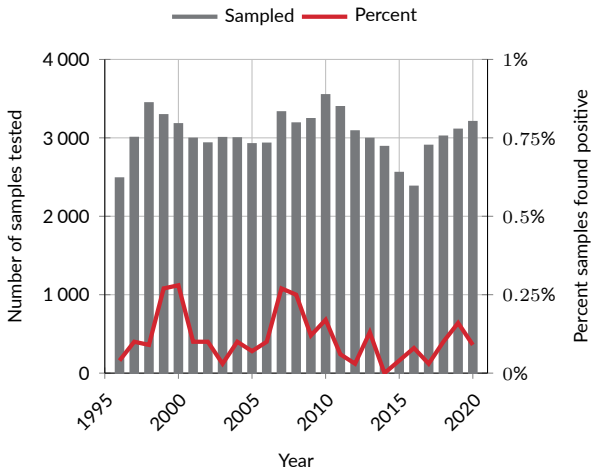

Figure 21: Samples tested (bars — left axis) and percentage of *Salmonella* found (line — right axis) in lymph node samples **fattening pigs** sampled at abattoirs.

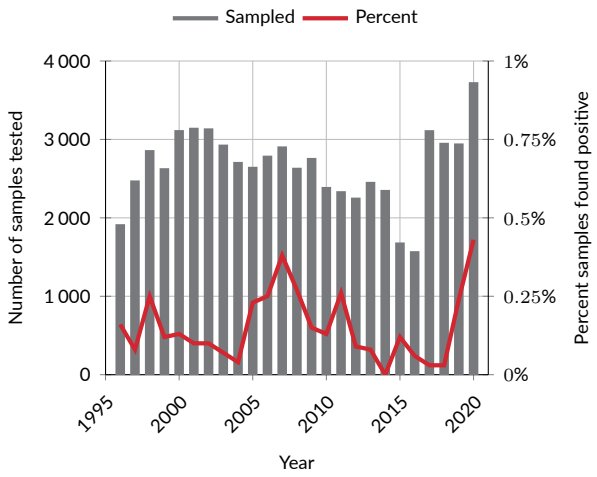

Figure 20: Samples tested (bars — left axis) and percentage of *Salmonella* found (line — right axis) in lymph node samples from **sows and boars**.

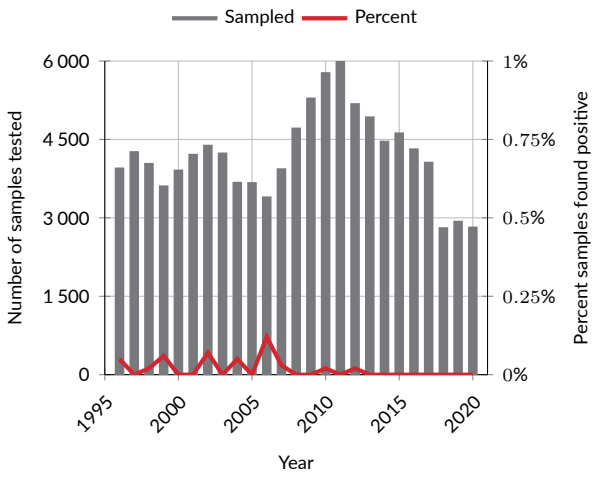

Figure 22: Samples tested (bars — left axis) and percentage of *Salmonella* found (line — right axis) in neck skin samples from **poultry** at major abattoirs.

Cattle

In total, *Salmonella* was detected in six new herds in 2020 (Figure 23). *Salmonella* was isolated from six (0.17%) of 3563 mesenteric lymph nodes from cattle at slaughter (Table 20 and Figure 19).

In the regional bulk milk screenings in Gotland, 3.0% of the tested herds were positive in April (4/132) and 5.5% in October (7/127), of which non were positive in the Dublin ELISA. This was a marked decrease compared to October 2019 when 22% (30/139) of the herds in Gotland had positive test results, but at the same level as seen in the national screening 2013 with 5.5% positive herds (12/218). Results in Öland were 16% (21/171) and 14.5% (19/131) test positive herds in April and October respectively, of which most were also positive in the Dublin ELISA. This confirms a continued endemic situation of *Salmonella* Dublin in Öland, but with a slightly lower level than expected in October when comparing to previous screenings. In the county of Östergötland 2.1% of the herds tested positive (4/194), of which most were also positive in the Dublin ELISA (n=3). These results were similar to previous results in 2013 and 2019. Regional screenings will continue to be performed in the following years to better understand variations between years and seasons and to follow the effect of a biosecurity program targeted on salmonella positive herds.

Pigs

Salmonella was detected in ten pig herds (Figure 24) and in 16 (0.43%) of 3703 lymph node samples taken from adult pigs and from three (0.09%) of 3189 lymph node samples from fattening pigs (Table 20, Figures 20 and 21).

In one of the herds, a breeding herd, the serovar *Salmonella* Choleraesuis was detected. This was the first detection of *Salmonella* Choleraesuis in domestic pigs in Sweden in over 40 years. The serovar was also detected in gilts in isolation in one of the contact herds. An extensive repeated sampling of contact herds has been performed during 2020 and is ongoing. So far, no further spread has been detected.

Other animals

Salmonella was detected in two stables with horses, in 1207 cats, in 7 dogs, in 27 wild birds (mainly passerine) and in one squirrel and one porpoise (Table 21).

Salmonella was detected in wild boar in 12 municipalities in the counties of Skåne, Södermanland and Uppland and 19 index isolates were notified from these municipalities (Table 21). In total, *Salmonella* Choleraesuis was detected in three out of 16 wild boar found dead and in 20 out of 152 shot wild boar from the counties Skåne and Södermanland. In addition, other serovars were found in two wild boar found dead and in six shot wild boar. Whole genome sequencing of S. Choleraesuis from wild boar revealed a very high level of similarity between the wild boar isolates and the isolates from the two herds with domestic pigs.

Food

Within the Swedish *Salmonella* control programme, swab samples were taken from 6757 pig carcasses and 3557 cattle carcasses. Neck skin samples were taken from 2792 poultry carcasses. *Salmonella* was detected in swab samples from three pig carcasses and one cattle carcass (Table 20). At cutting plants, *Salmonella* was not detected in any of the 4916 red meat or the 1251 poultry meat samples taken. (Table 20 and Figure 22).

In addition to the sampling performed within the control programme, 418 samples were taken by national and local authorities.

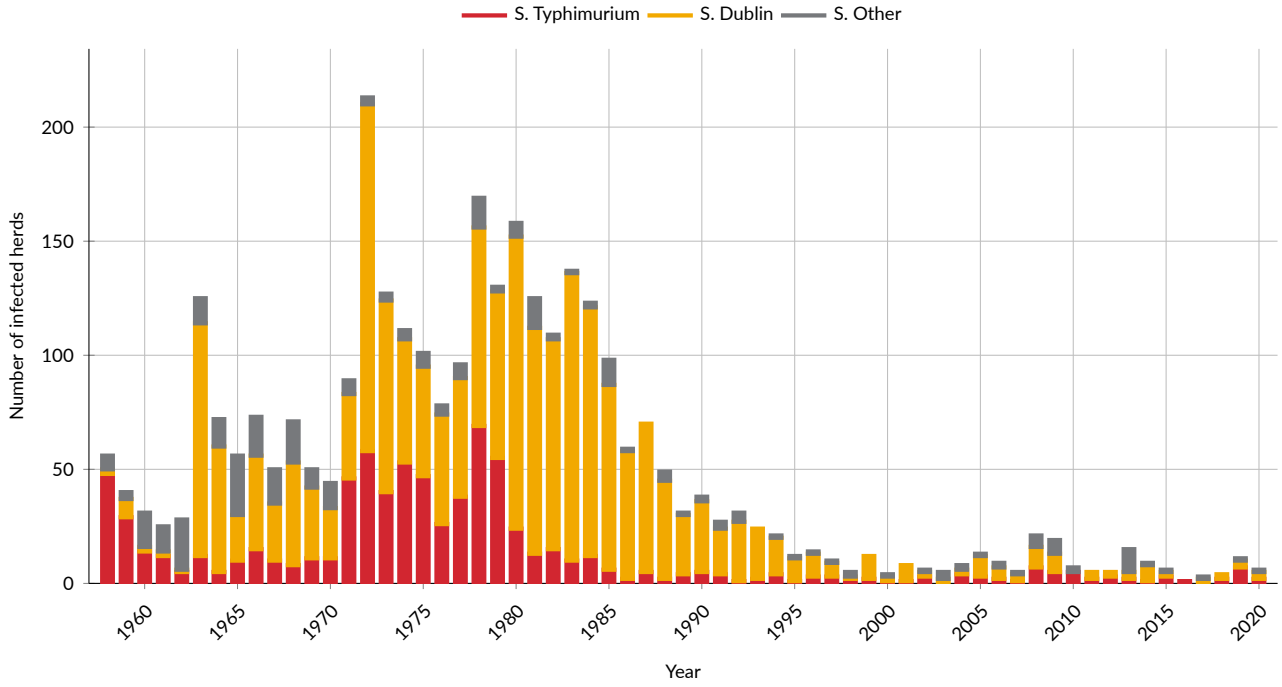

Figure 23: Annual notifications of *Salmonella* in Swedish cattle herds during 1958–2020. Data from 1958 through 1967 is extracted from a graph presented by J.Å. Robertsson (1985).

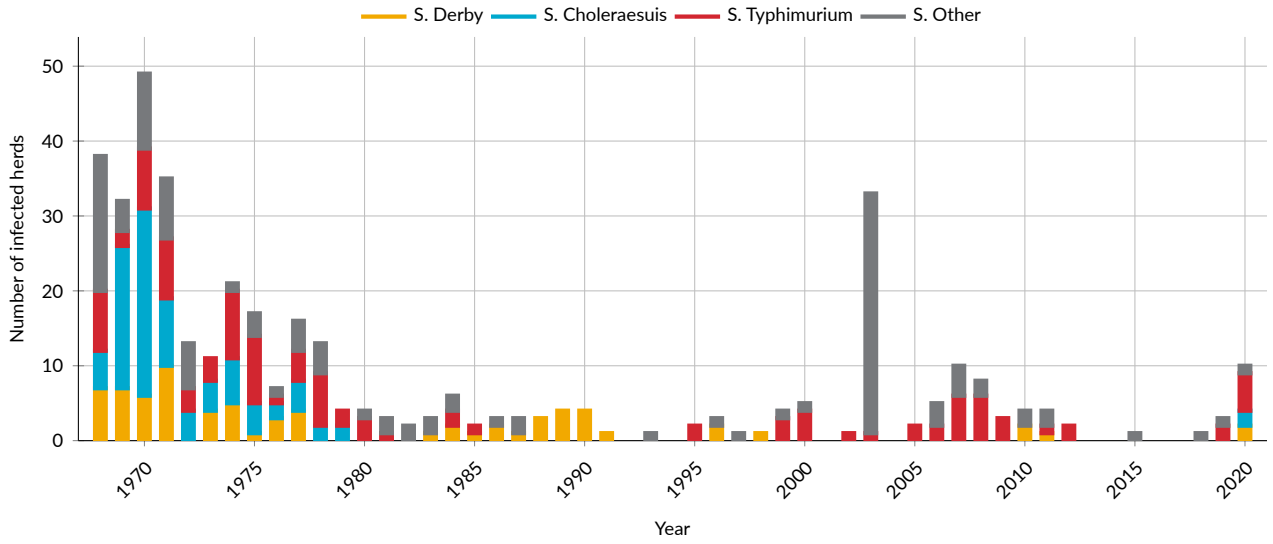

Figure 24: Annual notifications of *Salmonella* in swine herds during 1968–2020. In 2003, a feed borne outbreak of *S.* Cubana occurred in Sweden. In 2016 and 2017, *Salmonella* was not detected in any herd.

Table 20: Results from the *Salmonella* control programme at abattoirs and cutting plants in 2020.

Animal species	Sample type	No. samples	No. positive	Percentage	Serovar
Cattle	Lymph node	3563	6	0.17%	*S.* Umbilo (n=1), *S.* Dublin (n=1), *S.* Typhimurium (n=4)
	Carcass swab	3557	1	0.03%	*S.* Choleraesuis
Breeding swine	Lymph node	3703	16	0.43%	*S.* Enteritidis (n=1), *S.* Stanley (n=1), *S.* Newport (n=2), *S.* Derby (n=5), *S.* Typhimurium (n=8)[A]
	Carcass swab	3655	3	0.08%	*S.* Derby (n=1), *S.* Typhimurium (n=2)
Slaughter swine	Lymph node	3189	3	0.09%	*S.* Livingstone (n=1), *S.* Typhimurium (n=2)
	Carcass swab	3102	0	0.00%	-
Cattle and swine	Meat trimmings	4916	0	0.00%	-
Poultry	Neck skin	2792	0	0.00%	-
	Meat trimmings	1251	0	0.00%	-

[A]In one sample of lymph node, two serovars, S. Derby and S. Typhimurium were detected.

Table 21: Notified index isolates of *Salmonella* in cats, dogs, horses, wild birds and wild mammals in 2020. For all animal species except for wild boar the number of index cases is the same as the number of index isolates. For wild boar, 12 of the notified index isolates were index cases.

Serovar	Cats	Dogs	Horses	Wild birds	Wild boar	Other wild animals
S. Agona	0	1	0	0	0	0
S. Bovismorbificans	0	1	0	0	0	0
S. Choleraesuis	0	0	0	0	10	0
S. Coeln	0	0	0	0	1	0
S. Enteritidis	0	0	0	0	1	0
S. Lomita	1	0	0	0	0	0
S. Newport	0	0	0	0	2	0
S. Typhimurium	172	5	2	12	2	0
Salmonella enterica sp *arizonae*	1	0	0	0	0	0
Salmonella enterica sp *diarizonae*	0	0	0	0	2	1[A]
Salmonella, O:4,5:-:1,5	0	0	0	1	1	0
Salmonella, O:4	1033	0	0	14	0	1[B]
Total	**1207**	**7**	**2**	**27**	**19**	**2**
Number of samples[C]	2210	152	60	57	22	20

[A]A squirrel.
[B]A porpoise.
[C]Number of samples tested per household (pets), stable (horses) or municipality or location (wild animals).

Table 22: Results of *Salmonella* analyses of food samples taken by the authorities in 2020.

Reason for sampling	Total no. of samples	No. of positive samples
Survey	54	1[A]
Routine control	86	0
Suspected food poisoning or complaint	131	0
Border control	98	0
Other or not reported	49	0

[A]S. Dublin, meat from bovine animals sampled at retail.

IN FOCUS: Salmonella cases associated with domestic beef

Findings of *Salmonella* in Swedish cattle and food with Swedish meat are uncommon and outbreaks in humans related to this are rare. Recently, however, an increasing number of human cases of salmonellosis linked to domestic beef have been observed. Between 2019 and early 2021, 27 cases belonging to four different outbreaks involving the serovars Agona, Dublin, Düsseldorf, and Reading have been investigated.

Salmonella Agona: In August 2020, indistinguishable isolates of *S.* Agona were detected in samples from six cases from five different regions. In early August *S.* Agona was also detected in both Swedish minced beef and Swedish minced pork and beef meat in an in-house quality control of a large food-chain. The meat had been sold at other food chains and several locations across the country but trace-back to a specific herd was not possible because large volumes of meat of different origins had been mixed. At least one of the cases had tasted raw minced meat and another of the cases used to give its dog raw minced meat, after which the dog had probably infected its owner who had contracted a wound infection. Another case where both dog and owner became infected was identified and where the dog died after suffering from a necrotic udder inflammation.

Salmonella Dublin: Since September 2019, ten cases from nine different regions have been identified. For seven of the cases, the bacterium was isolated from blood, which is seen more frequently with this serovar and indicates a higher degree of invasiveness. In April 2020, the outbreak strain was identified in a lymph node sample from a cattle at a slaughterhouse whereupon the infection was traced to a large meat producing cattle herd. The outbreak strain had been identified in another cattle herd in the same region in 2018, indicating that the strain may be endemic in that area. In August 2020, the same subtype of *S.* Dublin was identified in a sample from Swedish minced beef. Back-tracing led to meat from animals delivered to three different slaughterhouses.

Salmonella Düsseldorf: Five notified cases from two regions had diseased in the autumn of 2019. They all had purchased Swedish minced beef and fell ill after having tasted the minced meat raw. Back-tracing led to two possible slaughterhouses, but tracing to a specific herd was not possible. The outbreak strain was also found in an environmental sample taken at a feed factory using meat from Swedish slaughterhouses for production of pet feed.

Salmonella Reading: Between September 2019 and August 2020, six cases from four different regions with clustering isolates were reported. At least one of the cases had tasted raw minced beef. The outbreak strain has a clear connection to more than 20 human isolates from the years 2007–2011, where a majority of the cases were resident in or had visited the southernmost region of Sweden. From 2007 until 2020, S. Reading has been identified in various animal species (cattle, pigs, sheep, horse, turkey, duck, chicken) as well as feed, wild birds and the environment in Skåne, and also in domestic minced beef meat. Whole genome sequencing of a subset of isolates from animals, meat, feed, environment and case patients has shown a clear link between isolates from the entire time period, although a small genetic variation seems to have developed over time. The analyses indicate that the strain was initially introduced via imported feed in 2007 and has since become endemic in several parts of Skåne.

Continuous typing of *Salmonella* isolates and sharing data for comparison between sectors is central for identification of sources. However, it is often difficult to trace the source of the infection due to big volumes of meat and the time delay between the findings. With typing, domestic and endemic subtypes can be identified. Typing data can thereby be a tool for identifying where measures to reduce the spread can be set in place.

Salmonella was detected in one sample taken from bovine meat at retail within the framework of a control project. (Table 22). At the EU-level, Sweden notified eight findings of *Salmonella* in food during 2020. All these concerned intra-community traded batches within the food categories meat and vegetables. In addition, two findings of *Salmonella* in meat were notified at the national level.

In total, data from serotyped isolates from 586 batches of food or carcasses sampled at retail, slaughterhouses, or other food enterprises between 2010 and 2020 is available. Of these, 345 were from imported food batches, 146 of domestic origin (36 food batches and 108 carcasses) and 80 from food batches of mixed or unknown origin. The distribution of serovars differ between the major food categories (Figure 25). *S.* Dublin was the most common serovar in beef meat whereas *S.* Typhimurium and *S.* Derby were most common in pork meat. The composition of serovars from poultry meat was quite variable, but *S.* Newport and *S.* Infantis were the most common. Isolates from lamb meat (mainly originating from swab samples of carcasses) were almost exclusively *S. diarizonae* serovar 61:(k):1,5(7), whereas the composition of isolates from vegetables varied a lot.

Humans

In 2020, a total of 826 cases of salmonellosis were reported, compared to 1993 cases in 2019 (Figure 26). Domestic cases decreased by 45% from 763 cases in 2019 to 422 cases in 2020, resulting in an incidence of 4.1 cases per 100 000 inhabitants. The domestic incidence varies slightly from year to year but has been largely stable between 5 and 11 cases per 100 000 inhabitants over a long period. The sharp decrease in domestic cases from 2019 and the record low incidence in 2020 likely reflects drastic changes in behaviour due to the COVID-19 pandemic.

A total of 46% of the cases (n=382) were considered to have been infected abroad. Since the turn of the millennium, a nearly fourfold decrease in incidence per 100 000 inhabitants among travel-associated cases had been observed until 2019, despite an increase in international travel. From 2019 to 2020, the proportion of travel-associated cases decreased by more than two thirds from 11.8 (n=1215) to 3.7 cases per 100 000 inhabitants. As many as 85 percent (n=326) of the travel-associated cases in 2020 were reported during the first three months of the year. Of the travel-associated cases over half (52%, n=198) reported Southeast Asia as region of infection and 38% (n=145) had Thailand as reported country of infection.

Among the domestic cases, the median age was 44 years (0–96 years) and the incidence was highest for children younger than 5 years of age with 10.9 cases per 100 000 inhabitants followed by the age group of 70–79 years with an incidence of 6.0 per 100 000 inhabitants.

Of the isolates from domestic cases, 84% were serotyped and the most common serovars among these were *S.* Typhimurium (21%), *S.* Enteritidis (16%) and monophasic *S.* Typhimurium (14%). An additional 55 serovars were identified in domestic cases during 2020. Of the cases infected in other countries, 16% were serotyped and *S.* Enteritidis was the most common serovar (40% of the isolates that were typed).

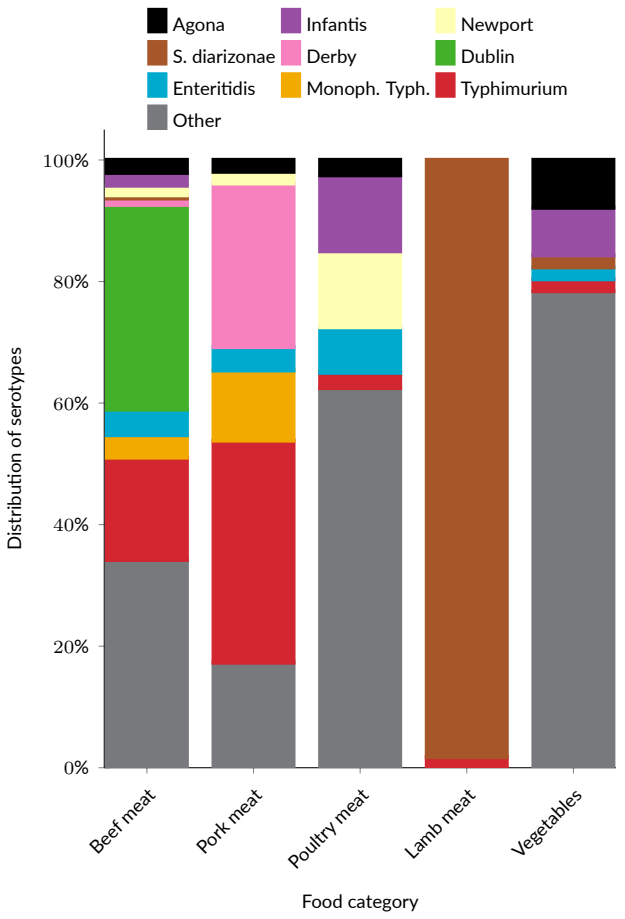

Figure 25: Distribution of *Salmonella* serovars in different food categories. Results of serotyping of isolates from samples taken at retail, slaughterhouses or other food enterprises by authorities or food business operators 2010 – 2020. In total, samples are from 447 batches of food or carcasses (beef meat 190, pork meat 52, poultry meat 40, lamb meat 114, vegetables 51). Food categories with isolates from samples of less than 20 batches of food are not included.

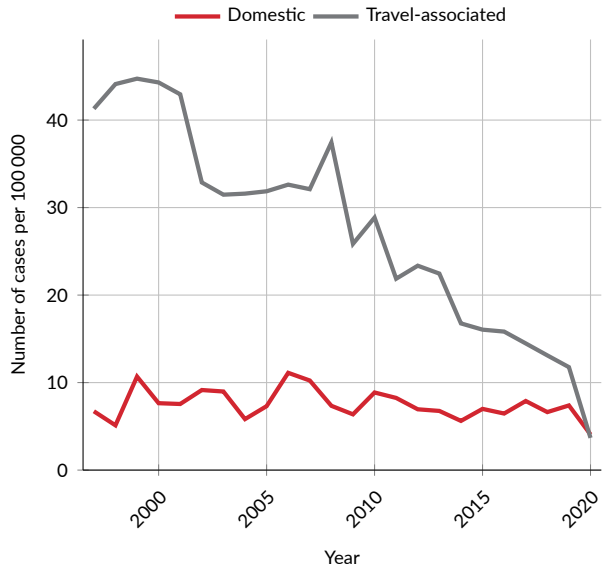

Figure 26: Incidence (per 100 000) of notified human cases of salmonellosis in Sweden, 1997–2020. Travel-associated cases are those where the patient has reported travel to another country during the incubation period prior to clinical presentation. Domestic cases are patients that have not travelled outside Sweden.

For domestic salmonellosis a clear seasonality is usually observed, with most cases occurring during late summer and early autumn. In 2020, the number of domestic cases followed normal seasonal levels until March after which the number of cases fell sharply. During the remainder of the year, a typical seasonal variation was seen, although with disease rates much lower than normal. Travel-related cases are usually the most common in summer and winter but in 2020 the numbers dropped sharply from April which coincides with extensive travel restrictions imposed in March (Figure 27).

Outbreaks

The low number of reported human cases of salmonellosis in 2020 is also reflected by a comparatively low number of outbreaks. In addition to a number of smaller clusters among isolates from cases, including some that could be linked to Swedish beef (see "In focus" section), five cases with *S.* Newport from late autumn could be linked to an outbreak investigated by Norwegian authorities. The probable source of the infection was iceberg lettuce. Only two outbreaks in which more than ten people were reported ill were identified. One of the outbreaks was caused by monophasic *S.* Typhimurium, in which 17 people fell ill between September and November and the source of infection remained unknown. The second outbreak was caused by the same types of *S.* Typhimurium as were found among wild birds, cats and dogs and affected 20 people (see below).

Outbreak of S. Typhimurium in wild birds, cats, dogs, and humans

In the early months of 2020, a large outbreak of *Salmonella* Typhimurium (MLVA profiles 2-[11-15]-[3-4]-NA-212) occurred among cats in Sweden. In total, *Salmonella* was detected in 1207 (54.6%) cats of 2210 tested. The number of index cases in cats was higher than before albeit close to the levels of 2018 and 2019. Of the 174 fully serotyped cat isolates, 172 belonged to the serovar Typhimurium. Cases in infected cats were reported predominantly in March (57.9% of the cases) and throughout the country, but especially from the region of Västra Götaland (24.0% of the cases). Simultaneously, *S.* Typhimurium with the same MLVA profiles were detected in isolates from four passerine birds, and five dogs. In addition, comparisons between genomic sequences for isolates of *Salmonella* Typhimurium with MLVA profiles typical for wild birds and cats to genomic sequences of human cases revealed a match for 20 cases. A majority of the human cases were children 0–3 years (n=12) or persons above 70 years (n=5) and most cases were reported in February-April (n=14).

DISCUSSION

The low proportion of domestic *Salmonella* infections in humans is unique to Sweden, Norway and Finland when compared to most other European countries, where such data is collected. This reflects the low *Salmonella* burden in domestic animals and food. Despite a reduction in the incidence of domestically infected from 7.4 cases per 100 000 inhabitants in 2019 to 4.1 in 2020, which is possibly linked to changed behaviour during the pandemic, the proportion of domestically infected was for the first time higher than the travel-related cases. An explanation is the large effect that travel restrictions have had during the pandemic that has reduced the number of travel-related cases by more than two thirds.

In the feed sector, in 2020 as in previous years, several different serovars were isolated in the weekly surveillance of feed mills where *S.* Typhimurium was the most common serovar (n=5). The findings were from several different feed mills, and most of them from the feed material intake area. This illustrates the importance of handling feed materials in a proper way even if the feed materials have been negatively tested for *Salmonella*.

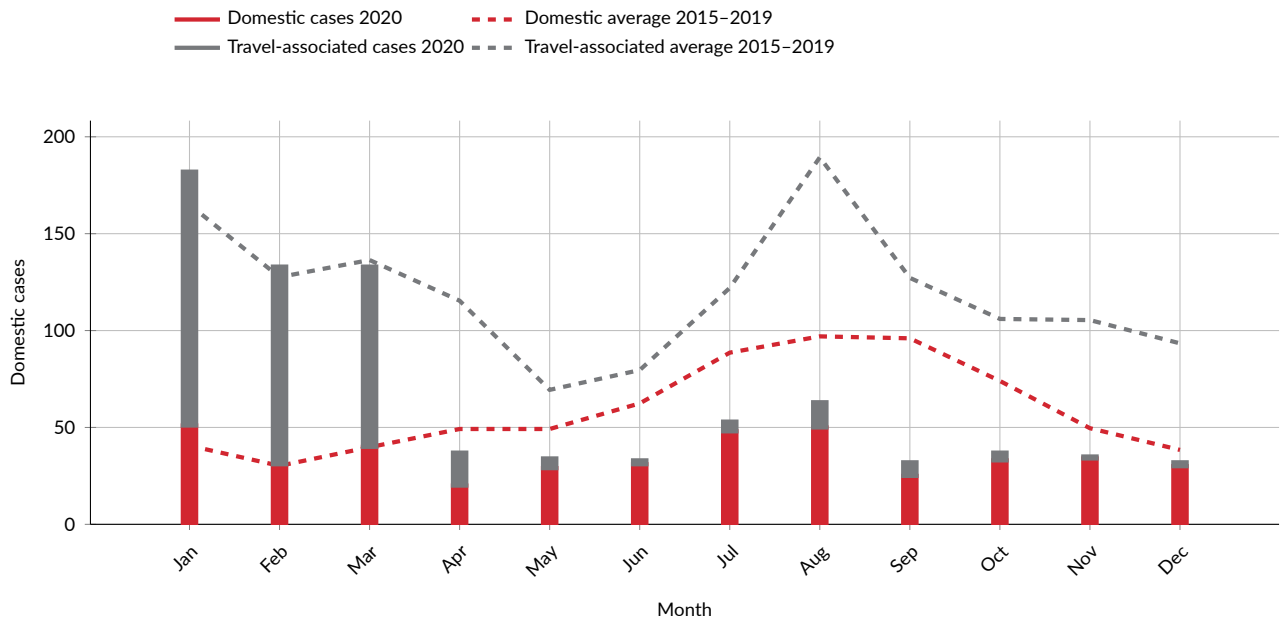

Figure 27: Monthly notifications of domestic and travel-associated human cases of salmonellosis in 2020 and a monthly average for domestic and travel-associated notifications in 2015–2019.

Salmonella was detected in ten pig herds during 2020. All these herds were geographically concentrated in one region in the south of Sweden. This is the highest number of detected herds since 2007 and the size and production structure of several of the herds made the control and eradication challenging and very costly. The detection of *Salmonella* Choleraesuis in a breeding herd called for thorough eradication and tracing plans to avoid a re-establishment of this serovar in the Swedish domestic pig population. These measures are ongoing including the surveillance of *Salmonella* Choleraesuis in wild boar. In addition, S. Choleraesuis was detected from a cattle carcass swab sample taken at a small abattoir that handles wild boar carcasses as well. Sequences of S. Choleraesuis isolates from wild boar and domestic pigs were very similar to the sequence of a human isolate from 2019. The findings so far, with high similarity between isolates from wild boar, domestic pigs and the human case indicate a common source and a recent introduction. The surveillance in wild boar is ongoing and will include all regions with a wild boar population.

In 2020, regional bulk milk screenings were used to follow up regions of special interest. This complements the national bulk milk screenings that are performed with several years interval, and will be continued in 2022.

The Swedish *Salmonella* control programme has been in place for decades and resulted in a very low *Salmonella* burden in domestic animals (Figures 23, 24 and 28). However, the programme is costly and could be modernised.

Good cooperation between the public health, food control and food safety and veterinary sectors is crucial in outbreak investigations, in control, in surveillance as well as in the further developments of the surveillance programmes.

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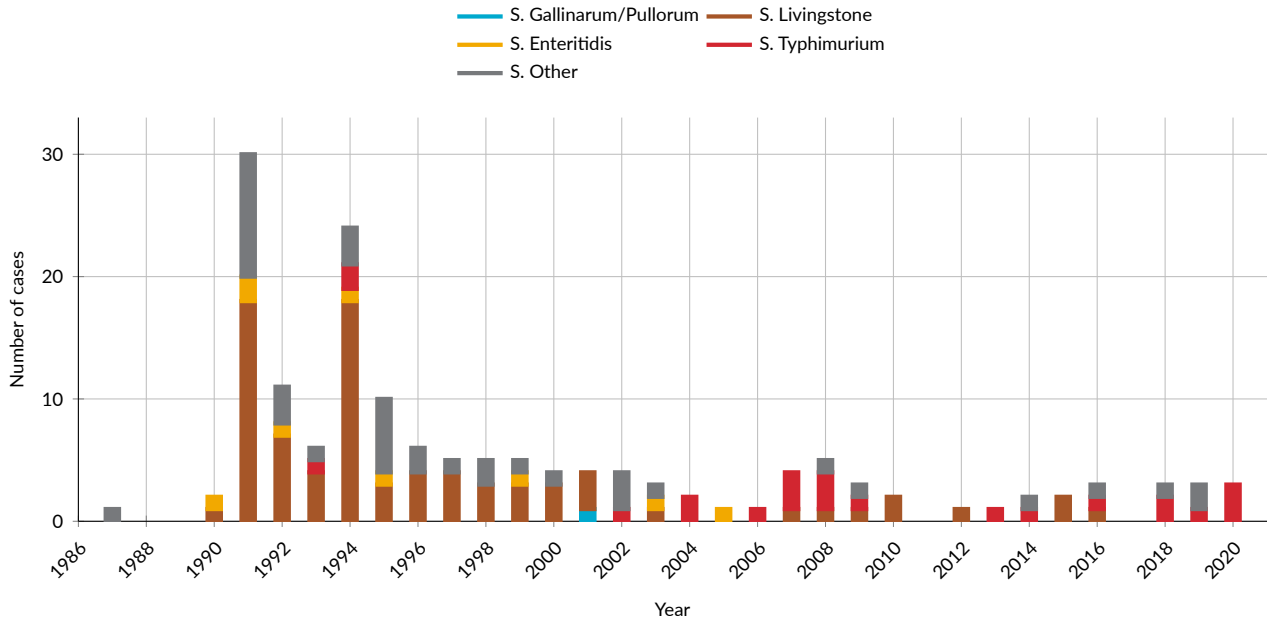

Figure 28: Annual notifications of *Salmonella* in layer holdings during 1987–2020.