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LESSONS FROM SWEDEN'S CONTROL OF SALMONELLA AND
CAMPYLOBACTER IN BROILERS

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Lessons from Sweden's Control of Salmonella and Campylobacter in Broilers

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Abstract:

By Swedish legislation; food from which Salmonella is isolated (regardless of serotype), is considered unfit for human consumption, and by that excluded to be placed on the market. Sweden has achieved an effective control regarding Salmonella in poultry. The key of success has been that all parts of the integrated production chain took their responsibilities with a holistic approach to the task. The economic support of the government during the start of the program and a close and fruitful cooperation between national authorities and the industry has also been of greatest importance.

The basic strategy of the program is:

Prevention: by hygienic measurements prevent introduction of Salmonella, regarding the whole production chain.

Monitoring critical control points in the whole integrated chain of production, with the focus to find Salmonella if present.

Action: Firm and immediate actions should be taken to avoid or minimise the effect of positive Salmonella finding.

The same strategy has been applied in all the Nordic countries and as a result of the control program, there are registered a rather low number of domestic cases of human salmonellosis. And in risk assessment evaluations – chicken does not come out as a risk.

Keywords: Holistic approach, Prevention, Monitoring, Action

Salmonella:

In the beginning of the 50-ies the structure of the red meat slaughter changed from have been very small with a local market, to larger units with a more extended distribution. A disastrous outbreak of Salmonella Typhimurium, caused by contaminated beef, where 8 845 people were clinical and bacteriological verified of whom more than 90 died, led the Swedish authorities to establish with a governmental regulation (Salmonellosis Order), these regulations were established to achieve a convenient tool in controlling Salmonella infections in animals, primarily in order to prevent infections in humans.

The implication of the Salmonellosis Order was that all Salmonella findings in food producing animals became: “notifiable disease” regardless of serotype. All veterinary laboratories are obligated, immediately to report any isolation of Salmonella to the National Board of Agriculture (NBA) and to the County Administration. All isolates are sent to the National Veterinary Institute for confirmation, serotyping and registration. In all definite or suspect cases the NBA may order a veterinarian to carry out necessary investigations, this procedure is the rule regarding all index cases.

In the late 60-ies, when broiler production in Sweden still was of minor importance, some severe outbreaks of human salmonellosis could be traced back to Salmonella contaminated broilers. A “voluntary” Salmonella control program for poultry was initiated by the broiler industry and approved by the authorities (NBA), and has been in force in Sweden since 1970. In addition to basic requirements concerning day-old chicks, housing and feed, all links of the complete chain of broiler production is monitored within a regulated testing scheme. Producers participating in the program have to apply to the NBA`s regulations . A salmonella control veterinarian, appointed by the NBA, will examine and approve the facilities before joining the program

Up to 1984 the government provided 90% compensation for all costs due to salmonella infection in poultry flocks that were affiliated in the voluntary program. Since 1984 bacteriological control of all meat fowl flocks, 10-14 days before slaughter is compulsory. Irrespective of participation in the voluntary program, the government does not provide any compensation to the broiler sector for any expenses / absence of income caused by the program. Broiler producers are today covered (participation in the voluntary program provided) to 90% by insurance to losses due to Salmonella infections.

The *objective* for the control is to supply food of animal origin to the consumers free from Salmonella.

The *concept* is that all food-producing animals shall be free from salmonella by applying the following *strategies*:

1. *Prevent* Salmonella contamination regarding all links of the production chain
2. *Monitor* the whole production chain at critical control points to detect if Salmonella contamination occurs
3. *Undertake actions* necessary to fulfil the objective of the control whenever Salmonella is detected.

In case Salmonella of any serotype is detected in any foodstuffs the lot shall be considered to be unfit for human consumption according to § 16 of the Food Act, which imply that the product is under prohibition to market.

Salmonella-free poultry production is based on five basic principles:

1. Salmonella-free day old chickens
2. Should be reared in a salmonella-free environment
3. Provided feed and water free from salmonella
4. Regularly monitoring of the whole production chain
5. Immediate action must be undertaken to fulfil the objective when ever salmonella is detected

Prevention

Day-old chicken:

All live poultry (layers, broilers, turkeys, geese and ducks) imported to Sweden have to be placed in quarantine. All commercial poultry are imported as day-old GrandParents (GP) and a minor part as day-old Parents (P). During this isolation period the flock will be tested with reference to diseases not present in our commercial poultry population as well as bacteriological examination regarding Salmonella. In case Salmonella is isolated, regardless of serotype, the flock will immediately be destroyed.

The results of the control of imported breeders show the impact of this control. In total 12 out of 39 (30.8%) flocks of broiler GP and 3 out of 38 (7.9%) flocks of layer GP were found to be

Salmonella contaminated during the years 1982-88. The Salmonella situation has dramatically improved and since 1995, and Salmonella has only been found in imported poultry breeding stock during quarantine at two occasions: one flock of turkey breeders (P) and a flock of layer breeders (P) in 2003

Salmonella control of day-old Grandparent or Parent imported to Sweden

Year	Broiler/layers	Positive/total	Percentage
1982-	Broilers	12/39	30.8
1988	Layers	3/38	7.9
1989-1992	Broilers+Layers	3/47	6.4
1995-2006	Broilers	0/103	0

The Swedish National Board of Agriculture

Since 1970 Salmonella has twice been detected in GP flocks after release from “quarantine”, and in two layer and three broiler parent flocks – all destroyed after confirmation.

Salmonella Enteritidis has up to now not been found in any broiler or layer breeder flock or in any commercial broiler flock.

Feed:

Initially the established feed factories on a voluntary basis analysed samples of imported feed ingredients that were considered being risk raw materials. Swedish legislation made this procedure mandatory in 1993. The sampling is usually performed at time of loading, and during the time of transportation the results of the bacteriological examination is ready. The other option is that sampling takes place after arrival; until results of the analysis are available the load is under arrest. In case Salmonella is found, the whole consignment has to be decontaminated before arrival to the feed mill.

All feed has to be sufficiently heat treated (75⁰ C), and only lines, silos and trucks designated for heat treated feed is accepted.

Whole grain is an exception where feed to poultry does not have to be heat-treated. In case whole wheat is used there are strict legal regulations regarding fertilizing, harvesting, transportation and storage. To the best of our knowledge there has not been one case of salmonella in broilers that has been traced back to the usage of whole grain.

Environment:

All houses affiliated to the voluntary program are closed houses, with solid hard-made floors, walls and ceiling that should be easily cleanable. All houses should be rodent and wild bird proof.

Due to these requirements organic production cannot be accepted into the voluntary program. All breeder and broiler houses are furnished with an “ante room” at the entrance. The “ante-room” is divided into a “dirty” and a “clean” area divided by a “hygiene barrier”. The area where the chickens are is from our salmonella control point of view, the clean zone. When crossing the “hygiene barrier” footwear and preferably coveralls should be changed. In many GP operations the “hygiene barrier” consists of a shower.

Immediately (within 24 hours) after the house has been depopulated all litter is removed. In case salmonella has been isolated in the flock all litter has to be composted for at least 6 months in order not to contaminate the surrounding environment.

Monitoring*Bacteriological sampling:**Breeding stock:*

Arrival	(GP/)	1x10 caeca + 1x10 liners
2v.	(GP/P)	5 pair of sock samples
4v.	(GP)	5 pair of sock samples
10v.	(GP)	5 pair of sock samples
17v.	(GP/P)	5 pair of sock samples
24v+ every 2v.	(GP/P)	5 pair of sock samples

An appointed veterinarian performs 2 times a year the sampling

Hatchery:

Parent production:

All GP flocks are monitored at every hatch – 250 meconium samples per flock

An appointed veterinarian performs 3 times per rotation the sampling.

Commercials:

10-14 days before slaughter, 2 pair of socks

When there is more than 2 weeks in between slaughter of a flock – retesting is required.

An appointed veterinarian performs once a year the sampling.

Final product:

To verify that the control program do achieve the objective; neck skin samples are taken 3 times a day at every slaughter plant and cultured for salmonella.

Feed:

Imported raw material – salmonella controlled.

Weekly samples are taken at the feed mill at critical control points as dust samples:

Unloading pit for raw materials

Aspiration filter

Top of pellet cooler

Processing area, pellet cooler

Top of bin, finished feed

Diagnostic procedures:

In the Salmonella control program the diagnostic procedure is based on cultivation, isolation and serotyping. The actual principles of cultivation and isolation of Salmonella are as follows:

1. Preenrichment – BPW (16-24 h.)
2. Selective enrichment – MSR/V (18-24 + 42-48 h.)
3. Selective cultivation – XLD and BG (18-24 h.)
4. Confirmation - Identification

Action

When for solid reasons salmonella is suspected an extended sampling procedure is performed. In all suspected or verified index cases a veterinarian is appointed by the NBA to carry out an investigation to try to find the source of introduction.

Whenever Salmonella is verified regardless of prevalence or serotype the flock is destructed.

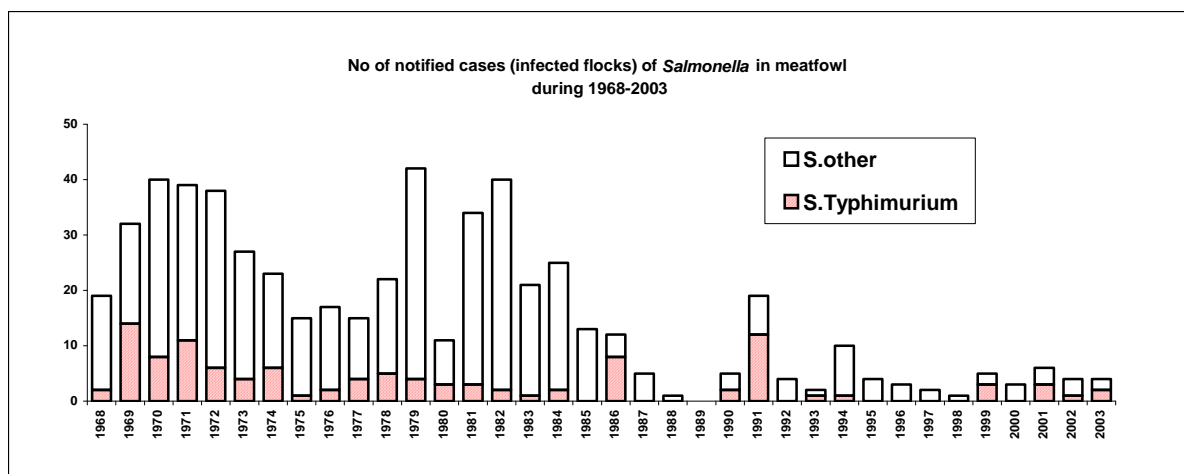
All manure is composted for at least 6 months.

Thoroughly cleaning and disinfection is followed by an inspection including environmental swabs for culturing.

Results - Sweden

Since 1968, there has been a proper registration of isolations of salmonella infections in broilers. The serotypes involved have mainly been exotic serotypes - the large numbers of outbreaks during 1979 and 1982-83 were caused by contaminated feed (*S.livingstone* and *S.embandaka*). The two involved feed mills were temporarily closed during cleaning and disinfection and some manufactory proceedings were improved. An egg born Salmonella contamination in 1993, due to a flock that became Salmonella positive after transfer to the production site resulted in spreading of *S.typhi murium* to 12 flocks involving +300 000 broilers.

Since 1995 the incidence of flocks contaminated and destroyed due to Salmonella has been less than 0.1%.



The Swedish National Board of Agriculture

Neither *S. enteritidis* nor *S. t.m.* DT 104 has ever been isolated in the integrated broiler chain.

During the period 1995-2005, out of 42 349 pooled samples taken at poultry slaughter plants, 13 samples have been found positive, a majority of these have been cross-contamination from spent hens

Table SA5. *Salmonella* in fresh broiler meat (unless otherwise stated) at slaughter, processing level and retail, in countries with a monitoring/control programme¹, 2001-2005

	2005		2004		2003		2002		2001	
	N	% Pos	N	% Pos	N	% Pos	N	% Pos	N	% Pos
At slaughter										
Belgium ²	228	5.7	-	-	189	17.5	171	9.4	222	12.2
Denmark ³	1,174	2.3	1,472	1.6	1,552	5.0	1,667	5.5	1,695	4.1
Spain ⁶	203	13.8	151	8.6	30	6.7	241	3.7	242	6.6
Sweden ⁴	3,506	0	3,730	0.1	4,209 ²	0	4,466 ²	0.1	4,243 ²	0
Norway ^{3,4,6}	6,056	<0.1	7,239 ²	1.0	7,183 ²	0	6,959 ²	0	7,135 ²	0
At processing/cutting plant										
Belgium ²	260	14.2	1,832	8.7	1,485	14.2	1,383	16.7	1,503	20.0
Finland ⁵	772	0	777	0.1	1,034	0.1	946	0.2	637	0.2
Ireland	7,485	2.2	6,955	2.7	1,869 ⁵	4.3	3,222	4.9	3,287	7.5
Spain ⁶	93	2.2	141	2.1	168	18.5	288	5.6	93	8.6
Sweden ⁵	1,014	0	1,025	0	1,130	0	1,146	0	1,121	0

Note: Data from 2001-2003 is on poultry meat

1. Data are only presented for sample size ≥ 25

2. Carcass (presence in 1g)

3. Batch based sampling

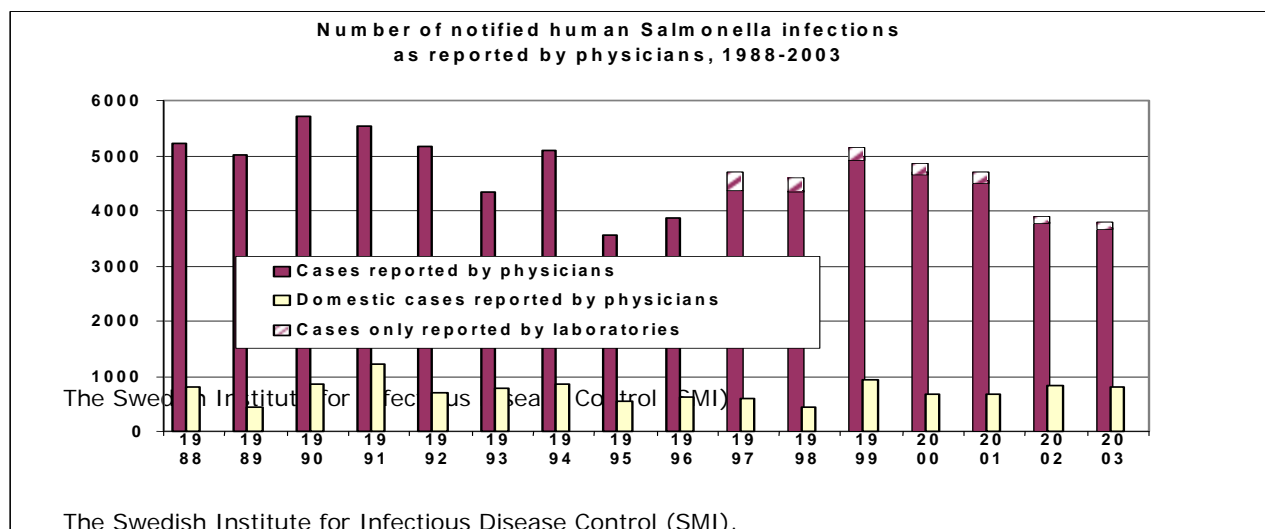
4. Neck skin (presence in > 10 g)

5. Crushed meat (presence in 25 g)

6. Meat from unspecified poultry

EFSA – The Community Summary Report 2006

Sweden have had a long tradition of combating salmonella infections in livestock, the precautions have led to Sweden having a very low number of domestic cases of human salmonellosis..



Conclusion:

- Sweden have achieved an effective control of Salmonella
- By prevention/hygiene is it possible to produce broiler meat free from salmonella
- Salmonella-free foodstuffs have an influence on human health
- Non acceptance of Salmonella contaminated foodstuffs by consumers, physicians and legislators

Campylobacter:

Since 1991, Sweden have had a supervision/registration control program. By hygienic measures, the incidence have decreased from 50% positive flocks to to-days level of 10%.

The epidemiology of Campylobacter is not fully understood; but our experience has excluded the following sources:

- The day old chicken – under natural conditions Campylobacter have never been isolated in chickens before 10 days of age.
- Persistent infection – “all in all out”, under natural conditions Campylobacter have never been isolated in chickens before 10 days of age
- Feed

As the surrounding environment appears to be the major Campylobacter risk, hygienic measurements is of greatest importance:

- Hygiene barriers
- Rodent and bird proof
- Water, if not community or deep well
- No “thinning”

As there is a pronounced seasonal variation, with an increase of Campylobacter positive flocks from June to October, insects might be of greater importance. Danish studies have shown, that the two species of flies (house and stable fly) act as carriers of Campylobacter in to closed chicken sheds through the ventilation system. This could be the explanation, why producers fulfilling all hygienic measures still come up with Campylobacter positive flocks.



Lessons from Sweden's Control of Salmonella and Campylobacter in Broilers

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Background to the Swedish Salmonella Control Programme(1)

- 1941 Voluntary programme to control S.Gallinarium/Pullorum.
- 1953 The Alvesta Epidemic – involved 9000, of whom 90 died.
- 1961 Governmental regulation, to combat S. infections in livestock.
- 1970 Governmental approved, voluntary programme regarding production of meat fowl.



Background to the Swedish Salmonella Control Programme(2)

- 1984 Mandatory S. control of meat fowl before slaughter.
- 1994 Mandatory S. control of layers
- 1995 Additional guarantee concerning Salmonella, accepted as Sweden entered the EU
- *If salmonella regardless of serotype, is found in any foodstuffs – the lot is considered to be unfit for human consumption according to the § 16 of the Food Act, which implies that the product is under prohibition to market.*



The Swedish Salmonella Controlprogram

The objective for the Control is to supply food of animal origin free from salmonella.



The *concept* is that all food-producing animals, shall be free from salmonella

by applying the following *strategies*:

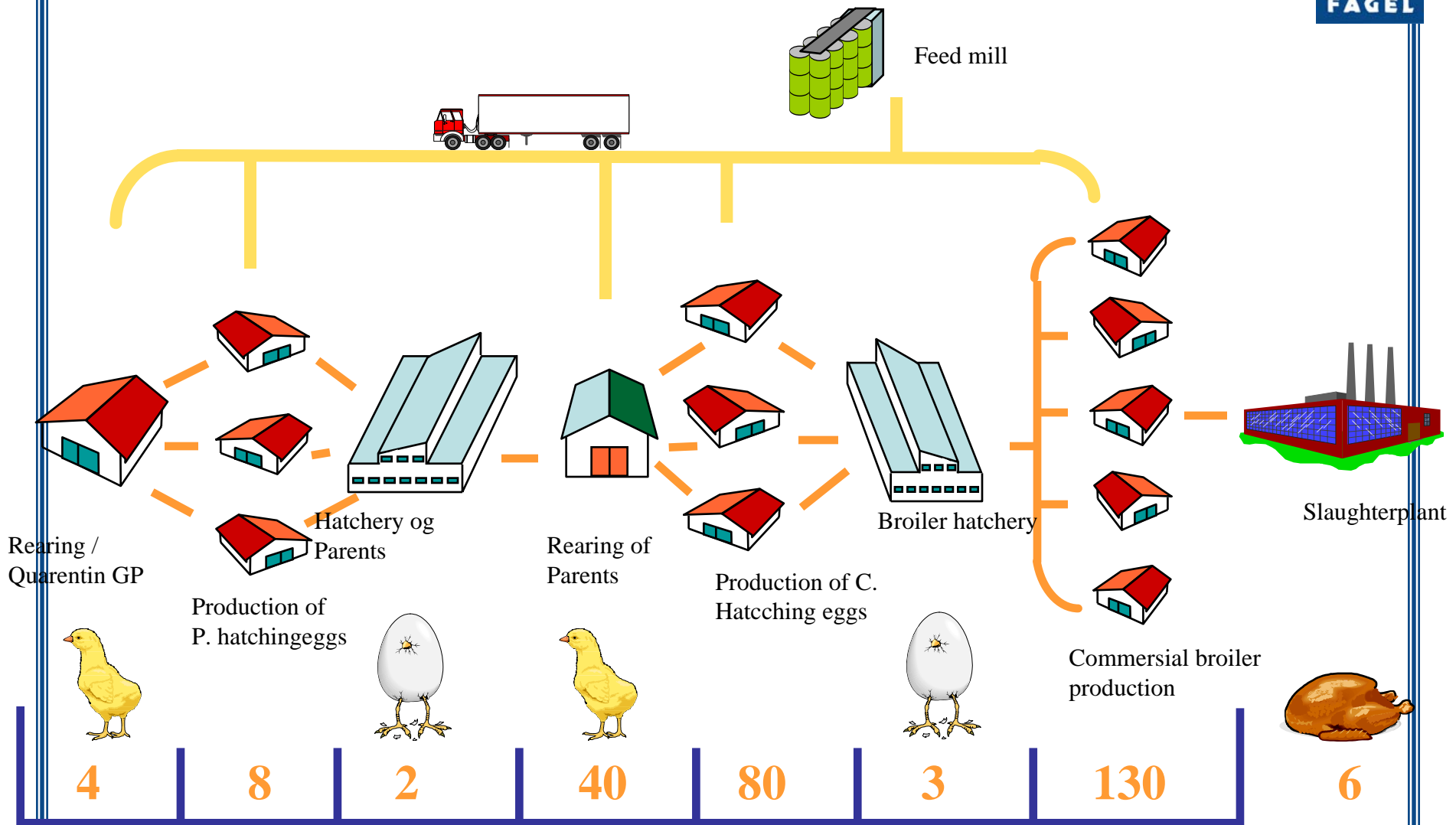
- ***Prevent*** Salmonella contamination regarding all links of the production chain.
- ***Monitore*** the whole production chain at critical controlpoints.
- ***Actions*** necessary to fulfil the objective whenever Salmonella is detected



Salmonella-free poultry production is based on five basic principles:

- 1 Each day-old chick has to be free from salmonella,
- 2 the birds have to be provided with feed and water that is free from salmonella,
- 3 the birds have to be kept in a salmonella-free environment,
- 4 the whole production chain has to be regularly monitored,
- 5 Immediate action must be undertaken to fulfil the objective when ever salmonella is detected.

Swedish broiler production



GP=Grand parents stock P=Parents stock C= Commerial broilers



Salmonella-free day-old chick

- **Breeding stock has to be salmonella free**
- All breeding stock imported, as Grand Parents
- 8 week Quarantine – salmonella testing
 - 1982-89 S.pos flocks 12/39 (30.8%)
 - 1989-92 3/47 (6.4 %)
 - 1995-2006 0/132 (0%)
 - S.Enteritidis is never isolated from breeders or commercial broilers
- Since 1970, salmonella has been introduced to:
 - 1 GP-flock after transfer, before start of production
 - 1 GP- flock in production (45 w.)
 - 2 P-flocks at start of production

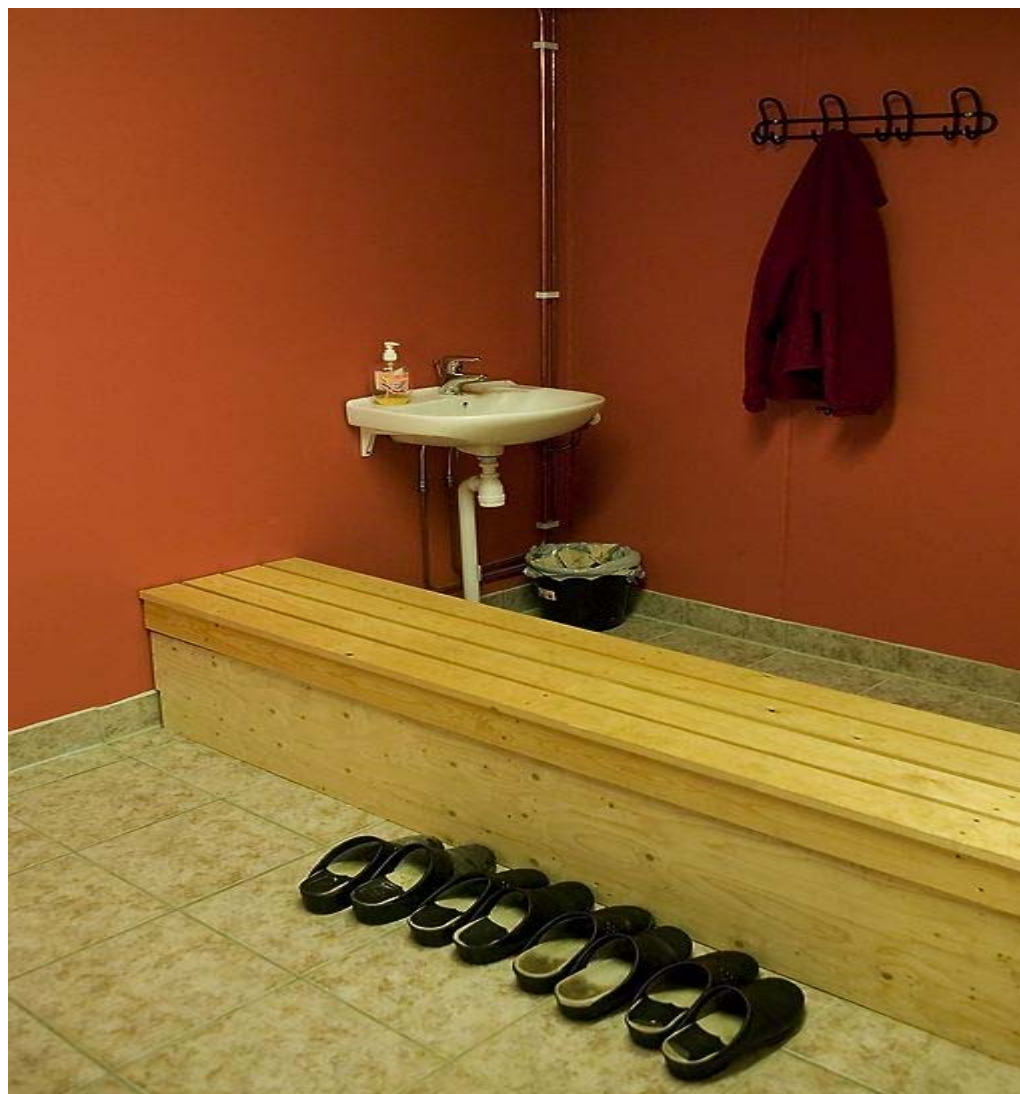
Salmonella-free feed and water

- Only factory produced feed allowed.
- All feed has to be sufficiently heat treated
 - Temperature / time
 - Monitoring of salmonella in feed mills
- Exception – Whole grain
 - Control program from harvest – storage - feeding
- Water
 - Community or deep wells
- *Feed has been related to some exotic salmonella findings in commercial broilers*

Salmonella-free environment.

- Housing:
 - Hygiene regimes
 - Concrete floors
 - Solid walls
 - Rodent and bird proof
- All in all out
- Cleaning and disinfection
- Litter material
 - GP/P – wood shavings,
 - broilers – wood shavings or straw

Entrance



Production unit



Hygien barier



Passing hygien barrier



Clean area



Hand hygien



Monitoring GP and P

- | | |
|-------------------------|--------------------------|
| • Arrival (GP) | 1x10 caeca + 1x10 liners |
| • 2v. (GP/P) | 5 pair of sock samples |
| • 4v. (GP) | 5 pair of sock samples |
| • 10v. (GP) | 5 pair of sock samples |
| • 17v. (GP/P) | 5 pair of sock samples |
| • 24v+ every 2v. (GP/P) | 5 pair of sock samples |

Monitoring hatchery:

All GP flocks are monitored at every hatch – 250 meconium samples per flock

Monitoring feed mill

- Risk raw materials – S. controlled.
 - Decontamination if S. contaminated
 - Heat
 - Acid
- Weekly samples are taken as dust samples:
 - Unloading pit for raw materials
 - Aspiration filter
 - Top of pellet cooler
 - Processing area, pellet cooler
 - Top of bin, finished feed

Monitoring of commercials

- 10-14 days before slaughter, 2 pair of sock samples
- When there is more than 2 weeks in between slaughter – retesting.
- Every farm has an appointed salmonella control veterinarian (Board of Agriculture)
- Once a year the sampling is performed by the appointed veterinarian



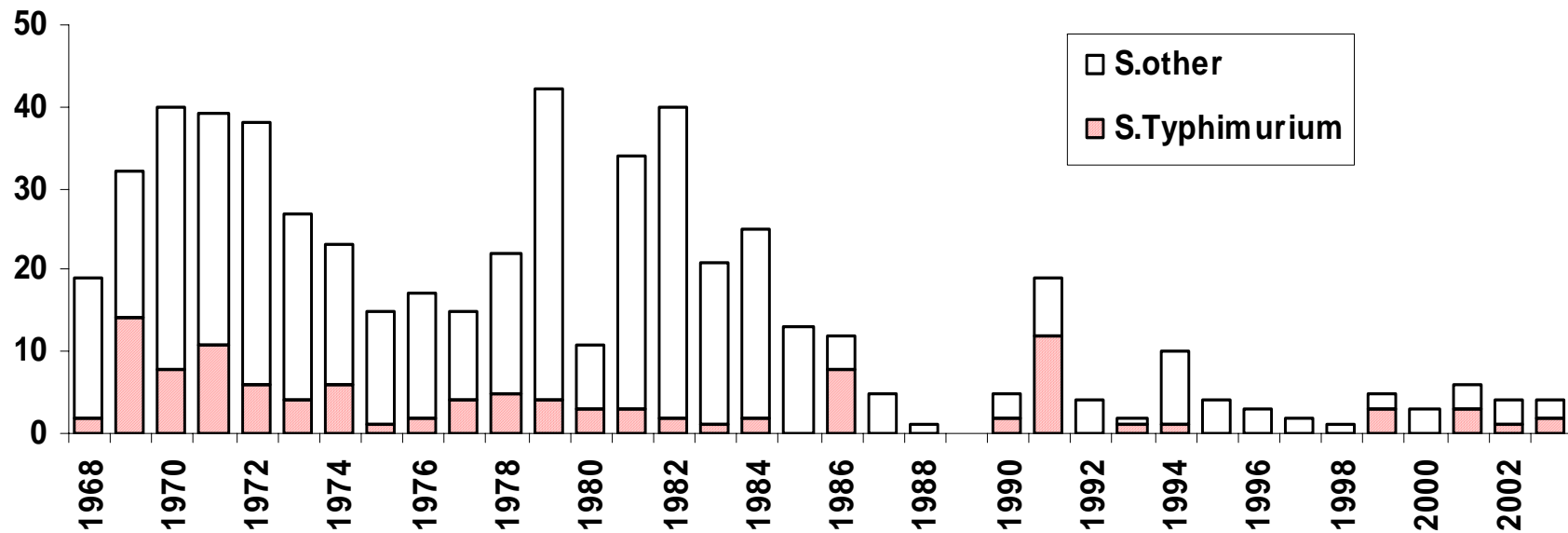
Monitoring of final product:

- To verify that the control program do achieve the objective; neck skin samples are taken 3 times a day at every slaughter plant and cultured for salmonella. During the period 1995-2003, out of 42 349 samples 13 positive has been found.
- S.enteritidis has so far never been isolated
- S.tm. DT 104 has not been isolated

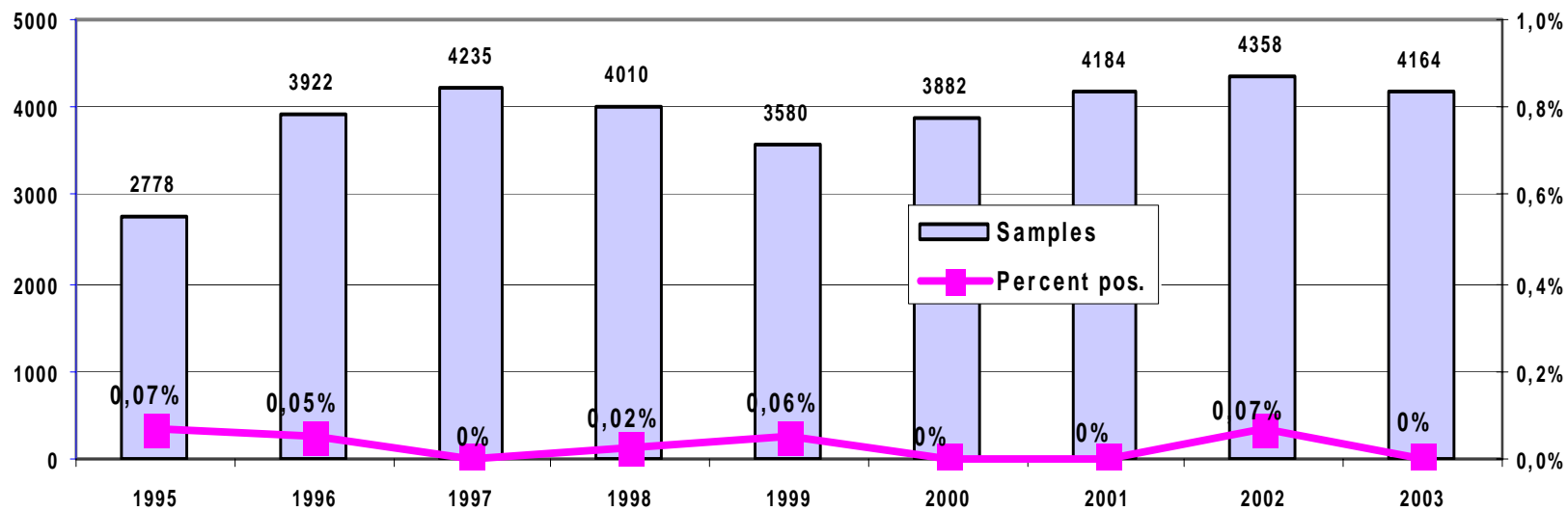
Action when salmonella has been suspected, later verified:

- When for excellent reasons salmonella is suspected, an extended sampling procedure is performed.
- Whenever salmonella is verified regardless of prevalence and serotype the flock is destructed.
- All manure is composted for at least 6 months
- Thoroughly cleaning and disinfection
- Inspection and environmental culturing

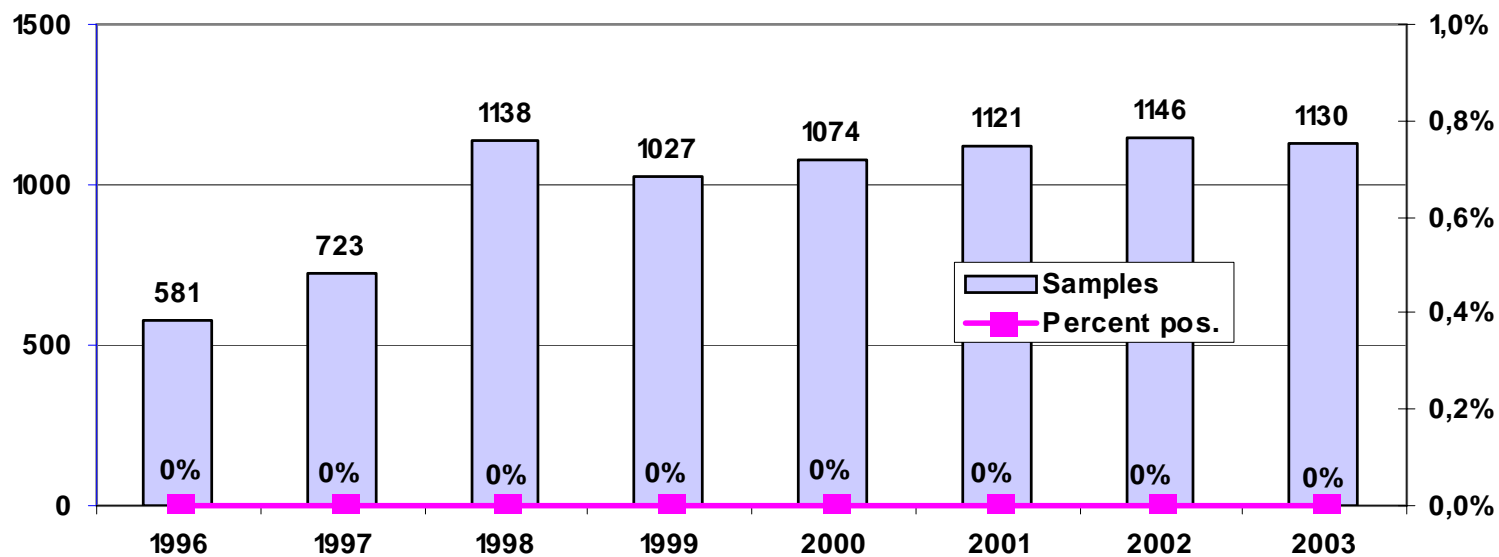
No of notified cases (infected flocks) of Salmonella in broilers during 1968-2003



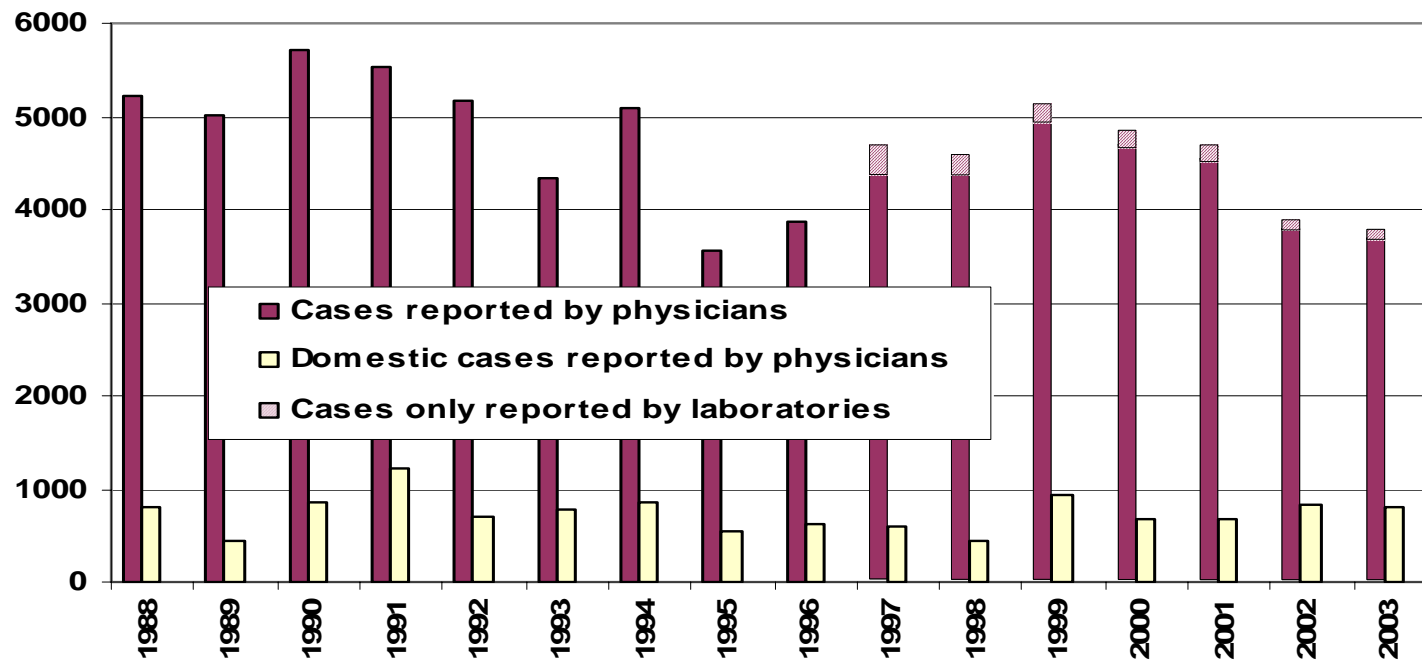
Salmonella control of poultry at major slaughter-houses during 1995-2003



Salmonella control at poultry cutting plants supervised by NFA (1995-2003)



Number of notified human Salmonella infections as reported by physicians.



Conclusions (1)

- The Nordic countries have achieved an effective control of Salmonella
- By prevention/hygiene it is possible to produce broiler meat free from Salmonella
- Salmonella-free foodstuffs have an influence on human health
- Non acceptance of Salmonella contaminated foodstuffs by consumers, physicians and legislators

Conclusions (2)

- Spinoff effects:
 - Improved animal health
 - Improved technical results
 - Less use of antibiotics
 - No antibiotic growth promoters
 - Less human exposure
 - Of antibiotic resistant pathogenes
 - Of Campylobacter
 - Less poluted environment



Campylobacter control

- 1989 Limited study – 60% positive
- Since 1991; Registration of Campylobacter status at slaughter of every single flock (neck skin) – 20% positive
- Information
- Bonus – Campylobacter free flocks
- 2001 Governmental approved and financed project
- 2006 – 10 % positive

Swedish experiences regarding Campylobacter control



- Non Risks:
 - As "all in – all out" is general practice, the day old chick environment.
 - Day old chicks.
 - Feed
- Risks:
 - Outside environment
 - Rodents/wild birds
 - Flies (house and stable fly)
 - Water

Campylobacter challenge

- Seasonal variation
 - Environmental differences
 - Wild birds
 - Insects
- Producer variation
 - Local differences
 - Different ventilation constructions
 - Obeying hygienic rules
 - Thinning
 - Transport crate/container hygiene