

***Salmonella* Isolated from Animals and Feed Production in Sweden Between 1993 and 1997**

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Boqvist S, Hansson I, Nord Bjerselius U, Hamilton C, Wahlström H, Noll B, Tysen E, Engvall A: *Salmonella* isolated from animals and feed production in Sweden between 1993 and 1997. Acta vet. scand. 2003, 44, 181-197. – This paper presents *Salmonella* data from animals, feedstuffs and feed mills in Sweden between 1993 and 1997. During that period, 555 isolates were recorded from animals, representing 87 serotypes. Of those, 30 serotypes were found in animals in Sweden for the first time. The majority of all isolates from animals were *S. Typhimurium* (n=91), followed by *S. Dublin* (n=82). There were 115 isolates from cattle, 21 from broilers, 56 from layers and 18 from swine. The majority of these isolates were from outbreaks, although some were isolated at the surveillance at slaughterhouses. The number of isolates from the feed industry was similar to that of the previous 5-year period. Most of those findings were from dust and scrapings from feed mills, in accordance with the HACCP programme in the feed control programme. It can be concluded that the occurrence of *Salmonella* in animals and in the feed production in Sweden remained favourable during 1993-97.

animal; cattle; feed; feed production; isolate; poultry; swine; Salmonella; Sweden.

Introduction

Salmonellosis is one of the most common food borne zoonoses reported world-wide (Gomez *et al.* 1997, Thorns 2000). However, in Sweden the prevalence of *Salmonella* in food producing animals is low (Hopp *et al.* 1999, Anonymous 2001, Thorberg & Engvall 2001). This is most likely due to the *Salmonella* control programme that started in 1961 with the aim to keep meat- and egg producing animals free from *Salmonella*. When Sweden joined the European Union (EU) in 1995, surveillance of *Salmonella* in cattle, pigs and poultry at slaughter was included in the control programme (Anonymous 1995).

Any finding of *Salmonella* from animals or the feed production, regardless of serotype, is notifiable to the Swedish Board of Agriculture (SBA). At least one isolate from each finding of

Salmonella in animals, feed or environmental sampling from feed mills has to be sent to the National Veterinary Institute (SVA) for confirmation and serotyping. This is performed according to the methods described by Kaufmann (1972). From each notifiable incident of *Salmonella* one isolate has to be tested for antibiotic resistance at the SVA. Apart from this, isolates of *S. Typhimurium* and *S. Enteritidis* are phage typed at the Swedish Institute for Infectious Disease Control (SMI). In January 1996, the phage typing system was changed from the Lilleengen to the Colindale system (Anderson *et al.* 1977, Ward *et al.* 1987).

The reporting of *Salmonella* has resulted in a series of articles by the SVA and the SBA with results presented from 1949 and onward (Thal *et al.* 1957, Rutqvist and Thal. 1958, Karlsson

et al. 1963, Hurvell et al. 1969, Gunnarsson et al. 1974, Sandstedt et al. 1980, Mårtensson et al. 1984, Eld et al. 1991, Malmqvist et al. 1995). The aim of the present study is to summarise *Salmonella* data from animals and the feed production in Sweden between 1993 and 1997.

Materials and methods

The results presented in this study were based on information collected at the SVA and the SBA. If several isolates of the same sero- and phage type were obtained from the same animal or from the same epidemiological unit (i.e. cattle farm, pig farm, kennel, water in reptile terrariums) only the first isolate was included (i.e. primary isolate). If *Salmonella* was re-isolated after an animal, herd or flock had been cleared from the infection, this isolate was also included. If more than one sero- or phage type was isolated from each individual or epidemiological unit, each serotype was included. Furthermore, isolates from autopsies, sanitary slaughter and lymph nodes collected at the surveillance at the slaughterhouses, were also included even if *Salmonella* could not be re-isolated at follow-up sampling at the farms. From

feed production, all primary isolates were included.

Results and discussion

Salmonella isolated from animals

In total, 555 isolates were recorded from animals during the present study period. Between 1989 and 1992, 598 isolates were recorded. However, comparisons of results between the different study periods must be made with caution as sampling strategy and surveillance may have differed (Thal et al. 1957, Rutqvist and Thal. 1958, Karlsson et al. 1963, Hurvell et al. 1969, Gunnarsson et al. 1974, Sandstedt et al. 1980, Mårtensson et al. 1984, Eld et al. 1991, Malmqvist et al. 1995).

In the present study, 78% of the isolates were *S. Subspecies I*, followed by *S. Subspecies III* (13%) and *II* (5%) (Table 1). The number of isolates of *S. Subspecies I* were fewer compared with results from the previous studies, which most likely is due to the decrease in number of isolates from cattle (Fig. 1). In all, but one, of the previous reports, cattle have been the most common animal specie from which *Salmonella* was isolated. However, in the present report, reptiles predominated. Most of those isolates

Table 1. The number of isolates of the various subspecies of *Salmonella enterica* in animals in Sweden during 1968-97.

<i>Salmonella enterica</i> subspecies	1968-72	1973-77	1978-82	1983-87	1988-92	1993-97
Subspecies I (Subsp. enterica)	1721	1077	1231	720	524	435
Subspecies II (Subsp. salamae)	10	2	4	6	11	29
Subspecies IIIa & IIIb (Subsp. arizonae & diarizonae)	14	19	14	13	59	73
Subspecies IV (Subsp. houtenae)	1	2	1	3	4	15
Not typed or typable	6	16	18	4		3
Total	1752	1116	1268	746	598	555

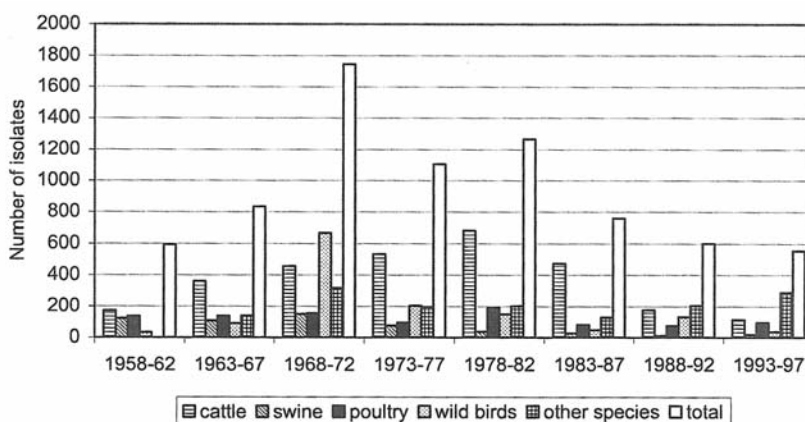


Figure 1. The number of recorded *Salmonella* isolates from various animal species 1958-97 in Sweden.

were *S.* Subspecies II, III and IV. An explanation for this may be the increased import of reptiles since March 1996 when the Swedish import regulations were harmonised with the EU regulations. It is likely that the increase in number of reptiles led to increased sampling of this animal specie.

During 1993-97, 87 different serotypes were identified from animals (Table 2), which is the largest number ever recorded. Of those, 30 were

found in animals in Sweden for the first time. The most common serotype was *S.* Typhimurium ($n=91$), followed by *S.* Dublin ($n=82$), which is in accordance with results from the previous study periods. Table 2 presents the distributions of serotypes during the study period. Two different phage typing system were used for *S.* Typhimurium in 1993-97. Up to 1995, the Lilleengen system was used, followed by the Colindale system introduced in 1996 (Table 3).

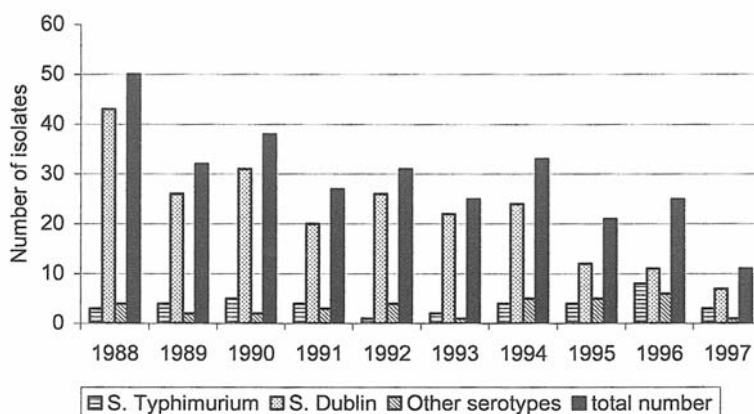


Figure 2. Recorded number of *Salmonella* isolates from cattle during 1988-97.

Table 2. The distribution of serotypes of *Salmonella* isolated from animals between 1993 and 1997.

Serotype	Last isolation before 1993	1993	1994	1995	1996	1997	Total
<i>S. Abony</i>	1978			2	2		4
<i>S. Adamstua</i>	1969				1		1
<i>S. Adelaide</i>	1988			4			4
<i>S. Afula</i>					1		1
<i>S. Agona</i>	1992	1	2	1	1		5
<i>S. Agoueve</i>				1			1
<i>S. Anatum</i>	1992	1	1	2			4
<i>S. Arechavaleta</i>						1	1
<i>S. Bardo</i>	1991			2	2		4
<i>S. Bassa</i>						1	1
<i>S. Bignona</i>					1		1
<i>S. Bissau</i>					1		1
<i>S. Bovismorbificans</i>	1992			1	2		3
<i>S. Braendrup</i>	1987	1			1		2
<i>S. Bredeney</i>	1991					1	1
<i>S. Burgas</i>				2			2
<i>S. California</i>	1984		1				1
<i>S. Chailey</i>						1	1
<i>S. Chester</i>	1982			1			1
<i>S. Cubana</i>	1983			1	2	1	4
<i>S. Derby</i>	1991				4		4
<i>S. Dublin</i>	1992	22	24	16	13	7	82
<i>S. Dusseldorf</i>	1992	1				1	2
<i>S. Durban</i>	1988			1			1
<i>S. Enteritidis</i>	1992	2	1	4	12	1	20
<i>S. Finkenwerden</i>	1984				1		1
<i>S. Fluntern</i>				1			1
<i>S. Fresno</i>	1978				4		4
<i>S. Giza</i>				1			1
<i>S. Hadar</i>	1991				1	1	2
<i>S. Havana</i>	1984				1		1
<i>S. Idikan</i>			1		1		2
<i>S. Indiana</i>	1982		1				1
<i>S. Infantis</i>	1992		3	6	1	1	11
<i>S. Ituri</i>						1	1
<i>S. Java</i>	1979		2		1	1	4
<i>S. Kingston</i>			1				1
<i>S. Korovi</i>			1				1
<i>S. Kottbus</i>	1981					1	1
<i>S. Koumra</i>			1				1
<i>S. Legon</i>						1	1
<i>S. Lexington</i>	1991		1				1
<i>S. Limete</i>				1			1
<i>S. Lindern</i>	1969				1		1
<i>S. Linguere</i>					1		1
<i>S. Livingstone</i>	1992	4	19	7	5	5	40
<i>S. Lomita</i>		1					1
<i>S. Mbandaka</i>	1992	1	1	3	1		6

Table 2 – continued

Serotype	Last isolation before 1993	1993	1994	1995	1996	1997	Total
S. Montevideo	1989		1	3		2	6
S. Mowanjum						1	1
S. Muenchen	1989			1	2		3
S. Muenster	1979				3		3
S. Nanga						1	1
S. New York				1			1
S. Newport	1988	1	1	2	6	6	16
S. Nima				1			1
S. Ohio	1992		1				1
S. Oranienburg	1990		1			3	4
S. Oslo	1982			2			2
S. Panama	1980					1	1
S. Plymouth					3		3
S. Poona	1987				2	1	3
S. Potengi						1	1
S. Ramatgan	1973				2		2
S. Reading	1968		1				1
S. Rissen	1992		2				2
S. Rubinslaw	1976		4				4
S. Ruiru	1972	1					1
S. San-diego	1988		1	4	1		6
S. Saintpaul	1989				1		1
S. Sao			1				1
S. Saphra				2			2
S. Schwabach						1	1
S. Schwarzengrund	1992			1			1
S. Sendai	1968					1	1
S. Senftenberg	1990		3	1			4
S. Shanghai	1981				1		1
S. Sheffield	1991					1	1
S. Stanley	1990				2		2
S. Tennessee	1992		1	1		1	3
S. Thompson	1987		1	1			2
S. Tshiongwe	1984			1			1
S. Typhimurium	1992	26	12	18	21	14	91
S. Welikade	1988					1	1
S. Widemarsh					2	1	3
S. Windermere	1986				1		1
S. Virginia				1	1		2
S. Species		2				1	3
S. Subspecies I	1992	4	5	3	4		16
S. Subspecies II	1992	12		2	11	4	29
S. Subspecies III	1992	2	2				4
S. Subspecies IIIa		8	10	6	6	5	35
S. Subspecies IIIb		1		7	15	11	34
S. Subspecies IV	1992	3	1	8	1	2	15
Total		94	108	123	146	84	555

I=enterica, II=salamae, III=arizone or diarizonae, IV=houtenae

Table 3. Phage typing of *Salmonella* Typhimurium strains isolated from animals 1993-97.**Lillengen system 1993-95**

Species/phage type	1	8	9	12	15	22	LNT	LNST	uk ¹	Total
Broilers								2		2
Cats			1					1		2
Cattle	2	1	2		1			1	1	8
Dogs			1			1		4	1	7
Horses	3							2	1	6
Layers			1		1		1	1		4
Lizards & snakes	1							1	1	3
Other domestic fowls ²	1							1		2
Swine	2									2
Wild birds	5	2	9	4						20
Total	14	3	14	4	2	1	1	13	4	56

Colindale system 1996-97

Species/phage type	1	2	12	40	41	85	104	120	129	170	195	196	LNT	LNST	u k1	Total
Cats				2												2
Cattle	2				1		3			2	2			1		11
Dogs						1		1					1			3
Horses			1													1
Other domestic fowls ²				1	2						1					4
Swine				2					1	1		1		1	1	7
Wild birds		2		5												7
Total	2	2	1	10	3	1	3	1	1	3	3	1	1	2	1	35

¹Unknown, ²duck, goose, turkey

The change of phage typing makes comparisons with previous results difficult.

Salmonella isolated from cattle

In cattle, 115 isolates representing 9 different serotypes were found (Tables 4-8). In Fig. 2 it is shown that the annual number of isolates from cattle has decreased during the last ten years. Seventy-eight isolates emanated from infected herds. The remaining isolates were collected at autopsies, sanitary slaughter and surveillance at slaughterhouses when *Salmonella* could not be re-isolated at follow-up sampling at the farms. The most commonly isolated serotype in cattle was *S. Dublin* (n=76), followed by *S. Typhi-*

murium (n=21), which is similar to findings presented in the previous reports. There were three *S. Typhimurium* DT 104 isolates phage typed in the Colindale system, one in 1996 and two in 1997 (Table 3). The isolate from 1996 could not be re-isolated in the herd of origin. Apart from this, there was one isolate of *S. Typhimurium* phage typed as LNT from 1995 that was retyped as DT 104. The strains were resistant to ampicillin, chloramphenicol, streptomycin, sulphonamides and tetracycline.

Salmonella isolated from swine

In swine, 18 isolates were reported representing 8 serotypes (Tables 4-8). The number of iso-

Table 4. *Salmonella* serotypes isolated from animals in Sweden in 1993.

	Broilers	Cattle	Cats	Dogs	Horses	Layers	Lizards & snakes	Swine	Turkey	Turtles	Wild birds	Total
<i>S. Agona</i>									1			1
<i>S. Anatum</i>								1				1
<i>S. Braenderup</i>			1									1
<i>S. Dublin</i>		22										22
<i>S. Dusseldorf</i>		1										1
<i>S. Enteritidis</i>							1	1				2
<i>S. Livingstone</i>						4						4
<i>S. Lomita</i>										1		1
<i>S. Mbandaka</i>						1						1
<i>S. Newport</i>							1					1
<i>S. Ruiru</i>							1					1
<i>S. Typhimurium</i>	1	2	2	3	3	2					13	26
<i>S. Species</i> ¹							1			1		2
<i>S. Subspecies I</i>						1	3					4
<i>S. Subspecies II</i>					1		6			5		12
<i>S. Subspecies III</i>							2					2
<i>S. Subspecies IIIa</i>							8					8
<i>S. Subspecies IIIb</i>							1					1
<i>S. Subspecies IV</i>							3					3
Total	1	25	3	3	4	8	27	2	1	7	13	94

¹Not typable

lates varied from 2 to 7 per year (Fig. 3). Eight of the isolates were from infected herds and the remaining were collected at sanitary slaughter or at the slaughterhouse surveillance, when *Salmonella* could not be re-isolated at follow-up sampling on the farm. The most common serotype was *S. Typhimurium* (n=9), followed by *S. Derby* and *S. Infantis* (n=2, respectively).

Salmonella isolated from fowl

Twenty-one isolates were from broilers and 56 from layers. An explanation for the higher number of isolates from layers may be that the *Salmonella* control programme was implemented in the broiler production earlier than in

the egg production. *Salmonella* Livingstone was the most commonly isolated serotype and seven of the isolates (33%) were from broilers and 31 (55%) from layers (Tables 4-8). During the last years, the annual number of isolates from layers, broilers and other domesticated fowls has decreased (Fig. 4). In 1994 there were 16 *S. Livingstone* isolates from layers and it was suspected that this was due to contamination of feed mills, which subsequently may have spread to poultry by the feed. Another more plausible explanation is that the industry led *Salmonella* control programme that was implemented among laying hens in 1991 became mandatory in 1994 and thereby increased the

Table 5. *Salmonella* serotypes isolated from animals in Sweden in 1994.

	Broilers	Cage birds	Cattle	Dogs	Layers	Lizards & snakes	Sheep	Various animals ¹	Wild birds	Zoo animals ²	Total
<i>S. Agona</i>	1				1						2
<i>S. Anatum</i>				1							1
<i>S. California</i>					1						1
<i>S. Dublin</i>			24								24
<i>S. Enteritidis</i>					1						1
<i>S. Idikan</i>					1						1
<i>S. Indiana</i>								1			1
<i>S. Infantis</i>		1			2						3
<i>S. Java</i>				1						1	2
<i>S. Kingston</i>	1										1
<i>S. Korovi</i>						1					1
<i>S. Koumra</i>				1							1
<i>S. Lexington</i>	1										1
<i>S. Livingstone</i>	2				16			1			19
<i>S. Mbandaka</i>					1						1
<i>S. Montevideo</i>				1							1
<i>S. Newport</i>										1	1
<i>S. Ohio</i>					1						1
<i>S. Oranienburg</i>						1					1
<i>S. Reading</i>										1	1
<i>S. Rissen</i>	1			1							2
<i>S. Rubinslaw</i>						4					4
<i>S. San-diego</i>			1								1
<i>S. Sao</i>	1										1
<i>S. Senftenberg</i>	1		2								3
<i>S. Tennessee</i>				1							1
<i>S. Thompson</i>										1	1
<i>S. Typhimurium</i>	1		4	1	2	1			3		12
<i>S. Subspecies I</i>	1	1	2		1						5
<i>S. Subspecies III</i>							1			1	2
<i>S. Subspecies IIIa</i>						9				1	10
<i>S. Subspecies IV</i>						1					1
Total	10	2	33	7	27	17	1	2	3	6	108

¹ 1 Mouse (Indiana), 1 polecat (Livingstone)² 4 Crocodiles (Java, Reading, Subsp III, Subsp IIIa), 2 marsupials (Newport, Thompson)

Table 6. *Salmonella* serotypes isolated from animals in Sweden in 1995.

	Broilers	Cattle	Dogs	Horses	Layers	Lizards & snakes	Other domestic fowls ¹	Swine	Turtles	Various animals ²	Wild birds	Zoo animals ³	Total
<i>S. Abony</i>									2				2
<i>S. Adelaide</i>						4							4
<i>S. Agona</i>							1						1
<i>S. Agoueve</i>						1							1
<i>S. Anatum</i>							2						2
<i>S. Bardo</i>						2							2
<i>S. Bovismorbificans</i>	1												1
<i>S. Burgas</i>									2				2
<i>S. Chester</i>						1							1
<i>S. Cubana</i>					1								1
<i>S. Dublin</i>		12								4			16
<i>S. Durban</i>						1							1
<i>S. Enteritidis</i>					1						2	1	4
<i>S. Fluntern</i>						1							1
<i>S. Giza</i>						1							1
<i>S. Infantis</i>	1				3			1	1				6
<i>S. Limete</i>												1	1
<i>S. Livingstone</i>	3			1	3								7
<i>S. Mbandaka</i>					2		1						3
<i>S. Montevideo</i>		1				2							3
<i>S. Muenchen</i>						1							1
<i>S. New York</i>			1										1
<i>S. Newport</i>												2	2
<i>S. Nima</i>										1			1
<i>S. Oslo</i>						2							2
<i>S. San-diego</i>		4											4
<i>S. Saphra</i>						2							2
<i>S. Schwarzengrund</i>						1							1
<i>S. Senftenberg</i>			1										1
<i>S. Tennessee</i>			1										1
<i>S. Thompson</i>									1				1
<i>S. Tshiongwe</i>												1	1
<i>S. Typhimurium</i>		4	1	3		2	1	2			5		18
<i>S. Virginia</i>						1							1
<i>S. Subspecies I</i>						1			1		1		3
<i>S. Subspecies II</i>									2				2
<i>S. Subspecies IIIa</i>						6							6
<i>S. Subspecies IIIb</i>						6						1	7
<i>S. Subspecies IV</i>						8							8
Total	5	21	4	4	10	43	5	3	9	5	8	6	123

¹ 1 Pheasant (*Agona*), 2 ostriches (*Anatum*), 1 turkey (*Mbandaka*), 1 goose (*Typhimurium*)² 1 Bear (*Nima*), 4 mink (*Dublin*)³ 1 Cayman (*Enteritidis*), 1 frog (*Limete*), 1 marsipual (*Typhimurium*), 1 monkey (*Subsp IIIb*)

Table 7. *Salmonella* serotypes isolated from animals in Sweden in 1996.

	Broilers	Cage bird	Cat	Cattle	Dogs	Horses	Layers	Lizards & snakes	Other domestic fowls ¹	Swine	Turtles	Various animals ²	Wild birds	Total
<i>S. Abony</i>											2			2
<i>S. Adamstua</i>											1			1
<i>S. Afula</i>											1			1
<i>S. Agona</i>									1					1
<i>S. Bardo</i>								2						2
<i>S. Bignona</i>											1			1
<i>S. Bissau</i>								1						1
<i>S. Bovismorbificans</i>								2						2
<i>S. Braenderup</i>											1			1
<i>S. Cubana</i>											2			2
<i>S. Derby</i>				1	1					2				4
<i>S. Dublin</i>				11		1						1		13
<i>S. Enteritidis</i>						1			5		5	1		12
<i>S. Finkenwerden</i>								1						1
<i>S. Fresno</i>								4						4
<i>S. Hadar</i>													1	1
<i>S. Havana</i>	1													1
<i>S. Idikan</i>									1					1
<i>S. Infantis</i>								1						1
<i>S. Java</i>										1				1
<i>S. Lindern</i>											1			1
<i>S. Linguere</i>								1						1
<i>S. Livingstone</i>	1						4							5
<i>S. Mbandaka</i>							1							1
<i>S. Muenchen</i>							1				1			2
<i>S. Muenster</i>									3					3
<i>S. Newport</i>	1							5						6
<i>S. Plymouth</i>											3			3
<i>S. Poona</i>							1				1			2
<i>S. Ramatgan</i>											2			2
<i>S. Sandiego</i>				1										1
<i>S. Saint-paul</i>											1			1
<i>S. Shanghai</i>											1			1
<i>S. Stanley</i>				2	2	1								2
<i>S. Typhimurium</i>			2	8	2	1			1	3			4	21
<i>S. Widermarsh</i>												2		2
<i>S. Windermere</i>								1						1
<i>S. Virginia</i>								1						1
<i>S. Subspecies I</i>				1			1	2						4
<i>S. Subspecies II</i>								4			7			11
<i>S. Subspecies IIIa</i>		5						1						6
<i>S. Subspecies IIIb</i>				1				14						15
<i>S. Subspecies IV</i>								1						1
Total	3	5	2	25	3	3	6	43	11	6	30	4	5	146

¹ 1 pheasant (*Agona*), 7 geese (4 *Enteritidis*, 3 *Muenster*), 2 ostrich (*Enteritidis*, *Idikan*), 1 duck (*Typhimurium*)² 3 hedgehogs (1 *Enteritidis*, 2 *Widermarsh*), 1 fox (*Dublin*)

Table 8. *Salmonella* serotypes isolated from animals in Sweden in 1997.

	Broilers	Cage birds	Cattle	Dogs	Horses	Layers	Lizards & snakes	Other domestic fowls ¹	Swine	Turtles	Zoo animals ²	Wild birds	Total
<i>S. Arechavaleta</i>							1						1
<i>S. Bassa</i>							1						1
<i>S. Bredeney</i>										1			1
<i>S. Chailey</i>										1			1
<i>S. Cubana</i>									1				1
<i>S. Dublin</i>			7										7
<i>S. Dusseldorf</i>					1								1
<i>S. Enteritidis</i>								1					1
<i>S. Hadar</i>	1												1
<i>S. Infantis</i>									1				1
<i>S. Ituri</i>							1						1
<i>S. Java</i>							1						1
<i>S. Kottbus</i>												1	1
<i>S. Legon</i>										1			1
<i>S. Livingstone</i>			1			4							5
<i>S. Montevideo</i>									1			1	2
<i>S. Mowanjum</i>							1						1
<i>S. Nanga</i>											1		1
<i>S. Newport</i>				1			5						6
<i>S. Oranienburg</i>							2					1	3
<i>S. Panama</i>							1						1
<i>S. Poona</i>							1						1
<i>S. Potengi</i>							1						1
<i>S. Schwabach</i>										1			1
<i>S. Sendai</i>							1						1
<i>S. Sheffield</i>										1			1
<i>S. Tennessee</i>	1												1
<i>S. Typhimurium</i>			3	1				3	4			3	14
<i>S. Welikade</i>				1									1
<i>S. Widemarsh</i>							1						1
<i>S. Species</i> ³										1			1
<i>S. Subspecies II</i>							3			1			4
<i>S. Subspeceies IIIa</i>		1					3			1			5
<i>S. Subspeceis IIIb</i>						1	10						11
<i>S. Subspeceis IV</i>							2						2
Total	2	1	11	3	1	5	35	4	7	8	1	6	84

¹ 1 Duck (*Enteritidis*), 3 geese (*Typhimurium*)² 1 Monkey³ Not typable

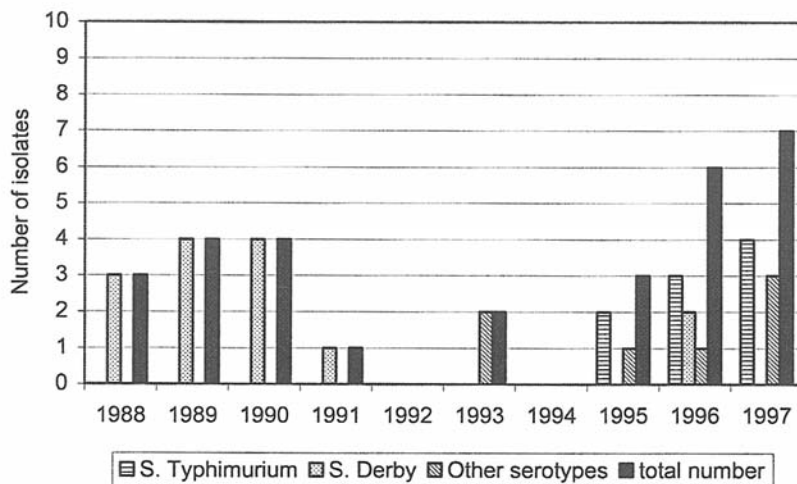


Figure 3. Recorded number of *Salmonella* isolates from swine during 1988-97.

chance of finding *Salmonella* through intensified sampling.

There were 19 *Salmonella* strains isolated from domestic fowl other than broilers and layers, such as geese (n=10), ostriches (n=4), turkeys (n=3) and ducks (n=2). Most isolates were *S. Enteritidis* (n=6) and *S. Typhimurium* (n=4; Tables 4-8). Furthermore, 35 isolates were from wild birds, of which the majority were *S. Ty-*

phimurium (n=28; Tables 4-8). The most common phage type in small passerine birds in the Colindale system was DT 40 (n=5; Table 3).

Salmonella in companion animals

In dogs, there were 20 isolates of which *S. Typhimurium* was the most commonly isolated serotype (n=8; Tables 4-8). There were 13 serotypes recorded in total. From cats there

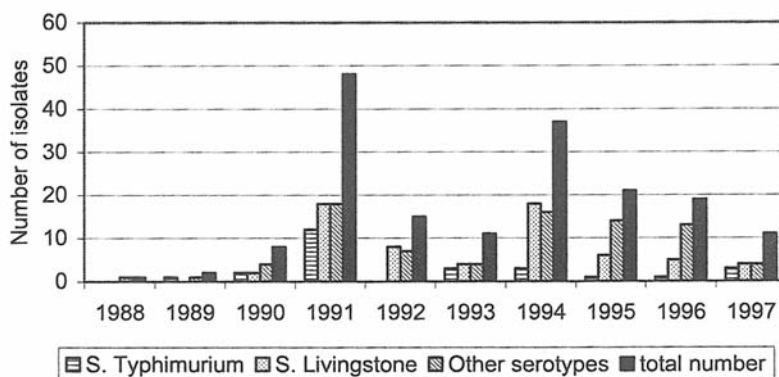


Figure 4. Recorded number of *Salmonella* isolates from layers, broilers and other domesticated fowl during 1988-97.

were one *S. Braenderup* and 4 *S. Typhimurium* isolates. Furthermore, 8 isolates were obtained from cage birds, and 4 of these came from the same zoological garden and were of *S. Subspecies IIIa*.

Salmonella in zoo, wild and farmed animals

Thirteen isolates were found in 6 species of zoo animals (Tables 4-8). Of those were 4 isolates from crocodiles and marsupials, respectively. Apart from this, there were 11 isolates from various other animal species, possibly farmed as well as wild.

Salmonella in reptiles

Out of the 555 isolates from animals, 165 (30%) were from snakes and lizards (Tables 4-8). The number of isolates from these 2 species showed a great increase compared with results from 1988-92 (n=47). The majority of isolates were *S. Subspecies III* (n=60), *IV* (n=15) and *II* (n=13). From turtles, there were 54 isolates, compared with 14 in 1988-92. Fifteen of the 54 isolates were *S. Subspecies II*. The increase in number of isolates from reptiles was probably the result of an increased sampling due to increased import when the Swedish import regulations were harmonised with the EU regulations in 1996.

Salmonella in feed production

The monitoring of commercial feed production follows the principles of HACCP based on identified risk factors (*Simonsen et al.* 1987). The system was initiated in 1991 and has been in operation for more than 12 years. A thorough monitoring of the production line has proved to be an effective means to prevent *Salmonella* contamination of feed for food producing animals. The samples investigated were from critical control points in the production line mostly consisting of dust samples and scrapings.

A minimum of five samples was taken each

week at feed mills producing poultry feed. Other mills producing feed for animal production collected samples from 2 critical control points. The total number of *Salmonella* findings from the critical control points was 464 (Table 9). The dominating serotypes were *S. Livingstone* (n=62), *S. Senftenberg* (n=37), *S. Cubana* (n=35) and *S. Mbandaka* (n=30). More prevalent serotypes in animal production such as *S. Typhimurium*, *S. Enteritidis* or *S. Dublin* were rarely detected in the feed production. However, *S. Livingstone* was frequently isolated from layers in 1994 and was found to be the most common serotype in feed production. Not previously reported serotypes from feed production was detected during the time period. A number of subtyping investigations were carried out using PFGE (pulse-field gel electrophoresis) to study the possible transmission of *Salmonella* from feedstuffs to animals.

Only *Salmonella* negative raw materials may be used in feed production, hence contaminated raw materials must undergo decontamination before use in the production of animal feed. In raw materials of vegetable origin 194 *Salmonella* isolates were recorded. The most frequently occurring serotypes were *S. Senftenberg* (n=23), *S. Mbandaka* (n=20), *S. Agona*, *S. Anatum*, *S. Cubana* (each n=15) and *S. Subspecies I* (n=21). The most frequently imported feed raw materials in which *Salmonella* was isolated were soybean meal, maize and rapeseed products. The most common serotype in raw materials of animal origin was *S. Senftenberg* (n=6) with a total of 28 positive samples. Few findings were made in finished feed including pet food (n=12).

During 1993-97, the total number of positive samples from the feed sector was 749, which was similar to the previous 5-year period. In the current period the greater part of isolates were from critical control points in the feed production, whereas in the last report over half of the

Table 9. *Salmonella* isolated from feedingstuffs and feed processing plants in Sweden 1993-97.

Serotypes	Raw materials		Raw materials, unspecified	Compound feed	Dust and scrapings from feed mills	Pet chews	Un-specified
	Vegetable origin	Animal origin					
<i>S. Aarhus</i>							1
<i>S. Aberdeen</i>					1		
<i>S. Abony</i>					1		1
<i>S. Agona</i>	15		1	2	29		8
<i>S. Alachua</i>					7		
<i>S. Albany</i>	1				1		
<i>S. Altona</i>					1		
<i>S. Amsterdam</i>	3		1		5		1
<i>S. Anatum</i>	15		1		14		13
<i>S. Babelsberg</i>					1		
<i>S. Barteilly</i>					1		
<i>S. Be</i>	1						
<i>S. Bere</i>	4				4		1
<i>S. Bergen</i>					2		
<i>S. Bonariensis</i>	1						
<i>S. Brandenburg</i>					4	1	1
<i>S. Bredeney</i>	1		1	1	3		1
<i>S. California</i>	2				1		1
<i>S. Cerro</i>	1	1			2		1
<i>S. Chester</i>							1
<i>S. Chincol</i>					1		
<i>S. Colorado</i>					1		
<i>S. Corvallis</i>					1		
<i>S. Cubana</i>	15		1		35		22
<i>S. Derby</i>	2		3		3		4
<i>S. Dublin</i>				1	2		1
<i>S. Dusseldorf</i>					5		1
<i>S. Ealing</i>							1
<i>S. Emek</i>	2		1		3		2
<i>S. Enteritidis</i>					4	1	1
<i>S. Florida</i>					1		
<i>S. Freemantle (S.II)</i>					1		
<i>S. Freetown</i>	1				1		
<i>S. Gatuni</i>					1		
<i>S. Give</i>					1		
<i>S. Gloucester</i>	1						
<i>S. Hadar</i>					3		
<i>S. Havana</i>	8		4		13	1	7
<i>S. Heidelberg</i>		1			1		2
<i>S. Hofit</i>							1
<i>S. Idikan</i>							1
<i>S. Infantis</i>	1	1		3	8		
<i>S. Irachau</i>					1		
<i>S. Irumu</i>							1
<i>S. Isangi</i>		1			2		1
<i>S. Java</i>					1		
<i>S. Jerusalem</i>		1			1		1
<i>S. Kainji</i>							1
<i>S. Kapemba</i>					1		
<i>S. Kentucky</i>	4		2		4		1
<i>S. Kibi</i>					1		
<i>S. Kingston</i>	3				3		

Table 9 – continued

Serotypes	Raw materials		Raw materials, unspecified	Compound feed	Dust and scrapings from feed mills	Pet chews	Un- specified
	Vegetable origin	Animal origin					
<i>S. Kinondoni</i>			1				
<i>S. Konstanz</i>							1
<i>S. Kortrijk</i>					1		
<i>S. Lamberhurs</i>	1						
<i>S. Leno</i>					1		
<i>S. Lexington</i>	6				8		1
<i>S. Liverpool</i>		3			3		1
<i>S. Livingstone</i>	7	4	3		62		18
<i>S. Llandoff</i>	1				6		1
<i>S. London</i>		2					
<i>S. Madelia</i>	1						
<i>S. Mandoff</i>					1		
<i>S. Mbandaka</i>	20		7		30		16
<i>S. Meleagridis</i>	1			1	2		3
<i>S. Montevideo</i>	2	5	3		12		8
<i>S. Muenchen</i>					1		
<i>S. Muenster</i>					1		2
<i>S. Newport</i>					2		
<i>S. Norwich</i>					1		
<i>S. Ohio</i>	3				11		3
<i>S. Ohlstedt</i>	1						
<i>S. Oranienburg</i>			1		3		
<i>S. Orion</i>					3		1
<i>S. Oslo</i>					1		
<i>S. Othmarschen</i>							1
<i>S. Ouakam</i>					4		1
<i>S. Pakistan</i>							1
<i>S. Poona</i>					3		3
<i>S. Rideau</i>							1
<i>S. Rissen</i>	3				1		
<i>S. Ruiru</i>	2				1		2
<i>S. Saint Paul</i>					1		
<i>S. Saloniki</i>					1		
<i>S. Sambre</i>					1		1
<i>S. San Diego</i>							1
<i>S. Schleissheim</i>					1		1
<i>S. Schoeneberg</i>					1		
<i>S. Schwarzengrund</i>					1		
<i>S. Seegefeld</i>	1						
<i>S. Senftenberg</i>	23	6	1		37		20
<i>S. Slade</i>	1						
<i>S. Taksony</i>							1
<i>S. Tees</i>					1		
<i>S. Tennessee</i>	14	2	2	2	15		6
<i>S. Typhimurium</i>			1		21		9
<i>S. Vejle</i>					1		
<i>S. Virchow</i>					1		
<i>S. Warragul</i>					1		
<i>S. Weltevreden</i>					1		
<i>S. Westhampton</i>					1		
<i>S. Westphalia</i>					1		
<i>S. Worthington</i>					6		4
<i>S. Subspecies</i>	5			2	8		6
<i>S. Subspecies I</i>	21	1	14		30		17
<i>S. Subspecies II</i>							2
<i>S. Subspecies IIIa</i>							1
Total	194	28	48	12	464	3	211

isolates emanated from raw materials of animal origin. There were considerably more findings in raw materials of vegetable origin in the present period compared to the one previous, which clearly indicates that feed raw materials are important carriers of *Salmonella* infection. It seems reasonable to assume that the surveillance programme with sampling according to HACCP principles has largely been successful in finding *Salmonella* before it reaches the finished feed product.

Conclusion

From the data presented in this study, it can be concluded that *Salmonella* in animals and in the feed production remained favourable in Sweden during 1993-97. It may be suggested that this was due to the *Salmonella* control programme in food producing animals and the testing in the feed production according to the HACCP principles. The final aim is to keep the whole chain of food production free from *Salmonella* contamination.

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Sammanfattning

Salmonella isolerad från djur och foder i Sverige under perioden 1993-1997.

Denna studie ingår i en serie som presenterar *Salmonella*-isolat från djur och foder i Sverige, med början 1949. Under perioden 1993 till 1997 rapporterades 555 isolat från djur. Under perioden 1988-92 isolerades 598 isolat från djur. Jämförelser av resultat mellan de olika studierna måste göras med försiktighet eftersom provtagning och övervakning kan ha varierat mellan de olika studieperioderna. Antalet isolat från nötkreatur var 115, medan 21 var från slaktkycklingar, 56 från värphöns, och 18 från svin. För första gången härrörde majoriteten av isolat från annat djurslag (165 isolat från reptiler) än nötkreatur. I

den aktuella studien registrerades 87 olika *Salmonella*-serotyper, vilket är det största antalet som har rapporterats i serien. Trettio av dessa serotyper isolerades från djur i Sverige för första gången. Majoriteten av isolat visade sig tillhöra *S. Typhimurium* (n=91), följt av *S. Dublin* (n=82). Antalet isolat från foder (n=749) skilde sig inte väsentligt från den föregående rapporteringsperioden. Majoriteten av de positiva proverna härrörde från prover som insamlades enligt HACCP principer i kontrollprogrammet för foder. Det kan sammanfattas att *Salmonella*-situationen i Sverige var god under den aktuella studieperioden och tyder på att kontrollprogrammet fungerar tillfredsställande i strävan att hålla hela livsmedelskedjan från jord till bord fri från kontamination.

(Received June 5, 2003; accepted September 23, 2003).

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