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Salmonella Isolated from Animals and Feedstuffs in Sweden during 1983-1987

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Eld, K., A. Gunnarsson, T. Holmberg, B. Hurvell and M. Wierup: Salmonella isolated from animals and feedstuffs in Sweden during 1983-1987. Acta vet. scand. 1991, 32, 261-277. – This survey describes the frequency of Salmonella in animals and feedstuffs isolated in Sweden 1983-1987. Since 1949 National Veterinary Institute (NVI) has published such reports every fifth year. During the period of this report 760 outbreaks of Salmonella were reported in animals. This includes both domestic and wild animals. The corresponding figure for the previous period was 1266 outbreaks. 56 different serovariants were reported, 17 of these were new to Sweden. In cattle and swine there were a decrease of outbreaks. In poultry 86 outbreaks were reported, compared with 220 outbreaks during the previous five-year periode.

Swedish feed producing plants are checked both voluntary and compulsory, for the presence of Salmonella in raw materials, scrape and dust samples and compound feed. During 1983-1987 a total of 236 strains at Salmonella were isolated. This is the lowest incidence found during the last 15 years.

All consignments of feedstuffs of animal origin intended for import to Sweden has to be examined for the presence of Salmonella. During 1983-1987 8.6% of the consignments were positive for Salmonella and were thus not allowed to be used in Sweden.

domestic animals; wild animals.

Introduction

The present paper contains a survey of the incidence of Salmonella isolated from animals and feedstuffs in Sweden during 1983-1987. It continues a series of periodic reports since 1949 published from the National Veterinary Institute (NVI) (*Thal et al.* 1957, *Rutqvist & Thal* 1958, *Karlsson et al.* 1963, *Hurvell et al.* 1969, *Gunnarsson et al.* 1974, *Sandstedt et al.* 1980, *Mårtensson et al.* 1984).

These reports make it possible to follow the Salmonella situation in the country and has been an important base for the control of Salmonella.

Material and methods

As a consequence of the national regulations samples for Salmonella examination have to be taken when suspected clinical cases are observed. In addition samples are taken as a consequence of special control programs for Salmonella. These have been presented by *Wierup et al.* (1989).

Since 1961 all Salmonella strains from animals, feedstuffs, and environment have to be sent to the NVI for verification, typing and registration. Strains with doubtful serological properties are sent to the National Bacteriological Laboratory, SBL, Stockholm, for final identification. SBL also ma-

kes the phage typing of the *S. typhimurium* strains according to *Lilleengen* (1948). Biochemical indentification and serotyping of different strains were made according, to *Kauffmann* (1972) and to the *WHO Collaborating Centre for Reference and Research on Salmonella, Institut Pasteur, Paris, 4 ème Revision* (1984). The isolations have to be reported to the National Board of Agriculture, to the County Veterinary Organisation, and to the State Epizootiologist.

The National Board's division for Contagious Animal Diseases keeps the records which yielded the basic data for this report. We have used the terms »outbreak« and »case« of Salmonella to denote isolation of Salmonella without regard to clinical or pathological findings. Several isolations of the same Salmonella type in the same herd of animals are referred to as one »outbreak« or one »case«. This report accounts for the Salmonella isolations made during 1983-1987.

Results and discussion

Salmonella isolated from all animal species

During 1983-1987, 760 outbreaks of Salmonella have been recorded (Table 1). This figure includes both domestic and wild animals. For previous periods the corresponding figures were 1266 (1978-1982), 1106 (1973-1977), 1746 (1968-1972). One factor affecting the number of isolations is a considerable variation from one period to another in the number of Salmonella cases in wild animals, which, in turn, mainly reflects the number of animals sent by the public for necopsy and bacteriological examination.

Table 1. Distribution of the outbreaks of salmonella in animals among different subspecies 1983-1987.

Subspecies	Number of outbreak
I	720
II	6
II	13
IV	3
Salmonella strains, untypable or not typed	18
Total	760

The 760 outbreaks comprised 720 (94%) serovariants of subspecies I, 6 of subspecies II, 13 of subspecies III, and 3 of subspecies IV (Table 1). A further 18 strains were not typable, the reason mostly being a lack of H-phase or R-dissociation. There were 56 different serovariants reported (Table 2). Of these 17 are new for Sweden (Table 3). One of them, *Salmonella goldcoast,* was isolated from chicken. The other 16 new serovariants were isolated from reptiles (snakes, lizards and tortoise). Table 4 present the most common isolated serotypes.

Salmonella isolated from cattle

During 1983-1987 474 outbreaks of salmonella in cattle were reported (Fig. 1). Of those, 429 (90,5%) were caused by *Salmonella dublin,* 26 (5,5%) by *S. typhimurium,* and 10 (2%) by 6 different serovariants. The remaining 9 (2%) were untypable due to lack of H-phase or R-dissociation (Table 5-9).

In cattle the number of outbreaks decreased by 31%, from 687 during 1978-1982 to 474 during 1983-1987. In 1972 total number of Salmonella isolations in cattle was over 200. During 1973-1977 the annual number of cases decreased to a maximum of 141 cases in 1973 and a minimum of 82 in 1976. During 1978-1982 the annual number of cases varied between 109 and 157. During 1983-1987 the number of Salmonella outbreaks continued to decrease, being as low as 59 in 1986 and 67 in 1987. One has to go as far back as to 1969-1970 to find such low yearly figures for Sal-

Table 2. Annual isolations of Salmonella serotypes from animals during 1983-1987.

Serotype	Last isolation before 1983	1983	1984	1985	1986	1987	Total
S. agona	1982	6	2	2	1	–	11
S. anatum	1982	3	1	–	4	–	8
*S. arizona III**	1982	2	1	1	4	–	8
S. bilthoven II	1982		1				1
S. bousso		–	–	–	1	–	1
S. braenderup	1980	–	–	–	–	1	1
S. california	1979	4	1	–	–	–	5
S. carrau	1974				1	1	2
S. christiansberg		1	–	–	–	–	1
S. cubana	1981	1					1
S. daressalaam II				1			1
S. derby	1978	1	3	2	2	2	10
S. dublin	1982	124	110	82	58	58	432
S. dusseldorf	1980	–	–	4	–	–	4
S. enteritidis	1981	1	–	–	1	1	3
S. finkenwerder		–	1	–	–	–	1
S. gallinarum-pullorum	1976	–	1	–	–	–	1
S. georgia		–	1	–	–	–	1
S. goldcoast		1	2	–	–	–	3
S. havana	1982	2	1	–	–	–	3
S. heidelberg	1973	–	–	–	–	1	1
S. houten IV	1973	–	1	–	–	–	1
S. infantis	1982	3	8	11	3	–	25
S. kentucky	1982	1	1	–	–	–	2
S. kralendyk IV		–	–	1	–	–	1
S. lexington	1973	1	–	–	–	–	1
S. litchfield	1977	–	1	–	2	1	4
S. livingstone	1982	1	1	–	1	4	7
S. london	1982	–	–	–	–	1	1
S. marina IV		–	–	–	1	–	1
S. mbandaka	1982	4	–	–	–	–	4
S. mikawasima	1972	–	–	–	–	1	1
S. montevideo	1980	–	–	1	1	–	2
S. newington	1982	3	2	–	–	–	5
S. newport	1982	–	–	–	2	–	2
S. paratyphi variant java	1979	1	–	–	–	–	1
S. pomona	1981	–	–	–	–	2	2
S. poona	1978		–	–	–	1	1
S. romanby		–	–	–	1	–	1
S. saint paul	1980	–	–	–	1	–	1
S. senftenberg	1980	3	1	1	–	2	7
S. singapore	1975	1	1	–	–	–	2
S. somone		–	–	–	1	–	1
S. stanley	1981	–	1	–	–	–	1
S. sunnycove	–	–	–	–	1	1	2
S. takoradi		–	1	–	–	–	1
S. tennessee	1981	–	–	–	1	1	2
S. thompson	1978	–	–	–	–	1	1
S. toucra		–	–	–	1	–	1
S. tschiongwe		–	1	–	–	–	1
S. typhimurium	1982	27	46	14	30	17	134
S. verity II		–	1	–	–	–	1
S. virchov	1979	–	1	–	–	–	1
S. welikade		–	–	–	–	6	6
S. windumere		–	–	–	1	–	1
CO-group I	–	–	–	–	1	–	1
DO-group I		–		4	–	1	5
Subspecies I		1	–	–	–	–	1
Subspecies II		–	1	–	2	–	3
Subspecies III		–	–	–	4	1	5
Untypable		2	5	3	3	5	18
		195	199	128	129	109	760

* II = subspecies II
III = subspecies III
IV = subspecies IV

Table 3. Salmonella serotypes isolated 1983-1987 but not isolated from animals in Sweden before 1983.

Serotype	Year of isolation	Animal species
S. bousso	1986	snake
S. christiansborg	1983	lizard
S. daressalaam	1985	lizard
S. finkenwerder	1984	tortoise
S. georgia	1984	chameleon
S. goldcoast	1983	chicken
S. kralendyk	1985	snake
S. marina	1986	lizard
S. romanby	1986	lizard
S. somone	1986	snake
S. sunnycove	1986	snake
S. takoradi	1984	lizard
S. toucra	1986	snake
S. tschiongwe	1984	tortoise
S. verity	1984	tortoise
S. welikade	1987	snake and lizard
S. windumere	1986	snake

monella outbreaks in cattle. This fact is due to a decrease in both *S. dublin* and *S. typhimurium*.

Salmonella typhimurium has been found to have decreased considerably. Since the 1950s yearly outbreaks have occurred in cattle. In these statistics 1983 is the first year where no outbreak of *Salmonella typhimurium* was recorded. In 1984-1987 the number of outbreak has been from 2 to 12 and from 17 to 70 for the preceding 5 years' period. The regional incidence of *S. typhimurium* is evenly distributed over the cattle stock in the country.

Outbreaks of *S. dublin* have since long been localized mainly to south-eastern Sweden. Roughly 70% occurred in Östergötland and Kalmar counties.

Salmonella isolated from swine

During 1983-1987, 28 outbreaks of Salmonella in swine were registered (Fig. 2). The corresponding figure for 1978-1982 was 37. *S. cholera suis* has not been reported since 1979. *S. typhimurium* caused 39% of the outbreaks in 1983-1987. The corresponding figure for 1978-1982 was 51%. During 1985-

Table 4. Most common Salmonella serotypes isolated from animals during 1983-1987.

Serotype	Domestic mammals	Domestic birds	Wild animals	Others (reptiles, zooanimals and aquariumfish)	Total
S. dublin	432				432
S. typhimurium	53	27	48	6	134
S. infantis	3	22			25
S. agona	7	4			11
S. derby	10				10
S. anatum	4	4			8
S. arizona	1	2		5	8
S. senftenberg	3	2		1	6
s. welikade				6	6
S. livingstone	3	2			5
S. newington	1	4			5
S. california		5			5

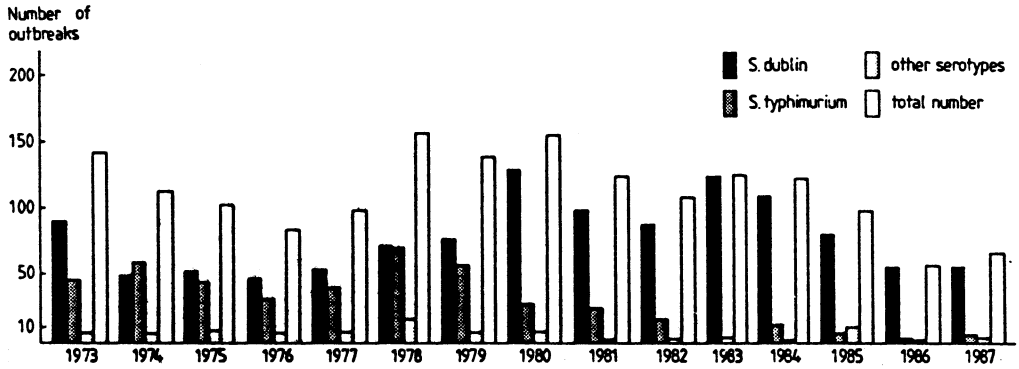

Figure 1. Recorded outbreaks of Salmonella in cattle 1973-1987.

Table 5. Salmonella isolated from various animal species during 1983.

Serotype	Cattle	Swine	Horses	Dogs	Cats	Hens & chickens	Ducks	Turkeys	Cage birds	Lizards & snakes	Hegdehogs	Wild birds	Total
S. agona			1	2		3							6
S. anatum		1				2							3
S. arizona										2			2
S. californiа						4							4
S. christiansberg										1			1
S. cubana						1							1
S. derby		1											1
S. dublin	124												124
S. enteritidis											1		1
S. goldcoast						1							1
S. havana						2							2
S. infantis	1					2							3
S. kentucky						1							1
S. lexington				1									1
S. livingstone						1							1
S. mbandaka						3		1					4
S. muenchen										1			1
S. newington			1			2							3
S. paratyphi variant java										1			1
S. senftenberg				1		2							3
S. singapore				1									1
S. typhimurium		9	1	1	1	1	1		2			11	27
subspec I 013, 23						1							1
Untypable	2												2
	127	12	2	6	1	26	1	1	2	5	1	11	195

Table 6. Salmonella isolated from various animal species during 1984.

Serotype	Cattle	Swine	Horses	Dogs	Cats	Hens & chickens	Turkeys	Carrier pigeons	Snakes & lizards	Tortoise & turtles	Foxes	Wild birds	Total
S. agona		1	1										2
S. anatum		1											1
S. arizona									1				1
S. bilthoven										1			1
S. california						1							1
S. derby		2		1									3
S. dublin	110												110
S. finkenwerden										1			1
S. gallinarum-pullorum						1							1
S. georgia									1				1
S. goldcoast						2							2
S. havana						1							1
S. houten									1				1
S. infantis						8							8
S. kentucky						1							1
S. litchfield										1			1
S. livingstone						1							1
S. muenchen									1				1
S. newington						2							2
S. senftenberg	1												1
S. singapore				1									1
S. stanley				1									1
S. takoradi									1				1
S. tschiongre										1			1
S. typhimurium	12	2		1	2	1	1	1			1	25	46
S. verity										1			1
S. virchow						1							1
Subspecies II									1				1
Untypable						5							5
	123	6	1	4	2	24	1	1	6	5	1	25	199

Table 7. Salmonella isolated from various animal species during 1985.

Serotype	Cattle	Swine	Horses	Dogs	Cats	Hens & chickens	Cage birds	Snakes & lizards	Penguins	Wild birds	Total
S. agona	1					1					2
S. arizona								1			1
S. daressalaam								1			1
S. derby		1			1						2
S. dublin	81	1									82
S. düsseldorf	4										4
S. infantis	2					9					11
S. kralendyk								1			1
S. montevideo				1							1
S. muenchen						1					1
S. senftenberg						1					1
S. typhimurium	6		1		1		1		1	4	14
DO-group	4										4
Untypable						2		1			3
	98	2	1	1	2	14	1	4	1	4	128

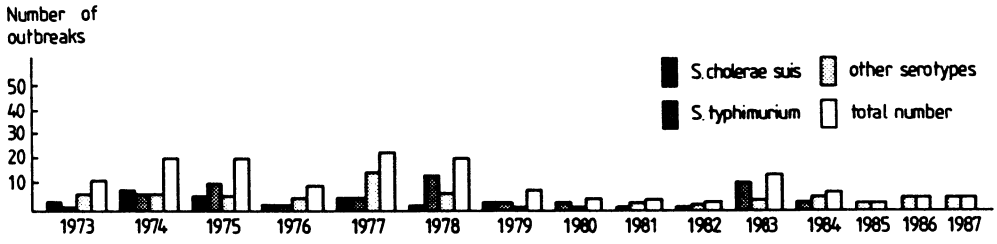

Figure 2. Recorded outbreaks of Salmonella in swine 1973-1987.

Table 8. Salmonella isolated from various animal species during 1986.

Serotype	Cattle	Swine	Horses	Dogs	Cats	Hens & chickens	Geese	Cage birds	Minks	Foxes	Tortoise & turtles	Snakes & lizards	Mice	Penguin	Loris	Wild birds	Total
S. agona				1													1
S. anatum				2		2											4
S. arizona								2				1	1				4
S. bousso												1					1
S. carrau												1					1
S. derby		2															2
S. dublin	56									2							58
S. enteritidis	1																1
S. infantis																	3
S. litchfield											2						2
S. livingstone		1															1
S. marina												1					1
S. montevideo												1					1
S. newport												2					2
S. romanby												1					1
S. saint paul		1															1
S. somone												1					1
S. sunnycove												1					1
S. tennessee							1										1
S. toucra												1					1
S. typhimurium	2		4		1	8	1	4	1	1		1		1	1	5	30
S. windumere												1					1
CO-group												1					1
Subspecies II												2					2
Subspecies III												4					4
Untypable												3					3
	59	4	4	3	1	13	2	6	1	3	2	23	1	1	1	5	129

1987 no outbreak of *S. typhimurium* occurred in pigs. For the time being Salmonella in pigs is no big problem in this country. However two large fattening herds have been chronic infected by *S. derby* for about 10 years.

Salmonella isolated from poultry

During 1978-1982 there were 220 outbreaks of Salmonella (Fig. 3). Of those 190 (87%) were reported from the domestic fowl. After the high number of outbreaks in 1981-1982 the incidence has decreased. Only 4 outbreaks were recorded during 1987. Compared with the years before this is an extremely low figure. During the last 5 years 86 outbreaks were reported. Of these cases, 81 (94%) were isolated from the domestic fowl, 1 from turkeys, 2 from geese and 1 from ducks. In all, 17 different serovariants were isolated. The most common serovariants were *S. infantis,* 22 cases (26%) and *S. typhimurium,* 12 cases (14%). There were 9 untypable strains lacking in H-phase or having R-dissociation (Tables 4-9).

During the 1960s and 1970s there occurred

Table 9. Salmonella isolated from various animal species during 1987.

Serotype	Cattle	Swine	Dogs	Hens & chickens	Cage birds	Snakes & lizards	Tortoise & turtles	Aquariumfish	Monkeys	Loris	Pigeons	Wild birds	Total
S. braenderup						1							1
S. carrau						1							1
S. derby		2											2
S. dublin	58												58
S. enteritidis										1			1
S. heidelberg							1						1
S. litchfield							1						1
S. livingstone		2		2									4
S. london			1										1
S. mikawasima							1						1
S. pomona							2						2
S. poona							1						1
S. senftenberg			1				1						2
S. sunnycove												1	1
S. tennessee												1	1
S. thompson							1						1
S. typhimurium	6		1		6			1	1		1	1	17
S. welikade						6							6
DO-gruppen	1												1
Subspecies III							1						1
Untypable	2			2		1							5
	67	4	3	4	6	9	9	1	1	1	1	3	109

food poisonings caused by Salmonella contaminated broilers. Grilled chicken that has not been sufficiently cooked has caused several food poisonings. A further common cause for Salmonella infection in humans is using the same cutting-board, knife, etc for the cooked chicken as for the raw one. Food poisoning caused by Salmonella contaminated chicken is rare today.

Salmonella does not occur in breeder flocks in Sweden. Compared to many other countries Sweden is unique in this respect. The few breeder flocks where Salmonella has been prevalent have been stamped out. Besides, infected birds have been rejected already when in quarantine, thanks to a rigorous import control.

A continous Salmonella control of feed is carried out in agreement with the producer. There has also been an improvement in feed handling, which has contributed to reducing the number of outbreaks caused by Salmonella contaminated feed.

Salmonella isolated from wild animals

The number of Salmonella cases in wild ani-

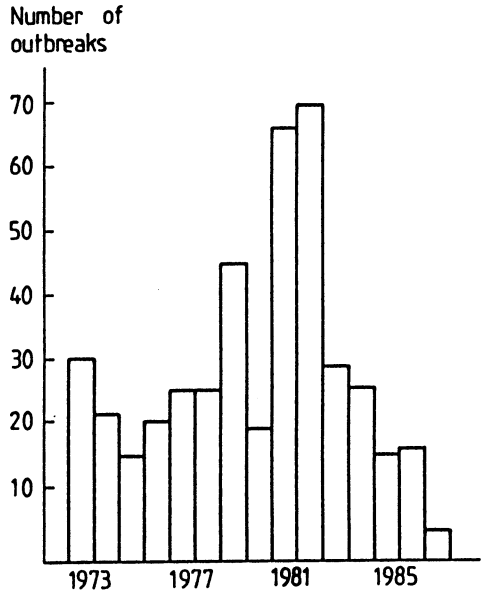

Figure 3. Recorded outbreaks of Salmonella in poultry 1973-1987.

mals depends mainly on the number of animals delivered for necropsy and bacteriological examination by the public. During the last 5 years period 50 outbreaks of Salmonella were recorded. Compared with the previous 5 year, when 190 cases were reported, this is a conspicuous decrease. Except for a hedgehog with *s. enteritidis* and a fox with *S. typhimurium* the Salmonella isolations were all from birds. The most commonly affected birds are bullfinches, 26 (52%), with *s. typhimurium* phage type 1 and 9. *S. typhimurium* of the same phage-types also occurs among other small birds (Table 10). In the late winter of 1984 there was a peak of 19 cases of *S. typhimurium* in small birds registered, mostly in bullfinches. Most of the cases of Salmonella infections in wild birds occur during the late winter, in February and March (*Hurvell et al.* 1969). Birdfeeders are a common source of infection allowing the spread of Salmonella between birds and to people handling the feeders.

From pigeons *S. typhimurium* phage type 6b was isolated twice, and *S. typhimurium* phage type 8 three times (Table 10).

Salmonella isolated from pet animals

Since 1969 import into Sweden of reptiles has not been licensed because of the frequent incidence of Salmonella in these animals. Exception has been made only for reptiles intended for in vivaries or zoological gardens exhibition. Requests for a more liberal policy for import of reptiles to be kept as pets have been made by herpetological associations.

Therefore a tentative limited import was made during July through December 1987. During this period imported reptiles were checked for Salmonella at the customs. Samples were sent to the NVI for bacteriological examination. Owing to frequent findings of Salmonella, however, the import was discontinued, the animals being considered extremely unsuitable as pets for children. The results of those examinations are not included in this study.

During 1978-1982, 23 outbreaks (1.8% of the total number of outbreaks) of Salmonella in reptiles were reported. During 1983-1987 the corresponding figure was 63 (8.3%). This is a considerable increase in the number of cases.

Recorded Salmonella cases in humans contracted from reptiles are few before July 1987. During the following 10 months some 20 cases of Salmonella were reported most of which were in children. During the last 5 years period we have registered 23 Salmonella cases in dogs and cats. In some of these cases owner family members were infected by the same serovariant.

Table 10. Phage typing of *Salmonella typhimurium* strains isolated from animals during 1983-1987.

	1	2	3	4	6a	6b	8	9	12	15	16	23	NST	NT	Not typed	Total
Cattle	5	3	1			1	7	1		9		1	4	3		35
Swine													2			2
Horses	1	2						1			1			1		6
Dogs	2								1							3
Cats	1		1					3								5
Hens & chickens			1								1		1	4	3	10
Ducks			1													1
Turkeys													1			1
Geese		1														1
Carrier pigeons				1									1			2
Wild pigeons						2	3									5
Cage birds													6	6	2	14
Minks		1														1
Snakes & lizards	1															1
Pengvins														1	1	2
Loris															1	1
Monkeys	1															1
Aquariumfish												1				1
Foxes		1												1		2
Wild birds	16		1					18						4	2	41
Total	27	8	5	1		3	10	23	1	8	2	2	15	20	9	135

Salmonella isolated from feedstuffs

The results of the Salmonella screening of feedstuffs of animal origin intended for import into Sweden during 1983-1987 are given in Table 11. The import control is supervised by the National Board of Agriculture. From each batch, samples are taken for bacteriological examination at the NVI, and if Salmonella is found importation of the feedstuff into the country is not allowed. This Salmonella control has played an important part over the years in reducing the incidence of Salmonella in raw materials of animal origin used by the Swedish feed industry. From Table 11 it can be seen that a variety of Salmonella serovariants may be present in meat meal, bone meal, and feather meal of different origin.

The number of batches examined during 1983-1987 was higher than during the proceeding ten years (*Sandstedt et al.* 1980, *Mårtensson et al.* 1984). This increase is mainly due to the ban in 1985 on domestic production of meat- and bonemeal from animals dead by themselves. Even if the raw materials seen in Table 11 that contain Salmonella (8.6% of the consignments), were not allowed to come into Sweden, the extended import of meat meal and bone meal still implies a potential risk for introducing Salmonella organisms into Swedish feedprocessing plants for compound feed.

The domestic meat meal, however, is not free from Salmonella contamination as can be seen from Table 12. The number of meat meal processing plants has decreased, and remaining plants are modernized to reach a better hygienic standard. Despite this fact Salmonella is found occasionally every year in most of the plants, and, as has been mentioned in earlier reports (*Sandstedt et al.* 1980, *Mårtensson et al.* 1984), some plants have stationary variants of Salmonella that are very difficult to eradicate.

Table 11. Salmonella isolated during 1983-1987 in connection with bacteriological import control of feed stuffs of animal origin.

Feed stuff	Country of origin	No of consignements investigated	No of samples examined	No of consigne-ments with Salmonella	No of samples Salmonella	Salmonella type
Meat meal	Denmark	227	3724	18	34	1)
	France	231	667	18	29	2)
	Belgium	30	291	8	14	3)
	New Zeeland	10	139	0	0	
	West Germany	11	120	7	25	4)
	Holland	10	100	2	14	5)
	Schweiz	7	91	2	2	6)
	Finland	13	82	0	0	
	USA	6	62	0	0	
Bone meal	Denmark	198	3133	30	100	7)
	Finland	10	49	0	0	
	England	2	20	0	0	
	Belgium	1	2	0	0	
	Scotland	1	1	0	0	
Feather meal	Holland	139	1916	0	0	
	West Germany	117	693	12	17	8)
	Belgium	1	15	0	0	
Protein powder	Denmark	36	560	2	2	9)
Pig's bristle meal	Denmark	11	225	1	1	10)
Fish meal	Norway	56	145	0	0	
	France	7	61	0	0	
	Denmark	2	25	0	0	
Blood meal	Denmark	3	46	0	0	
Meat broth	France	19	19	0	0	
	Denmark	2	2	0	0	
	West Germany	2	2	0	0	
	England	2	2	0	0	
Haemoglobin powder	West Germany	4	40	0	0	
Milk powder	West Germany	5	11	0	0	
		1163	12243	100	238	

All isolations of Salmonella from feedstuffs and feed processing plants in Sweden during 1983-1987 are presented in Table 13. The isolations were made at the NVI or at regional veterinary laboratories. In total, 236 strains of Salmonella were isolated from raw materials of vegetable or animal origin, commercially available compound feed, and scrape and dust samples taken in plants producing compound feed. This is a much lower incidence than the one found during the last 15 years, (*Gunnarsson et al.* 1974, *Sandstedt et al.* 1980, *Mårtensson et al.* 1984).

The incidence of Salmonella in the feeds and samples presented in Table 13 to some extent reflects which kinds of materials that are most often checked, compulsory or voluntary, for the presence of Salmonella. Whenever a Salmonella infection is found in a broiler flock as a result of the compulsory Salmonella control of broilers or otherwise, an investigation is started in the plant sup-

Table 11. (continued):

1) *S. bredeney (11)*
S. montevideo (9)
S. tennesse (8)
S. give (2)
S. senftenberg (2)
S. bredeney + S. tennessee (1)
S. EO-group (1)

2) *S. derby (9)*
S. lille (4)
S. duisburg (3)
S. wien (3)
S. schwartzengrund (2)
S. bredeney (2)
S. thompson (2)
S. saint-paul (1)
S. ohio (1)
S. rissen (1)
S. senftenberg (1)
S. spp (1)

3) *S. spp (4)*
S. butantan (2)
S. typhimurium (2)
S. singapore (1)
S. ependorf (1)
S. montevideo (1)
S. livingstone (1)
S. thompson (1)
S. irimu (1)

4) *S. bredeney (17)*
S. EO-group (3)
S. livingstone (2)
S. typhimurium (2)
S. taksony (1)

5) *S. livingstone (11)*
S. brandenburg (2)
S. senftenberg (1)

6) *S. bredeney (2)*

7) *S. montevideo (88)*
S. senftenberg (4)
S. bredeney (2)
S. tennessee (2)
S. agona (1)
S. typhimurium (1)
S. spp (1)

8) *S. senftenberg (8)*
S. bredeney (3)
S. orion (1)
S. EO-group (1)
S. minneapolis (1)
S. dublin (1)
S. ruiru (1)
S. keve (1)

9) *S. mbandaka (2)*

10) *S. montevideo (1)*

plying its feed. This investigation includes Salmonella examination of samples of raw materials, scrapings and dust samples along the entire processing line, as well as samples of compound feed. Such an investigation is also started whenever Salmonella is found in the voluntary control of compound feeds for poultry and swine, that is carried out at the regional veterinary laboratories for a majority of the Swedish feed industry. Some of the feed mills also routinely check dust and scrapings from the processing line, since this has proved to be a good aid in revealing Salmonella contamination present in the feed mill. A large portion (98 strains) of the Salmonella isolations presented in Table 13, therefore, originates from dust and scrape samples. In some instances the investigation of feed mills has revealed a connection between Salmonella types found in compound feed and raw materials used. Raw materials of animal origin, especially meat meal and

Table 12. Salmonella found in meat meal from Swedish plants during the years 1983-1987.

Meat meal producing plant	1983	1984	1985	1986	1987
Krutmöllan	*S. anatum* *S. livingstone*	*S. infantis*	-	*S. agona*	*S. mbandaka*
Kil	*S. senftenberg*	*S. senftenberg*	-	*S. senftenberg*	*S. senftenberg*
Stidsvig	*S. anatum* *S. braenderup* *S. EO-group* *S. infantis* *S. livingstone* *S. newington*	*S. agona* *S. infantis*	*S. anatum* *S. braenderup*	*S. derby* *S. gombe*	*S. agona* *S. georgia*
Aneby	*S. havana* *S. lille*	*S. havana*	-	-	*S. livingstone*
Stenstorp	-	-	-	*S. senftenberg*	*S. senftenberg*
Långebro	-	-	-	*S. infantis*	*S. anatum* *S. livingstone*

Table 13. Salmonella isolated from feedstuffs and feed processing plants in Sweden during 1983-87.

Variants	Raw materials		Compound feeds						Dust and scrapings from feed mills
	Vegetable feeds	Feeds of animal origin	fish feed	cattle feed	swine feed	poultry feed	mink feed	pet feed	
S. agona	1[1)]							1	
S. anatum		8[2)]							
S. braenderup		1[2)]							
S. broughton									3[3)]
S. california							1		
S. dublin							1		
S enteritidis						1			1[5)]
S. havana	1[4)]								1[5)]
S idikan								1	
S. infantis		4[2)]					1		
S. kentucky									3[6)]
S. liverpool									1[7)]
S. livingstone	7[8)-4)]	51[2)-9)]		1	4	27			32[10)-13)]
S. mbandaka	1[14)]					1			
S minnesota	1[7)]	1[15)]							
S. newington									48[16-17)]
S. ohio	1[4)]							1	
S. oranienburg	1[18)]	1[15)]							
S. poona								1	
S. saint-paul				1					
S. schwartzengrund	3[4)]					1			2[19)]
S. senftenberg	1[4)]	1[15)]							2[19)]
S. tennessee					2				8[20)]
S. typhi murium phagetype 1				1		2			
S. typhi murium									
S. 0-4,5 NST			1						
S. yaba						1			
BO-group						1			
EO-group		1[4)]							
OB-group		1[15)]							
subspecies (untypable)						1			
	17	69	1	3	6	35	3	4	98

Table 13. (continued).

		No of strains
1)	soya bean meal	1
2)	meat meal	28
3)	scrapings from the processing line in a feed mill producing swine and poultry feed	3
4)	maize gluten	7
5)	scrapings from the processing line in a feed mill producing swine and poultry feed	1
6)	scrapings from the cooling system for pelleted broiler feed	3
7)	scrapings from the cooling system for pelleted broiler feed	1
8)	maize grits	7
9)	bone meal	36
10)	scrapings from the feed mixer in a feed mill producing swine and poultry feed	4
11)	scrapings from a feed mill for poultry feed contaminated by *S. livingstone*	23
12)	scrapings from the processing line in a feed mill producing swine and cattle feed	2
13)	scrapings from the processing line in a bone meal producing plant contaminated by *S. livingstone*	3
14)	maize meal	1
15)	fish meal	4
16)	scrapings from the processing line in a feed mill for poultry feed contaminated with *S. newington*.	45
17)	dust and scrapings from a feed mill for dog feed contaminated with *S. newington*	3
18)	rape seed meal	1
19)	scrapings from the conveyor line for raw material in a feed mill producing poultry and swine feed.	2
20)	scrapings from the processing line in a feed mill producing poultry feed	8

bone meal, were more often found to be contamined by Salmonella than materials of vegetable origin. Nevertheless, Salmonella was isolated in 15 cases from imported maize products (maize gluten, maize grits and maize meal). In one case the same serotype, *S. livingstone* was found in the same feed mill in maize grits, in compound feed for chickens, and in scrape samples from the processing line. The voluntary control of Salmonella in feedstuffs therefore also includes imported raw materials of vegetable origin such as maize and soya products.

Broilers seem to be the animals feed-borne Salmonella contamination is most easily demonstrated. In some cases during the last 5 year period the same variants of Salmonella found in chickens were also found in samples from the plant supplying the feed. This was the case for *S. infantis* (found in meat meal), *S. kentucky* and *S. newington* (found in scrapings and pelleted feed), *S. tennessee* (found in swine feed) and *S. senftenberg* (found in fish meal).

The most serious incident happened in 1987 when domestic meat meal and bone meal, heavily contaminated by *S. livingstone,* was delivered to one feed mill producing pelleted broiler feed and to another one producing swine feed. Via the contaminated feed 2 flocks of broilers and 2 swine herds were infected by *S. livingstone.* The 2 feed mills as well as the plant producing the meat meal had to close down for sanitation. In the feed mill producing pelleted broiler feed the Salmonella bacteria had succeeded to pass through the pelleting machine during the first few minutes before it had reached it's working temperature (70-75°C). Salmonella bacteria were then present in dust and deposits in the cooling system, in the conveyor line, and in silos for the pelleted feed and could thereby contaminate the feed produced. In principle the same way for the esta-

blishment of Salmonella contamination of pelleted broiler feed has been reported before by *Mårtensson et al.* (1984). In 2 further cases during 1983-1987 contamination by Salmonella (*S. kentucky* and *S. newington*) in wet coatings present in the cooling system most likely was established in the same way. Even in these 2 cases Salmonella contaminated feed was produced, which infected flocks of broilers.

The salmonella-contaminated feed mills mentioned above not only had to be thoroughly mechanically cleaned and disinfected but also had to have their equipment reconstructed, ensuring all pelleted feed produced to be sufficiently heat treated before entering the humid environment in the cooling system. By these measures it was made possible to produce Salmonella free feed in the mills.

All these incidents when Salmonella contamination has occurred in feed mills have lead to an improvement of the hygienic standard of the Swedish feed production. The producers of broiler feed are now asked to minimize the risk for salmonella-contamination of the feed by:

i) avoid use of Salmonella contaminated raw materials
ii) completely separating heat treated feed from raw materials and not heattreated feed
iii) not allowing pelleted feed to pass into the cooler before it has been fully heated (minimum 72°C) in the pelleting machine
iv) applying good cleaning routines for the processing line, especially for eliminating wet coatings and feed deposits
v) having routines for continuous checking of the presence of Salmonella in the final feed product and in dust and scrape samples from the processing line.

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Sammanfattning

Salmonella isolerad från djur och fodermedel i Sverige 1983-1987.

Sedan 1949 har Statens Veterinärmedicinska Anstalt (SVA) publicerat 5 års-rapporter. Salmonella-isoleringar angående fall från djur och fodermedel. Under 1983-1987 har 760 salmonellautbrott rapporterats. Detta innefattar både vilda och tama djur.

Föregående period var motsvarende siffra 1266 utbrott. Av 56 rapporterade serovarianter är 17 nya för Sverige. Jämfört med föregående rapporteringsperiod har antalet utbrott minskat på nöt och svin. På fjäderfä är 86 utbrott rapporterade, vilket är en extremt låg siffra jämfört med 220 under föregående rapporteringsperiod.

Svenska foderfabriker kontrolleras både frivilligt och obligatoriskt, på förekomst av Salmonella i råvaror, skrap- och dammprov samt i färdigt foder. Under perioden 1983-1987 påvisades 236 salmonellastammar. Detta är den längsta frekvensen under de senaste femton åren.

Alla fodervaror av animalt ursprung avsedda för import till Sverige kontrolleras på förekomst av Salmonella. Under perioden 1983-1987 var 8.6% av importerna salmonellapositiva och tilläts därför ej komma in i Sverige.

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