

Incidence of salmonella infection in animals in England and Wales, 1968–1974

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(Received 29 June 1976)

SUMMARY

Of a total of 23,609 incidents of salmonella infection reported during the period 1968–74, 20,326 occurred in cattle, 1744 in poultry and other birds, 675 in sheep, 558 in pigs and 306 in other species of animals.

Despite the large number of serotypes isolated (153), 88% of incidents were due to only two serotypes: *S. dublin* (15,929 incidents of which 15,446 occurred in cattle) and *S. typhimurium* (4842 incidents of which 3785 occurred in cattle and 732 in birds).

S. choleraesuis was the third (314 incidents which with only 5 exceptions occurred in pigs) and *S. abortusovis* (243 incidents all in sheep) was the fourth most commonly isolated serotype. The following six serotypes were each recorded in more than 100 incidents: *S. newport* (177), *S. agona* (170), *S. virchow* (169), *S. anatum* (152), *S. enteritidis* (150) and *S. montevideo* (111). The other 143 serotypes accounted for only 5.8% of total incidents.

The trends of annual incidence of salmonella infection in cattle, sheep, pigs, poultry and other birds during the 17-year period 1958–74 and the distribution of the main serotypes in the individual species of animals from 1968 to 1974 are discussed.

INTRODUCTION

Two previous accounts based on the monthly reports from the Ministry of Agriculture, Fisheries and Food Veterinary Laboratories have been published on the incidence of salmonella infection in animals in England and Wales. The first (Sojka & Field, 1970) covers the period 1958–67, the second (Sojka, Wray, Hudson & Benson, 1975) 1968–73. The present account expands the details given in the second paper by listing all the serotypes isolated between 1968 and 1973 and their distribution in different species of animals and birds and also gives the data pertaining to incidents recorded during 1974. The trends in the incidence of salmonella infection in the various species of animals and birds during the period 1958–74 are also discussed.

Table 1. *Number of incidents of salmonella infection in animals caused by host-adapted serotypes and serotypes infecting more than one animal species in England and Wales diagnosed by the Ministry's laboratories, 1968-1974*

Serotypes	Cattle	Poultry and other			Pigs	Other species	Total
		birds	Sheep				
<i>S. dublin</i>	15,446	48	302	78	55	15,929	
<i>S. typhimurium</i>	3,785	732	59	97	169	4,842	
<i>S. abortusovis</i>	.	.	243	.	.	243	
<i>S. agama</i>	44	.	4	.	3	51	
<i>S. agona</i>	64	90	4	8	2	168	
<i>S. anatum</i>	114	16	.	1	3	134	
<i>S. bareilly</i>	2	3	.	.	.	5	
<i>S. blegdam</i>	2	7	.	.	.	9	
<i>S. braenderup</i>	2	1	.	.	.	3	
<i>S. bredeney</i>	32	15	4	3	2	56	
<i>S. californica</i>	2	1	3	.	1	7	
<i>S. cerro</i>	1	2	.	.	.	3	
<i>S. chester</i>	1	14	.	.	.	15	
<i>S. choleraesuis</i>	1	.	3	309	1	314	
<i>S. coeln</i>	3	.	.	.	1	4	
<i>S. derby</i>	7	30	2	4	.	43	
<i>S. drypool</i>	3	1	1	.	.	5	
<i>S. enteritidis</i>	36	105	1	5	4	151	
<i>S. farmsen</i>	2	.	5	.	.	7	
<i>S. gallinarum</i>	.	44	.	.	.	44	
<i>S. give</i>	13	1	.	1	.	15	
<i>S. gnesta</i>	2	1	.	.	.	3	
<i>S. haardt</i>	1	2	.	.	1	4	
<i>S. hadar</i>	7	3	1	.	.	11	
<i>S. hartford</i>	1	11	.	.	.	12	
<i>S. hato</i>	1	1	.	.	.	2	
<i>S. havana</i>	7	.	.	.	1	8	
<i>S. heidelberg</i>	9	32	.	1	8	50	
<i>S. indiana</i>	31	39	2	3	4	79	
<i>S. infantis</i>	15	19	.	2	1	37	
<i>S. kaapstad</i>	4	.	1	.	.	5	
<i>S. kiambu</i>	4	17	.	1	.	22	
<i>S. liverpool</i>	2	1	.	.	.	3	
<i>S. livingstone</i>	9	47	1	3	3	63	
<i>S. london</i>	13	2	.	.	.	15	
<i>S. meleagridis</i>	7	.	1	.	.	8	
<i>S. menston</i>	6	54	.	3	6	69	
<i>S. montevideo</i>	23	60	25	2	1	111	
<i>S. muenchen</i>	9	1	.	.	.	10	
<i>S. muenster</i>	15	2	1	.	1	19	
<i>S. newport</i>	167	1	3	.	6	177	
<i>S. ohio</i>	2	3	.	.	.	5	
<i>S. oranienburg</i>	7	.	1	.	1	9	
<i>S. othmarschen</i>	8	3	.	1	1	13	
<i>S. panama</i>	13	1	.	13	1	28	
<i>S. poona</i>	5	.	1	.	.	6	
<i>S. pullorum</i>	.	65	.	.	.	65	
<i>S. reading</i>	18	12	.	.	.	30	
<i>S. regent</i>	1	2	.	.	.	3	
<i>S. saintpaul</i>	34	11	.	.	1	46	

Table 1 (cont.)

Serotypes	Cattle	Poultry and other birds	Sheep	Pigs	Other species	Total
<i>S. sandiego</i>	2	3	.	.	.	5
<i>S. schwarzengrund</i>	8	3	.	.	.	11
<i>S. senftenberg</i>	7	81	.	.	8	96
<i>S. stanley</i>	8	25	1	4	2	40
<i>S. stanleyville</i>	1	.	1	.	1	3
<i>S. takoradi</i>	3	1	.	.	.	4
<i>S. telaviv</i>	22	.	.	1	.	23
<i>S. tennessee</i>	13	16	.	.	2	31
<i>S. thomasville</i>	1	.	1	.	.	2
<i>S. thompson</i>	14	15	1	3	4	37
<i>S. tournai</i>	14	4	.	.	.	18
<i>S. virchow</i>	133	30	2	2	6	173
<i>S. westhampton</i>	2	1	.	.	.	3
<i>S. worthington</i>	1	2	.	1	.	4
<i>S. 4, 12:d:—</i>	5	24	.	8	.	37
Rough salmonellas	7	2	.	.	.	9

RESULTS AND DISCUSSION

Total incidence of salmonella infection in different species of animals

The salmonella serotypes in domestic animals, poultry and other species of animals and birds reported during the period 1968–74 inclusive are summarized in Tables 1 and 2.

Of a total of 23,609 incidents reported and represented by 153 different serotypes, 20,326 occurred in cattle (119 serotypes), 1744 in poultry and other birds (74 serotypes), 675 in sheep (28 serotypes), 558 in pigs (27 serotypes) and 306 in other species of animals (36 serotypes). Table 3 details the species of animals referred to in Tables 1 and 2 as 'other species' and the serotypes involved.

Despite the large number of serotypes isolated, the majority of incidents were due to only a few serotypes. Thus 88% of incidents were caused by two serotypes: *Salmonella dublin* and *S. typhimurium*. *S. dublin* was by far the most common, being recorded in 15,929 incidents (representing 67.5% of the total), the majority of which occurred in cattle (15,446 incidents) in which it accounted for 76% of the incidents. It was also the most common serotype reported in sheep (302 incidents) and it was third in frequency in pigs (78 incidents).

S. typhimurium, the second most common serotype, accounted for 4842 incidents (20.5% of the total). In poultry and other birds this ubiquitous serotype was reported in 732 (42%) incidents and was also the most common serotype in 'other species' of animals (169 incidents); it was second in frequency in cattle (3785 incidents) and pigs (97) and third in sheep (59).

S. choleraesuis and *S. abortusovis*, the third and fourth most commonly isolated serotypes, accounted for 314 and 243 incidents respectively. All incidents due to the latter serotype were entirely confined to sheep while those due to the former serotype, with the exception of only 5 incidents (3 of which were recorded in sheep and 1 each in cattle and in a cat), occurred in pigs.

Table 2. Number of incidents of salmonella infection affecting only one animal species diagnosed by the Ministry's laboratories, 1968-1974

Cattle			
<i>S. aberdeen</i> (2)	<i>S. epicrates</i>	<i>S. locklease</i>	<i>S. paratyphi B</i> (2)
<i>S. amager</i> (2)	<i>S. fresno</i> (6)	<i>S. makumira</i>	<i>S. presov</i>
<i>S. amersfoort</i>	<i>S. gera</i>	<i>S. manchester</i>	<i>S. rostock</i>
<i>S. amsterdam</i> (3)	<i>S. goerlitz</i> (3)	<i>S. manila</i>	<i>S. singapore</i>
<i>S. bedford</i>	<i>S. haifa</i>	<i>S. molade</i>	<i>S. stockholm</i>
<i>S. bournemouth</i>	<i>S. kibusi</i>	<i>S. mons</i>	<i>S. sundsvall</i>
<i>S. bovismoribificans</i> (5)	<i>S. kiddermminster</i>	<i>S. moscow</i>	<i>S. uganda</i>
<i>S. brandenburg</i> (4)	<i>S. kimvuenza</i>	<i>S. nagoya</i>	<i>S. urbana</i>
<i>S. butantan</i> (14)	<i>S. kokomlemle</i>	<i>S. niarembe</i>	<i>S. vejle</i>
<i>S. corvallis</i> (9)	<i>S. kottbus</i>	<i>S. niloese</i>	<i>S. 4, 12: z: —</i>
<i>S. cubana</i> (2)	<i>S. labadi</i>	<i>S. nyborg</i>	<i>S. 1, 9, 12: —: —, (5)</i>
<i>S. dugbe</i>	<i>S. lagos</i> (2)	<i>S. okerara</i>	<i>S. 1, 42: z₄z₂₃: —, (3)</i>
<i>S. durham</i>	<i>S. lexington</i>	<i>S. orion</i>	<i>S. 1, 3, 19: —: —</i>
<i>S. ealing</i>	<i>S. lille</i>	<i>S. oritamerin</i>	
<i>S. emek</i>			
Poultry and other birds			
<i>S. ayinde</i>	<i>S. isangi</i> (6)	<i>S. newhaw</i>	<i>S. westerstede</i> (2)
<i>S. coleypark</i>	<i>S. javiana</i>	<i>S. newington</i> (2)	<i>S. 4, 5, 12: b: —</i>
<i>S. colorado</i>	<i>S. kentucky</i> (3)	<i>S. preston</i> (2)	<i>S. 6, 7: —: —, (2)</i>
<i>S. dessau</i>	<i>S. kinshasa</i> (5)	<i>S. simsbury</i> (2)	
<i>S. duisburg</i>	<i>S. lomita</i>	<i>S. teddington</i>	
<i>S. durban</i>	<i>S. mission</i>	<i>S. tyresoe</i>	
Sheep			
<i>S. idikan</i>			
Pigs			
<i>S. huttingfoss</i>	<i>S. kapemba</i> (2)	<i>S. wangata</i>	
Other animal species			
<i>S. bonariensis</i>	<i>S. java</i>	<i>S. lethe</i>	<i>S. onderstepoort</i>
<i>S. bonn</i>	<i>S. sofia</i>		

Figures in parentheses after the serotype indicate the number of isolations from the particular species. All not so marked were single isolations.

Serotypes other than the above occurred relatively less frequently. The following six serotypes were each recorded in more than 100 incidents: *S. newport* (177), *S. agona* (170), *S. virchow* (169), *S. anatum* (152), *S. enteritidis* (150) and *S. montevideo* (111). The other 143 serotypes accounted for only 5.8% of total incidents.

Table 4 lists salmonellas which were isolated from a variety of materials such as animal feedingstuffs, water, sewage, sludge, hatchery waste, etc. One hundred and seventy-one such isolations were represented by 45 different serotypes, the majority of which were also found among salmonellas recovered from various species of animals during the similar period of time (see Tables 1-3).

Two hundred and thirteen additional isolations of salmonellas from faeces, rectal swabs, fetuses and viscera were reported, but they were not included in any of the tables presented in this paper since the species of animals from which these strains originated were not specified in the reports. Their distribution amongst the serotypes followed a similar pattern to Table 1.

Annual incidence of salmonella infection in animals

The trends of the annual incidence of salmonella infection in cattle, sheep, pigs, poultry and other birds during the 17-year period 1958–74 inclusive are illustrated in Fig. 1. Tables 5–8 summarize the main features of the annual incidence of salmonella infections during the period 1968–74 in cattle, sheep, pigs, and poultry and other birds respectively, and also give the distribution of the main serotypes in the individual species of animals.

The above Tables were compiled from the results published by Sojka *et al.* (1975), and from the unpublished reports pertaining to the data recorded in 1974. Fig. 1 includes in addition data presented by Sojka & Field (1970).

Incidence of salmonella infection in cattle

The number of reported incidents of salmonella infection in cattle rose from 188 in 1958 to a peak of 4498 in 1969. This was due mainly to a dramatic increase in *S. dublin* incidents, rising to 4012, the highest number reported since records started in 1958 (Sojka & Field, 1970). There are probably many reasons for this increase, which may in part be explained by the spread of *S. dublin* from the traditional endemic areas to other parts of the country, by the great increase in the movements of calves for rearing and by the expansion of laboratory facilities available to veterinary surgeons.

Since 1969 the decline in the incidence of *S. dublin* infection to 1216 incidents in 1974 is reflected in the decline in the total number of incidents to 2290 in that year. While the number of incidents due to *S. dublin* infection declined from 4012 in 1969 (89.2% of all incidents) to 1216 in 1974 (53.1% of incidents), the lowest proportion ever recorded, the number of incidents due to *S. typhimurium* rose from 415 (9.2%) in 1969 to 802 (30.6%) in 1973, but fell to 706 (30.8% of incidents) in 1974 (Table 5).

The number of incidents due to serotypes other than *S. dublin* and *S. typhimurium* increased suddenly from an annual average of 69 incidents in the years 1968–72, to 383 incidents in 1973 (14.6%) and 368 in 1974 (16.0%). The sudden increase in the isolation of these other serotypes coincided with the period of acute shortage of animal protein feeding stuffs in May 1973. It is therefore likely that many of the serotypes isolated during this period had their origin in imported animal feeds, since it has been shown that these are frequently contaminated with salmonellas. The role of feeding stuffs of animal origin in the epidemiology of salmonellosis has been discussed by Williams (1975) in his comprehensive paper dealing with environmental consideration of salmonellosis.

The third most common serotype isolated in cattle during the period was *S. newport* with 167 incidents, the majority of which occurred during the last 3 years of the study. *S. newport*, which is one of the relatively few long established serotypes found in man throughout the world (Edwards & Galton, 1967) has been found as a cause of serious disease in cattle in Canada (Dreumal, Boycott & Boroski, 1969) and some parts of the USA (Moore, Rothenbacher, Bennett & Barner, 1962). Until recently, however, this serotype was relatively uncommon in farm animals or

Table 3. Incidents of salmonella infection in 'other' species of animals in England and Wales diagnosed by the Ministry's laboratories, 1968-1974

Serotypes	Horse	Dog	Mink	Guinea-pig	Cat	Badger	Rabbit	Antelope	Lion	Goat	Tortoise	Coypu	Cheetah	Tiger	Camel	Elephant	Giraffe	Monkey	Donkey	Chinchilla	Lynx	Rat	Fox	Hedgehog	Puma	Wallaby	Ferret	Terrapin	Lizard	Total
<i>S. typhimurium</i>	86	23	18	11	6	2	4	3	1	2	1	1	2	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	169
<i>S. dublin</i>	17	17	5	6	2	1	3	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	55
<i>S. agona</i>		2				1																								3
<i>S. agona</i>		1	1					2																						4
<i>S. anatum</i>	1																													1
<i>S. bonariensis</i>															1															1
<i>S. bonn</i>																														1
<i>S. bredeney</i>	1																					1								2
<i>S. californica</i>																						1								1
<i>S. choleraesuis</i>																														1
<i>S. coeln</i>																														1
<i>S. enteritidis</i>			1	2																										3
<i>S. haardt</i>			1																											1
<i>S. havana</i>		1																												1
<i>S. heidelberg</i>	3	2			2													1												8
<i>S. indiana</i>	1	2																												4
<i>S. infantis</i>												1																		1
<i>S. java</i>																														1
<i>S. lethe</i>	4										1																1			5
<i>S. livingstone</i>		1	2																											3
<i>S. menston</i>			4		1																			1						6
<i>S. montevideo</i>					1																									1
<i>S. muenster</i>	1																													1
<i>S. newport</i>	2	2												1		1														6
<i>S. onderstepoort</i>																														1
<i>S. oranienburg</i>																														1
<i>S. othmarschen</i>	1																													1
<i>S. panama</i>		1																												1

Table 3 (cont.)

Serotypes	Horse	Dog	Mink	Guinea-pig	Cat	Badger	Rabbit	Antelope	Lion	Goat	Tortoise	Coypu	Cheetah	Tiger	Camel	Elephant	Giraffe	Monkey	Donkey	Chinchilla	Lynx	Rat	Fox	Hedgehog	Puma	Wallaby	Ferret	Terrapin	Lizard	Total
<i>S. saintpaul</i>	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
<i>S. senftenberg</i>	.	.	8	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8
<i>S. sofia</i>	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
<i>S. stanley</i>	.	1	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
<i>S. stanleyville</i>	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
<i>S. tennessee</i>	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
<i>S. thompson</i>	.	2	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
<i>S. virchow</i>	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
Total	119	57	42	19	14	7	7	5	4	3	4	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	306

One incident each of *S. gnesta*, *S. guinea* and *S. havana* in man were reported by the V.I. Service, but they are not included in the table

Table 4. *Salmonella* isolations from miscellaneous materials (feeding stuffs, water, sludge, sewage, hatchery waste, etc) reported by the Ministry's laboratories in England and Wales, 1968–1974

Serotypes	Number of isolations	Serotypes	Number of isolations
<i>S. typhimurium</i>	34	<i>S. johannesburg</i>	1
<i>S. dublin</i>	15	<i>S. levington</i>	1
		<i>S. livingstone</i>	2
<i>S. aberdeen</i>	1	<i>S. manila</i>	1
<i>S. adelaide</i>	2	<i>S. montevideo</i>	3
<i>S. agona</i>	18	<i>S. menston</i>	1
<i>S. alachua</i>	1	<i>S. muenchen</i>	1
<i>S. anatum</i>	9	<i>S. molade</i>	2
<i>S. blegdam</i>	1	<i>S. newport</i>	2
<i>S. bornum</i>	2	<i>S. ohio</i>	1
<i>S. brancaster</i>	1	<i>S. oranienburg</i>	1
<i>S. brandenburg</i>	1	<i>S. poona</i>	3
<i>S. bredeney</i>	5	<i>S. senftenberg</i>	5
<i>S. cubana</i>	1	<i>S. stanley</i>	1
<i>S. derby</i>	2	<i>S. stanleyville</i>	2
<i>S. eimsbuettel</i>	2	<i>S. taksony</i>	1
<i>S. enteritidis</i>	7	<i>S. telaviv</i>	1
<i>S. heidelberg</i>	3	<i>S. thomasville</i>	1
<i>S. kentucky</i>	3	<i>S. urbana</i>	2
<i>S. kinshasa</i>	1	<i>S. vejle</i>	1
<i>S. indiana</i>	12	<i>S. virchow</i>	11
<i>S. isangi</i>	1	<i>Salmonella</i> 4, 12: d: —:	2
<i>S. java</i>	1	Rough salmonellas	2
Total			171

poultry in the U.K. Thus of a total of 24,389 incidents of salmonellosis in cattle reported by the V.I. Service in England and Wales during 1958–72 inclusive, only 21 incidents were due to *S. newport*; a similar number of incidents due to this serotype was reported during this period in other species of animals. However, during 1973, the number of isolations from cattle of *S. newport* increased considerably (99 incidents) and outbreaks were widespread. During 1974, however, the number of incidents declined to 61. Two other serotypes were reported in over 100 incidents during the period; *S. virchow* (133) and *S. anatum* (114).

Sheep

The trends of the annual incidence of salmonella infection in sheep are shown in Fig. 1 and Table 6. The latter also illustrates the annual incidence of the principal salmonella serotypes (*S. abortusovis*, *S. dublin* and *S. typhimurium*) in this species.

The highest number of incidents (217) due to salmonella infection was recorded in 1969 and this was caused by an increase in *S. dublin* infection (131 incidents) which coincided with the highest number of incidents due to this serotype in cattle. Since then the incidence of ovine salmonellosis has declined in parallel with the decrease in the number of *S. dublin* incidents. Thus during 1974 a total of 62 incidents of ovine salmonellosis was reported, of which 18 were due to *S. dublin*

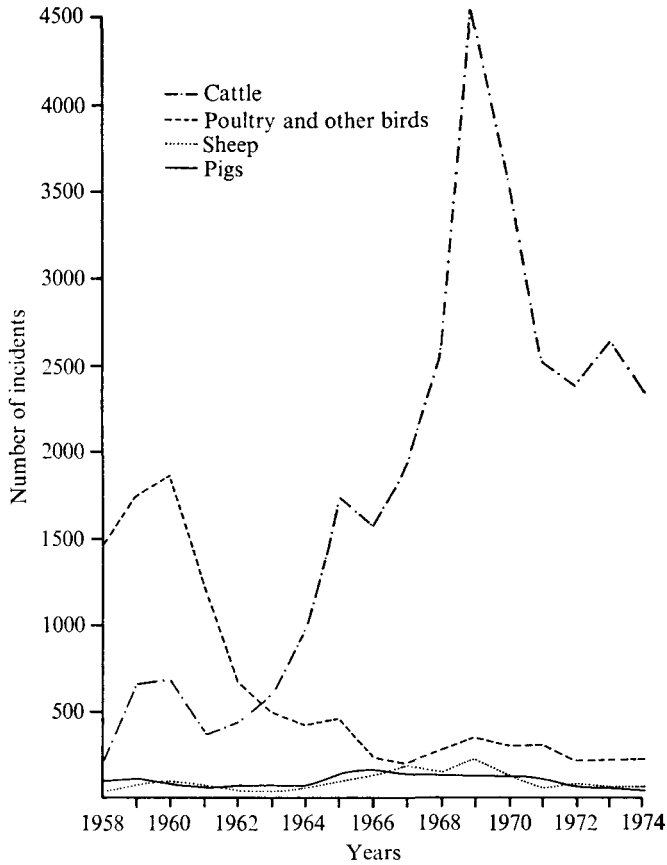


Fig. 1. Incidents of salmonella infection in cattle, poultry and other birds, sheep and pigs in England and Wales diagnosed by the Ministry's laboratories during the period 1958-74. Data for the period 1958-67 from a publication by Sojka & Field (1970).

Table 5. Number of incidents of salmonella infection in cattle in England and Wales diagnosed by the Ministry's laboratories, 1968-1974

Serotypes	Years							Total (7 years)
	1968	1969	1970	1971	1972	1973	1974	
<i>S. dublin</i>	1,970 (78.6)	4,012 (89.2)	3,056 (85.7)	2,074 (83.4)	1,684 (71.5)	1,434 (54.8)	1,216 (53.1)	15,446 (76.0)
<i>S. typhimurium</i>	511 (20.4)	415 (9.2)	426 (11.9)	337 (13.5)	588 (25.0)	802 (30.6)	706 (30.8)	3,785 (18.6)
Other serotypes	27 (1.0)	71 (1.6)	85 (2.4)	77 (3.1)	84 (3.5)	383 (14.6)	368 (16.0)	1,095 (5.4)
Total no. of incidents	2,508	4,498	3,567	2,488	2,356	2,619	2,290	20,326
No. of serotypes identified	15	39	33	30	32	65	59	118

Figures in parentheses are percentages of the annual total.

Table 6. *Number of incidents of salmonella infection in sheep diagnosed by the Ministry's laboratories in England and Wales, 1968-1974*

Serotypes	Years							Total (7 years)
	1968	1969	1970	1971	1972	1973	1974	
<i>S. abortusovis</i>	77 (56.6)	72 (33.1)	44 (41.5)	19 (46.3)	8 (12.7)	11 (22.0)	12 (19.4)	243 (36.0)
<i>S. dublin</i>	47 (34.6)	131 (60.4)	51 (48.1)	17 (41.5)	20 (31.7)	18 (36.0)	18 (29.0)	302 (44.8)
<i>S. typhimurium</i>	11 (8.1)	11 (5.1)	9 (8.5)	5 (12.2)	10 (15.9)	6 (12.0)	7 (11.3)	59 (8.7)
Other serotypes	1 (0.7)	3 (1.4)	2 (1.9)	0	25 (39.7)	15 (30.0)	25 (40.3)	71 (10.5)
Total no. of incidents	136	217	106	41	63	50	62	675
No. of serotypes identified	4	6	5	3	10	13	16	29

Figures in parentheses are percentages of the annual total.

Table 7. *Number of incidents of salmonella infection in pigs diagnosed by the Ministry's laboratories in England and Wales, 1968-1974*

Serotypes	Years							Total (7 years)
	1968	1969	1970	1971	1972	1973	1974	
<i>S. choleraesuis</i>	89 (74.2)	72 (66.7)	50 (47.2)	46 (51.1)	22 (47.8)	15 (31.3)	15 (37.5)	309 (35.4)
<i>S. typhimurium</i>	7 (5.8)	11 (10.2)	23 (21.7)	24 (26.7)	14 (30.4)	11 (22.9)	7 (17.5)	97 (17.4)
<i>S. dublin</i>	22 (18.3)	20 (18.5)	19 (17.9)	7 (7.8)	1 (2.2)	6 (12.5)	3 (7.5)	78 (14.0)
Other serotypes	2 (1.7)	5 (4.6)	14 (13.2)	13 (14.4)	9 (19.6)	16 (33.3)	15 (37.5)	74 (13.2)
Total no. of incidents	120	108	106	90	46	48	40	558
No. of serotypes identified	5	8	10	14	10	12	14	27

Figures in parentheses are percentages of the annual total.

infection. Although the number of reported incidents due to *S. abortusovis* has declined the true incidence of infection due to this serotype is not known, possibly because, as pointed out by I. H. Fincham (personal communication) many farmers no longer submit material for laboratory examination.

The proportion of incidents due to *S. typhimurium* (third commonest serotype isolated) varied from less than 4% in 1958 to nearly 16% in 1972: during 1974, 11.3% of incidents were due to this serotype.

The percentage of serotypes other than the above increased from nil in 1958 and 1971 and less than 1% in 1966 and 1968 to over 40% recorded in 1974. While each of the 'other serotypes' was recorded in 1-5 occasions, *S. montevideo* was reported in 25 incidents in sheep.

Table 8. Number of incidents of salmonella infection in poultry and other birds diagnosed by the Ministry's laboratories in England and Wales, 1968-1974

Serotypes	Years							Total (7 years)
	1968	1969	1970	1971	1972	1973	1974	
<i>S. typhimurium</i>	113 (42.6)	119 (36.8)	120 (42.4)	110 (38.2)	88 (46.3)	86 (43.2)	96 (49.0)	732 (42.0)
<i>S. enteritidis</i>	9 (3.4)	35 (10.8)	10 (3.5)	6 (2.1)	10 (5.3)	26 (13.1)	9 (4.6)	105 (6.0)
<i>S. pullorum</i>	17 (6.4)	27 (8.4)	3 (1.1)	5 (1.7)	5 (2.6)	4 (2.0)	4 (2.0)	65 (3.7)
<i>S. gallinarum</i>	10 (3.8)	19 (5.9)	9 (3.2)	4 (1.4)	0	1 (0.5)	1 (0.5)	44 (2.5)
Other serotypes	116 (43.8)	123 (38.1)	141 (49.8)	163 (56.6)	87 (45.8)	82 (41.2)	86 (43.9)	798 (45.8)
Total no. of incidents	265	323	283	288	190	199	196	1,744
No. of serotypes identified	31	39	33	35	26	27	32	74

Figures in parentheses are percentages of the annual total.

Pigs

The trends in the annual incidence of salmonella infection in pigs are shown in Fig. 1 and Table 7. The latter also illustrates the annual incidence of the main serotypes: *S. choleraesuis*, *S. typhimurium* and *S. dublin*.

The percentage of incidents due to *S. choleraesuis* infection, the commonest serotype, declined from 90% in 1958 to 31.3% in 1973; during 1974, 37.5% of incidents were due to this serotype.

The proportion of incidents due to *S. typhimurium*, the second in frequency, fluctuated from 5% in 1960 to 30.4% in 1972, but since then it declined to 17.5% in 1974.

While the percentage of incidents due to *S. dublin* infection was relatively high during the years 1968, 1969 and 1970 when a large number of isolations of this serotype were also made in cattle, it declined to 2.2% in 1972; during 1974, 7.4% of incidents were due to this serotype.

The percentage of serotypes other than the above increased from less than 2% in 1968 to 37.5% in 1974, following the trend in other species.

Poultry and other birds

Of a total of 1744 incidents reported in birds during this survey (Tables 1 and 2) 1396 were in 'poultry' which included domestic fowl (750), turkey (302) and other 'table birds' (duck, pigeon, goose, partridge and quail) (120). The remaining 348 isolations were from a variety of species of birds, wild and ornamental.

The trends in the annual incidence of salmonella infection in poultry and other birds during the 17-year period are shown in Fig. 1. Table 8 illustrates the annual incidence of four serotypes: *S. gallinarum*, *S. pullorum*, *S. typhimurium* and *S. enteritidis*. Though *S. gallinarum* and *S. pullorum* were most frequently

reported during the earlier survey (1958–67) when they were encountered in 67.4% (37.4% and 30.0% respectively) of incidents, they accounted for only 6.2% (2.5% and 3.7%, respectively) of incidents during the present survey, 1968–74. The decrease in the incidence of these two serotypes was attributed to the success of the blood testing programme carried out under the Poultry Stock Improvement Plan (Sojka *et al.* 1975). Only one incident due to *S. gallinarum* and four due to *S. pullorum* were reported during 1974. Similar figures were recorded in 1973.

Though in the earlier survey (1958–67) *S. typhimurium* was listed as the serotype third in frequency of isolation (17.8% of total incidents), during the present survey it became the most common serotype (42% of total incidents). The percentage of incidents due to this serotype during the present survey varied from 36.8% in 1969 to 49.0% in 1974.

S. enteritidis was second in frequency of isolation during the present survey (105 incidents) and the proportion of incidents due to this serotype varied from 2.1% in 1971 to 13.1% in 1973; during 1974, 4.6% incidents were recorded.

S. thompson, which was listed among the more frequent serotypes during the earlier survey (1958–67), when it accounted for 495 incidents (5.8% of the total), particularly in 1958, 1959 and 1960 (164, 181 and 103 incidents, respectively), was reported on only 15 occasions during the whole 7-year period of the present survey.

S. agona was third in frequency of isolation (90 incidents) during the present survey. This serotype, however, was not reported in poultry by the V.I. Service until 1970 when 13 incidents occurred. The number of incidents due to this serotype in 1971, 1972, 1973 and 1974 were 20, 24, 12 and 11 respectively.

S. menston which was listed as fourth in frequency of isolation (221 incidents) during the earlier survey, was reported during the present survey in 54 incidents, 24 of which occurred in 1968. Since then the number of incidents has declined (only 1 was recovered in 1972 and 4 in 1974).

Other serotypes causing more than 20 incidents during the present survey included *S. senftenberg* (81), *S. montevideo* (60), *S. livingstone* (47), *S. indiana* (39), *S. heidelberg* (32), *S. virchow* (30), *S. derby* (30), *S. stanley* (25) and *Salmonella* 4, 12: d: — (24) incidents.

Borland (1975*a*) considered that clinical salmonella infections in poultry are relatively uncommon, and not *per se* important as a source of food poisoning. She pointed out, however, that healthy carriers 'pose a much more serious problem because of the concentration of infection and subsequent dissemination which occurs in the processing stage. There appears to be a constant input of salmonella serotypes into various sections of the poultry industry... particularly from food and infected breeding stock'. Borland also suggested that incidents of salmonella food poisoning derived from poultry give an indication of salmonella status of the national flock.

Watson & Brown (1975) pointed out that a reduction in the hazard to public health from poultry products contaminated with salmonellas will depend in the longer term on the prevention of infection in the live birds, which can be best achieved by the use of uncontaminated feedstuffs, and in this connexion they

express hope that the proposed protein processing legislation will reduce the amount of contamination at present found in poultry food. These workers also suggested that any birds suspected to be carrying salmonella should be handled last through a processing plant. They stressed that 'although processing will not remove salmonellae already present on the bird, strict attention to hygiene will reduce the possibility of cross contamination. Suitable precautions must be taken in storage, preparation and cooking of poultry to avoid risk of food poisoning which may be present'.

Borland (1975*a*) also suggested that although reduction of the 'general level of salmonella contamination of poultry is of major long term importance much could be achieved in the short term by further education of the public in matters of food hygiene'.

Other species of animals

The incidence reported under the heading 'other species' (see Table 3) probably represents only a very small proportion of the actual number of salmonella infections in animals other than the species discussed above because they are not normally dealt with by the State Diagnostic Laboratories. Most of the incidents reported during 1968–74 in this group, taken as a whole, were due to *S. typhimurium* (169) and *S. dublin* (55).

Incidents of salmonella infection were most frequently reported in horses (119), followed by those recorded in dogs (57), mink (42), guinea-pigs (19) and cats (14). The number of incidents in 24 other species of animals were recorded less frequently (1–7 incidents).

Salmonellosis in horses has been reviewed by Buxton (1959) and in pet animals by Buxton (1957, 1959), Kaufmann (1966) and Bowmer (1964). More recently salmonella infections in dogs, cats, tortoises and terrapins were discussed by Borland (1975*b*).

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