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Epidemiological studies on *Salmonella senftenberg*

I. Relations between animal foodstuff, animal and human isolations

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INTRODUCTION

Of all the *Salmonella* serotypes, *Salmonella senftenberg* is the one most commonly isolated in animal foodstuffs, but it constitutes less than 1 % of human or animal isolations (Taylor *et al.* 1965). This is true not only of the United Kingdom but of all other countries (van Oye, 1964). Even when isolated, it has seldom been associated with disease. It was therefore of some interest when a series of isolations of *S. senftenberg* started in 1963 at Ryhope Hospital, Sunderland, and developed into an epidemic of salmonellosis in April 1965 (Sanford *et al.* 1969).

BACKGROUND

A comparison of the weekly Public Health Laboratory Service and monthly Veterinary Investigation Service reports and the Ryhope Hospital records of salmonella isolations (1963–June 1967) show that the Ryhope outbreak was part of a widespread increase in *S. senftenberg* isolations (Fig. 1), but with the exception of outbreaks at Oxford and Sunderland the human isolations were of a sporadic nature. The Oxford outbreak occurred in November 1963, when *S. senftenberg* was isolated from a nurse, four children and an adult patient in the same hospital.

Thirteen animal strains were isolated in the period August 1964 to November 1965, and latterly three more were isolated in early 1967. Of the thirteen strains, six were from turkey poults on two farms, three from chicks, and the rest from a duck farm, a ewe flock and a dairy herd (Table 1). The isolations from foodstuffs only (Table 2) have been interpreted as 'isolation weeks'; that is, the number of weeks when a laboratory isolated the serotype in a product, as it was not possible from the reports to eliminate the possibility of multiple sampling and reporting from single shipments or plants; it is therefore an underestimate of the actual situation. The serotype was most frequently reported by the Preston, Colindale, Hull and Cardiff Public Health Laboratories in meat and bone meals in conjunction and separately. The individual isolations from sewers, abattoirs and rivers reflect both the animal and foodstuff conditions.

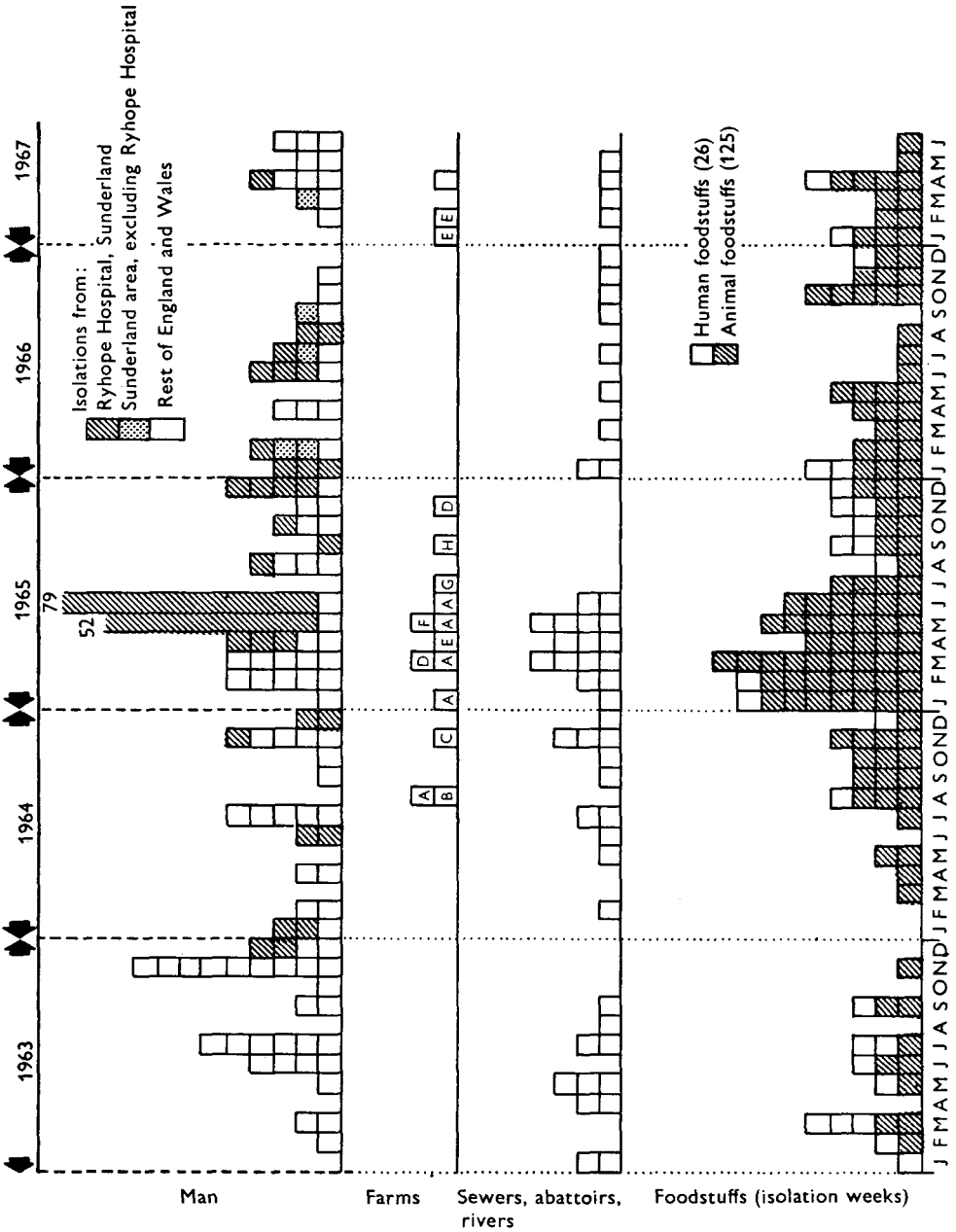

Fig. 1. Isolations of *S. senftenberg*, 1963 to June, 1967, as reported by the Public Health Laboratory Service, the Ryhope Hospital Laboratory and the Veterinary Investigation Service.

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Table 1. *Isolations of* Salmonella senftenberg *from animals by the Veterinary Research and Investigation Services, Public Health Laboratory Service, and the Houghton Poultry Research Station, January* 1963 *to December* 1966

Month	Animals	Age	Supplier	Farm
		1964		
Aug.	Turkey poults	14 days	'Z' Hants.	Farm A (Yorks.)
	Broiler chicks	14 days	'Y' Mont.	Farm B (Ches.)
Nov.	Broiler chicks	5 days	Co. I., Yorks.	Farm C (Durh.)
		1965		
Jan.	Turkey poults	5 days	'X' Yorks.	Farm A
Mar.	Turkey poults	15 days	'Z' Hants.	Farm A
	Duck	?8 weeks	Farm D	Farm D, (Lincs.)
Apr.	Turkey poults	4–5 weeks	Farm E	Farm E, (Scot.)
May	Cows	Adult	.	Farm F, (Sussex)
	Turkey poults	13 days	'X' Yorks.	Farm A
June	Turkey poults	?	'X' Yorks.	Farm A
July	Ewe flock	Adult	.	Farm G (Yorks.)
	(? broilers)		('V' Yorks.)	(farm G_2)
Sept.	Layer chicks	6 days	'U'	Farm H (Essex)
Nov.	Ducks and geese	Not available	Farm D	Farm D

Table 2. *Isolations by 'isolation weeks'* of* Salmonella senftenberg *from various animal and human foodstuffs by Public Health Laboratories, January* 1963 *to June* 1967

(The figures are taken from the P.H.L.S. Weekly Salmonella Reports.)

Public Health Laboratory	No. isolation weeks	Feedstuffs	No. isolation weeks
Hull	25	Animal	125
Cardiff	25	Meat and bone meal	42
Colindale	24	Bone meal	26
Preston	19	Imported bone meal	10
Liverpool	13	Meat meal	17
Bristol	10	'Animal foodstuffs'	11
Ipswich	7	Fish meal	5
Northallerton	5	White fish meal	2
Glasgow	5	Imported fish meal	2
Conway	4	Protein concentrate meal	4
Newcastle	2	Cotton cake meal	2
Wakefield	2	Calf milk powder	1
Coventry	2	Feather meal	1
Manchester	1	Pig feed	1
Lincoln	1	Soya bean meal	1
Bournemouth	1		
Guildford	1	Human	26
Brighton	1	Imported Meat	11
County Hall	1	Dried Egg	8
Epsom	1	Coconut	5
Sunderland	1	Prawns, Yeast	2
Total	151	Total	151

* Number of weeks in which a laboratory isolated *S. senftenberg* in a product.

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POSSIBLE SOURCES OF INFECTION

There were three questions to be answered in relation to possible sources outside Ryhope Hospital: was there a relationship between the known farm isolations and Ryhope Hospital, how did the serotype reach the farms, and what were the circumstances of its isolation on the farms? The last question will be covered in a separate paper (Hugh-Jones, 1969). Visits were made to all farms concerned, where possible, either by M.H.-J. or by the Veterinary Field Service. The relevant background information was provided by the laboratories and the Medical Officer of Health concerned. The feed companies were most helpful in providing details of feed constituents and the results of their own bacteriological examinations.

Relationship between known farm outbreaks and Ryhope Hospital

The hospital was provided with poultry by a firm which retails frozen dressed turkeys and slaughters chickens. The majority of the chickens were older laying birds which had been cleared from local battery units as they came off lay. The firm also bought in prepared chickens from a large concern which bred, reared, killed and packed their own birds. The turkeys came from three companies. There was an indirect connexion between one of these companies, company I, and farm C (as in Table 1). The turkeys hatched and reared by company I poultry hatcheries at their central establishment, and the broiler chickens at farm C, were fed on feeds from the company I feed compounders. The second of the three turkey companies regularly bought turkeys from farm E. There was a relationship between the turkeys on two farms on which *S. senftenberg* had been isolated and Ryhope Hospital.

On tracing the birds in the opposite direction—that is, from the farms—it became clear that although contracts controlled a fraction of the birds passing from farms to particular retail outlets, a significant proportion of birds could not be traced once they left the farm. This was not due to lack of co-operation by those concerned. These birds went either to large markets, such as Smithfield, or to wholesale chains which had widespread and numerous outlets. In either case an individual bird could be eaten anywhere in England.

Sources of infection on farms

On the eight farms recognized in 1964 and 1965 to have *S. senftenberg*, the animal species involved were turkey poults and growers, broiler and layer chicks, ducks and geese, ewes and cows. In spite of the variety of animals and ages suggesting a food-borne infection the possibility of a hatchery-disseminated infection was investigated. The true origins of day-old poultry are never completely certain because of hatcheries selling other birds to make up orders, but no poultry farm had knowingly received chicks or poults from hatcheries supplying any of the other farms (Table 1). The Veterinary Investigation Service salmonella records from January 1964 to June 1966, inclusive, were searched for other serotypes isolated from the relevant hatcheries and farms. As some of the flocks are accredited with

the Poultry Health Scheme, inquiries were also made from their records with the Divisional Veterinary Officers in their areas. Farms A, C and H had no histories of serotypes other than *S. senftenberg* being isolated. Farm B had an isolation of *S. typhimurium* in March 1965, from turkey growers. This agreed with the information gained directly from the farms when they were visited. But in January 1965, on farm A, 147 of 2600 poults had died by the fifth day. The initial diagnosis was 'failing to start to eat', but *S. senftenberg* was isolated from their yolk sacs. Inquiries showed that it was probable that the hatchery supplying the day-old poults had obtained infected eggs from farm E. Farms D and E are parts of large complexes with their own hatcheries and extensive trade in young stock. The duck farm D had a severe salmonella problem involving a number of serotypes but *S. senftenberg* was isolated once on the farm and from a duck in the local slaughter-

Table 3. *Constituents of poultry feeds*

+ = constant, ± = alternates, (+) = not constant. Under 'Scandinavian herring meal', N = ex Norway, I = ex Iceland, D = ex Denmark, S = ex Scotland.

	Maize/maize gluten	Sorghum	Soya	Sunflower/sesame	Wheat/oats/barley	Brewer's yeast	Distiller's grains	Vegetable fats	Fish meal (imported)	Scand. herring meal	White fish meal (Co. V)	White fish meal (Iceland)	Feather meal	Meat/meat and bone meals	Farm and feed at time of isolation(s)
Company I															
Broiler starter crumbs	+	+	+	.	.	.	+	+	.	NDI	+	+	.	.	C
Turkey prestarter	+	.	+	.	.	+	.	+	.	+	+	+	.	.	.
Turkey starter	+	.	+	.	.	+	.	+	.	+	+	+	.	.	.
Turkey grower 1	+	.	+	.	+	+	.	+	.	.	+	.	.	.	.
Turkey grower 2	+	±	+	.	±	+	.	+	.	.	+	.	.	.	.
Turkey finisher	+	±	+	.	±	+	.	+	.	.	+	.	.	.	.
Company II															
Broiler chick crumbs	+	+	.	.	+	.	.	+	.	NIS	+	.	.	.	G_2
Broiler finisher pellets	+	+	.	.	+	.	.	+	.	NIS	+	.	.	.	G_2
Company III															
Layer chick mash	+	+	+	+	+	.	.	+	±	N	.	.	.	.	H
Layer chick 1	+	+	+	+	+	.	.	+	±	±	.	.	.	.	.
Layer chick 2	+	+	+	+	+	.	.	.	±	±	.	.	.	.	.
Layer rearer	+	+	+	+	+	.	.	+	±	±	.	.	.	(+)	.
Broiler starter crumbs	+	+	+	+	+	.	+	+	±	N	(+)	.	.	(+)	B
Broiler pellets	+	+	+	+	+	.	.	+	±	±	.	.	.	(+)	.
Company IV															
(*a*) Scotland															
Turkey starter	+	+	+	.	+	+	+	.	.	+	.	.	.	.	E
Growing mash	+	+	+	.	+	.	.	.	.	+	.	.	+	+	E
(*b*) Midlands															
Turkey starter	+	.	+	+	+	.	+	.	.	+	.	.	.	.	A

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house. Apart from the one time when an egg-transmitted infection may have occurred, there was no evidence to suggest that the infections were hatchery-disseminated. For example, *S. senftenberg* was isolated only from day-old poults subsequently delivered to farm A, while poultry from the same hatches delivered elsewhere were not infected.

With the exception of farm D, the names of the feeds being used at the time of the isolation of *S. senftenberg* were obtained from the farms. Direct inquiries were then made about the constituents of the chick and poult feeds as these would represent a known source, while the cows and ewes (farms F and G) might have been passing the serotype for some time before being identified as excretors. The companies supplying the feed at the times when outbreaks occurred in chicks and poults were questioned on the probable feed constituents at the time of the outbreaks (Table 3) and on *S. senftenberg* isolations from these constituents either in their own laboratories or others.

The different farm outbreaks had occurred between 1 and 2 years before these investigations were made and it was therefore fortunate that any useful information was still available. Farm C had sent twelve 5-day-old broiler chicks into a Veterinary Investigation Centre on 16 November 1964, and they had been fed on broiler starter crumbs made by company I. *S. senftenberg* was recovered from these chicks. The company I bacteriologist isolated *S. senftenberg* from a sample of company V white fish meal delivered to a southern subsidiary on 16 November. *S. braenderup* was also isolated. Deliveries made on 18 and 20 November contained *S. bredeney*. Another laboratory confirmed the 16 November findings but not the others. Three separate samples received by this laboratory about 20 December contained *S. cubana*. Further inquiries revealed that this particular fish-meal constituent contained only 10% of white fish meal, and that the protein level was made up with unspecified animal and vegetable proteins. All the turkey feeds made up by company I feed compounders contain company V white fish meal. It is of interest to note that the only poultry isolation of *S. braenderup* by the Veterinary Investigation Service in 1965 was in April from turkey growers on company I feed at a farm on contract to company I. The poulterer supplying Ryhope Hospital obtained turkeys from company I.

The broiler chicks on farm B were begun on company III broiler starter crumbs followed by broiler pellets. Gumboro disease broke out on the 14th day with a number of sudden deaths; *S. senftenberg* was also recovered from these birds. The starter crumbs contained both company V white fish meal and meat and bone meal, and the broiler pellets contained meat and bone meal. Unfortunately the company did not begin bacteriological examinations of their feed constituents until the autumn of 1965. The meat and bone meal could not be traced because there were various suppliers and there were delays between purchase, compounding and sale.

The birds from farm E were sent to a Veterinary Laboratory, it appears, as part of the routine examination of any dead or moribund birds, and *S. senftenberg* was isolated from them. The turkey poults were between 4 and 5 weeks old and had just been changed from a company IV turkey starter feed to a growing mash, which only differed from the former by containing feather meal and meat meal.

Unfortunately the Glasgow Public Health Laboratory only began to examine local animal feedstuffs in a regular manner in 1966 and the Scottish branch of company IV also only began to send them material at about the same time. J. E. Wilson (personal communication) exposed nineteen day-old turkey stags to an 18–24 hr. broth culture aerosol of *S. senftenberg* and recovered it from one of these birds 5 months later.

Farms A and H were provided with feeds containing Scandinavian herring meal which was common to all the farms. The chicks on farm H died in an outbreak of omphalitis (yolk-sac infection). The 14-day-old turkey poults from which *S. senftenberg* was initially isolated on farm A were part of a respiratory disease problem including aspergillosis. On this farm it was customary to move the poults at 5 weeks old to rearing sheds where they were put on a diet of company V white fish meal and grain.

The isolation of *S. senftenberg* on farm F from two random bovine dung samples occurred during a Medical Officer of Health's investigation of an outbreak of human dysentery. *Shigella sonnei* was recovered from two persons and *S. senftenberg* from six of thirteen persons examined. No disease was noted in the cows at the time nor was the source of infection discovered. The ewe flock on farm G was grazing in a field 3 weeks after it had been spread with manure from a broiler flock on a separate farm G_2. No disease was reported in these birds and 5363 broilers were reared from 5610 day-old chicks. Their diet had contained both Scandinavian herring meal and company V white fish meal.

There is thus circumstantial evidence linking animal feedstuffs with the farm outbreaks; white fish meal, known to have been contaminated and readily available could have been responsible. Of the five turkey and chicken outbreaks, all the birds received Scandinavian herring meal, and Norwegian herring meal in three outbreaks. Two turkey farms, C and E, could be linked to Ryhope Hospital, but because of the wide and increased prevalence of contaminated animal foodstuffs other sources of infection cannot be excluded.

DISCUSSION

S. senftenberg is widely disseminated through the country in animal foodstuffs and especially meat and bone meals. The records from the farms involved in the August 1964 to November 1965 incident would suggest that outbreaks in animals on farms can be used as indicators of the increased incidence of a serotype, although clinical salmonellosis was not associated with the isolations of *S. senftenberg*. Overt and covert individual outbreaks would increase the number of animals excreting the serotype and the duration of excretion. A general rise in prevalence of *S. senftenberg* in abattoirs and foodstuffs can be reflected in the general human population (e.g. in 1963 and 1964–65), but without the acute outbreak at Ryhope Hospital there would have been only a slightly raised incidence in the human population. Thus there is a potentially hazardous situation when a serotype is more generally available. As this can occur with *S. senftenberg*, which is relatively rare in animal and human populations, owing possibly to a lack of invasiveness or of adaptation

or to some other cause, better adapted serotypes might be expected to behave in a similar way but with more serious consequences.

SUMMARY

It was possible to demonstrate from retrospective records that a link existed between contaminated animal feedstuffs, turkeys and an outbreak of *Salmonella senftenberg* infection at Ryhope Hospital. Possibly infected or contaminated turkeys were supplied to the hospital from two turkey farms in one of which the birds were fed on contaminated white fish meal and the other had had infected birds.

This work was carried out months after the events described and would not have been possible without the help and co-operation of the Public Health Laboratory Service, The Veterinary Field, Investigation and Research Services, Houghton Poultry Research Station, The Medical Officer of Health for Brighton, Dr Rosetta Parker, and the various feed companies involved, who very kindly made their records available to us.

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