Salmonellosis in the different species of slaughterstock is reviewed. Circumstances which build up infection in animals before slaughter are considered. Improved abattoir practice is required to eliminate contamination of meat. Clean premises and equipment, a high standard of personal hygiene and good slaughtering techniques are essential. Adequate veterinary and health inspection staff are essential for effective meat inspection and meat hygiene. Veterinary bacteriological control of feed supplements of animal origin is desirable in the Republic. Scientific investigation into the incidence of salmonellosis in farm animals in South Africa is needed.

**SUMMARY**

Salmonellosis in the different species of slaughterstock is reviewed. Circumstances which build up infection in animals before slaughter are considered. Improved abattoir practice is required to eliminate contamination of meat. Clean premises and equipment, a high standard of personal hygiene and good slaughtering techniques are essential. Adequate veterinary and health inspection staff are essential for effective meat inspection and meat hygiene. Veterinary bacteriological control of feed supplements of animal origin is desirable in the Republic. Scientific investigation into the incidence of salmonellosis in farm animals in South Africa is needed.

**INTRODUCTION**

The outdated slaughter facilities in the Republic have been a long-standing matter of concern, culminating in the appointment during March, 1961, of the Government Commission of Enquiry into Abattoir and Allied Facilities which reported its recommendations in May 1964.

During the parliamentary session in May, 1965, the Government announced acceptance of certain of the Commission's recommendations, but the eventual national pattern of new abattoir development only became evident after the Minister of Agriculture's statement in the House of Assembly on April 24th, 1972. The projected new abattoirs will be required to ensure a safe and suitable meat supply for local inhabitants, as well as to comply with overseas hygienic requirements for meat exports.

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Many reviews in recent years have dealt with the food poisoning problems presented by salmonellas. This paper, regarding the abattoir implications of salmonellas, may prove helpful to the many individuals and organizations concerned with these problems in developing and operating the projected new abattoirs.

**SALMONELLOSION IN SLAUGHTERSTOCK**

Suspected food poisoning is notifiable in England and Wales. Of the 4,256 reported incidents of food poisoning in England and Wales in 1967, 3,259 were due to salmonella organisms. Salmonellas accounted for 97 per cent of all incidents of which the cause was ascertained, and for 23 of the 27 deaths from food poisoning. The commonest source of the infection in man was meat and meat products.

Food animals are the main source of salmonella food poisoning in Britain, where the most frequent causal serotypes are common in these animals and their products. Contrary to earlier ideas, livestock (including poultry) are now believed to be the main source of human salmonellosis infections in Britain. The blame for food poisoning in man falls less and less on the human excreter. Human to human spread is relatively unimportant in maintaining salmonellosis in man. The human carriers are regarded as victims of the infected environment arising from the food animals. Human infections are expected to dwindle if salmonellosis in animals can be reduced substantially.

Salmonella contamination may be spread from emergency-slaughtered and also from apparently healthy animals. Efficient meat inspection services should prevent the flesh and organs of an ill animal being distributed for food. In the abattoir, possible salmonella contamination of meat and meat products by the intestinal contents of the apparently healthy food animal itself, or by another such animal, or by man, must also be prevented by improved abattoir practice.

Beef, veal, pork and poultry are responsible for sporadic cases and outbreaks of human disease. Sheep are usually not considered a source of human salmonella infection from meat.

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Cattle

Twenty-one per cent of abattoir drain swabs were positive, and salmonellas were found more frequently where a high proportion of cattle was slaughtered. Forty-one per cent of positive drain swabs were obtained in Glamorgan abattoirs over three years. The serotypes isolated from sewer swabs in an abattoir may be different from those infecting the local population.

Clinical disease is more common in calves, but cattle of all ages may become infected with salmonellas. The clinical course is usually short, so that actively infected cattle are rarely sent to an abattoir. In any event, appropriate ante-mortem and post-mortem meat inspection procedures at the abattoir should obviate the possibility of infected meat being distributed from cattle suffering from generalized systemic salmonella infection.

The animals which recover from clinical disease, or those with subclinical infections, may remain healthy carriers, excreting salmonellas in their faeces for many years. Conditions of stress or inter-current disease may also lead to salmonellas being excreted. A survey in New Zealand showed that 13 per cent of calves and 15 per cent of dairy cattle were symptomless excreters of salmonellas. Apparently healthy active carriers and latent carriers therefore present an insidious hazard, necessitating satisfactory slaughterhouse hygiene if contamination of their carcases or others is to be avoided. A clinically normal cow, constantly excreting S. paratyphoid B and unlikely to be detected as an active carrier, is an extremely dangerous animal, likely to yield a grossly contaminated carcass.

Faecal samples are more reliable for isolating salmonella than rectal swabs. A carrier rate of 10 per cent of healthy Irish cattle was revealed by faeces testing. The carrier state may persist for at least two years. The customary methods of meat inspection cannot detect symptomless excreters and this presents a grave problem to the veterinary meat inspector. The factors which transform the symptomless carrier into a bacteraemic animal of greater disease potential need to be studied.

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Agricultural workers found salmonellas in 45 per cent of ruminal fluid specimens from apparently healthy slaughtered cattle after the viscera had been passed for consumption. Salmonellas were isolated from 18 per cent of bovine rumen samples as compared with 10 per cent of faecal samples. A greater incidence of salmonellas was found in the rumen of cattle held for a longer period between farm and slaughter. In Holland, 1.6 per cent of rumen samples yielded salmonellas, compared with 0.5 per cent of faeces samples. Salmonella positive rectal swabs were collected from 10.1 per cent of live cattle and 5.2 per cent of goats in an abattoir at Colombo. In Botswana, a salmonella carrier rate of 7 per cent was found by testing faeces samples from apparently normal cattle.

The development of intensive cattle rearing has introduced a further food poisoning risk. Associated with the changing of husbandry practice to intensive rearing of calves for producing baby beef, a striking increase of salmonella infection occurred in cattle in Britain during the ten-year period 1958 to 1967. Important causal factors were the dealing in and handling of calves from a variety of breeders or markets, together with the various associated conditions of holding and cross-infection, and possible overcrowding and unsuitable transport during distribution.

Transport conditions of animals, their penning at the abattoir and the period of holding many promote cross-infection with salmonellas. Measures will have to be taken to reduce salmonellosis in food animals and possible transfer of infection to man. The isolation rate of salmonellas 12—18 hours after cattle arrived was not significantly different from that found soon after arrival, yet the longer animals are exposed to cross-infection from latent carriers or diseased animals within the lairage the greater must be the risk from contamination and infection.

Calves

An outbreak of human infection owing to *S. typhimurium* and involving 90 people was caused by the introduction of contaminated calves' heads to butcheries. In Sweden, in 1953, *S. typhimurium* in veal was responsible for approximately 8 000 notified cases, with 90 deaths. Evidence is also accumulating of *S. typhimurium* infection of persons working in intensive calf units.
Between 1958 and 1960, an increased incidence of salmonella infection in calves was observed in Britain and a closer relationship was found between outbreaks of salmonella infection in calves and man than previously recorded. A build-up of infection within a calf rearing unit may follow the admission of infected animals. The carrier rate may reach 50 per cent in small groups of calves in certain areas. During an outbreak of S. typhimurium most of the calves excreting salmonellas were symptomless and could have contaminated an abattoir severely if sent for slaughter. Salmonellas were isolated from the mesenteric and portal lymph nodes, gall-bladder and faeces of 12 per cent of normal slaughter calves, and the incidence of S. typhimurium was 55 per cent. One to seven per cent of calves coming to two slaughterhouses from different regions in the Netherlands were positive for salmonellas. In another investigation, 23 per cent of abattoir calves yielded salmonellas of 16 serotypes with S. typhimurium the commonest in approximately half the cases.

Calves lack resistance to transport stress. On the farm they may suffer sporadically from mild or subclinical disease, but exposure to secondary aetiological factors, such as travel weariness, chilling, dietary abuse and intermittent infections, may provoke an outbreak of severe disease. Bringing calves together in early life from different farms and markets for transport over long distances under conditions of unfavourable environmental temperature, hunger, and fatigue, all serve as important stress factors. Ideal conditions for the spread of salmonellas are provided by the opportunities for cross-infection during the congregation and transporting of calves, as well as the terminal holding period in a lairage at the abattoir. During a sudden brief outbreak of S. typhimurium infection in a group of 60 calves, half were excreting salmonellas in their faeces with little evidence of clinical disease.

An increased rate of salmonella infection between farm and abattoir has been reported. Compared with only 0.6 per cent positive samples from calves shortly before entry to the abattoir, 36 per cent positive faeces samples were obtained in calves held and fed together for two to five days. In New Zealand, 6.6 per cent of calves slaughtered at meat works yielded salmonellas; S. typhimurium was the most common serotype. Transit and holding times totalling less than 12 hours yielded 10 per cent of samples positive for salmonellas, compared with 40 per cent for longer times after leaving the farm.

At least 18 per cent of calves condemned for enteritis at Johannesburg abattoir during 1949/50 were infected with salmonella. The calf management problems during 1961 at Johannesburg abattoir culminated in statutory prohibition of admission into the abattoir from Friday midday until 7 a.m. Monday each weekend, and during public holiday periods.

Difficulties in feeding calves in abattoir lairages make it desirable that calves be penned in small groups and slaughtered as soon as possible after arrival. Amongst many important features aggravating calf infections are:

(i) Transportation from farm to abattoir, predisposing calves to digestive upset.
(ii) Unavoidable change of diet from farm to abattoir.
(iii) Wrong quantity of feed. Small amounts of properly mixed milk substitute at body temperature are desirable.
(iv) Irregular feeding. Calves should be fed at least twice per day.
(v) Mass feeding. Individual feeding is desirable, by bottle or by bucket. At the abattoir this is not possible owing to the practical difficulties of feeding large numbers.

Careful attention to the above factors, as well as discriminating exposure in sales yards, improved hygiene and animal management, and vaccination may reduce the incidence of infection.

Pigs

An outbreak of food poisoning affecting 472 persons was associated with the occurrence of S. typhimurium in pigs. S. cholerae-suis, which is almost host-specific for the pig, is usually responsible for incidents of acute or chronic disease. The incidence of salmonellas in the mesenteric lymph nodes of healthy domestic animals was investigated: the isolation rate was higher than for faeces and S. typhimurium was the type most commonly found. Salmonellas were
found more frequently in pigs than in the other species. The examination of occasional faecal samples, or of one or several lymph nodes, is misleading as they indicate only a fraction of the real salmonella infections. The many salmonellas causing subclinical infections in apparently healthy pigs throughout the world can usually be isolated from the mesenteric lymph nodes. Although S. typhimurium is more commonly found than S. cholerae-suis in these carriers, the surveys may have underestimated the incidence of S. cholerae-suis because of suppression by the generally used culture media.

An outbreak of disease in a piggery of 200 pigs with morbidity up to 75 per cent and resulting in 15 per cent mortality, was due to S. cholerae-suis.

Healthy pig excreters were common in Britain. Infection was persistently spread from farms to breeding establishments supplying healthy, excreting pigs. Sixty specimens were positive from 500 healthy pigs at an abattoir in Essex. Salmonellas were isolated from the tissues and livers of 15 out of 18 clinically normal pigs excreting salmonellas in their faeces. Nevertheless, a recent appeal by a survey team asks for information concerning actively infected pig herds, because the investigation of nearly 12,000 pigs has revealed only 1.47 per cent of symptomless excreters.

In the Netherlands, 25 per cent of normal slaughterhouse pigs harboured salmonellas in the mesenteric and portal lymph nodes and faeces, as well as an internal infection of the meat (0.5—1.5%), and of the organs (diaphragm 5.5%, spleen 3.3%; liver 3.7%). Normal slaughterhouse pigs suffering infection of the meat and/or organs constitute a serious problem of meat inspection. Salmonellas were isolated from 36 per cent of faeces samples from pigs and from 30 per cent of mesenteric lymph nodes in carcasses passed for human consumption. The salmonella infection rate in the portal and mesenteric lymph nodes and faeces of normal pigs slaughtered in 7 abattoirs in the Netherlands increased from 25.3 per cent in 1960 to 30.1 per cent in 1969. Salmonellas were found in 12 per cent of mesenteric lymph nodes of pigs slaughtered in Athens.

In an Australian abattoir 27 per cent positive results were obtained from the intestine and mesenteric lymph nodes of slaughter pigs (ileum 18%; colon 17%; lymph nodes 15%). Salmonellas were isolated from 8.7 per cent of carcases examined at slaughter. Canadian workers detected salmonellas in the mesenteric lymph nodes of 20 per cent of pigs investigated, which procedure they believe to be the most effective means of isolating salmonella from pigs. In Dakar, 28 serotypes of salmonellas were isolated from the mesenteric lymph nodes of 137 healthy, slaughtered pigs.

After accidental S. typhimurium infection of pathogen-free pigs, this organism was excreted sporadically in the faeces for 6 months and S. typhimurium was present in the tissues in various sites up to 6 months after clinical recovery (e.g. tonsils: 10 out of 12 cases).

The frequency of infection in apparently normal pigs means that abattoir personnel must constantly be alert to the public health hazards which may originate in the abattoir and can be conveyed by pork products. In 1946 a large outbreak of meat-borne salmonellosis, affecting approximately 4,000 persons and resulting in 3 deaths, came from infected pigs in Essex. At the Colindale Central Laboratory, S. cholerae-suis was isolated from approximately 10 humans per year between 1950 and 1966.

The incidence of infection in pigs before they leave the farm is less than after they have been held at the abattoir before slaughter. Seven per cent of pigs at the farm were positive, compared with 25 per cent in the abattoir holding pens and 50 per cent on the killing floor. Another survey established that only 2.9 per cent of pigs examined immediately after arrival at the abattoir were excreting salmonellas in their faeces but that holding pigs for one to seven days increased the incidence to 13.5 per cent. Positive caecal swabs were derived from 9.1 per cent of pigs held 1—7 days at the abattoir as compared with only 3.2 per cent for pigs held less than one day. The mesenteric lymph nodes from 5 to 11 per cent of short-stay pigs were positive for S. brandenburg compared with 32 to 91 per cent of long-stay pigs kept two days to one month or longer before slaughter. Limiting the duration of the stay in the lairage and preventing overcrowding, substantially reduce the proportion of animals found to be infected at slaughter. Salmonella-excreting pigs which had consumed infected

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feed ingredients on the farm were responsible for the build-up of salmonella infection in contact pigs in the contaminated abattoir environment\textsuperscript{174}. After four hours transport, 21 per cent of previously negative pigs were giving positive rectal swabs. After 12 to 19 hours in the holding pens, this was reduced to 2.5 per cent, but 23 per cent of caecal swabs were positive after slaughter\textsuperscript{173}. Twenty-eight per cent of the faecal samples from pigs slaughtered on arrival at the abattoir were infected as compared with 44 per cent after pigs had been held in lairage for 1 to 2 days\textsuperscript{175}. Of caecal swabs, 3.2 per cent positive ones were obtained from pigs retained less than 24 hours, compared with 9.1 per cent from pigs retained for one to seven days\textsuperscript{176}. Despite a low rate of salmonella infection at farms, the isolation of salmonella from mesenteric lymph nodes increased from 5 to 11 per cent after one day at the slaughterhouse, and to 32 to 96 per cent in pigs held for longer periods\textsuperscript{177, 178}.

After marketing, mixing and holding, pigs have an increased infection when examined at slaughterhouses. The risk of infection of healthy animals in contact with diseased animals or latent carriers is increased, as well as the risk of contamination of meat from animals of the group.

An alternative point of view is presented by other investigations, which show that the differences in the rate of recovering salmonellas at the farm and slaughterhouses are the result of physiological change rather than active infection, i.e. the pigs react to the stresses by an evacuation of the caecum with rapid passage of faeces, thus preventing control of the numbers of salmonellas by the host's defence mechanism\textsuperscript{179}. After 20 rectally swabbed salmonella-negative farm pigs had been transported in a specially cleaned motor lorry for approximately 3 hours, further rectal swabs showed that 6 pigs (30\%) were excreting salmonellas\textsuperscript{177}. Rectal swab measurement of the undisturbed pig cannot be taken to indicate salmonella infection in a meaningful way, so that the extent of pig infection on the farm does not appear to be measurable. It is believed that the changed bowel action owing to stress results in detectable excretion of the infectious agents previously unascertainable by the usual methods. Temperature extremes of hot or cold weather may also act as a contributory stress factor, leading to increased prevalence of salmonellas\textsuperscript{178, 179}.

Against the general idea that prevalence of salmonellas in market swine is attributable to contaminated abattoir holding pens, a build-up of infection may represent an exacerbation of existing infection\textsuperscript{173}. Investigations concerning the presence or absence of salmonella serotypes before and after marketing have in fact suggested that the high prevalence of salmonella-infected animals at slaughter may be independent of the abattoir lairage contamination factor\textsuperscript{18, 44}.

Sheep

In Britain, salmonella infection is infrequent in sheep, which are not an important source of infection for man\textsuperscript{51, 174}. During 1966 a severe outbreak of \textit{S. typhimurium} in ewes and lambs caused the deaths of 108 animals in a flock of 800 sheep; the report is believed to be the first published account of the enteric form of the infection in Britain\textsuperscript{178}. Another outbreak, characterized by abortion, caused 5 per cent mortality amongst ewes and 7 per cent amongst lambs\textsuperscript{58}. From 1958 to 1967, \textit{S. abortus-ovis} was involved in 481 of 768 episodes of salmonella infection in sheep (62.8\%), followed by \textit{S. dublin} (26.4\%) and \textit{S. typhimurium} (7.4\%) and others. No cases of human food poisoning were reported as being due to \textit{S. abortus-ovis}, which is host specific for sheep\textsuperscript{142}. In Australia and New Zealand, sheep salmonellosis outbreaks are common\textsuperscript{58, 134, 140}. Intensified husbandry and housing of sheep in future years are likely to aggravate salmonella infections\textsuperscript{51, 82}.

Horses

Greater salmonella contamination of horsemeat was found amongst horses slaughtered on the first three days of the week, compared with horses slaughtered on Thursdays and Fridays on arrival at the plant. This was attributed to infection in the holding pens amongst the horses held in the abattoir lairages over the week-end\textsuperscript{142}.

Contamination of imported horsemeat has frequently been reported\textsuperscript{45, 87, 168}.

\textbf{IMPORTED MEAT}

Of samples of frozen meat imported into the United Kingdom between 1959 and 1961, 2.9 per cent were infected with salmonellas\textsuperscript{87, 62}. During the years 1961—63 salmonellas were frequently isolated from frozen, packed, boneless meat imported into Britain.
for human consumption (veal 18.5%; beef 15.2%; mutton 9.8%). Salmonellas were isolated from 4.3 per cent of samples of carcass meat and from 10.3 per cent of samples of boneless meat. As cutting-up, deboning, the increased handling, and the greater meat surfaces exposed favour increased bacterial contamination, boneless meats have twice the contamination rate of carcass meat. Approximately 42 per cent of samples of horsemeat and 50 per cent of samples of horse offal were contaminated with salmonellas. In 1965 the positive results obtained for meat imported from Holland were: carcass meat 6.2%; boneless meat 7.4%; offal 8.6%. Horsemeat from South America was found to be contaminated with salmonellas to the following extent: carcass meat 15%; boneless meat 57%. Sixty-one per cent of samples of imported boneless horsemeat were contaminated with salmonellas.

Beef imported into the United Kingdom from Botswana in 1960–61 was found to be salmonella-infected. Continued contamination of beef exported from South West Africa into Britain during 1971/72 was traced to Ovambo operators carrying the same serotype of Salmonella detected at Southampton.

**PETS' MEAT**

A chain of salmonella infection has been demonstrated from the farm via knackers-yard, pets' meat shop and kitchen to human beings. Pets' food is an important source of human salmonellosis. Twenty-seven per cent of samples of horsemeat, sixteen per cent of other raw meat and twelve per cent of prepared meat were contaminated by salmonellas. Salmonellas were isolated from 94 of 375 samples of raw meat on sale. Over a three year period salmonellas were isolated repeatedly from pets' meat.

**ANIMAL FEEDSTUFFS**

Animals eating contaminated feedstuffs suffer a latent infection and excrete organisms. Feeding slaughterstock with salmonella-contaminated foods is likely to establish a large reservoir of infection, which may pass through animals to human food and constitute a great hazard to the population.

The infection of animals by contaminated food with resultant contamination of carcasses and meat products has been considered by many workers.

Many different salmonellas occur in feedstuffs of both animal and plant origin. Feedstuffs of animal origin, such as meat meal, carcass meal and bone meal, are frequently contaminated with salmonellas. Fifty-six out of fifty-seven samples of crushed bone yielded salmonellas. A wide-spread outbreak of bovine salmonellosis resulted from the feeding of cow meal containing contaminated bone meal. Twenty-six per cent of samples of fish meal were positive for salmonellas with ten per cent contamination due to *S. typhimurium*. Foods of vegetable origin may also be contaminated.

The degree of contamination of the animal protein derivative incorporated into animal feedstuff did not improve over a nine year period. Meat meal, carcass meal and bone meal are often heavily contaminated owing to faulty processing, or to post-processing contamination from personnel, equipment, rodents, dust and dirty sacks. During the later stages of processing abattoir by-products, the salmonella-free, post-melting and expelled rendered material may become contaminated from the environment. For instance, salmonellas are isolated most frequently from the percolator area in the heat rendering plant. Contamination from this environment is an important source of salmonella organisms in meat and bone meals.

Two-thirds of samples from the animal protein meal deliveries to a feed mill were positive for one or more serotypes (meat meal 86%; feather meal 57%; fish meal 18%). Salmonellas were isolated from 9.0 per cent of raw ingredients and 2.8 per cent of finished meals from a large manufacturer, and from 13.1 per cent of raw ingredients and 9.0 per cent of finished meals from twelve other factories. Twenty-four per cent of samples of pig meal from farms contained salmonellas. Salmonellas could be isolated from the mesenteric lymph nodes of pigs without clinical symptoms fourteen days after the feeding of salmonella-contaminated feeding meals to healthy pigs. Salmonella species isolated from the mesenteric lymph nodes of 20 per cent of swine examined in abattoirs were traced to salmonella-contaminated feed supplies. Animal excretion of the same serotypes introduced with fish meal feeds was reported. The primary source of infection for baconer-pigs in a factory was traced to salmonella-contaminated feedstuffs. Salmonella-contaminated feed ingredients create a
In order to reduce the spread of salmonellas, the salmonella-containing sheep debris were sprayed monthly with a 5 per cent aqueous solution of formalin. Salmonella organisms were eliminated after two sprayings.

With the change from dairy cowsheds to loose housing, cow faeces are washed down with water to form slurry instead of being mixed with bedding to form dung. *S. typhimurium* and *S. dublin* survived for 12 weeks in cattle slurry. *S. dublin* survived 13 to 24 weeks on pasture spread with slurry. An outbreak of *S. typhimurium* caused the death of 9 cattle in a herd of 77 animals which grazed pasture irrigated three weeks previously with slurry, and the overflowing slurry also introduced *S. typhimurium* into a stream. Calves grazing pasture polluted the previous day with 10° *S. dublin* per ml of slurry became infected. Long persistence of salmonellas in slurry spread on to pastoral land constitutes a risk to grazing animals. Slurry should be applied to arable land rather than to pasture. Not more than 15,000 gallons of slurry should be applied per acre per year, and before grazing is permitted, 6 months should elapse after the organic irrigation.

A stream contaminated by human effluent is believed to have caused a serious outbreak of *S. paratyphoid B* infection in a dairy herd. Human sewage effluent on grazing land caused *S. aberdeen* infection of a herd of dairy cows. A time interval of two to three weeks between discharging settled sewage effluent on to irrigated pasture land and introducing cattle to the pasture obviates significant danger of animal infection.

Salmonella can be identified frequently in abattoir effluents. Adequate treatment of abattoir effluent is important because of its high organic content, helminthic eggs, pathogenic bacteria and infectious viruses. Seventy per cent of waste water samples from Duisberg abattoir contained salmonella organisms. Fifty-three per cent of sewage effluent was positive for salmonellas in cattle slurry. Up to 94 per cent of samples of bone meal fertilizer were contaminated with salmonellas, and the potential danger of bone meal fertilizer as a source of salmonellosis is emphasized.

Organic fertilizers may be a source of unexplained salmonella outbreaks in man and animals. Forty per cent of samples of organic fertilizers and seventy per cent of bone meal specimens were positive for salmonellas. Up to 94 per cent of samples of bone meal fertilizer were contaminated with salmonellas, and the potential danger of bone meal fertilizer as a source of salmonellosis is emphasized.

### Fertilizers

Organic fertilizers may be a source of unexplained salmonella outbreaks in man and animals. Forty per cent of samples of organic fertilizers and seventy per cent of bone meal specimens were positive for salmonellas. Up to 94 per cent of samples of bone meal fertilizer were contaminated with salmonellas, and the potential danger of bone meal fertilizer as a source of salmonellosis is emphasized.

### Manure, Sewage, Effluent and Abattoir Waste

*S. typhimurium* survived not less than 280 days in soil exposed to ordinary weather conditions, and *S. paratyphi B* not less than 213—259 days in soil from cow pastures. In order to reduce the spread of salmonellas among sheep congregated in earthen yards, the salmonella-containing sheep debris were sprayed monthly with a 5 per cent aqueous solution of formalin. Salmonella organisms were eliminated after two sprayings.

With the change from dairy cowsheds to loose housing, cow faeces are washed down with water to form slurry instead of being mixed with bedding to form dung. *S. typhimurium* and *S. dublin* survived for 12 weeks in cattle slurry. *S. dublin* survived 13 to 24 weeks on pasture spread with slurry. An outbreak of *S. typhimurium* caused the death of 9 cattle in a herd of 77 animals which grazed pasture irrigated three weeks previously with slurry, and the overflowing slurry also introduced *S. typhimurium* into a stream. Calves grazing pasture polluted the previous day with 10° *S. dublin* per ml of slurry became infected. Long persistence of salmonellas in slurry spread on to pastoral land constitutes a risk to grazing animals. Slurry should be applied to arable land rather than to pasture. Not more than 15,000 gallons of slurry should be applied per acre per year, and before grazing is permitted, 6 months should elapse after the organic irrigation.
with the usage of 500 to 1 000 gallons of water in overseas abattoirs. Increasing dilution of abattoir effluent could be expected to diminish salmonella infectivity commensurately.

CONTAMINATED MEAT AND OFFAL IN SOUTH AFRICA

Salmonellosis in South Africa constitutes a serious public health problem as well as being a frequently occurring zoonosis.

In 1959, 4,3 per cent of prospective or employed food handlers were found to be infected with salmonella or shigella organisms, despite the acknowledged limited value of examining single faecal specimens.

Of rural Bantu school children, examined regularly during twelve months, 44 per cent had at least one salmonella infection. Seventy-two per cent of rural Bantu school children in the Rustenburg area were infected with salmonella and 29,3 per cent in the peri-urban area of Witkoppen outside Johannesburg. In the Eastern Transvaal lowveld 8 of 99 Bantu school children investigated in winter and summer had either salmonellas or shigellas on both occasions, indicating a carrier state.

Notwithstanding negative bile and caecal test results for approximately 50 000 sheep and 8 000 cattle slaughterings, a variety of salmonella serotypes were found in different sites at the new Port Elizabeth abattoir. Thirty-four serotypes were isolated from 458 samples of ruminant meat and viscera investigated during a survey of the municipal abattoir and retail butcher shops in Pretoria, i.e. 7,4% positive samples.

The public health problem of human salmonellosis attributable to offal foodstuffs was investigated in Soweto township. It was concluded that the paunches and intestines from faecal contamination, giving rise to risk of infection, particularly of salmonellas. S. typhimurium (23%) and S. london (18%) were the types most frequently isolated. S. dublin was isolated on only one occasion.

The distribution of salmonella-contaminated meat because of the need for cheap protein foods has been deplored. A special orientation of environmental hygiene and general sanitation has been recommended towards improved processing and distribution of offal. A Departmental Committee of Inquiry into the cleaning and handling of abattoir offal for human consumption recommended that specific investigation be undertaken into economically feasible ways of rendering gastro-intestinal offal hygienically acceptable for use as food.

PREVENTION AND CONTROL OF SALMONELLOSIS

Despite the isolation by the late Professor Henning of approximately 600 strains of salmonellas from calves, relatively little is known about salmonella infection of slaughter stock in South Africa. Detailed monitoring of the incidence of salmonellas in South African abattoirs has not been carried out. Considerable research is needed to investigate the reservoirs in the domestic and other animal's, as well as the prevalence of salmonellas in our slaughterhouses. As with any salmonella infection, there is a public health hazard with salmonella abortion in cattle which has a world-wide distribution, including South Africa and Rhodesia, and which has similar epidemiology to salmonella enteritis.

The purpose of this paper is not to cover all the projected control measures already reviewed in many excellent publications. Matters directly and indirectly associated with the chain of transmission of infected meat via abattoir to man are mentioned, and attention is drawn to various local circumstances.

1. Farm

The prevention of salmonellosis in meat has to start on the farm.

(i) Producers will need to apply the appropriate animal husbandry measures to prevent salmonellosis in their slaughter stock. Hygiene and cleanliness are vitally important because of the trends towards intensified animal production for veal, pork and beef. Good animal housing can aid considerably in controlling salmonellosis. Improved animal husbandry and optimal hygiene offer the best hope for controlling animal infection. Accumulation of dung and mud on hide, skin, fleece and feet during finishing of fatstock should be prevent-

*See also Horton B. G. W. & Van den Heever L. W. This Jl, 43 : 251 (Ed.)
ed. Dung and mud should be removed before consignment to the abattoir. A build-up of skin contamination with salmonellas occurs when animals are placed in improperly cleaned vehicles or pens.

(ii) Bacteriological control of the manufacture of animal feeding stuffs and the institution of efficient feed sterilization methods are necessary to prevent the introduction of salmonellas to farms through contaminated animal feeds. Gamma radiation as an alternative process for heat treatment also merits consideration.

(iii) Active adult salmonella carriers should be identified and removed.

(iv) It has been suggested that clinical salmonellosis of adult animals should be declared a notifiable disease. The British Veterinary Association, however, considered that compulsory notification would contribute less to control of the disease than the adoption of a suggested code of practice.

(v) The Swann Report recommends creating a Veterinary Officer of Health, the equivalent of the Medical Officer of Health, to be responsible in each area at least for all infectious diseases of animals which may threaten public health, with the right of entering, investigating and using adequate powers to curb the spread of disease.

(vi) Warning has been given that antibiotic treatment of sick animals is ineffective and results in acquisition of transferable drug-resistant S. typhimurium of almost entirely bovine origin.

(viii) Food hygienists point to the factors at the farm which break the epidemiological cycle (sufficient colostrum, regular feeding, isolation of purchases, early treatment of disease, superior housing, effective cleaning and disinfection); and to the slaughterhouse need for comfortable transit, humane ante-mortem penning and handling, best standards of slaughter and bacteriological aids to diagnosis.

2. Transit

Improved treatment of food animals being transported to the abattoir by rail and by road is desirable, e.g. direct marketing, comfortable accommodation, cleanliness and reasonable duration. Seepage on to and contamination of the bottom sheep on a double decker vehicle is undesirable. Careful hand-

3. Abattoir

There is no practical means of detecting slaughter animals with a subclinical infection. Each infected animal is a potential source for the spread of salmonellas in the abattoir. An infected cow without clinical sign of disease excreted S. paratyphi B for five months and was likely to escape detection as an active carrier during life and as a grossly contaminated carcass after death. During an outbreak of S. typhimurium infection most of the calves excreting salmonellas were symptomless so would have spread infection at a slaughterhouse. In order to minimize cross-contamination of slaughter animals, and of their carcasses and offal, the over-all abattoir environment needs to be improved, from off-loading the animal to the final dispatch of meat and offal from the abattoir.

(i) Lairage: Important considerations are:

(a) suitable design of lairages, feed and water troughs and hayracks;

(b) regular cleaning of lairages to reduce build-up of bacteria and contamination of the animal exterior;

(c) adequate pre-slaughter rest;

(d) optimal animal management;

(e) minimal feeding to prevent pre-slaughter loading of the alimentary tract;

(f) shortest possible time of holding stock before slaughter;

(g) veterinary ante-mortem inspection;

(h) separation of stock suspected of disease for slaughtering separately from healthy animals.

(ii) Slaughterfloor: It is essential to prevent faecal contamination of carcass and offal by employing good techniques of slaughtering, dressing, meat inspection and handling carcasses. The practical requirements are stated in many excellent publications.

(a) Premises and fittings: Effective clean-up procedure of premises and plant is necessary, and the state of cleanliness must be ensured by bacteriological surveillance.

(b) Personnel and equipment: Essential features are:

(i) the cleanliness of the equipment (clothing, hands, knives and scabbards);
(ii) the immediate washing of hands and equipment whenever they become contaminated;
(iii) adequate and convenient hand-washing water spray facilities;
(iv) effective sterilization of knives, steels and scabbards;
(v) regular cleaning of mechanical flayers, saws, leg- and brisket-cutters, containers and hide-pullers.

The shortcomings of the current methods of cleaning hands and knives do not prevent indirect contamination of meat. Knives, for example, must be immersed for 2 minutes at 82°C (180°F) to reduce the count of contaminating organisms to $10^2$ per square centimetre.

Persons who work as abattoir operators are insensitive to cleanliness and resist change. Coercion is necessary to ensure that regular washing of hands after toilet use becomes habitual. A hand-washing water spray is preferred to a basin, with warm water at a controlled temperature issuing from a single point. Even if a hand basin is not fitted with a plug, the outlet will be plugged and the hands rinsed in filthy water. Supervision is necessary to ensure effective hand washing. Strategic placing of basins in view of everybody and also where observation can easily be maintained, such as outside a toilet door, may prove helpful. Washing the hands with soap and warm running water for 15 seconds is needed to remove an inoculum of 100 or less salmonellas per finger-tip, while larger inocula leave viable salmonellas on the hands even after such washing.

Education and practical demonstration are needed to motivate abattoir operators to work hygienically, and to have increased pride in their work, knowing that they are doing all they can to prevent contamination of food.

(c) Slaughtering, dressing and handling carcases: The transverse cutting of the throat generally performed in South African abattoirs for bleeding cattle spreads salmonellas and other contamination. It is time that the throat cut was prohibited in favour of sticking, except for ritual slaughters. The tongue and cheek meat commonly contaminated by ruminal contents should be washed thoroughly with hot water to remove infection.

Salmonella contamination of meat is essentially gastrointestinal pollution. Therefore, ligature of the oesophagus before severance, and tying of the rectum, are important. It is also important to prevent the hide or fleece from contaminating the surface of the carcass, and to avoid puncture or rupture of the alimentary tract, or the opening of the viscera, on the slaughterfloor. Transfer of contamination by splashing on to the carcass, and from personnel and equipment, should be avoided.

(d) Meat inspection: The purpose of meat inspection is to prevent food poisoning in man. Only sound healthy meat free from contamination must leave the slaughterfloor for human consumption. Deficient personnel means a reduced standard of meat inspection and increased risk to the consumer. Clearly then, provision to attract adequate numbers of competent veterinarians and meat inspectors must be accorded priority. Successful slaughterfloor supervision rests upon these individuals to break the chain of transmission from infected food to man at the level of the abattoir.

Owing to the poor image of the veterinarian in abattoir work, meat inspection does not attract veterinary students and graduates in New Zealand. A chronic reluctance on the part of veterinarians to take up abattoir appointment also prevails in Johannesburg. The unattractive slaughterhouse environment cannot compare with the more pleasant working conditions in State research and field work and in university teaching, and abattoir remuneration lags behind the steadily improving potential of veterinary private practice and commercial and university employment.

A serious shortage of meat inspectors over the past 20 years in the Witwatersrand and Pretoria and elsewhere has not yet been relieved, and deserves urgent attention.

The population needs an adequate supply of food. The meat industry is vital in the local and national economy (the Johannesburg meat output alone is worth approximately R60—70 million per annum at the primary cycle of distribution) and abattoir staffing deficiencies affect producers, traders, consumers and many others. Adequate veterinary and technical supervisory abattoir personnel is essential to ensure that the meat is sound and healthy. The vital public health problem of possible faecal pollution of meat supplies will persist until the chronic deficiencies of abattoir veterinarians and meat inspectors are suitably corrected.
(e) Bacteriological meat inspection: Bacteriological examination of meat is an important aid to acceptance or rejection of carcasses conditionally passed at visual inspection 69, 111, 128, 160. Laboratory methods are also indispensable in ensuring a high standard of abattoir hygiene. Already unseen dirt and contamination receive considerable attention in overseas countries. Laboratory procedures, therefore, must become a regular feature of meat inspection 128. This will require proper laboratory facilities under the control of veterinarians trained in abattoir laboratory procedures 32.

(f) Contamination of meat:

(i) Cleaning: Requirements for improving the sanitary dressing of carcasses of sheep and lambs have been adopted by the New Zealand meat industry 97. Soiling is best washed off the surface by water spray before drying occurs 114.

(ii) Papering: Contamination of lamb and mutton carcass may be diminished by protecting the surface of the freshly exposed crutch and brisket by applying water-proof paper 114.

(iii) New techniques for dressing sheep: Improved techniques may be applied for removing the carcass from the skin in order that the carcass will not be contaminated by loose flaps of skin 47.

(iv) Washing: The unopened, flayed carcass is best washed immediately the hide or fleece is dropped. When dressing has been completed, there should be a final washing of the upper and lower carcass by suitable high pressure water sprays 8, 83, 98.

A fan jet at a dynamic line pressure of 21429.6 Pa (100 p.s.i.), with a surface water temperature of 60°C (140°F), surface impact of 32.14 Pa (0.15 p.s.i.) and flow rate of 8.5 L/min (1.9 gallons per minute) yields clean lamb carcasses with good bloom and relatively low numbers of residual bacteria. Spraying the carcass for 1 minute, as compared with ¼ minute, reduces the residual carcass bacteria 4.

(v) Cleaning aids: Warm washing water at 43°C is advantageous. Residual free chlorine up to 20 ppm in the wash water is an additional precaution to offset unavoidable bacterial contamination 8, 83, 98. The use of chlorinated washing water was beneficial at all concentrations from 15 to 350 ppm 6.

(vi) Bacteriological check: Bacteriological monitoring of the surface cleanliness of the freshly dressed and chilled carcasses is necessary to correct defective slaughter floor practice 28, 49.

(vii) Refrigeration: Some microbial contamination will occur even with the best slaughterhouse hygiene; refrigeration is essential to check proliferation of food poisoning and spoilage organisms. As salmonellas can multiply at temperatures below 10°C (50°F), a chilling temperature below 4°C (40°F) is recommended to restrain the growth of the accidental bacterial contaminants and to reduce the food poisoning hazards 150, 151, 171.

(viii) Meat transportation: The preceding precautions are worthless unless carcasses are properly loaded and transported in mechanically refrigerated, enclosed vehicles.

(ix) Animal by-products: Statutory control of the abattoir production of by-products must be vested in veterinary authorities 72, 128. Contamination of the animal by-products at the abattoir must be avoided by rigid isolation of the raw materials area, together with its associated personnel, change-room, eating and toilet facilities, from the processing side of the by-products plant; and by proper plant clean-up 46, 67, 184.

Code of Abattoir Practice

The drawing up of a code of abattoir practice recommended in 1964 by the Commission of Enquiry into Abattoir and Allied Facilities has not yet proceeded 123.
A code of practice providing guidance by laying down minimum standards concerning all aspects of hygiene is called for, in order that the various individuals and interests who handle slaughter stock and carcases will appreciate and apply the procedures necessary for good meat hygiene, e.g.—

(i) factory practice relating to the abattoir;
(ii) the ante-mortem treatment of the slaughter animals;
(iii) the slaughtering, dressing and inspection of animals;
(iv) the treatment of carcases and condemned material, and the removal of carcases, offal, hides and skins and other products;
(v) the transport of carcases and edible offal in distribution from abattoir to wholesaler and to retailer;
(vi) general practices regarding meat hygiene.

Abattoir Personnel: Health Examination

The U.K. regulations require that persons suffering from salmonellosis be excluded from employment in abattoirs and processing plants exporting meat to Britain. The European Economic Community demands that for intra-community trade in fresh meat the operators in an abattoir must be free of active or carrier states of infectious enteritis (salmonellosis, including typhoid fever and paratyphoid A and B). Other carrier states must also be excluded, such as dysentery, infectious hepatitis and scarlet fever, and contagious tuberculosis. In South Africa the Standing Regulations under the Animal Slaughter Act require that no person who is suffering from a communicable disease or is a carrier of any infectious disease shall handle meat in an abattoir.

During 1971 and 1972 the abattoir operators at Johannesburg were examined medically with the co-operation and assistance of the Medical Officer of Health and the South African Institute for Medical Research according to the following schedule:

(i) Thoracic X-ray examination.
(ii) Laboratory blood tests.
   (a) Widal agglutination tests (lowest serum dilution 1/50)—
      - S typhi O
      - S typhi H
      - S paratyphi AH
      - S paratyphi BH
      - S paratyphi CH.
   (b) Vi agglutination test (lowest serum dilution 1/10)—

Further blood tests or stool and urine samples for *S. typhi* "Vi" culture were done on persons showing significant Widal/Vi titres, finally giving 15 positive results out of 824 (2%).

There is doubt concerning the efficacy of this type of health examination. The rectal swab culture method cannot be relied upon to detect carriers unless several swabs are taken, the number depending upon the duration of the carrier state and the number of organisms excreted. Regular examination of staff excreta is unlikely to be a profitable means of discovering carriers, nor of preventing contamination of food products. Anderson has warned against over-playing the human element in the epidemiology of salmonellosis, perhaps resulting in wasted effort examining food handlers for infection, while the salmonellas continue to enter food establishments in meat and poultry.

Exporting abattoirs will perforce have to comply with the health requirements demanded by importing countries. The majority of slaughterhouses in the Republic, however, serves the local population, and these slaughterhouses require a clear directive from the health authorities prescribing the specific medical tests for personnel, the frequency of testing and other technical details. Until the Government authorities define the national policy, uniform procedures for testing the health of slaughtermen and handlers of meat are unlikely to evolve.
6. Shop, Home and Kitchen

The possibility of manually transferring salmonellas from infected raw meat was demonstrated by the isolation of enteric organisms from the fingers of 13 of 110 butchers, as compared with negative findings from 100 people not handling meat. Nearby. Unless shop hygiene is good, widespread contamination of surfaces and equipment may promote outbreaks of food poisoning. Defective shop hygiene can spread a source of infection widely. Rigid separation of cooked meat from raw meat during processing, slicing, packing, storing, transporting and display is necessary as is also the avoidance of cross-contamination by personnel (separate clothing). Outbreaks of food poisoning cannot be excluded absolutely from raw meat due to the hazards of contaminating food from infected raw meat via hands, surfaces, clothes and utensils; or of inadequate time and temperature of cooking; or of lengthy ambient temperature storage of joints and meat dishes after cooking.

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