FIELD AND EXPERIMENTAL EPIDEMIOLOGY OF SALMONELLA INFECTION IN CALVES

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SUMMARY

A survey of 2,868 calves, approximately 4 days old, from 78 randomly-selected dairy farms showed a low level (<1%) of animals excreting salmonella organisms in the faeces. Where young calves are congregated in large groups, rapid transfer of infection can occur. Retaining calves on the farm until 14 to 21 days of age is likely to reduce cross infection occurring during transport and holding prior to slaughter.

Salmonellae can be isolated from 14- to 21-day-old calves either dosed with approximately 10^6 *Salmonella typhimurium* at 2 days of age or exposed to infection from other excreting calves on the farm. The longer calves are retained on a property the more likely are they to clear themselves of *S. typhimurium* infection. Where calves are brought on to a property at a young age for rearing, isolation in groups for two to three weeks is sound husbandry practice. Clinical salmonellosis in young calves is often associated with poor hygiene and management.

THERE have been many published reports throughout the world on the presence of salmonella organisms in apparently healthy animals and in foodstuffs, particularly those of animal origin. The increase in literature on this subject is probably due to improved techniques of detection of organisms and a greater awareness of the public health importance of salmonellosis. With present techniques, it is difficult to produce salmonella-free food from infected livestock, although improvements in meat hygiene can ensure that the level of contamination is kept as low as possible. Therefore, avoidance of salmonella infection in the live animal is desirable and study of methods of husbandry directed towards that objective would seem worth while.

The purpose of this paper is to report studies on salmonella infection in young dairy calves and discuss methods of husbandry which may lead to a decrease in the incidence of infection.

FIELD EPIDEMIOLOGY OF SALMONELLA INFECTION

In this country, virtually all cows calve outside; calving usually occurs in a "maternity" paddock close to the milking shed or house, or it may occur anywhere over the whole property or on a run-off. There is little evidence that pre-

natal infection occurs with the salmonella serotypes (predominantly *S. typhimurium* and *S. bovis morbificans*) present in New Zealand. If the cow is suffering from clinical salmonellosis during parturition, indicated by acute diarrhoea, high temperature, low milk yield and almost complete loss of appetite, then it is most likely to be excreting salmonellae in the colostrum. However, the number of animals affected is low. On farms where infection is present, observations on clinically normal cows soon after parturition show salmonellae in the faeces and on udder and teat surfaces of some cows, but not in the milk. In most instances, the calves from these cows are excreting salmonellae within 24 to 36 hours after birth.

Besides direct cow-to-calf transmission, the presence of salmonella organisms in the environment of calves can also result in calfhood infection at an early age. It is usual to bring recently-calved cows and calves to the dairy shed for preliminary inspection and milking. The young calf is placed in a small paddock, yard or shed for varying periods. After a day or two, the cow may be run with the herd, and the calf allowed to suckle for a short period twice daily prior to being sent for slaughter or retained and kept with the older calves. These maternity and/or feeding areas usually bear a heavy "through-traffic" and, if there are cattle in the herd excreting salmonellae, these paddocks can become grossly contaminated. Furthermore, the environment of these areas usually favours persistence of the organisms.

Various factors appear to accentuate spread of infection when calves are run together. The most important is probably the overall hygiene of the feeding equipment, housing and environment of the young calf. Observations on field outbreaks of disease show that in the majority of instances the feeding equipment used is grossly contaminated. As salmonellae can be recovered from the mouths of infected animals, the habit of calves sucking one another tends to spread infection, particularly during or after feeding. Robinson (1966) has demonstrated cross-infection between calves using contaminated feeding equipment. The use of feeding equipment where animals are able to move from one teat to another also probably assists the spread of infection.

Salmonellae have also been found in bulk milk containers on occasions where disease is present in the calves. In these circumstances, heat treatment might be undertaken to prevent unnecessary spread of infection. Although pathogenic bacteria are not normally present in manufactured

milk powders, these materials can be readily contaminated by hands, utensils or even rodents and can act as a medium for multiplication of organisms when reconstituted. In these circumstances, the practice of reconstituting milk powders more than four hours before use and leaving at room temperature is not a wise procedure.

Overcrowding of young calves particularly during inclement weather in poor housing can also assist the spread of infection. Some calf houses are unsatisfactory since regular or even efficient cleaning is virtually impossible. The importance of contamination due to environmental conditions is shown by the observation of British workers (E. A. Gibson, pers. comm.) that four uninfected calves, placed in a loose box occupied 12 months previously by a cow excreting *S. dublin*, subsequently commenced to excrete this organism within 2 to 4 days. In New Zealand, there have been several reports of losses from salmonellosis when calves were housed in shearing sheds, pig houses or poultry houses. If the housing used cannot be readily cleaned, particularly between groups of calves, it may be advisable to resort to some form of temporary shelter.

So-called "stressing" or "nutritional" factors are often invoked as precipitating an outbreak of salmonellosis. However, it is likely that much disease may be due to overcrowding and poor hygiene resulting in exposure of animals to high numbers of salmonella organisms. There is no evidence that debilitated calves are more likely to harbour salmonellae than apparently healthy calves (Robinson, 1965), although little is known of the interactions of salmonellae and intercurrent diseases.

TABLE 1: SURVEYS OF SALMONELLA INFECTION IN BOBBY CALVES

Calves on farms (1965)		
No. of farms surveyed	78	
No. of farms with salmonella-excreting calves	8	
No. of calves examined	2,868	
No. of calves excreting salmonella organisms	25	(0.87%)
*Calves at Meat Works (1959–61)**		
No. of calves examined	1,110	
No. of calves infected	140	(12.6%)

* Nottingham and Urselmann (1961).

Where calves are forwarded for sale at a young age, the risk of cross-infection is likely (Anderson *et al.*, 1961). The results of surveys of salmonella infection in bobby calves (Table 1) from randomly-selected farms in one calf-collection area, and at meat works, also suggest the likelihood of cross-infection occurring. Although in the survey of calves on farms, some infected animals may not have been detected owing to the absence, or very low numbers of salmonellae in the faeces, a comparison of the data from the two surveys appears to substantiate the belief that the young calf is very susceptible to infection. Thus, in the survey of calves on farms, 18 of the 25 animals excreting salmonella organisms came from the one property. At this farm, 57 calves were examined and there had been a history of laboratory-diagnosed salmonellosis in adult stock within the previous year. Although no cattle excreting salmonella organisms were detected during the calving season, cows were calving in a paddock that had been used as a "hospital" area for sick animals. Furthermore, approximately 80% of the bobby calves on this farm were hand-fed at some stage under unhygienic conditions. It is postulated that some of the early calves were infected possibly soon after birth and "seeded down" the housing and feeding areas with salmonellae. The 18 calves excreting salmonella organisms showed no clinical symptoms which suggests they may have been exposed to low numbers of organisms only. The other seven excreting calves all came from different properties; again, no evidence of adult excretion of salmonellae could be detected. The origin of these calfhood infections is obscure. Conversely, salmonella excretion in adult stock has been recorded on properties during the calving period but no calfhood infection has been noted. This suggests differences in husbandry of the freshly-calved cow and calves which requires further investigation.

EXPERIMENTAL EPIDEMIOLOGY OF SALMONELLA INFECTION

Study of the response of young calves to varying dose rates of *S. typhimurium* (de Jong and Ekdahl, 1965) has shown the rapidity with which infected animals can re-excrete the organism, often in high numbers. These workers suggested that if calves were retained on the farm until at least two weeks of age the incidence of infected calves entering the meat works would be reduced. Adoption of this recommendation would mean considerable changes for

the dairy industry and reluctance of farmers to hand-feed the animals for the added period; it is also unlikely that the financial return from such a calf would be greater than from disposal of a 4-day-old animal at present. In view of the low number of excreting calves presented for sale, it may seem unfair to penalize the remaining calves; nevertheless the problem of cross-infection during transport and holding of animals at meat works is difficult to avoid (Kampelmacher, 1965). The highest standards of hygiene in transport vehicles can be demanded but probably the most important factors concerned in cross-infection of animals are the number of animals carried per unit area and the time calves are congregated prior to slaughter. Obviously any decrease in the number of animals carried per vehicle places an added financial burden on this industry; also, holding calves together for up to 5 days at the abattoir results in a high rate (36.5%) of salmonella isolation (Anderson *et al.*, 1961).

To study the spread of salmonella infection under conditions similar to current farm and transportation practice, the following types of trials were conducted during the 1965–6 dairying season: (a) Calves slaughtered 24 hours after exposure to infection from salmonella-excreting calves; (b) Calves slaughtered at varying periods after they had ceased excreting salmonella organisms in the faeces.

SIMULATED TRANSPORT AND HOLDING TRIALS

TRIAL 1

Two 2-day-old calves were dosed orally with approximately 10^6 *S. typhimurium* and at 4 days of age were placed on a truck with eight 4-day-old calves which had not previously excreted salmonella organisms. The animals were allowed 3 sq. ft of floor space per calf, transported for 25 miles and held on the truck without food for another 20 hours, and slaughtered.

TRIAL 2

This was similar to Trial 1 except that two 2-day-old calves were dosed with *S. typhimurium* and then held in isolation until 3 weeks of age. These two calves were placed on a vehicle as before with eight 3-week-old calves previously not excreting salmonella organisms and, after transport and holding for 20 hours, were killed.

In both trials, the four calves dosed with *S. typhimurium* were excreting salmonellae when joined with the uninfected calves. Examination of animals at slaughter showed that salmonella organisms were isolated from 7 of 8 calves in Trial 1 and 0 of 8 calves in Trial 2.

Unfortunately in the first trial no counts were made of the number of salmonellae the artificially-infected calves were excreting. However, observations made on other animals infected at this age have shown that 10^5 to 10^6 salmonellae/g faeces are produced about 2 days after being dosed with approximately 10^6 organisms. By the time these calves are 3 weeks of age, the level of excretion in the faeces has generally fallen to 10^2 organisms/g or less. This was true for the calves in the second trial. None of the artificially-infected calves was scouring when placed with the uninfected animals; a scouring animal if excreting salmonellae is obviously more prone to spread contamination.

SIMULATED FARM-GROUP TRIALS

Although the present studies suggested that cross-infection in 24 hours was less likely in older calves than in very young animals, trials with groups of animals under conditions found on a farm seemed desirable. Accordingly, two groups of 10 and 12 calves respectively were reared and each contained 2 animals dosed with 10^6 *S. typhimurium* at 2 days of age. A third group of five 4-day-old calves was purchased from a farm known to have produced a large number of infected calves. Fortuitously, one of the five animals was excreting salmonellae on arrival at Ruakura. Calves were set-stocked on small areas of pasture which allowed approximately 20 to 25 sq. yd per calf. Hay was given *ad lib.* and raw whole milk fed twice daily, using a "calfeteria" system. Feeding equipment was dismantled after use, flushed with cold water and then immersed in hot water for five minutes. Temporary shelter was provided in inclement weather.

Faeces of calves were examined daily for salmonella organisms. All animals were slaughtered 3 to 4 weeks after the last day of salmonella excretion and various body sites examined for infection. Figures 1 and 2 show the occurrence of salmonella organisms in the calves of groups 1 and 2, respectively. Apart from the two calves which died in the first week, salmonella excretion was recorded in all the remaining animals. However, of the 10 calves that died, only three deaths (0015, 0047 and 0048) appeared to be the direct

result of salmonellosis. Persistent diarrhoea, regular excretion of salmonellae in the faeces in increasing numbers and the isolation of the organisms from a wide range of organs after death, were considered as evidence of salmonellosis.

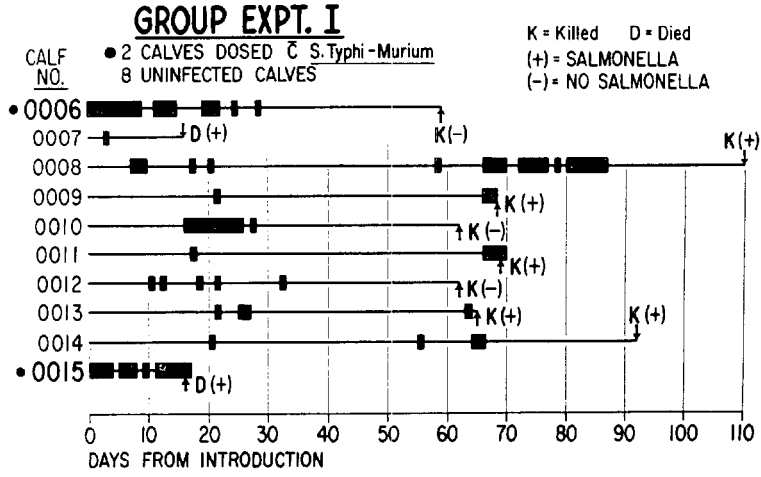

Fig. 1: The occurrence of salmonella organisms in the calves of group 1.

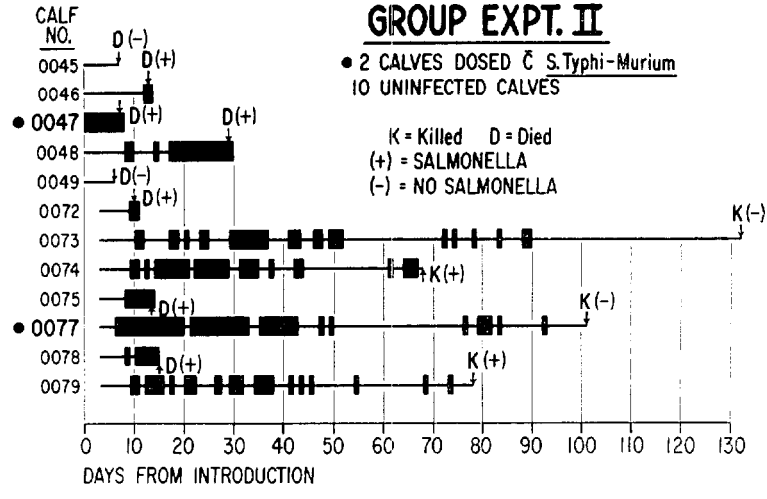

Fig. 2: The occurrence of salmonella organisms in the calves of group 2.

In some instances, limited salmonella excretion was recorded prior to death, but the organisms were isolated from the caecal or rectal contents only after death. In the absence of tissue invasion, it is difficult to ascribe these deaths to salmonellosis.

Study of the faecal excretion of calves in the first group showed that from 30 days after introduction, to approximately 60 days, there was virtually no excretion recorded. Two calves slaughtered at 62 days were negative for salmonellae. Five calves, however, commenced to excrete again during the 60 to 70-day period and salmonellae were isolated at slaughter. It is unknown whether these five calves were excreting salmonellae as a result of their original exposure to infection or whether they were subsequently reinfected. These animals were constantly re-exposed to infection since, for instance, the hay was fed off the ground and salmonella contamination was readily demonstrated in the fly population surrounding the pens. If fresh infection was acquired from the environment, then the system of set-stocking used here might influence the results considerably.

Considerably more faecal excretion of salmonellae was observed in the second group trial. This could have been due to greater prevalence of diarrhoea, resulting in more extensive environmental contamination, although diarrhoea was not always associated with the isolation of salmonellae. Two calves died within the first week with symptoms of acute diarrhoea and collapse but no salmonellae were isolated.

The results of the third group, where one naturally-infected calf was run with four non-excreting calves from the same farm, showed that on three occasions the infected animal was found to be excreting 10^2 organisms/g faeces, but salmonella infection was not detected at slaughter on day 55. Salmonella organisms were not found in the faeces or at slaughter (day 36) in three of the other calves. The remaining calf died on day 12, as a result of intussusception, and salmonella infection was found.

DISCUSSION

It is of interest to compare the results of these trials with groups of calves with observations made at a large veal-producing unit which buys calves off transport from unknown sources. At that property, calves are identified

when purchased and examined for salmonella excretion. The veal calves are slaughtered about 150 days of age when tissues are again studied for salmonellae. To date, some 300 calves have been observed and in three instances groups of excreting calves were purchased. The practice on this property is to isolate the freshly-purchased group of calves for about 21 days before placing them in a large calf house where all animals run together. Spread of infection in the isolation area has been observed but, by the time the animals are released into the main group, salmonella excretion has ceased. No excreting animals have been detected in the large calf house and at slaughter only a few animals have revealed salmonella organisms in the mesenteric lymph nodes. No clinical case of salmonellosis has occurred.

Recent work at Ruakura has suggested that the calf infected at 2 days of age will excrete salmonellae for a period some three times longer than that of the calf infected at 2 to 3 weeks of age with a similar number of organisms. Younger calves also excrete more organisms than the older calf. The importance of initially isolating young or recently-bought calves from older animals is clear; further, the isolated calves are likely to obtain better supervision particularly when being taught to drink or if requiring treatment. It is advisable to feed young calves with separate utensils and also to clean and disinfect isolation pens or sheds between groups of calves. Purchase of calves in small groups direct from another property would minimize the risk associated with purchasing infected calves.

Some farmers place great reliance in prophylactic antibiotic treatment of the milk for calves during the first few weeks of life. While there may be gains in liveweight and a reduction in the prevalence of scouring where facilities and management are poor, a reduction in either the period or rate of excretion of salmonella organisms from calves fed 50 mg daily of chlortetracycline for the first 3 months of life has not been noted. Furthermore, in many clinical outbreaks of salmonellosis, prior antibiotic feeding has had little apparent effect.

Many questions on the problem of cow-to-calf transmission of salmonella infection, particularly the sources of infection for the adult stock and also the persistence of infection within a herd, remain unanswered. Unlike the more chronic cattle diseases such as tuberculosis or brucellosis, *S. typhimurium* infection does not appear to result in chronic excretors within a herd. This could however be a reflection of the inadequacy of present diagnostic methods.

ACKNOWLEDGEMENTS

The writer would like to thank Dr K. I. Loken and Miss R. E. Allen for assistance and discussion during this work; also Miss J. Herrold, Mrs C. Clarke and D. C. Westwood for technical assistance.

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DISCUSSION

I. M. CAIRNEY: *What information is there on the persistence of salmonella organisms in paddock conditions under New Zealand climatic conditions?*

Josland (1951; *Aust. vet. J., 27*: 264) reported on the viability of *S. typhimurium* on various substances under natural conditions, such as water, pasture and faeces. Viable organisms were recovered for 4 to 28 weeks; similar studies reported by other workers confirm that viability in these environments is dependent upon factors such as temperature, pH, moisture, presence of organic material, and the presence of other antagonistic bacteria, protozoa, etc. A major criticism of this approach is that it tells little about the number of salmonellae present as the above results were all obtained with enrichment technique. If the dose rate is accepted as a major factor in determining infection in animals, then the relative level of environmental contamination becomes very important. Therefore, attempts must be made to define this on a farm basis to show whether or not organisms from pasture, sheep yards, water supplies, for example, are responsible in perpetuating infection on a property.

R. CRAWFORD: *Are increased stocking rates associated with greater morbidity in both calves and sheep? Also, are higher mortalities in sheep observed when they are heavily stocked to avoid facial eczema?*

In general, where the concentration of livestock is increased the chances of transmission of any infectious agent are increased. However, with sheep, for example, although the stocking rate over the whole farm may be relatively constant throughout the year, the morbidity as measured by the number of animals excreting salmonellae in the faeces at any one time varies markedly throughout the year suggesting that day to day management practices are important in the spread of infection. Mortalities (up to 10%) have

been observed when animals are heavily stocked to avoid facial eczema; however, recent outbreaks with similar mortalities have been seen where the stocking rates would not be considered unduly high.

DR C. S. M. HOPKIRK: *Is rat-infested calf meal a possible source of salmonella infection?*

Yes. It should be kept in mind, however, that if the meal is likely to contain animal by-products it may be recontaminated during the manufacturing process. Overseas workers place great stress on the importance of salmonella contamination of animal feeding stuffs but it appears that in this country the problem is unlikely to be very significant in the epidemiology of the disease.

DR L. R. WALLACE: *How efficient is a single faecal examination for presence or absence of infection in an animal?*

If the animal is excreting salmonellae at the time of examination it is believed that present techniques will detect approximately 10 organisms or less per gram of faeces. However, in the very recently-infected animal, it may be that excretion has not commenced. For instance, in the first cross-infection experiment where salmonella isolations were obtained from 7 or 8 calves, none of these animals was excreting at slaughter.