Salmonella Reservoirs in Animals and Feeds

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Abstract

Salmonellosis is an important worldwide problem involving all species of wild and domestic animals and fowl. With few exceptions serotypes are not host specific and cross infections are frequent. Carriers exist in most species including man. Probably no species is free of the disease. Animal feeds frequently contain the organisms. Transmission is most often due to ingestion of fecal-contaminated food or water, but infection by contact is a frequent and serious problem. Control by sanitation and protection against contamination of feeds would appear to solve much of the problem. Improved serologic methods for detecting carriers are badly needed.

In 1889 Salmon and Smith (1) isolated a bacillus from swine and proposed it as the cause of hog cholera. This was the first isolation of a salmonella from a mammalian source. The organism is now classified as *Salmonella choleraesuis*. Dr. Salmon, for which the genus was named, was the first Chief of the Bureau of Animal Industry. In 1885 Moore (2) isolated a salmonella from an outbreak of infectious enteritis in pigeons. The first report of a salmonella in turkey poults in the United States was that of Rettger et al. (3) in 1933 although Pomeroy (4) had observed the infection in turkeys in Minnesota in 1932.

As the importance of the disease was recognized and received increasing attention, it was soon realized that salmonellosis was a problem in virtually all species throughout the world. It is most difficult at present to compile valid statistics on the incidence of salmonella infections in domestic animals because of inaccuracies in diagnosing and reporting outbreaks. It would be a fair supposition that salmonellae have been present in animal feeds, or material fed to animals, since the time animals were domesticated and used as food for man. Somewhere in that remote past, the relationship of man to animals began to assert itself. As man took animals for food and clothing, he inadvertently inherited harmful agents which he now recognizes and struggles against.

Man is now confronted with the problem of salmonella contamination of feed ingredients, livestock are infected with the organisms, and occasionally some are found in human foods.

The problem in animals is found in several areas. Where does animal feed become contaminated? If it does, how responsible is it for the disease seen in our domestic animals and birds? How can we get rid of it? How wide-spread is the organism in wild animals and birds? Are there other reservoirs?

The salmonella problem concerning commercial feeds should be examined. Feeds for cattle, horses, swine and poultry vary in their components. Many cattle feeds do not contain meat scraps or rendered by-products. These feeds are mostly cereal grains and are infrequent sources of salmonella. Protein supplements such as cottonseed meal and soybean meal have been found to contain salmonella. Bone meal, which is sometimes found in cattle feeds, may be contaminated. Mineral mixes fed free choice are a possible vehicle. For example, some years ago the largest selling mineral mix in Florida was found heavily contaminated with *S. anatum* (5). About one hundred salmonella infections in cattle were seen over a period of three months at the diagnostic laboratory during the time this contaminated mix was being distributed and sold. This was considered circumstantial evidence, but after some study, no other source was apparent.

An interesting experience in feed transmission was carried out at the National Animal Disease Laboratory by the Animal Services Section (10). The work was undertaken to see whether pigs could be raised free of salmonella and other disease organisms. One hundred and thirty-two duplicate fecal samples were obtained from a group of 66 pregnant sows. On only one occasion was salmonella isolated, and from only one sow. The serotype was *S. saint-paul*. A group of the animals were delivered near term by hysterectomy, and 22 of the baby pigs were placed in separate incubators in isolation. Techniques were used to prevent contamination. The piglets were fed a sterile milk replacer and not allowed to obtain chlostrum from their dams. At 7 days of age all piglets were started on a diet, #538, which consisted of a complete baby pig ration including rendered by-products. Prior to feeding this, 247 randomized samples of the feed were taken for culture. Two of the samples yielded salmonella. The serotypes found were *S. oranienburg* and an organism having the antigenic formula 28:1,7 monophasic. The results of feeding this ration to the hysterectomy derived, chlostrum deprived pigs are seen in Table I. Salmonellae were not found in any of nine swabs in one pig of the 22.

As a sequelae to the study, basic components of feed #538 were obtained from the feed blender. These were bone meal, meat scraps, and meat and bone mixture. A culture, 28:1,7 monophasic was isolated from the bone meal; *S. senftenberg* and *S. tennessee* from the meat scrap; and *S. montevideo*, *S. newington* and *S. schwarzengrund* from a mixture of meat and bone. It is interesting to note that of the serotypes from the complete feed, the meat ingredients, and the sow, only one, *S. oranienburg*, was found in the piglets. In addition, *S. bareilly* and *S. livingstone* were isolated from the piglets.

More studies of this kind are being completed at various laboratories, and a number are now in the literature. How much transmission of this kind occurs in the farm situation is not known.

A few other facts are known regarding animal feeds. For example, in most feeds the numbers of salmonellae are usually small. A study by Leistner

TABLE I

Hysterectomy-derived Pigs Fed a Commercial Feed From 7 Days of Age

No. of Pigs	Test No.	Sample	Results
22	1	9–28–63	Negative
22	1	9–29–63	Negative
22	1	9–30–63	Negative
22	2	10–15–63	15 positive; 7 negative
22	2	10–16–63	16 positive; 6 negative
22	2	10–17–63	13 positive; 9 negative
22	3	11– 3–63	15 positive; 7 negative
22	3	11– 4–63	10 positive; 12 negative
22	3	11– 5–63	9 positive; 13 negative

et al. (6) has shown this. They also indicated that storage of complete feeds reduced the numbers of salmonellae. In some, 40 days were required for the feed to become negative for salmonella.

Salmonellae are getting into animal feeds, and any of the 1200 serotypes are capable of causing clinical disease when accompanied by certain stress factors. Because animal by-products seem to be the most often incriminated vehicle for salmonella, many studies have been conducted at rendering plants. Although the heat of the extractor should be sufficient to destroy salmonella, recontamination occurs somewhere in the final processing, bagging or storage operations so that the product is shipped to the blender contaminated. As yet, no practical solution has been found to correct this situation.

The number of food animals that become infected annually from contaminated feed is not known. Figures are not available for the total disease due mainly to the lack of a national reporting system. The disease is reportable in many countries, but not in the United States. Many serious outbreaks occur in calves, adult cattle, swine, sheep and poultry. Unfortunately, most of these are not investigated unless humans become involved. Simple economics many times may prevent adequate studies, and serious outbreaks pass with little information derived from them.

The problem may be best examined by species, as each has its own peculiarities. Poultry have received more attention than other species because of human involvement with egg products and the recognition of the importance of pullorum disease and fowl typhoid. The poultry interests have been most active in this area and have accomplished a great deal. For example, pullorum disease is practically non-existent when viewed nationally. Blood testing is carried out in turkeys in two states for *S. typhimurium* and successful programs are in operation. Little progress has been made, however, with paratyphoids, and these are still a tremendous problem. It appears that again the greatest difficulty in the production of human food concerns the build-up of salmonella organisms at the processing plant producing a recontamination of the dressed poultry. A report in 1964 by the Scientific Advisory Committee for the Pacific Dairy and Poultry Association (7) summarized the situation regarding salmonella in poultry and poultry products. The chief recommendation that came out of this report is most important. The report emphasized that animal producers must be educated in the basic principles of sanitation, animal supervision and quality control. This applies in the poultry house, in the poultry dressing plant, in the egg handling and marketing, and in the home. Most problems could be eliminated, or at least appreciably reduced, if simple rules of good sanitary practice were followed. It has also been brought out by many individuals that the practice of using cracked or otherwise low-grade eggs poses a constant problem and occasionally even where pasteurization is carried out.

Salmonellosis in swine has been studied by many workers in Europe and in the United States. Galton et al. (8) and Leishner et al. (6) have shown that a great area of concern is related to the shipping, holding and slaughter of swine. These excellent studies point out that although most swine leaving the farm may be negative for salmonella organisms, the build-up of these bacteria among swine in the holding pens of abattoirs is tremendous. As high as 80% of the swine entering the slaughtering facility were found to harbor salmonella, and this contamination was carried through the plant and occasionally to the final product. It would seem that there is ample evidence upon which to act in cleaning up this problem area.

S. cholerae-suis, erroneously thought to be the cause of hog cholera (1), is recognized as a serious disease of swine. This serotype is primarily species related. Animal feed is not known to act as a vehicle for the organism. Clinical salmonellosis is also seen in swine at the farm and is generally associated with poor sanitary conditions. However, here again pig feeds do contain meat scraps and other rendered products. The extent to which these salmonella-contaminated feeds are responsible for frank disease at the farm level is not known.

Salmonellosis in cattle has long been overlooked and underestimated. Numerous reports of serious outbreaks in calves and adult cattle are available. A study by Rude in Wisconsin indicated a high incidence of *S. typhimurium* infection in calves. Similar studies in California by Lewis (9) revealed 276 salmonella isolations from cattle. Of these, 134 or 49% were *S. typhimurium* followed by *S. dublin* and *S. newport*. These infections were not confined to single areas of the industry, but were spread through the dairy cattle, calves and feeder cattle. It was generally agreed that a form of stress was required for most outbreaks to take place. However, in most cases the significance of environmental factors was not always clear. The part played by feed contamination, poor sanitation at all levels, wild animals and soil contamination is not well known.

The most important thing to be said today is basically that all phases of the problem in animals need to be examined. Animal by-products were selected because they were the most frequently contaminated ingredient in animal feed. This is an area where control measures can be applied. It will never be possible to evaluate the effectiveness of control measures in animals as long as they are constantly receiving the organism in the feed. Many believe the chain of infection could be broken by producing a feed free of salmonella. This would certainly help; however, the attack must be made in all quarters if success is to be achieved.

The trouble areas must be investigated. This must be done by trained epidemiologists. In outbreaks where no work of this kind is done, the high cost and value of salmonella serotyping can be seriously questioned. A more simple laboratory confirmation might be provided.

The frequent appearance of some serotypes over others needs to be studied. For example, *S. typhimurium* constitutes about 20% of the recoveries from animals and birds. Better methods for isolation of the organism from feeds, animals and the environment are needed. A better understanding of the resistance of these organisms to physical and chemical agents would be valuable. A good test for the detection of salmonella antibodies in all species needs to be developed. For example, cattle do not have significant titers to the "O" antigen while titers to the "H" or flagellar antigens are found. Other areas of possible contamination between the rendering plant and the consumer, i.e., wholesalers, mixers, feed companies, haulers and on-the-farm storage must be investigated. Controlled studies must be done on stored feeds to observe the effect of storage on viability and virulence of salmonella. Methods must be found for the sterilization of feeds if this is found necessary.

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