Prevalence, Clinical Aspects, Treatment and Control of Bovine Salmonellosis

Erskine V. Morse, *D.V.M., Ph.D.**, **Margo A. Duncan***, **John S. Baker,** *D.V.M.†*
H. E. Amstutz, *D.V.M.†*, **Edith P. Myhrom,** *B.S.,** and **Kent A. Gossett***
School of Veterinary Medicine
*Department of Veterinary Microbiology, Pathology and Public Health**
Department of Large Animal Clinics†
Purdue University
Lafayette, Indiana 47907

© Copyright American Association of Bovine Practitioners; open access distribution.

Salmonellosis represents the most prevalent zoonotic infection of *Bovidae.* Approximately 111 of the over 1700 salmonellae serotypes have been found in cattle (1). Eighty-one types of *Salmonella* have been cultured from cattle in the U.S. (1). It may be assumed that the bovine animal is potentially susceptible to all the salmonellae which colonize lower animals. A summary of the predominant serotypes found in U.S. cattle is given in Table 1.

Table 1
Prevalence of Serotypes Identified in the U.S. During 1933-73 (1)

Serotype	Number of Isolates Typed	Percentage
typhimurium	6872	72.27%
newport	967	10.17%
dublin	713	7.50%
anatum	224	2.36%
heidelberg	167	1.76%
saintpaul	104	1.09%
enteritidis	99	1.04%
Total:	9146	96.18%
Grant Total:	9509 isolates	

Interestingly, *S. typhimurium* is the most prevalent isolate in the U.S. (72.7%), while *S. dublin* is more common in foreign lands (40.73%)! However, *S. typhimurium* is the second in prevalence (36.19%). *S. dublin* has been the most frequently encountered in England, and this fact has ranked it as the most common agent for all Europe. Recently, however, *S. typhimurium* appears to be increasing and rivals *S. dublin* as the most common *Salmonella* in cattle abroad. From a clinical standpoint, these facts are primarily of academic interest; however, in considerations concerned with epizootiology and epidemiology, they are significant.

Several points should be firmly kept in mind when discussing salmonellosis with laymen: 1) the typhoid organism, *Salmonella typhi,* is essentially a strict human pathogen. It has been isolated just once from animals (2). Milk-borne typhoid epidemics occur when milk is contaminated after it leaves the cow. Such is due to contamination by a human carrier or water supplies which are polluted on the farm, during transportation or at processing plants. The cow is not the carrier, nor is she responsible for human typhoid outbreaks! Contaminated milk merely serves as the vehicle to transmit typhoid from one human being to another. 2) *Salmonella paratyphi B,* primarily found in food poisoning outbreaks traced to human carriers, has been incriminated in milk-borne paratyphoid outbreaks in which dairy cows were infected (3). 3) *S. cholerae-suis* (both varieties), *S. pullorum* and *S. meleagridis* have been isolated from cattle (4). It may be theorized that the bovine infections may have resulted from contact with swine, and for the latter two serotypes, avian species may have been the carriers.

Clinical Aspects

Salmonellosis in cattle, as in other livestock, is seldom an uncomplicated disease (5). Some peracute and acute cases may be due to salmonellae, per se. The infecting dose in such instances is overwhelming, e.g., over 10^7 bacteria. The animal develops a fulminating septicemia and dies. Such is not uncommonly observed in dairy calves which are colostrum-deprived and stabled in a salmonellae contaminated environment.

Generally, various stress factors precipitate salmonellosis in cattle (5). Transportation for long distances with sojourns in sale barns which may be unsanitary and contain fecal shedders. The carriers may be other cattle, swine, sheep, horses, dogs, birds, cats, rodents and, theoretically, man himself.

Marginal or inadequate rations, water deprivation and radical changes in diet may contribute to the advent of a bovine salmonellosis epizootic. The authors estimate that 10% subclinical carriers exist in bovine populations, the environment is well-seeded with *Salmonella.* Exposure to the pathogens may well be continual.

Parasitism and worming may provide the stress

Published with the approval of the director of the Purdue Agricultural Experiment Station. Journal Article 6114.

mechanism to trigger a salmonellosis outbreak. Freezing, wet weather, as well as radical weather changes may provide an environmental stress factor favoring infection. Hot, humid weather has an effect on hospitalized cattle which often precipitates outbreaks when carriers are present.

Concurrent diseases, i.e., metritis, mastitis, ketosis, milk fever, cystitis, pneumonia, etc., all contribute to the severity of an individual case and may produce fecal shedding of salmonellae by a carrier. In fact, most any infectious disease process in a subclinical carrier may result in a fulminating fatal course of salmonellosis. One may recall that hog cholera was frequently a simultaneous infection with *S. cholerae-suis.* Both the virus and the bacterium were present in cholera-infected swine. *S. cholerae-suis* was originally reported as the etiological agent of hog cholera by Salmon and Smith.

The clinical forms of bovine salmonellosis may be defined as the peracute, acute, and chronic. A fourth, the subclinical or occult fecal shedder of salmonellae, should be recognized as the real source of the disease among livestock and poultry.

The peracute form is seen frequently in calves and on occasion in older animals which are subjected to severe stresses, i.e., environmental, physiological, or other infectious disease processes. Fever, depression, diarrhea, dehydration, prostration are major signs. Mortality rates may range from 50%-70%. The feces may be yellow and contain flecks of blood and mucus. In the terminal phase the excretia often is watery, port-wine in color and contains strands of mucus and portions of the sloughed intestinal mucosa. The body temperature initially ranges from 104-106° F, while within 24 hours of death it is often normal or subnormal. The course of the disease is generally 3-5 days. Animals which recover frequently become chronic carriers of salmonellae. Such occurs more often in adult cattle than with calves (4).

The acute phase is ushered in with fever (104° F or +), anorexia, depression and diarrhea; blood and mucus are often present in the feces. Various degrees of dehydration are observed. Weight loss is apparent. The body temperature may be normal following the first onset of the infection and suddenly rise to 104° F for a day or two. Mortality rates are generally under 50% with adequate symptomatic and supportive therapy. The acute phase frequently progresses to the chronic type infection, or the animal makes a clinical recovery in two to three weeks.

Chronic bovine salmonellosis is characterized by intermittent fever (103-104° F) and diarrhea. The feces are watery, and on gross examination do not appear to contain blood or mucus. Progressive dehydration and gradual weight loss are observed. Frequently the herdsman reports that an animal just isn't doing well and seems to have loose feces about half the time. The chronic form lasts several weeks. Mastitis, metritis, ketosis, calving or pneumonia may suddenly intervene and then death often occurs within three to seven days. Mortality in the chronic cases is unpredictable. If the infection is uncomplicated by other stresses and judicious supportive treatment administered, mortality rates are 25% or less. Clinical recovery is slow depending upon the duration and severity of the disease. Recovered cases, particularly in adult cattle, may become salmonellae fecal shedders for months.

Salmonellae have been incriminated as causes of bovine abortion (6) and mastitis (3). Such infections can present serious hazards to the dairyman, veterinarian and those who might tend the cows or consume unpasteurized milk (1).

The subclinical or occult carrier presents a serious problem in the prevention and control of bovine salmonellosis. The enteric pathogens are not infrequently present in the rumen ingesta as well as the feces (7,8). The carrier poses a continual threat of infection to susceptible calves and mature cattle through contamination of pastures, barns, feed bunkers and water receptacles. In order to detect the occult carrier, the authors recommend at least five negative fecal cultures to be taken at 7 to 10 day intervals before an animal is considered to be noninfected. Details of our bacteriological culture methods appear elsewhere (9,10).

A number of diseases may be confused with salmonellosis. A list of these is given in Table 2.

Table 2

Differential Diagnosis of Bovine Salmonellosis

*Colibacillosis (calves)
*Virus Diarrheas (both calves and adults)
*Winter Dysentery (adults)
*Coccidiosis (calves)
*Metazoan Gastrointestinal Parasites (calves)
*Pasteurellosis, i.e., Yersiniaosis (both)
*Ingestion of Toxic Materials (both)
*Malnutrition or Dietary Change (both)
*Traumatic reticuloperitonitis (adults)
*Displaced Abomasum (adults)
*Tumors of the Gastrointestinal Tract (adults)
*Johne's Disease, i.e., paratuberculosis (adults)
*Tuberculosis (adults)

Treatment

A variety of symptomatic and supportive therapeutic regimens were employed for the 20 bovine patients which were studied. These salient measures are described briefly:

At the time of hospitalization, cattle suspected of being salmonellae carriers were treated with ampicillin (i.m.) and nitrofurazone or nifuraldezone orally (see Table 3). Prior to treatment a fecal sample was submitted for *Salmonella* culture. Appropriate supportive therapy was instituted according to the immediate needs and requirements of the patient. Such administrations usually consisted of ca. 20 liters of fluid via an intravenous drip. Ringer's solution containing 5% dextrose with one liter of soluble amino acid-vitamin preparation added, e.g., Ambex® (Lil-

© Copyright American Association of Bovine Practitioners; open access distribution.

Table 3

Antimicrobials Used in Treatment of Bovine Cases of Salmonellosis

Drug and Manufacturer	Regimen
Procaine penicillin G (Crysticillin, 300 A.S., Squibb)	5000-10,000 Units/lb. i.m., s.i.d. for 3-4 days, postoperatively.
Dihydrostreptomycin sulfate & procaine penicillin G (Combiotic, Pfizer; Penstrep, Merck, Sharp and Dohme)	5 mg. streptomycin/lb. and 5,000 U penicillin/lb., i.m., b.i.d. for 3-5 days, postoperatively.
Oxytetracycline (Liquamycin, Pfizer)	5 mg/lb., i.v., s.i.d. for 4-5 days.
Sulfonamides (Sulfa 24, Bio-Ceutic Labs) 8 gm, a.a. sod. sulfapyridine, sod. sulfamethazine and sod. sulfathiazole/100 ml.	41 ml/100 lb. on intial dose; then 20 ml/100 lb. i.v., s.i.d., for 3-5 days.
Ampicillin (Polycilln N, 250 mg/vial, Bristol Labs)	5 mg/lb., i.m., s.i.d. for 5 days.
Daribiotic (100 mg/ml neomycin sulfate and 100,000 U polymyxin B sulfate/100 ml, Beecham - Massengill) discontinued drug	1-2 gm neomycin and 1 mil. U polymyxin B/1000 lb., i.m., s.i.d. for 7-10 days.
Chloramphenicol (Chloromycetin, Parke-Davis)	15 mg/lb. oral, t.i.d. or 5 mg/lb. i.v., s.i.d. for 3-4 days.
Neomycin sulfate/sulfamethazine (sulkamycin S, Norden), neomycin sulfate 200 mg and sulfamethazine 2 gm per bolus.	1 bolus/75 lbs., oral b.i.d. for 3-4 days.
Nifuraldezone (Entefur bolus, Eaton - 1 gm Furamazone/bolus)	1 bolus/100 lbs., oral, b.i.d. for 2-3 days.
Nitrofurazone (Furacin Eaton)	100 gm/1000 lbs., oral, b.i.d. for 5-6 days.
Kanamycin (Bristol Labs)	2-5 gm/1000 lbs., i.m., b.i.d. for 4-5 days.
Tylosin (Tylan, Eli Lilly)	4 mg/lb., i.m., s.i.d. for 4 days.

Table 4

Ages, Type, Course and Outcome of 20 Cases of Bovine Salmonellosis*

Holsteins, less than 1 year. Peracute: 2 recovered.

Holsteins, more than 1 year. Peracute: 2 died. Acute: 2 died, 8 recovered. Chronic: 1 recovered. Occult: 1.

Beef (1 Angus, 3 Hereford), less than 1 year. Peracute: 1 recovered.

Beef, more than 1 year. Chronic: 1 died, 2 recovered.

TOTALS: Peracute: 2 died, 3 recovered. Acute: 2 died, 8 recovered. Chronic: 1 died, 3 recovered. Occult: 1.

*14 cases of *S. tymphimurium;* 1 case, Group B (probably *typhimurium);* 1 case *S. anatum;* 4 cases untyped.

Table 5

Antimicrobial Sensitivity Patterns for Salmonellae Isolated from Infected Cattle*

	Total	Resistant	Sensitive
Chlortetracycline Aureomycin R (30 mcg.)	31	31	0
Kanamycin (30 mcg.)	26	23	3
Neomycin (30 mcg.)	26	23	3
Sulfonamides (1 mcg.)	31	31	0
Streptomycin (10 mcg.)	31	31	0
Chloramphenicol (30 mcg.)	31	0	31
Naladixic Acid (30 mcg.)	29	0	29
Polymyxin B (300 U.)	31	0	31
Gentamicin (10 mcg.)	29	1	28
Furacin (Furadantin)Macrodantin (300 mcg.)	31	0	31

*Kirby-Bauer Disk Method (11).

ly) was generally prescribed. The intravenous medication was administered over a 5- to 8-hour period dependent upon the patient's degree of dehydration. As soon as the animal was drinking water in normal amounts, the therapy was discontinued.

Various antimicrobial therapies were administered. Several were directed toward preventing postoperative sepsis, or controlling concurrent infections, e.g., cystitis, metritis, mastitis, pneumonia, etc.

The patients were classified according to age, breed, type, course and outcome of the salmonellae-infection (these data are summarized in Table 4.)

The antimicrobial sensitivity patterns for a number of *Salmonella* isolated from the patients was established.

Bovine salmonellae isolates were examined, prior to, during and following treatment with specific compounds to ascertain their antimicrobial sensitivity patterns (11). In general, the infecting agents remained sensitive to furacin(s), polymyxin, and chloramphenicol throughout the periods of examination. Salmonellae which were originally resistant to tetracycline(s), kanamycin, ampicillin, streptomycin and sulfonamides remained resistant. This would be expected. Concrete evidence pertaining to neomycin-developed resistance could not be concluded (Table 6).

Prevention and control of bovine salmonellosis from the standpoint of economics and public health is imperative. Common sense principles of animal management and veterinary medicine are the foundation for any herd health program to reduce the incidence of bovine salmonellosis. These include: 1) Provide colostrum for newborn calves; 2) Prevent shipment of calves under one week of age; 3) Prevent overcrowding in barns and feedlots; 4) Reduce manure accumulations; 5) Use sanitized trucks for cattle and feed transport; 6) Provide an adequate "clean" water supply; 7) Keep cattle from streams, ponds, etc.; 8) Keep cattle from hog and poultry lots; 9) Store feed properly in rodent/vermin-free areas; 10) Furnish an adequate balanced diet; 11) Quaran-

© Copyright American Association of Bovine Practitioners; open access distribution.

Table 6

Sensitivity Patterns of Salmonellae Isolated from Cattle During and Following Various Antimicrobial Treatments

	PRIOR TO (more than 1 week)		DURING (+ 1 day)		FOLLOWING (2-7 days)		FOLLOWING (more than 1 month)	
	Resistant	Sensitive	Resistant	Sensitive	Resistant	Sensitive	Resistant	Sensitive
Furacin(s)		4		13		5		2
Neomycin	1	1	2		2		2	1
Polymyxin				2		2		3
Chloramphenicol				6				1
Tetracycline(s)	8		3		1		2	
Kanamycin			1		1			
Ampicillin			1		1			
Streptomycin	8		3		2			
Sulfonamide(s)	4		4		1		1	

*Kirby-Bauer Disk Method (11).

tine replacement stock; 12) Provide adequate shelter in inclement weather; 13) Prompt treatment of metritis, pneumonia, diarrhea, etc.; 14) Reduce periods of hospitalization; 15) Appropriate preoperative and postoperative care.

Cattle may serve as sources of human salmonellosis and this fact is well documented. Prevention of transmission of the disease to man is dependent upon: 1) Prompt and adequate refrigeration of milk; 2) Pasteurization of all milk for farm family consumption; 3) Prevent fecal contamination of hands-especially when handling "sick" cattle; 4) Keep children away from "sick" cattle; 5) Custom/home slaughter of cattle should be under sanitary conditions; 6) Emergency slaughter of cattle should be prohibited; 7) Persons with persistent diarrhea and concurrent fever should see their family physician. If cattle are sick on the farm, the attending physician should be informed.

Salmonellosis in livestock cannot be eradicated. Much can still be accomplished in the prevention and control of the infection. Salmonellosis represents the most prevalent and economically significant zoonosis. Cattle are not an uncommon source of the disease for man. It should be remembered, also, that human beings may serve as sources of the zoonosis for livestock. Salmonellosis is a model environmental health probelm of past, current, and future political, economic, and public health significance.

References

1. Morse, E. V., Duncan, M. A., Baker, J. S., and Weinland, K. M.: The status of Bovine Salmonellosis-Prevalence and Epizootiology with Public Health, Clinical and Control Aspects. Proced. U.S. Ani. Hlth Assoc, 68th Ann. Mtg., Nov. 2-7, 1975, Portland, Oregon. (in press) - 2. Dack, G. M.: In Hull's, "Diseases Transmitted from Animals To Man," 5th ed., pg. 214, Chas. Thomas Publishers, Springfield, Illinois: 1963. - 3. Edwards, P. R.: Salmonella and Salmonellosis. Ann. N.Y. Acad. Sci., 66, 45-53: 1956. - 4. Gibson, R. E.: Reviews of Progress in Dairy Science. Section E. Diseases of Dairy Cattle. Salmonella Infection in Dairy Cattle. Jour. Dairy Res., 32, 97-134: 1965. - 5. Morse, E. V., and Duncan, M. A.: Salmonellosis-An Environmental Problem. Jour. A.V.M.A., 165, 1015-1019: 1974. - 6. Hinton, H. H.: Salmonella dublin Abortion in Cattle, Vet. Rec., 93, 162: 1973. - 7. Grau, F. H., and Brownlie, L. E.: Occurrence of Salmonella in the Bovine Rumen. Aust. Vet. Jour., 41, 321-323: 1965. - 8. Grau, F. H., and Brownlie, L. E.: Effect on Some Preslaughter Treatments on Salmonella Population in the Bovine Rumen and Faeces. Jour. Appl. Bact., 31, 137-163: 1968. - 9. Morse, E. V., Duncan, M. A., Fessler, J. F., and Page, E. H.: The Treatment of Salmonellosis in Equidae. Mod. Vet. Pract. (in press) - 10. Morse, E. V., Duncan, M. A., Page, E. H., and Fessler, J. F.: Salmonellosis in Equidae: A Study of 23 Cases. Cornell Vet. (in press 1976). - 11. Bauer, A. W., Kirby, W. M. M., Sherris, J. C., and Turck, M.: Antibiotic Sensitivity Testing by a Standard Single Disk Method. Am. Jour. Clin. Path., 45, 493-496: 1966.

© Copyright American Association of Bovine Practitioners; open access distribution.

FIVE WAYS OMNIZOLE® (thiabendazole) PUTS YOU IN CHARGE OF DAIRY CATTLE WORMING PROGRAMS

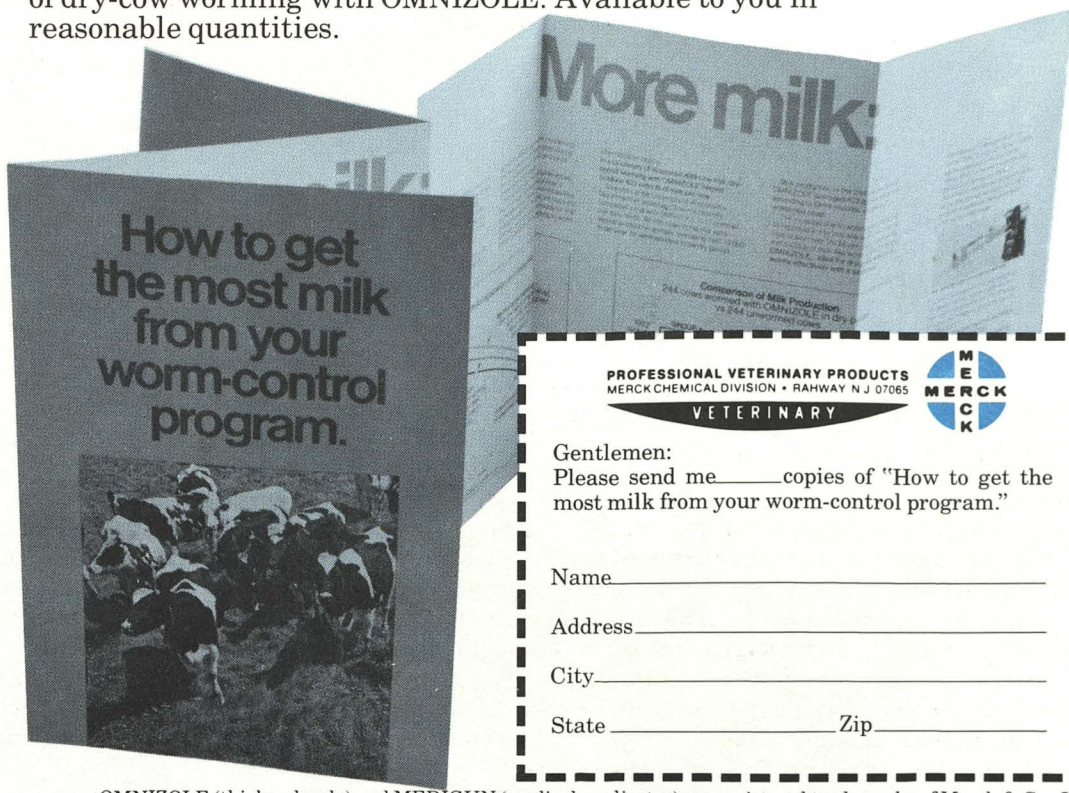
1. *It's a one-time treatment* whether given with the OMNIZOLE Paste-MEDIGUN® System, or as boluses, suspension, or as OMNIZOLE crumbles.

2. *It helps you help your client's cows produce more milk from worming.* New data prove that dry-cow worming with OMNIZOLE promotes more milk production than worming during lactation with other anthelmintics.

3. *It's a dry-cow treatment* that fits in with your other dry-cow regimens.

4. *It's ideal for dispensing.* No side effects. OMNIZOLE is easily administered by your clients as paste, suspension, boluses, or crumbles.

5. Full-color folder for use with your clients explains advantages of dry-cow worming with OMNIZOLE. Available to you in reasonable quantities.



PROFESSIONAL VETERINARY PRODUCTS
MERCK CHEMICAL DIVISION • RAHWAY N J 07065
VETERINARY

MERCK

Gentlemen:
Please send me_____copies of "How to get the most milk from your worm-control program."

Name_____

Address_____

City_____

State_____ Zip_____

OMNIZOLE (thiabendazole) and MEDIGUN (medical applicator) are registered trademarks of Merck & Co., Inc.

© Copyright American Association of Bovine Practitioners; open access distribution.