

# Descriptive Epidemiology of Salmonella Serotypes From Cattle in the USA (1982-1991)

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## Introduction

Clinical and subclinical bovine *Salmonella* infections have long been the source of concern to the industry from both the animal disease and human health perspectives. In recent years there has been a perception that these infections are being seen with increasing frequency, but this may be due to a combination of increased awareness by producers and veterinarians, improved culture techniques, and the publicity given to both beef and dairy product-associated human outbreaks. Nevertheless, the trend to larger dairies, together with increased inter-herd movements and changing feed practices may all contribute to the spread of salmonellae among cattle.

While there have been a number of single and multiple herd case reports of both calfhood and adult salmonellosis in the USA, no attempt has been made to summarize national data over time and by region. The National Veterinary Services Laboratories (NVSL) at Ames, Iowa provides a *Salmonella* confirmation and serotyping service to state diagnostic laboratories. Quarterly reports are made to submitters and an annual summary is published in the Proceedings of the U. S. Animal Health Association. This service has been provided without charge but submitters are required to provide basic herd/flock data as follows: name and address of owner, source animal species, number of animals in the herd or flock, morbidity, mortality, age groups affected, and whether these are considered primary or secondary infections.

## Materials and Methods

A subset of the NVSL computerized *Salmonella* database comprising all bovine *Salmonella* isolates by serotype and associated herd and clinical data was obtained for the 10 calendar years (Jan. 1 - Dec. 31) 1982-1991 inclusive. These data was transferred to the

'Statistix '\*\* program for analytical purposes.

The use of data from diagnostic laboratory accessions for making estimates of national disease incidence and/or prevalence or other epidemiological characteristics must be carried out with caution. Most diagnostic laboratories in the USA only accept specimens from licensed veterinarians thus livestock producers who do not utilize the services of a veterinarian are excluded. Although a high percentage of dairy producers (>90%) use a veterinarian on a regular or intermittent basis, beef producers are much less likely to utilize veterinary services except for some routine herd health purposes. Nevertheless, clinical salmonellosis in both calves and adult animals is usually severe enough that the progressive owner will seek veterinary assistance.

Some of the acknowledged deficiencies of the NVSL *Salmonella* data base for surveillance purposes include the following:

- a) Apart from *S. pullorum*, *S. gallinarum* and *S. enteritidis* isolates from poultry which are reportable to state animal health agencies in the U.S.A., there is no uniform reporting requirement for *Salmonella* isolates from other livestock including cattle. Some individual states, however, may have legal requirements to report *Salmonella* isolates by veterinarians or laboratories.
- b) No distinction is made between beef, dairy, veal or other sub-groups within the cattle populations.
- c) A total of 305 laboratories submitted cultures to NVSL during the 10 year period. The majority were sent from state or university diagnostic laboratories from clinical cases of bovine salmonellosis. A few have come from animal disease surveillance studies, research projects, and environmental studies. Few laboratories carry out routine serotype identification because of the costs involved.

\*Statistix, Version 3.5 Analytical Software, P.O. Box 13204, St. Paul, MN 55113

- d) Increasingly veterinarians are providing a clinical microbiological service for their clients, but their *Salmonella* isolates may not be sent for serotyping unless the culture is needed for autogenous bacterin production.
- e) It is difficult to draw conclusions on the seasonality of bovine salmonellosis from the NVSL database primarily because laboratories often batch cultures over a period before sending them to the laboratory.
- f) The information on mortality and morbidity has to be considered as tentative, primarily because it is often estimated based on events occurring early in an outbreak. Also in some cases this section of the submission form is left blank.
- g) Classification as to the clinical role, i.e. primary or secondary, is also open to considerable inter-laboratory or pathologist variation. For example an isolate may be assigned a primary role only if it is the only potential pathogen isolated or certain serotypes such as *S. typhimurium* or *S. dublin* tend to be assigned a primary role.

In summary, therefore, while it cannot be considered that the NVSL *Salmonella* database represents a random sampling of cattle or herds in the U.S.A., it does represent the most comprehensive and consistent collection of data on bovine *Salmonella* serotypes available on a nationwide basis.

The fact that most of the frequently identified serotypes in any given year tend to recur from year to year provides evidence that the cultures received are representative of the serotypes that occurred in cattle.

### Results and Discussion

Over the 10 year period (1982-1991), 17,488 *Salmonella* isolates were identified at NVSL from clinical incidents in cattle. These isolations came from 12,355 herds indicating that multiple isolates were made from some herds. There was minimal variation in the total number of serotypes identified each year with a range of 56 to 84 and a mean of 70. During this period, the ten most common serotypes identified are shown in Table 1.

Over the period under consideration *S. typhimurium* including variety Copenhagen (38.7%) and *S. dublin*, (16.8%) have consistently been the leading two serotypes isolated from cattle. The other serotypes in Table 1 have also figured prominently in the top 10 list over this time period indicating possibly an adaptation to, or cycling within cattle herds.

*S. dublin* continues to be an ever increasing cause of morbidity and mortality in cattle since its original identification in the U.S.A. in the late 1930's.

Table 1. Ten most Common *Salmonella* Serotypes Isolated from Cattle (1982-1991)

SEROTYPE	NUMBER OF ISOLATES (%)
Typhimurium	4812 (27.5)
Dublin	2933 (16.8)
Typhimurium (variety Copenhagen)	1958 (11.2)
Newport	771 (4.4)
Anatum	669 (3.8)
Montevideo	513 (2.9)
Cerro	462 (2.6)
SAL 9,12:Nonmotile*	426 (2.4)
Meunster	361 (2.1)
Agona	275 (1.6)
All other isolates	4308 (24.7)
TOTAL	17488 (100)

\*A serogroup D isolated which cannot be definitively identified as a recognized serotype.

During the last few years, there has also been a very significant increase in Group D non-motile variants, almost entirely confined to cattle. Genetic studies in progress would suggest that these are almost certainly variants of *S. dublin*. Previously reported as "untypeable" they have been identified separately in the NVSL database since 1989. Prior to 1988, *S. enteritidis* was also a relatively uncommon serotype in cattle but, with the dramatic increase and public health concern of this serotype in poultry and table eggs, an increase has also been noted in cattle. NVSL results show phage types 8 and 13A predominate in cattle, but these types are also commonly found in poultry.

Human epidemiological studies on salmonellosis have tended to be serotype specific on the assumption that patterns of infection and mode of transmission are relatively constant for a given serotype.<sup>1</sup> There is evidence that certain serotypes enter the human population, assume a significant clinical role, decline and may even disappear completely. In this brief review, it is obviously impossible to summarize the epidemiology of the 100 or so individual *Salmonella* serotypes identified from cattle over the 10 year period. Therefore, a decision was made to divide all the reported clinical incidents as follows:

- All *S. typhimurium* (including variety Copenhagen);
- All *S. dublin* (including Group D non-motile variants);
- All other serotypes.

The reasons for these divisions were that *S. typhimurium* is clearly the most widely distributed serotype in terms of hosts affected. These hosts include non-bovine species such as rodents, poultry, cats, other

free-living mammals and birds commonly found in contact with cattle. *S. dublin* is primarily a cattle-adapted serotype. NVSL data show that over the 10 year period the greatest percentage of isolates came from cattle, i.e. 2933/3247 (90.3%) *S. dublin* isolates have been recorded from antelope, avian species, cats, deer, dogs, fox, goats, horses, mink, rabbit, reptiles, rodents, sheep, and swine. Finally, both *S. typhimurium* and *S. dublin* are very rarely isolated from feed, whereas the other serotypes, such as *S. anatum*, *S. montevideo*, *S. cerro*, and *S. agona* have periodically been isolated from feed ingredients and finished feeds, especially those containing animal protein supplements.

### Trends Over Time

All bovine isolations including *S. typhimurium*, *S. dublin* and all other isolates for the 10 year period are shown in Fig. 1. The number of isolates identified has steadily increased from approximately 1000/year to a maximum of 3700 in 1989. The reasons for this peak and apparent decline in 1990 and 1991 are unclear. There are no marked differences between the three groups of salmonellae over time, although in 5 of the 10 years other salmonellae exceeded both *S. typhimurium* and *S. dublin* isolates.

The increase in salmonellae was also paralleled by a similar increase in the number of infected herds (from 897 in 1982 to 1,896 in 1991), including those where the actual herd size was reported (Fig. 2). During this period, the number of cattle herds in the U.S.A. actually decreased from 1,512,000 to 1,246,470 and cattle numbers decreased from 115.4 to 98.9 million animals. No obvious association with the average herd size and type of *Salmonella* identified was detected (Fig. 3).

### Mortality and Morbidity in Relation to Clinical Role and Age

An analysis of the trends over time of the morbidity and mortality data of primary v. secondary infections (Fig. 4) failed to show any statistically significant differences. Therefore, a decision was made not to consider this distinction in subsequent analyses.

Although age is categorized into four groups (prenatal, immature, mature and mixed), it was decided to group the prenatal and immature categories and the mature and mixed together, primarily because "prenatal" and "mixed" categories made only a very small contribution (< 2%) to the overall database. Figures 5 and 6 indicate a fairly consistent trend over time with an overall approximate case fatality rate (mortality/morbidity) of 48% for younger (pre-weaned) animals and approximately 30% for the older animals.

Examination of data in Table 2 showed that there were significant differences ( $p < .0001$ ) between the approximate case-fatality rates of the young versus the mature animals for all 3 groups of salmonellae but there was no significant difference between the case-fatality rates of *S. typhimurium*, *S. dublin* and other salmonella infections.

### Regional Distribution of Bovine Salmonella Isolates

Data from the 48 contiguous states were arbitrarily classified into 7 regions for comparative purposes viz. Northeastern (CT, ME, MA, NH, NJ, NY, PA, RI, VT), North Central (IL, IN, MI, OH, WV, WI), Southeastern (AL, DE, FL, GA, KY, MD, MS, NC, SC, TN, VA), South Central (AR, KS, LA, MO, OK, TX), Northern Plains (IA, MN, NE, ND, SD), Rocky Mountain (AZ, CO, ID, MT, NV, NM, UT, WY), and Pacific Coast (CA, OR, WA).

Bovine salmonellosis obviously occurs throughout the U.S. (Fig. 7). Time trends (not shown) suggest that the increase in 1989 was seen throughout the country with the exception of the Rocky Mountain region which peaked in 1988. *S. dublin* is now becoming much more widespread with the exception of the South Central and South Eastern regions following its initial isolation from California and other states east of the Rocky Mountains. In Midwestern dairy states such as Minnesota, where this serotype was first identified in 1980, it now comprises 35 to 40% of all bovine *Salmonella* isolates.

### Antibiotic Resistance of Bovine Salmonellas

Antibiotic resistance in *Salmonella* sp. has long been of concern both to veterinarians, physicians, and public health authorities especially where food-borne transmission has occurred. While antimicrobial sensitivity testing of isolates submitted to NVSL is not routinely carried out, a study of 3,500 isolates from 1981/82 submissions to NVSL revealed that of the 12 antimicrobials evaluated, multiple resistance patterns were found in 79% of 1,307 cattle isolates. The percentage of bovine isolates resistant to the following antibacterial drugs were as follows: ampicillin (54%), chloramphenicol (28%), carbenicillin (54%), cephalothin (4%), erythromycin (93%), gentamicin (1%), kanamycin (57%), neomycin (56%), penicillin G (69%), streptomycin (65%), triple sulfonamides (56%), tetracycline (62%).<sup>2</sup> However, in recent data from the Minnesota Veterinary Diagnostic Laboratory, there is a relatively high degree (> 75% of isolates tested) of susceptibility to amikacin, apramycin, cephalothin, ceftiofur, trimethoprim-sulfa combination, and enrofloxacin.<sup>3</sup>

**Table 2. Morbidity, mortality and approximate case-fatality rate by age group and type of *Salmonella*.**

Type of <i>Salmonella</i>	AGE					
	Immature & Prenatal			Mature & Mixed		
	Morbid. (%)	Mortal. (%)	Approx. Case-fatality	Morbid. (%)	Mortal. (%)	Approx. Case-fatality
<i>S. typhimurium</i>	13.3	7.3	55.8%	12.3	3.5	28.5%
<i>S. dublin</i>	10.5	4.6	43.8%	12.3	3.2	26%
other <i>Salmonella</i>	11.5	4.9	42.6%	11.4	3.7	32.5%

### Role of Cattle and Dairy Products in Human Salmonellosis

Humans can acquire *Salmonella* infections directly from clinically ill or asymptomatic excreting animals, eg. young calves, or indirectly via consumption of dairy products (milk, cheese, ice cream, milk powder) which have either not been pasteurized, inadequately pasteurized, or contaminated post-pasteurization. A number of studies have shown that up to 5% of on-farm bulk tanks may contain viable salmonellae. The adverse publicity for the dairy industry such as the 1985 milk associated *S. typhimurium* outbreak in Illinois, where up to 200,000 people may have been infected, must be avoided in the future.

Based on these data *Salmonella* infections are widespread in the U.S. cattle population. However, as discussed previously these results cannot be extrapolated to the total population at risk. The results of the National Animal Monitoring Systems (NAHMS) study of preweaning dairy calf health based on a statistical sample of herds in 28 states hopefully will provide a more accurate estimate of the percentages of *Salmonella* infected dairy herds.

### Future Directions in Salmonella Control

The control, prevention or even eradication of certain *Salmonella* serotypes from cattle is fraught with many problems. Readily available sensitive and specific individual and herd tests for bovine *Salmonella* infections currently do not exist, although current studies, particularly with *Salmonella dublin* look promising.<sup>4</sup> A more active surveillance program including the systematic investigation of outbreaks needs to be developed, particularly to measure the impact of Salmonellosis on production and reproduction, its relationship to other infectious agents, and its economic effects. Case-control studies are also needed to identify both herd and indi-

vidual cow risk factors, particularly in large dairy herds.

Environment hygiene remains a high priority particularly in view of the ability of salmonellae to survive, especially in housing that is difficult to clean. Post-purchase quarantine of both calves and mature animals for several weeks may reduce the risk of introducing new infections. The microbiological quality of purchased cattle and calf feeds, particularly those containing animal protein supplements urgently needs to be addressed as does the on-farm storage and feeding practices in relation to *Salmonella* contamination. Finally the supplementary use of serotype bacterins for both active and passive protection of young calves is indicated particularly in persisting herd infections.

### Summary

During 1982-1991 a total of 17,488 *Salmonella* isolates from 12,355 cattle herds were serotyped at the National Veterinary Services Laboratories, Ames, Iowa. *S. typhimurium* (38.7%) was the most common serotype identified, followed by *S. dublin* (16.8%) and other salmonellae constituting the remainder.

The total number of bovine isolates increased steadily over this 10 year period but the number of serotypes identified was relatively constant with a mean of 70 per year. *S. dublin* has spread widely over the Northern states presumably as a result of cattle movements.

The average recorded morbidity and mortality for preweaning age groups was 11.8% and 5.6% and for mature and mixed age groups was 11.9% and 3.5% respectively. The approximate case-fatality rate for mature and mixed age groups was 11.9% and 3.5% respectively. The approximate case-fatality rate for young animals (48%) was significantly higher than that for older cattle (30%).

## Résumé

17,488 souches de *Salmonella* isolées entre 1982 et 1991 à partir de 12.355 bovins furent sérotypées au Laboratoire National des Services Vétérinaires, à Ames, Iowa. Le sérotype le plus fréquemment isolé fut *Salmonella typhimurium* (38,7%), suivi par *S. dublin* (16,8%), les autres sérotypes constituant le reste (44,5%).

Le nombre total de souches isolées à partir de bovins s'est accru régulièrement durant ces 10 années, mais le nombre de sérotypes identifiés est resté relativement constant avec une moyenne de 70 par an. Le sérotype *Salmonella dublin* s'est largement étendu aux Etats du nord, probablement à la suite de mouvements d'animaux.

La morbidité et la mortalité moyennes enregistrées furent respectivement de 11,8% et 5,6% pour les bovins avant sevrage et 11,9% et 3,5% pour les bovins appartenant aux autres groupes d'âge.

## Summario

El Laboratorio Nacional de los Servicios Veterinarios Americanos (Ames, Iowa) ha establecido el serotipo de *Salmonella* en 17.488 ocasiones, en materiales provenientes de 12.355 establecimientos durante el período 1982-1992. Comúnmente el serotipo más identificado fue *S. typhimurium* (38,7%), seguido por *S. dublin* (16,8%) correspondiendo el resto a otros tipos de salmonella.

En este período de 10 años, el número total de aislaciones bovinas se incremento regularmente mientras que el número de serotipos se mantuvo relativamente constante, con una media de 70 por año. Presumiblemente, como resultado del movimiento de ganado bovino *S. dublin* se ha dispersado ampliamente en los estados del norte.

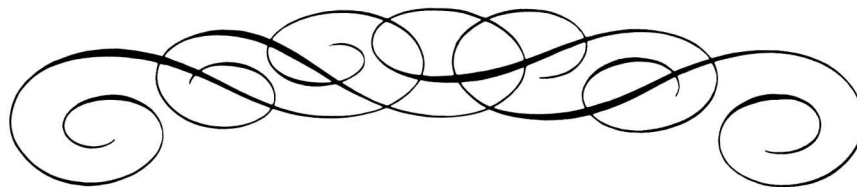
La morbilidad y mortalidad promedio en las categorías lactantes fue de 11,8% y 5,6% respectivamente, mientras que en animales maduros de diferentes edades fue de 11,9% y 3,5%.

## Acknowledgements

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## References

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## FUTURE MEETINGS

### American Association of Bovine Practitioners

1993	Albuquerque	September 16-19
1994	Pittsburgh	September 22-25
1995	San Antonio	September 14-17
1996	San Diego	September 12-15

### World Association for Buiatrics

1994	Bologna, Italy
1996	United Kingdom