SPORADIC BACTERIAL ABORTION IN THE BOVINE

by

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TABLE OF CONTENTS

INTRODUCTION

The term abortion has been derived from the Latin verb aboriri,
which means to miscarry. According to Roberts (1956), abortion is
the expulsion from the uterus of a living fetus before it reaches a
viable stage, or the expulsion of a dead fetus of recognizable size
at any stage of gestation. Many embryos or early fetuses may be
aborted without being seen. This early death and expulsion of the
embryos results in the cow being classified as infertile. The
term abortion, as commonly used, has come to mean the expulsion of
nonviable or dead fetuses of recognizable size. When a fetal cadaver
is expelled at full term, it is called stillbirth.

The occurrence of abortion has been noted by biblical and other
early writers and was frequently recorded in medieval times. Abortion
among animals has generally caused greatest concern in cattle, since
their milk and meat have occupied an important place in the food sup-
ply of most people. The economic significance of cattle has increased
as civilization advanced, and today it is the most important of all
domesticated animals as a producer of milk, meat and hides. Therefore
any interference with reproduction of the cow means economic loss.

Reproductive efficiency is a requisite for the economic success
of livestock production. The occurrence of abortion and stillbirth
deranges the herd program and results in serious loss of animals and
animal products. In association with their occurrence, there exists
the possibility of transmission of infection to other animals and to
man. Hence the problem of abortion deserves attention.

Exact figures regarding losses in cattle due to abortion are difficult to obtain, but indications can be gathered from surveys which have been carried out in various parts of the world.

According to Lawson (1963) the Report of New Zealand Dairy Board of 1956 estimates a 2.8 percent incidence of abortion occurring annually in that country. He estimates that only about half of the actual abortions are recorded. A 1960 survey of 1,158 British herds, comprising approximately 31,000 dairy cows revealed that 2.07 percent of the total pregnancies ended in abortion and 1.78 percent in still-birth. A 1955 survey of 200,000 beef cows in the U.S.A. by Ensminger, Calgan and Slocum revealed that only 79.5 percent produced live calves.

Mitchel (1960) reported the occurrence of abortion in 12.1 percent of 1,881 breeding cows around Ottawa, Canada, during the years 1957 to 1959. Of these, 6 or 2.6 percent of the abortions were caused by sporadic bacterial agents, i.e., one case caused by Streptococcus, one by Corynebacterium pyogenes and four by Pasteurella hemolytica.

A report by Wilson (1959) concerning herds in southwest Britain stated that 10 of 188 abortions or 5.3 percent were caused by sporadic bacterial agents.

Bacteriologic studies of bovine abortions in California during the periods of 1949 and 1950 from 43 herds at the Animal Pathology Laboratory, Department of Agriculture, California, revealed that 47 percent was caused by sporadic agents, which included coliform organisms, Pseudomonas sp., Staphylococcus sp., Streptococcus sp. and Proteus sp. Forty-seven percent were negative when cultured and

the remainder were caused by <u>Vibrio</u> <u>fetus</u>. Brucellosis and trichomoniasis were not encountered in this study.

There are numerous single factors or combinations of factors that may result in abortion. In general abortions may be caused by infectious disease, nutritional disturbance, hormonal imbalance and trauma. The infectious diseases can be classified as bacterial, viral, protozoal or mycotic.

This report deals with sporadic bacterial conditions associated with bovine abortion. It does not include bacterial abortions caused by <u>Brucella</u> <u>abortus</u>, <u>Leptospira</u> sp. and <u>Vibrio</u> <u>fetus</u>, which occur epizootically. Sporadic abortions to be reported are those resulting from <u>Listeria</u> <u>monocytogenes</u>, <u>Salmonella</u> spp., <u>Corynebacterium</u> <u>pyogenes</u>, <u>Streptococcus</u> sp., <u>Staphylococcus</u> sp. infections. Infections of several miscellaneous bacteria, i.e., <u>Mycobacterium</u> <u>tuberculosis</u>, <u>Pasteurella</u>, <u>Escherichia</u> <u>coli</u> and <u>Pseudomonas</u> are merely mentioned because of the paucity of data covering these latter diseases.

LISTERIOSIS

Listeriosis is of world-wide distribution. The disease affects a wide variety of hosts, including man. In cattle, the disease is manifested primarily as an encephalitis, but localization can occur in the pregnant uterus and cause abortion.

History and Occurrence

Microorganisms belonging to the genus listeria were first iso-
lated from animals by Murray, Webb, and Swann (1926) and Pirie in
1927 (Dubos and Hirsch, 1935). Since then listeriosis has been en-
countered in many countries throughout the world.

The first reports of listeriosis in cattle in the U.S.A. were
by Jones and Little (1934), and Graham, Dunlap, and Brandly (1938).
According to these reports the predominant signs were that of ence-
phalitis. Similar outbreaks have been recorded by Schwarte and
Biester (1942), Pommeroy, Fenstermacher, and Andberg (1943), Cole
(1946), Jensen and Mackey (1949), and Gray, Stafseth, and Thorp (1951).

Graham, Hester, and Levine (1939) at the University of Illinois
were the first to associate <u>Listeria monocytogenes</u> with abortion in
cattle. They isolated the organism from a seven-month old aborted
bovine fetus. The dam was unavailable for culture and there was no
history of encephalitis in the herd from which the fetus originated.
The culture from the fetus was inoculated intravenously into a
pregnant heifer and produced abortion within ten days. Listeria was
reisolated in pure culture from the aborted fetus.

Evans and Sawyer (1942) isolated <u>Listeria monocytogenes</u> from a
bovine fetus which showed extreme decomposition at the time of
abortion. The dam was not available for culture. The herd involved
was brucellosis free and several abortions of undetermined cause had
occurred.

According to Smith, Reynolds, and Bennett (1955), Olson reported,

in 1945, the isolation of _Listeria monocytogenes_ from 6 cows, which had aborted at gestation periods of eight and one-half, six, six and four-months, and two unknown. The organism was recovered from the fetal membranes in two cases, in two cases from the fetal intestine, and in two cases from both fetal membranes and intestine. The dams were not available for further study.

Ferguson, Bohl and Ingalls (1951) reported the isolation of the listeria organism from two bovine fetuses in different herds. Injury in one animal and malnutrition in the other appeared to be pre-disposing factors.

Stockton, Neu, Carpenter, and Gray (1954) isolated _Listeria monocytogenes_ from the aborted fetus of a nine year old cow which had previously delivered six normal calves. No history of herd infection could be ascertained.

Smith, Reynolds, and Bennett (1955) reported a case of bovine abortion in which _Listeria monocytogenes_ was isolated from the aborted fetus. The dam showed initial signs indicating the development of the encephalitic syndrome of listeriosis. The organism, however, was not isolated from the dam nor did gross or microscopic pathology support the diagnosis except for the abortion.

Young and Firehammer (1958) described the occurrence of abortion which was attributed to infection with _Listeria monocytogenes_ in a herd of beef cattle in Montana.

Osebold, Kendrick, and Njoku-Obi (1960) reported that _Listeria monocytogenes_ was isolated from three herds with a disease problem characterized by abortions in the last trimester of gestation, fever

in the dam with visible depression, frequent retention of fetal membranes, and by fetuses aborted either dead or alive.

Etiology

The final diagnosis of listeriosis associated with abortion is dependent on the isolation of the organism <u>Listeria</u> <u>monocytogenes</u> from the fetus or its membranes. The tissues of preference for the isolation of the organism from the aborted fetus are lung, liver, spleen and stomach contents (Howarth, 1960). The organism can sometimes be isolated from uterine exudates collected from the dam following abortion. The listeria organisms can be cultured from uterine exudates for 13 days following abortion (Osebold, Kendrick, and Njoku-Obi, 1960). The fetus and fetal fluids play important roles in the spread of the disease since they may serve as the source of infection to other cattle which lick the fetus or ingest uterine fluids. From sporadic examinations of the mammary gland secretions, Osebold, Kendrick, and Njoku-Obi (1960) could isolate the listeria organism on the first, second and fourth days following abortion.

The organism is a small, straight or slightly curved, with rounded ends, gram-positive rod of 2-3 microns long and 0.5 micron wide which shows pallisade formation, parallel arrangement, or occurs in pairs or short chains. It is sluggishly motile at a temperature of 37°C, and actively motile at 25°C in broth cultures (Stableforth and Galloway, 1959). The viability of listeria is remarkable; they can survive drying of the medium in which they are growing. They will survive without loss of virulence for 3 to 4 years at 4°C

(Murray, 1955). Listeria is less susceptible to heat than many pathogens, having been shown to survive 5 minutes at 80°C. Added to food pellets, straw and wood shavings, they will survive up to 26 weeks in the dry state. There is evidence that they may persist for at least 2 weeks in animal pens and bedding straw (Gray, Singh, and Thorp, 1956).

Listeria organism can be cultured in broth media. Such media is useful only if the specimen is free of contaminating micro-organisms. Acids, but no gas, are produced if the organism is cultured in dextrose, maltose, levulose, rhamnose and salicin. Most observers have agreed that listeria will produce a variable amount of true hemolysis on blood plates (Graham et al., 1939, Paterson, 1940, Smith et al., 1955). Hence cultures isolated can be identified as listeria by their action on blood agar plates and characteristic reactions in various differential media. The identification can be further confirmed by the instillation of culture material into the eye of a rabbit with the subsequent production of characteristic conjunctivitis.

Pathogenesis

The organisms appear to have predeliction for establishing themselves in certain anatomical locations, e.g., the brain stem, the liver and spleen, and the pregnant uterus.

In cattle, meningoencephalitis of the brain stem is common, and results in a flaccid paralysis of various muscle groups. The head and the neck are turned to one side and the animal tends to

move in circles; hence the common name of "circling disease."

Septicemia and monocytosis are uncommon in adult cattle. In their experiment, Osebold, Kendrick, and Njoku-Obi (1960) encountered at least two changes in the white blood cells. Neutrophilia was observed approximately 48 hours after inoculation of the bacteria into the cow, and neutropenia was observed following abortion. The neutropenia was thought to be due to toxemia caused by the retention of the fetal membranes.

In natural occurring cases either the encephalitic or uro-genital form will usually predominate. When the disease is produced experimentally by injection both forms may occur in one animal.

The expulsion of the fetus either dead or alive from the uterus, is the sequela to uterine infection. Abortions usually occur between four and eight and one-half months of pregnancy, with the most fre-quent occurrence during the later stages. When uterine infection de-velops, the placenta and fetal tissue are quickly invaded by the organism and the fetus dies as a result of septicemia (Jubb and Kennedy, 1963). Infection late in pregnancy may result in still-births or the delivery of young, which rapidly develop a fatal septicemia. The dead fetus is expelled in approximately 5 days, at which time autolytic changes will usually mask the minor lesions produced by the organism. Microscopic changes are slight, all organs teem with bacteria, and the tissue alterations include small foci of hepatic necrosis. In addition to the necrotic lesions in the liver, similar ones may be noted in the spleen.

The route of uterine infection is obscure. Distribution of the agent to the genital tract is, very likely, hematogenous. The effects on the dam are sufficiently severe to produce a febrile response with sufficient metritis to cause frequent retention of fetal membranes and occasional deaths. The body temperature commonly approaches 105° F. Death of the dam can not be considered a specific effect of the listeria infection, since endometritis following abortion is usually complicated with other organisms. The placenta contains the most advanced lesions. The necrotic tips of the villi are covered by a purulent exudate in which many bacteria are present. The severity of the uterine infectious process would vary with the type of microbial population developing following abortion.

Listeria abortion must be differentiated from other causes of abortion in cattle. Acute septicemia of newborn animals may be due to many causes, however its association with abortion and still-birth should suggest the possible presence of listeriosis. Necropsy lesions are distinctive and positive cultural findings will confirm the diagnosis.

In summary it may be stated that infection by <u>Listeria</u> <u>monocyto-genes</u> in cattle is usually associated with encephalitis. Localization of <u>Listeria</u> <u>monocytogenes</u> can occur in the pregnant uterus resulting in abortion or stillbirth. The syndrome of encephalitis and abortion may occur simultaneously in a herd, but this is the exception. More commonly one or the other syndrome occurs almost exclusively. Usually the abortions produced are sporadic. The route of infection in natural outbreaks is not known. Intravenous injection with <u>Listeria</u>

monocytogenes experimentally has been shown to produce abortion. Cases of abortion in cattle due to Listeria monocytogenes usually occur during the last trimester of pregnancy. If uterine infection develops during the early part of the last trimester, the placenta is quickly invaded by the organisms and the fetus dies as a result of a septicemia. The dead fetus is expelled in approximately 5 days; by this time autolytic changes mask the lesions produced by the organism. The microscopic changes are slight; all organs teem with bacteria; tissue alterations consist of small foci of necrotic lesions in the liver and in the spleen. The abortions are not usually accompanied by severe systemic disease in the dam. The placenta is usually retained. The organism and the associated inflammation will usually be cleared from the uterus following abortion, however in few instances severe metritis complicated by septicemia may occur.

SALMONELLOSIS

Salmonellosis is a disease affecting almost all domestic animals, caused by a number of types of Salmonella spp., and is of world-wide occurrence. A particular animal species may be commonly affected with one type of salmonella and act as its host reservoir. Such types of salmonella are not commonly found in species other than the host reservoir. Other types of salmonella are more cosmopolitan and do not favor a particular animal species as host reservoir. For example, Salmonella typhimurium has been found in rodents, pigs, cattle, sheep, fowl and horses. Therefore, while a

given species of domestic animal may harbor its own particular type
of salmonella, the same species not infrequently harbors some of the
more cosmopolitan types.

Salmonellosis in animals is generally manifested by an intestinal
infection. Under various conditions it may develop into a septicemia,
and in some cases, pneumonia. The disease is commonly known as
paratyphoid and may be associated with food poisoning in man. In
cattle, the disease occurs as an acute or chronic infection in animals
of all ages. In adult stock, it is generally sporadic in nature,
however in the more unusual extensive outbreaks, abortions are com-
mon and the organism is present in the fetus.

History and Occurrence

Merchant and Packer (1958) reported that the first organism
representative of the salmonella group was isolated in 1885 by
Smith and Salmon from pigs. The name **Bacillus choleraesuis** was
given to it. The second isolation was made by Gaertner in 1880
from a fatal case of gastroenteritis in man. The organism was named
Bacillus enteritidis. Since then numerous types fulfilling the
description for this genus have been described. There are now more
than 700 recognized types of salmonella. The name **Salmonella** was
proposed for the genus by Lignieres in 1900 in honor of D. E. Salmon,
the first Chief of the United States Bureau of Animal Industry.

In the United States extensive studies of salmonella have
been conducted by Jordan (1917, 1923), Jordan and Victorson (1917),
and Krumwielde, Valentine, and Kohn (1918, 1919), and in the recent

years by Shotts, Martin, and Galton (1961), Galton (1961), Pomeroy and Grady (1961), Niven (1961), Wadman (1961), and Newell (1961).

Diseases of cattle caused by salmonella organisms have been described and investigated since the eighth decade of the last century. According to Field (1949) de Nobele in Aertryke and Kaensche in Breslau described *Salmonella typhi-murium* as a bacteria found in diseases in cattle which was capable of causing food poisoning in man.

Olson (1942) from Sweden reported *Salmonella dublin* as being the cause of diarrhea, abortion and death in cattle. John (1946), Bythel (1946), Grunsall and Osborne (1948), and Field (1948), all of Great Britain reported on salmonellosis in adult cattle. Their findings revealed that the organism most commonly responsible for disease in adult cattle was *Salmonella enteritidis* var. *dublin*, which generally caused abortion during the height of the disease and sometimes several weeks after recovery. The organism was re-covered from all organs of the fetus. Seller and Sinclair (1953) reported the abortion of a seven month-old fetus by a cow three weeks after the cow had suffered a mild attack of diarrhea of 3 to 4 days' duration. They also reported the abortion of an eight month-old fetus from a cow which had shown no premonitory symptoms. *Salmonella typhi-murium* was isolated in both instances.

In Germany, Bert (1945) isolated *Salmonella dublin* from an aborted fetus of four to five months of age. Liebermann, Mueller, and Heinke (1960) reported the recovery of the same organism from two aborted fetuses.

Lawson (1962) reported the isolation by Savov in 1959 of
Salmonella dublin and *Salmonella paratyphi B* following abortion in
cows in Bulgaria. Masynkov in 1949 recovered salmonella from fetuses
in the U.S.S.R., as did Shone *et al.* in 1958 in Rhodesia, and
van Ulsen in 1960 in Holland.

Josland (1950) reported *Salmonella typhi-murium* infection among
cattle in New Zealand, and stated that *Salmonella dublin* had not yet
been identified in that country. Mortelmans, Huygelen, and Pinckers
(1958) reported the isolation of *Salmonella infantis* from a five-
month old bovine fetus in the Belgian Congo.

Terpstra (1963) reported the occurrence of abortion among
cattle in Holland caused by *Salmonella dublin* and *Salmonella typhi-
murium*. Most of the cases were caused by *Salmonella dublin*. In cases
of *Salmonella typhi-murium*, he assumed that the abortion was due
to toxic influences, because of repeated failures to recover the
organism from the aborted fetus. He also noted that about 80 percent
of the aborting cows were not sick.

In the United States salmonellosis in cattle is not infrequently
observed. Johnson and Graham (1945) recovered *Salmonella choleraesuis* var. *kunzendorf* from an aborted fetus. Abortion occurred in a
pregnant heifer, which had been intravenously injected with the
culture confirmed the abortifacient property of this type of
salmonella bacteria. Edwards, Bruner, and Moran (1948), and Moran
(1961) described the occurrence and distribution of salmonellosis
in the United States. Ellis (1961) reported the occurrence of acute
and chronic salmonellosis in Florida. The types, isolated from adult

cattle, have included Salmonella typhi-murium, Salmonella miami, Salmonella litchfield, Salmonella newport, Salmonella anatum, Salmonella habana, Salmonella java, Salmonella montivideo, Salmonella tennessee, and Salmonella kentucky. Moore, Rothenbacker, Bennett, and Barner (1962) reported salmonellosis in cattle, associated with a dysentery syndrome, with signs of acute septicemia and intoxication. They incriminated Salmonella newport to be the most common serotype for cattle with fatal infection, while Salmonella dublin and Salmonella typhi-murium were more commonly associated with bovine abortion. Rude (1962) reported that Salmonella typhi-murium infection in cattle produced a watery, fetid diarrhea and persistent elevation of body temperature. As the disease progressed, there were varying amounts of blood and mucus in the feces.

The above reports indicate that salmonellosis is widespread over the world and may be accompanied by abortion in pregnant cattle, whether the disease is mild or severe. According to several authors Salmonella dublin is most commonly responsible for the disease in adult cattle in Great Britain, West European countries, South Africa and Australia. Salmonella typhi-murium is concerned to a considerable lesser extent in these countries, and occasionally other types are encountered. On the contrary, in the United States, Salmonella typhi-murium is the prevalent type of salmonella in cattle. In New Zealand Salmonella dublin has not been reported whereas Salmonella typhi-murium has been isolated.

Etiology

The salmonella organism can be isolated from the stomach content
and heart-blood of aborted fetuses, and from the fecal material and
blood of the affected cow. Microscopically they are short, plump
rods of 2 to 4 microns in length and 0.5 to 0.6 microns in width,
which may become pleomorphic, showing coccobacillary or filamentous
forms. They are gram-negative and do not form spores. They are not
acid-fast and are readily stained by common laboratory staining methods.
They are motile with peritrichous flagella (Merchant and Packer,
1958).

The organisms are easily killed by temperatures of 60°C in 20
minutes, and are quickly destroyed by common chemical disinfectants.
In feces or other material where they are protected from sunlight
and desiccation they can survive for longer periods of time. Ac-
cording to Moore and his coworkers (1962) Salmonella dublin was found
viable in dried feces after 3 years and Salmonella typhi-murium sur-
vived in water, pasture, and feces for periods from 4 to 28 weeks.
Both organisms survive freezing and can live through winter periods.

Carbohydrate fermentations and serological studies are employed
in attempting to classify the various salmonella.

Pathogenesis

According to Moore and his coworkers (1962), the most common
method of spread of salmonella infection is via subclinical carriers
among cattle, swine, rats, birds, dogs and reptiles. Contaminated

feeds and feed supplements such as blood and bone meals, may be a source of infection. Young cattle are more susceptible to acute and fatal infections than adults. Salmonella are considered of low infectivity for adult cattle. This is shown by the fact that adult carrier animal may be present in a herd for years with no further clinical cases appearing although the carrier is constantly excreting the organism in feces. In addition the organism remains viable in feces for many months.

Experience shows that animals are rendered susceptible to bacterial infection through a variety of causes, e.g., concurrent infection, fatigue, nutritional disturbances, shipping, and climatic conditions. If the host is debilitated, septicemic infections are likely to occur. Infection with salmonella results in rapid multiplication of the organism in the intestine and subsequent invasion of the bloodstream. Stress factors would seem to explain the sporadic character of acute salmonella infections in adult cattle and their seasonal incidence.

The acute disease is of sudden onset with high temperature, prostration, loss of appetite, cessation of rumination and milk production, and is characterized by increasing exhaustion which may be fatal in 24 hours. In mild cases the signs are less severe. Initial signs are followed by diarrhea, which is characterized by an offensive odor and which may contain blood or fibrin shreds. There is complete anorexia although great thirst may be manifested. The pulse rate is rapid, the mucosa is reddened and respirations are rapid and shallow. Affected animals rapidly become emaciated, may

show abdominal pain, and the majority will die within five to seven days. The mortality rate ranges from 70 to 75 percent. Pregnant cattle may abort and the organism can be recovered from all the organs of the fetus. According to Field (1949) abortion usually occurs during the first few days of illness, however abortions two or three weeks after recovery are reported. Terpstra (1963) assumes that in Sal-monella typhi-murium infection the abortion is due to toxic influences since the organism has not been isolated from the aborted fetuses.

Animals which recover continue to shed bacteria for long periods. The main reservoir of infection would appear to be the gallbladder. Field (1949) examined carriers periodically for periods up to three years, and on all occasions the organisms could be detected in the feces. The organism also localizes in the spleen, liver and all lymph glands and associated the gastrointestinal tract.

The diagnosis is confirmed by bacteriological examination. The organism can be recovered from the feces, and during the early febrile stage of the disease it can be recovered from the blood. Agglutinins are formed during the progress of the disease and may be used for diagnosis. Salmonella organisms may be excreted in the milk during the early, febrile stage of the disease, whereas in carriers the milk occasionally becomes infected by fecal contamination (Stableforth and Galloway, 1959).

In summary it may be said that salmonellosis is a disease caused by a number of types of salmonella bacteria and is of world-wide occurrence. The disease is generally manifested by an intestinal

infection. Under various conditions it may develop into a septicemia and in some cases, pneumonia. In cattle, the disease may be either an acute or chronic infection which occurs in animals of all ages. In adult stock, it is generally sporadic in nature. Affected animals may show evidence of abdominal pain. Pregnant cattle generally abort and the organism can be recovered from the various organs of the fetus. Recovered animals continue to shed bacteria for long periods. The main reservoir for the organism in the carrier animals is the gallbladder.

CORYNEBACTERIUM PYOGENES

Corynebacterium pyogenes may be found as either a primary or a secondary invader in several disease conditions. The organism is usually associated with suppurative lesions. Synonyms of Corynebacterium pyogenes include Bacillus pyogenes, Bacterium pyogenes or Hemophilus pyogenes. The organism has been associated with abortion from time to time and recovered from the aborted fetuses.

History and Occurrence

Merchant and Packer (1959) were of the opinion that Kitt was the first to observe the organism in a case of caseous pneumonia in the pig, in 1890. In 1893 the organism was isolated from the cow and described by Lucet. In 1903 Kunneman observed it in cases of suppuration in cattle. Glage studied bovine and swine strains of the organism in 1903, concluded that they were identical, and used the name Bacillus pyogenes. The organism was first classified

in the diphtheroid group by Eberson (1918) who called it Corynebac-
terium pyogenes. In cattle the organism is involved in several
diseases including mastitis, uterine infection and abscess formation.

The organism has been reported from many countries. Smith (1919)
found the organism in two of 109 abortions. According to Gilman (1939),
Zwick and Zeller encountered the organism in one fetus out of 17
examined, while Traum isolated it from two of 40 aborted fetuses.
Holth recovered the organism in one of five aborted fetuses and
Carpenter reported that he found it in two of 40 aborted fetuses.
Reisinger, in 1928, recovered Corynebacterium pyogenes in pure culture
from four out of seven aborted fetuses. A suspension of the culture
was injected intravenously into a six months pregnant cow. Abortion
followed in 30 days and the bacillus was recovered from the fetal
fluids, placental membranes, and stomach, spleen, and liver of the
fetus.

Maxwell (1943) reported the occurrence of abortion and macerated
fetuses due to Corynebacterium pyogenes in cattle with a history of
suppurative mastitis.

Boyd and Kelly (1943) reported abortion in a cow with no ap-
parent illness. Corynebacterium pyogenes was recovered from the
heart, lung, liver and spleen of the fetus. The fetal membranes
were retained because of placentitis.

Johnson and Graham (1945) isolated Corynebacterium pyogenes
from a five months premature bovine fetus. Inoculation of a sus-
pension of the organisms intravenously into a four months pregnant
cow resulted in abortion on the 14th post injection day. The abortion

was accompanied by an elevation of temperature, inappetence, constipation, accelerated heavy breathing, and edema of the extremities. The cow collapsed and remained in a recumbent condition from the day of abortion until her death two weeks later.

Olson (1948) recorded Corynebacterium pyogenes associated with abortion in cattle, in Sweden. Hess and Bruner (1951) reported the occurrence of 245 abortions caused by Corynebacterium pyogenes out of 9,261 abortion cases occurring in Zurich during the period of 1939 to 1948.

Weikl (1957) reported Corynebacterium pyogenes abortions in cattle following an investigation in Bavaria during 1954 to 1956.

Agrimi, D'Ascani, and Tozzini (1959) described an outbreak of Corynebacterium pyogenes infection of the genital tracts in 54 cows after service by two infected bulls. Corynebacterium pyogenes was isolated from the aborted fetuses.

Mitchel (1960) in Canada recovered Corynebacterium pyogenes from the stomach contents of an eight month-old bovine fetus. Terpstra (1963) reported abortion caused by Corynebacterium pyogenes in Holland, and suggested that it occurred in farms where cases of mastitis, abscesses and endometritis due to the same organism were frequently found. He also observed that the number of cases of abortion due to Corynebacterium pyogenes infections had increased with the increased utilization of artificial insemination.

Kolar (1963) reported 39.1 percent of the bovine abortions in Prague between 1955 and 1960 were caused by Corynebacterium pyogenes. Abortions have been reproduced experimentally in cattle

following the administration of cultures both intracervically
and intravenously.

Etiology

Merchant and Packer (1958) described Corynebacterium pyogenes
as a small, coccoid, pleomorphic bacillus varying from 0.2 to 0.3
micron in breadth and 0.5 to 2.0 microns in length. Cells with
swollen or pointed ends are common. The organisms are usually
single with a tendency to form clumps. Palisade arrangements are
frequently observed. The organism is gram-positive, non-motile and
non-capsule-producing. It produces an exotoxin which is lethal to
rabbits. According to observations by Roach (1946) the organism
will be killed at 60°C after three minutes, while by heat of 80°C
the organism will be readily destroyed. Roach also reported that
iodine and lysol were the best disinfectants to use in attempting
to destroy the organism. A dilution of 1:1000 aqueous iodine killed
the organism in two minutes, whereas one percent lysol destroyed
the organism in 15 minutes.

Pathogenesis

Corynebacterium pyogenes infection in the bovine has been
responsible for chronic abscessing mastitis, suppurative pneumonia,
abscesses in the peritoneal and thoracic cavities, arthritis, endo-
metritis, abortion and pyometra. Abortions have been produced ex-
perimentally in cattle following the administration of Corynebac-
terium pyogenes by different routes (Reisinger, 1928, Johnson and

Graham, 1945, Kolar, 1963). While the intravaginal route during
gestation has never been successful, the administration of the
organism by the intracervical and intravenous routes has produced
abortion with regularity. This would indicate that the placental
and the fetal tissues are the sites within the uterus most favorable
for the multiplication of Corynebacterium pyogenes and that it is
at these sites where the organism exerts its proteolytic action.
These investigations also revealed the protective role of cervical
mucus against natural infection via the vaginal route, and emphasized
the care which must be taken in carrying out artificial insemination
by the intracervical route. While Corynebacterium pyogenes may be
isolated from the healthy bovine tract, it is suggested that uterine
infection with Corynebacterium pyogenes is usually conditioned by
some dysfunction or interference with the uterine tract. Evidence
has accumulated which indicates that Corynebacterium pyogenes infec-
tion in cattle becomes clinically apparent when the general resistance
is weakened through specific or nonspecific causes. It would seem
apparent then that the number of cases of abortion due to Corynebac-
terium pyogenes could be reduced by maintaining the general health
of the individual animal.

Rowson, Lamming and Fry (1953) suggested that exogenous progesterone
would promote conditions suitable for the growth of bacteria within
the genital tract, while exogenous estrogen would render the bovine
uterus more resistant to infection. In their experiment they demon-
strated that cows which were inseminated with semen infected with a
culture of Corynebacterium pyogenes during the luteal phase led to

pyometra, while animals that were inseminated with the infected semen during the estrual phase failed to show pyometritis.

Fetal membranes are retained as a result of placentitis and the involution of the uterus is usually retarded.

The diagnosis is based on isolation and identification of the organism. Characteristic morphology and colony size are significant in making the identification.

STREPTOCOCCUS

Streptococci are widely distributed and cause a wide variety of diseases in both man and animals. Acute, subacute or chronic infections associated with local pyogenic processes, spreading inflammations or septicemic manifestations are relatively common. The organisms have been isolated from the mouth, nose, throat, genital tract, skin and feces of healthy individuals, both human or animal, from milk and milk products, from contaminated dairy utensils and from human and animal environments. They have also been reported in association with abortion in cattle.

History and Occurrence

According to Stableforth (1959) the first description of streptococci as a cause of disease in animals was recorded by Nocard, Mollereau and Schutz in 1887. Since that time many other workers have published their studies.

As reported by Lawson (1962), Lionet described an outbreak of streptococcal bovine abortion in Mauritius in 1934. Seventy-six

of 234 pregnant cows aborted at about the third month of gestation
and Streptococcus viridans was implicated.

Olson (1945) reported 194 cases of streptococcal abortion in
Sweden. The species isolated included Streptococcus schutz, Strepto-
coccus schutz variants, Streptococcus equi and Streptococcus lanceo-
latus. De Lay and Rucker (1951) reported that one out of a series of 43
abortions investigated in California was caused by Streptococcus sp.
Hess and Bruner (1949) recorded 48 abortions due to streptococci out
of 9,261 cases occurring in Zurich during the period 1939 to 1948.
According to Weikl (1957) 13 percent of 1,496 bovine abortions in
Bavaria, investigated in 1954 to 1956, were caused by streptococci.

In Canada, the isolation of Streptococcus zooepidemicus from the
stomach contents of an eight-month-old fetus and from 8 vaginal
mucus samples was reported by Mitchel in 1960. He noted that the
organism had been isolated frequently from "repeat breeders." Terpstra
(1962) reported that bovine abortion caused by streptococci occurred
occasionally in Holland.

Gilman (1939) recovered a hemolytic streptococcus in pure culture
from a well developed aborted fetus and proceeded to inoculate a
suspension of the organism intravenously into a pregnant cow. Abortion
occurred and the same organism was recovered in pure culture from the
internal organs of the aborted fetus and from the placenta. He also
reported the frequent recovery of streptococci in pure or mixed cultures
from very young fetuses, i.e., 2 months old or under. Such abortions
are frequently unobserved and the animal may be classified as sterile.

Etiology

The streptococcus group of organism are gram-positive and
nonspore forming. There are many systems of classification utilized
to distinguish the various species. The systems are based on mor-
phology, hemolytic properties, ability to ferment various carbohy-
drates and other substances, resistance to heat, dyes, bile, and
high salt concentrations, limiting ph for growth, ability to grow
at high or low temperatures and serological characteristics. Based
on the publication of Lancefield (1933) the streptococci can be
divided into a number of broad, well defined serologic groups, i.e.,
A, B, C, D, to S. The groups bear a close relationship to source
of the organism and the pathogenic characteristics. According to
Stableforth (1959), group C streptococci have been indicted in
bovine abortions and have been isolated from the uterus and vagina.

The organisms are not resistant to desiccation or sunlight.
The thermal death point is 68°C in 10 minutes and boiling is ef-
fective immediately. The organism is easily killed by the ordinary
chemicals used in disinfection.

Pathogenesis

Most pathogenic streptococci in cattle are of the hemolytic
group C of Lancefield. They produce severe infections, often ending
in septicemia and death. In the bovine these organisms may cause
cervicitis, mastitis and abortion.

Experimentally Gilman (1939) has been successful in producing abortion by intravenous injection of a suspension of hemolytic streptococci into a pregnant cow. In natural cases the intra-carvical or intrauterine routes of infection are more likely to occur. Straptococcus organisms may also be found in the genital tract and sheath of bulls.

Bellar (1927) stated that tha abortions could be attributed to the multiplication of bacteria in the fetal membranes and fluids. He found that the fatuses were lacking evidence of septicemia, but hearing evidence of having died from asphyxia shortly prior to ax-pulsion.

STAPHYLOCOCCUS

Staphylococci are widely distributed in nature. Many lead a purely saprophytic axistence, but some are pathoganic for man and animal. They are commonly found in pyogenic processes and in con-taminated wounds in all species of domestic animals.

History and Occurrence

Some of the more specific forms of staphylococcal infaction have been recognized for a very long time. According tq Stable-forth (1958) the first description of these bacteria occurring in lesions appears to have been made by Boillinger in 1869 in botryo-mycosis in tha horse. They were noted in pus by Koch in 1878 and were cultivated for the first time by Pasteur in 1880. The first thorough study of staphylococci was made by Rosenbach in 1884, who

classified them into 2 species, <u>Staphylococcus</u> <u>pyogenes</u> <u>aureus</u> and
<u>Staphylococcus</u> <u>pyogenes</u> <u>albus</u>. In 1885, a third species, <u>Staphylo-</u>
<u>coccus</u> <u>pyogenes</u> <u>citreus</u> was added by Passet.

Reports of staphylococci in association with bovine abortion in
the literature are very rare. Gilman (1939) remarked that only
isolated cases of abortion were caused by staphylococci. He referred
to but one specific instance, in which <u>Staphylococcus</u> <u>albus</u> was in-
criminated in association with a mold.

Pounden and Krauss (1947) reported 2 cases of abortion due to
staphylococci in cattle which had been inseminated artificially.
The expulsion of the fetuses was accompanied by approximately 8
liters of light, grayish tan-colored pus, tinged with pink and of
curdlike consistency. Normal amnionic and allantoic fluids were
not visibly present. The placentae were retained, and examination
of the cotyledons in the fresh state revealed necrotic areas on
their attachment surfaces. This necrosis resulted in a red gray
mottled appearance of the cotyledon. Gram-positive cocci were ob-
served in massive numbers in stained smears made from the uterine
exudate. A staphylococcus resembling <u>Staphylococcus</u> <u>albus</u> was re-
covered in pure culture from the uterine exudate of the cow and
from the lungs, heart, and fourth stomach of the fetuses. Toxemia
and other indications of systemic reactions in the cows were com-
pletely lacking.

Pounden, Ferguson, Knoop, and Krauss (1947) reported 3 cases of
abortion due to <u>Staphylococcus</u> sp. in cattle. Two cows were in-
seminated artificially with semen from the same bull as the two

described previously. The third animal conceived to a natural breeding by the same sire. A staphylococcus resembling <u>Staphylococcus albus</u> was recovered from the abnormal uterine exudate and necrotic cotyledons from the cows, and from the lungs of the aborted fetuses. Culture media were inoculated with semen from the sire of the aborted calves, and staphylococci were recovered which had characteristics very similar to those associated with the abortions.

Etiology

Staphylococci are spherical or ovoid cells, usually arranged in grapelike clusters, although pairs and short chains are frequently seen in fluid media. The diameter of a single organism varies from 0.8 to 1 micron. They are nonspore-forming, nonmotile, noncapsule-producing, and gram-positive. The organisms are found in suppurative processes in man and animals.

Staphylococci are the most resistant of the cocci. Varying reports are given concerning their resistance to heat. Usually a temperature of 60°C for 30 minutes will destroy most of the cells, but some individual cells require 80°C for the same length of time. Staphylococci are more resistant to chemicals than many nonspore forming organisms.

Pathogenesis

Pathogenic staphylococci are most commonly associated with cases of suppurative infection in man and animals. They may localize in any tissue of the body and are the most common cause of pyemia.

Staphylococci have been incriminated as a cause of abortion in a herd of cows in the United States (Pounden and Krauss, 1947; Pounden, Ferguson, Knoop, and Krauss, 1947). They were isolated from the uterine exudate of the cows that had aborted and from two of the aborted fetuses. Staphylococci resembling these strains were also isolated from the semen of the bull with which those cows had been mated by artificial insemination. Based on these observations it would seem logical to assume that the route of infection is either the intracervical or intrauterine introduction of infected semen. The organisms invade the uterus and cause necrotic lesions in the placenta. Merchant and Packer (1958) considered such cases as unusual and suggested that additional research must be done.

Of the laboratory animals, the rabbit is the most susceptible and is frequently chosen as the experimental animal in staphylococcus research.

MISCELLANEOUS ORGANISMS

Tuberculosis has been reported in association with abortion in cattle. As tuberculosis eradication programs proceed, tuberculosis infection as a cause of abortion becomes less important in the United States. But in countries where the disease is still endemic, it may be a significant factor.

Tuberculosis in cattle may produce abortion or infertility due to the general reduction of health, directly from tuberculous infection of the genital organs, or by the production of lesions which interfere with the ova or spermatozoa. Infection is most

frequently due to the mammalian type which may lead to abortion (Roberts, 1956; Laing, 1955). Occasionally the avian type may also cause abortion in cattle (Laing, 1955; Plum, 1926). In examining a series of 834 consecutive fetal membranes Plum (1926) found tuberculous abortion in 1.79 percent, however, he stated that the true proportion in Denmark should be two percent. In his further study Plum encountered six cows proved to be infected with avian tuberculosis among 151 tuberculous abortions. The avian type of tubercle bacillus does not seem to cause progressive lesions of the uterus capable of preventing conception, however infected animals may abort habitually (Laing, 1955).

The incidence of genital tuberculosis has not been documented. In an extensive survey carried out in Sweden in 1925 involving some 12,000 cows, it was found that 4.22 percent were affected with tuberculosis and that 11.36 percent of the tuberculous animals had lesions in the reproductive organs (Nielsen and Plum, 1935). Lockau observed that four to five percent of cows slaughtered in Germany were affected with uterine tuberculosis. Burrow (1937) reported that 19 or 23.75 percent of 82 cows slaughtered under the Tuberculous Order, showed definite lesions of tuberculosis in the mucosa and or submucosa of the uterus. According to Laing (1955), tuberculosis of the reproductive organs is usually secondary to a primary focus elsewhere in the body. The origin of tuberculosis of the uterus is considered to be most frequently hematogenous, although it may arise by direct extension from the peritoneum and fallopian tubes. Vaginal and vulval as well as uterine tuberculosis

may be secondary, however it is reported that primary lesions may occur as a result of venereal infection. Primary tuberculosis of the female genitalia may also result from the use of contaminated instruments (Laing, 1955).

Lesions in the genital organs are similar in nature to those which occur at other sites. Their character and extent varying very greatly with their age. Tuberculous pyometra with gross enlargement of the uterus may be found. Maceration of the fetus sometimes occurs. The fetal cotyledons in tuberculous abortion are necrotic and often covered by a thick exudate.

Infection with the avian type of tubercle bacillus may produce a mild endometritis and placentitis with an occasional submucous abscess. According to Laing (1955), their lesions were reproduced by the intravenous injection of cultures of the avian bacillus in an experiment conducted by Plum. Gilman (1939) recorded that 225 cases of abortion in cattle due to the avian tubercle organism had been reported in Denmark in 1925 by Plum. Burgisser and Schneider (1958) reported the occurrence of abortion in two cases caused by the avian tubercle bacilli in a farm that had been free from bovine tuberculosis for over four years. The organisms were demonstrated in the uterus and placenta.

Mitchel (1960) reported the isolation of _Pasteurella hemolytica_ from the placenta of a four weeks premature calf born alive in a herd which had experienced three previous abortions at the same stage of gestation during a six-month period. This finding was considered of possible significance.

Laboratory examinations of the fetal material from abortion cases may occasionally yield other bacteria. Bacteriologic studies of the specimens, submitted following abortions, during the periods of 1949 and 1950 from 43 herds, to the Animal Pathology laboratory, Department of Agriculture, California, revealed coliform organisms and Pseudomonas sp. in addition to Vibrio fetus, Staphylococcus sp., Streptococcus sp. and Proteus sp. Brucellosis and trichomoniasis were not encountered in this study. The coliform organism comprised 23.3 percent of the isolations, while the Pseudomonas sp. were isolated in 2.3 percent of the specimen. Terpstra (1963) reported that abortion in cattle caused by Escherichia coli and Pseudomonas sp. occurred occasionally in Holland.

SUMMARY

A review of the occurrence and distribution of sporadic bacterial infections associated with bovine abortion has been attempted. Listeria monocytogenes, Salmonella sp., Corynebacterium pyogenes, Streptococcus sp., Staphylococcus sp., and to a minor extent other miscellaneous bacteria, i.e., Mycobacterium tuberculosis, Pasteurella sp., Escherichia coli and Pseudomonas sp. are listed as organisms capable of producing abortions.

Listeriosis is of world-wide distribution. The disease affects a wide variety of hosts, including man. Infections by Lysteria monocytogenes in cattle are mainly associated with encephalitis. Localization can occur in the pregnant uterus and result in abortion or stillbirth. The syndromes of encephalitis and abortion may occur

simultaneously in a herd, however this is an exception. More commonly one or the other syndrome will occur almost exclusively. Abortion in cattle due to _Listeria monocytogenes_ usually occurs during the last trimester of pregnancy. If a uterine infection develops the placenta and the fetal tissues are invaded by the organism and the fetus dies as a result of a septicemia. The dead fetus is expelled in approximately five days. Most of the parenchymatous organs of the fetus teem with bacteria. Tissue alterations consist of small focal necrotic lesions in the liver and spleen. Abortions are not usually associated with severe systemic disease in the dam. The organism and the associated inflammation are quickly cleared from the uterus following abortion. The placenta is frequently retained as a result of placentitis. Metritis may develop and septicemia is the common complication.

Salmonellosis is a disease affecting domestic animals, caused by a number of types of salmonella bacteria and generally manifested by an intestinal infection. Under varying conditions it may develop into a septicemia or pneumonia. Salmonella infection is commonly known as paratyphoid and may be associated with food poisoning in man. In cattle, the disease occurs as either an acute or chronic infection in all ages of animals. In adult stock it is generally sporadic in nature. Pregnant animals usually abort and the organism can be isolated from the uterus. Salmonella are considered of low infectivity for an adult cow. Debilitated animals are more susceptible to the infection and under such conditions septicemic infections are likely to occur. The presence of stress factors would seem to

explain the sporadic character of acute salmonella infection in adult cattle as well as its seasonal incidence. The systemic disease is characterized by a sudden onset with high temperature, prostration, anorexia, and an increasing exhaustion which may be fatal within 24 hours. Pregnant animals generally abort, usually during the first few days of illness, however abortions are reported as long as three weeks after recovery. Recovered animals continue to excrete the bacteria for long periods. In Great Britain, West Europe, South Africa and Australia Salmonella dublin is the most common type responsible for the disease in adult cattle. Surprisingly this same organism has not been reported in New Zealand. Salmonella typhi-murium is of lesser importance and other types are occasionally encountered. In the United States, however, Salmonella typhi-murium is the prevalent type.

Corynebacterium pyogenes infection in cattle may result in mastitis, abscess formation and uterine infection. The organism has been associated with abortion from time to time and has been recovered from the aborted fetuses. Evidence would indicate that Corynebacterium pyogenes infection in cattle becomes apparent when the general resistance is lowered by anycause. It seems then that the number of abortions due to Corynebacterium pyogenes can be reduced by maintaining the general health of the individual animal.

Hemolytic streptococci have been incriminated in abortion in cattle. The streptococcus organism is usually isolated from very young fetuses, i.e., two months old or under. Such abortions may go unobserved and the affected animal consequently classified as a

sterile female.

Staphylococcus albus has been reported in association with bovine abortion. The expulsion of the fetus is usually accompanied by purulent exudate from the uterus and the placenta is frequently retained.

Tuberculosis as a cause of abortion is of minor importance in the United States. Tuberculosis infections which lead to abortion are most frequently due to the mammalian type of tubercle bacillus. Occasionally the avian type may also cause abortion in cattle. Tuberculosis of the uterus is considered to be hematogenous in origin although it can arise by direct extension from affected peritoneum and fallopian tubes. Vaginal, vulval and uterine tuberculosis may be secondary, however primary lesions have been reported in these sites as the result of venereal transmission or the use of contaminated instruments.

Other bacteria reported in association with abortion in cattle include Pasteurella hemolytica, Pseudomonas sp. and Escherichia coli. The survey of literature reveals only a very occasional incidence of these latter infections in the United States.

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SPORADIC BACTERIAL ABORTION IN THE BOVINE

by

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An attempt was made to review the occurrence of sporadic bacterial infections associated with bovine abortion. Organisms reviewed included Listeria monocytogenes, Salmonella sp., Corynebacterium pyogenes, Streptococcus sp., Staphylococcus sp., and other bacteria, i.e., Mycobacterium tuberculosis, Pasteurella sp., Escherichia coli and Pseudomonas, which were considered to be of minor importance.

Listeriosis is world-wide in distribution and affects a wide variety of hosts, including man. In cattle, infections caused by Listeria monocytogenes are mainly associated with cerebral involvement and subsequent encephalitis. Involvement of the pregnant uterus will cause abortion. The syndromes of encephalitis and abortion may occur together in a herd, or separately. In infection of the pregnant uterus, the organisms will invade the placenta and fetal tissues, and the fetus will die as a result of a septicemia. The dead fetus will than be exposed in approximately five days. The bacteria can be isolated from most of the parenchymatous organs of the aborted fetus. Tissue alterations consist of small necrotic foci in the liver and spleen. Generally animals which abort do not show evidence of severe systemic disease. The placenta is usually retained as a result of placentitis. In few instances severe metritis may develop and septicemia is the most common complication.

Salmonellosis is a disease affecting domestic animals, caused by several types of salmonella bacteria, and generally manifested by an intestinal infection. Under varying conditions it may develop into a septicemia, and occasionally into pneumonia. In cattle, the disease may occur as an acute or chronic infection and is generally

sporadic in nature in adult animals. Pregnant animals may abort and the organism can be recovered from the aborted fetus. Salmonella are considered of low infectivity for an adult cow, however in the event of debility the susceptibility to infection is enhanced. Stress factors would seem to contribute to the sporadic character and seasonal incidence of acute salmonella infections. Recovered animals continue to excrete the bacteria for long periods. In Great Britain, West Europe, South Africa and Australia Salmonella dublin is most commonly responsible for the disease in adult cattle. Salmonella typhi-murium is considered to occur to a lesser extent, and other types of salmonella are encountered on occasion. In the United States, Salmonella typhi-murium is the prevalent type and Salmonella dublin is of a lesser consequence. In New Zealand, where Salmonella dublin has not yet been found, the most prevalent type is Salmonella typhi-murium.

Corynebacterium pyogenes infection in cattle may result in mastitis, abscess formation or uterine infection. The organism has been associated with abortion from time to time and recovered from the aborted fetuses. Current evidence would indicate that Corynebacterium pyogenes infection in cattle becomes apparent when the general resistance is weakened through specific or nonspecific causes.

Hemolytic strains of streptococci are sometimes incriminated in abortion in cattle. Streptococcus organisms have been isolated from very young fetuses. Such abortions are frequently unobserved and the animal may be classified as a sterile female.

Staphylococcus albus has been reported in association with abortion in cattle. The expulsion of the fetus is usually accompanied by purulent exudate from the uterus and the placenta is frequently retained.

Tuberculosis as a cause of abortion in cattle is of minor importance in the United States. Infections which lead to abortion are frequently due to the mammalian type of tubercle bacillus. Occasionally the avian type may also cause abortion in cattle.

Other bacteria reported in association with abortion in cattle are Pasteurella hemolytica, Pseudomonas sp., and Escherichia coli. The survey of literature revealed only three reports in which these organisms were incriminated as a cause of abortion in the bovine.