

SOME FACTS ABOUT ABORTION DISEASE

By E. C. SCHROEDER, *Superintendent*, and W. E. COTTON, *Assistant*, Bethesda (Md.)
Experiment Station, Bureau of Animal Industry, United States Department of Agriculture

CHARACTERISTICS OF THE ABORTION BACILLUS

While most bacterial diseases have two prime or main factors, a pathogenic microparasite and a susceptible host, infectious abortion disease of cattle is more complex, in that it has three prime factors, a pathogenic microparasite and two hosts. How imperfect our knowledge about this perplexing evil has remained at once becomes apparent when we consider that it has not been certainly determined which of the two hosts, the cow or the fetus, is primarily attacked by the microparasite. That is to say, we do not know whether the abortion bacillus primarily causes a disease of the cow's uterus which leads to the expulsion of the fetus, or whether, in the first place, it causes a disease of the fetus which subsequently impels the uterus to expel its contents.

One of the superlatively important facts about abortion disease is that cows often remain carriers of abortion bacilli long after they have ceased to abort, and that cows which have never aborted and regularly and normally produce seemingly healthy calves may be chronic carriers and disseminators of abortion bacilli.

As far as the writers have been able to learn, the abortion bacillus is an obligatory parasite. It may live and retain its virulence for a long time in infected material expelled from the uteri of infected cows, as such period of time can be measured through bacteriological cultivation and guinea-pig inoculation tests; but no data are available to support the belief that it can maintain itself or multiply under natural conditions as a saprophyte. Hence, the chronic persistence of the microparasite in the bodies of infected cows probably is the most important among the causes responsible for the propagation, the perpetuation, and wide prevalence of the disease.

The favorite habitat of the abortion bacillus in the bodies of cows is the udder, and the udder is seemingly its only habitat in the bodies of nonpregnant cows. Our work regarding this fact includes hundreds of carefully made tests with milk from numerous cows. Some of the cows had aborted, and others had not; the milk of some was infected with abortion bacilli continuously, and that of others intermittently; that of some cows remained infected year after year and that of others for shorter periods of time. In one case (a cow that remained under observation for seven years) periodic tests proved the milk to be infected continuously.

Another fact related to the expulsion of abortion bacilli with milk from the udders of cows is that in the numerous tests made with milk from many different cows the abortion bacillus was never found in the milk of a cow unless both her milk and her blood serum possessed agglutinating properties for suspensions of abortion bacilli. This fact is interesting and important not only on its own account but also because it serves as strong circumstantial evidence to prove that the work of the writers on the occurrence of abortion bacilli in the milk of cows is trustworthy. It does not mean, however, that the milk of all cows which react with the agglutination test for abortion disease is infected, as the writers have repeatedly tested milk from reacting cows without detecting abortion bacilli.

Regarding reacting cows with uninfected udders, it appears that their blood serum gradually loses its power to agglutinate suspensions of abortion bacilli. The writers wish, however, to have this statement taken cautiously, as the evidence behind it is not yet sufficient to give it the rank of a proved fact. If this statement, on further study, should prove true, it, together with other facts, will justify the conclusion that the persistence of agglutinating and complement-fixing substances in the blood of cows, relative to abortion disease, is intimately associated with the abortion bacilli that enter the body through the lymphatics from infected udders, as abortion bacilli do not maintain themselves in the bodies of cows elsewhere than their udders and gravid uteri.

That abortion bacilli do not maintain themselves in the bodies of cows elsewhere than the regions named is a fact of which the writers have obtained fairly convincing proof. It was found that abortion bacilli injected into the veins of normal, nonpregnant cows disappeared from their circulating blood in the course of a few hours; and when such cows were killed sometime afterwards, though their blood had become positive with agglutination tests, the germs could not be found in their bodies unless it was in their udders and associated lymph glands. One case in the records of experiments is remarkably impressive as an illustration of the tendency of abortion bacilli to lodge in the udder. The case is that of an adult, virgin, female animal, a heifer, approximately 4 years old, which was given an injection of abortion bacilli into one of her jugular veins. Later it was found that the infection¹ had established itself in her virgin udder, which was not functioning and never had functioned.

Another series of tests, probably even more convincing than the foregoing, was a careful search for abortion bacilli in the bodies of naturally infected as distinct from artificially infected cows. The cows were killed and their blood, spleens, livers, kidneys, brains, ovaries, uteri, udders, milk, synovial fluid from various joints, nerve tissue, lymph glands from all portions of the body, etc. tested for abortion bacilli

¹ The term "infection" is used here and elsewhere in this paper as signifying the discoverable presence of abortion bacilli, and not as implying the development of observable lesions of disease.

through animal inoculation and cultural methods, with the following results: In all cases two or more quarters of the udder, the milk from the infected quarters, and one or more supramammary lymph glands, and in one instance some of the pelvic lymph glands, were infected. All other organs and tissues were invariably free from infection.

When abortion bacilli are injected into the nonpregnant uterus of a cow, they disappear in the course of a few days. When the discharge from the uterus of a cow which has aborted is tested, abortion bacilli for 20, 30, or even 40 or 50 days may be found; but they eventually disappear, and it is the impression of the writers that their abundance and period of persistence are intimately related to the magnitude of the lesions in the uterus attendant upon an abortion.

It is the belief of the writers that the evidence they have supplied is sufficient to prove two facts: (1) that the udders of cows are a common habitat of abortion bacilli, and (2) that abortion bacilli do not maintain themselves in the bodies of nonpregnant cows elsewhere than in their udders. The occurrence of the bacilli in the supramammary glands, and in one instance in pelvic lymph glands, and no farther in the body, merely proves that the germs tend to penetrate into the body from the udder through the lymph channels, but that they can not go very far before they are destroyed.

PRODUCTION OF SEEMINGLY NORMAL CALVES BY INFECTED COWS

When abortion bacilli are injected into the udder through the teat, by a method which avoids a trauma, the bacilli are established in the udder, and the cow, according to all available tests, becomes an infected cow.

There is a remarkable and truly important fact concerning the production of calves by cows with infected udders. Such cows, irrespective of whether they have, at some time in the past, aborted or not, may give birth to seemingly normal calves in a seemingly normal manner associated with the occurrence of abortion bacilli in their uteri and in the afterbirth. Quite a number of records prove this, and although it does not occur every time a cow with an infected udder calves, it is far from uncommon. As has been stated, it may occur with a cow which has never aborted; and it may occur with the third seemingly normal parturition after an abortion. In the experience of the writers, in which they have made a number of tests, this remarkable fact has never been observed in connection with cows which react positively with the agglutination test but the udders of which were free from infection. And the fact becomes all the more remarkable when it is viewed in the light of another fact—namely, that numerous careful tests of the uteri of nonpregnant cows, irrespective of whether their udders were infected or not, tests made both between and during periods of oestrus, in no instance revealed the presence of abortion bacilli.

Another fact which merits consideration in this connection was derived from tests with newly born calves. A number of calves produced by cows with infected udders were killed immediately after they were born and their bodies tested for the presence of abortion bacilli through guinea-pig inoculation methods. These calves were not permitted to come into contact with their mothers or other sources of infection that would tend to introduce germs into their bodies not present at the moment of completed parturition. It was found that such calves—those that were delivered alive and seemingly vigorous and healthy—may harbor abortion bacilli in their stomachs and gastrohepatic lymph glands; but invariably, when the calves were infected, the afterbirth and the uteri of their dams were also infected. In aborted fetuses the stomachs, intestines, lymph glands, spleens, livers, blood, and subcutaneous extravasations of serum may contain abortion bacilli.

EXPERIMENTAL INFECTION INTRODUCED THROUGH TEAT

One record of the injection of abortion bacilli into the udder of a cow, through the teat without trauma, is particularly interesting. The cow was well advanced in pregnancy and, according to all tests that could be made, was free from abortion disease prior to the injection. This record is given in detail because it is very instructive and also illustrates the laborious application the investigation of abortion disease requires. In this connection it may be observed that in this work the writers have used the agglutination test rather than the complement-fixation test for abortion disease. The reason for this is that the writers are convinced that the agglutination test for this disease is fully as reliable as the complement-fixation test, but far less complex; hence, in the hands of those who have many and varied duties, it is more reliable.

RECORD OF COW 1154

September 9, 1914. Received at the experiment station from an abortion-free herd. About 8 years old. Was negative to all tests for abortion disease and was carefully protected against exposure to infection.

August 21, 1915. Served by bull 1150 and conceived. The bull was received at the station on the same day on which the cow was received, and was and is now negative to all tests for abortion disease, and has been carefully protected against exposure to infection.

December 10, 1915. Agglutination tests with blood serum from the cow and the bull were made. Negative in both cases.

March 27, 1916. Agglutination tests with blood serum from the cow and the bull were made. Negative in both cases.

March 27, 28, 29, 30, 31, 1916. Material was obtained on each day from the udder of the cow and injected into guinea pigs. The guinea pigs were subsequently killed and examined post mortem and found to be free from lesions of the kind caused in guinea pigs by abortion bacilli; in fact, they had remained perfectly healthy and showed no lesions of any kind.

April 3, 1916. The growth on two culture tubes of abortion bacilli was scraped off and suspended in 30 c. c. of sterile normal salt solution and injected into

the right front teat of the cow. The method of injection was through gravity, and the pressure used did not exceed that exerted by a column of fluid 12 inches high. Two guinea pigs were injected with samples of the suspension, and both later showed typical lesions of the kind caused in guinea pigs by abortion bacilli.

April 8, 1916. Five days after the injection agglutination tests with blood serum from the cow were negative.

April 17, 1916. Two weeks after the injection agglutination tests with blood serum from the cow were positive with dilutions of 1 to 400, which must be regarded as a very strong reaction.

April 22, 1916. Material from the infected quarter of the cow's udder was injected into guinea pigs, which subsequently developed typical abortion-bacillus lesions.

May 3, 1916. Material from each quarter of the cow's udder was injected separately into guinea pigs, all of which subsequently developed typical abortion-bacillus lesions, showing that the infection originally introduced into one quarter had spread to the other three quarters. On the same day material from the udder agglutinated suspensions of abortion bacilli in the following dilutions:

Right front, or injected quarter.....	1 to 6, 400
Left front quarter.....	1 to 1, 600
Right hind quarter.....	1 to 800
Left hind quarter.....	1 to 1, 600

It is interesting to note how much higher the agglutinating value of material from the injected quarter is than from the other quarters. The material obtained from the cow's udder is not called "milk," because the cow was practically dry; and it is questionable whether the material which can be stripped from a practically dry udder shortly before parturition can reasonably be looked upon as milk.

May 9, 1916. The agglutinating value of material from the injected quarter of the udder was positive in a dilution of 1 to 12,800, and on May 15, 19, and 24, in a dilution of 1 to 25,600. On these days the agglutinating value for suspensions of abortion bacilli of material from the other quarters of the udder remained constant for a dilution of 1 to 1,600, and that of the blood serum of the cow for a dilution of 1 to 400.

May 26, 1916 (279 days after service by the bull). The cow produced an undersized, weak calf, which, however, rapidly gained strength and is now a normal, healthy, vigorous animal. On the day of parturition the following agglutination tests were made:

Colostrum, injected quarter of udder, positive, dilution 1 to 25,600.
Colostrum, other three-quarters of udder, positive, dilution 1 to 1,600.
Blood serum, cow, positive, dilution 1 to 400.
Blood serum, calf, positive, dilution 1 to 400.

When agglutination tests are made with blood serum, it is common for newly born calves of infected cows to react in the same dilutions or quite as strongly as their mothers, but this power to react does not persist; it is a rapidly declining phenomenon, as is well shown by the following tests of the blood serum of the calf concerned in this record.

On the day of its birth, as above recorded, the agglutination value of the calf's blood serum and that of its mother were identical; positive in dilutions of 1 to 400. Seven days later, June 2, the agglutination value of the calf's blood had declined to 1 to 200; on June 7 it had fallen to 1 to 100; on June 9 it was still at 1 to 100; but on July 10

all agglutinating power for suspensions of abortion bacilli had disappeared.

Contrary to this, the agglutinating power of the cow's blood serum remained constant for dilutions of 1 to 400. Not so, however, with the agglutinating power of material from her udder. Colostrum, as has been seen, agglutinated in dilutions, injected quarter, 1 to 25,600; other quarters 1 to 1,600. The milk as early as June 8, or 13 days after parturition, was positive in dilutions no higher than 1 to 200 in the injected quarter, and 1 to 50 in the other quarters, at which points it remained fairly constant.

The most interesting fact about this cow was that parturition was associated with retention of the afterbirth, which, on removal, was found to contain much abnormal material of a yellowish color, and this was proved to be infected with abortion bacilli. Vaginal discharge from the cow was also proved to be infected with abortion bacilli on June 1, 3, and 12, and free from infection on and after June 20.

THE UDDER AS A POSITIVE CHANNEL OF INFECTION

This one cow illustrates a number of abortion-disease phenomena. First, the introduction of abortion bacilli into the udder through the teat, though a method of injection was used which almost certainly precluded mechanical injury, positively infected it and caused the gradual development of agglutinating power for suspensions of abortion bacilli in the blood serum. In other words, the udder is a possible channel through which abortion bacilli may penetrate into the body.

Second, the passage of abortion bacilli from the udder to the uterus is an experimentally demonstrated fact. The writers have already stated that, in all cases in which they found abortion bacilli in the uterus after seemingly normal parturitions, the cows had infected udders; and it is only necessary to add that, in practically half of the cows with infected udders that have been examined relative to this matter, the uterus and placenta were infected with abortion bacilli.

It has been suggested that the abortion disease may perpetuate itself through abortion bacilli that enter the udder through the teat. When we consider how cows are milked, and how the milker goes from cow to cow without disinfecting his hands, and that the udders of cows are the commonest habitat of abortion bacilli, this mode of infection can not be regarded too lightly, or as an untenable supposition. That this is a means of perpetuation has not been proved, but it should be considered as a possibility.

In the third place, the record of cow 1154 illustrates another fact—namely, the high agglutinating power of colostrum from cows with infected udders. This phenomenon, together with the rapid decline of agglutinating power of material from the udder as milk takes the place of colostrum, has been repeatedly observed.

In the fourth place, the rapidly declining agglutinating power of the blood serum of the calf of an infected cow is shown, and this also is a repeatedly observed phenomenon. The writers have found that agglutinating properties can be engendered in the blood of calves by injecting them with abortion bacilli; but such injections must be repeated from time to time, otherwise the agglutinating properties of the blood serum disappear.

In the fifth place, as the calf was suckled by its mother, whose udder was known to be heavily infected, it may be judged from the rapidly declining agglutinating value of its blood that abortion bacilli in ingested milk do not seem to penetrate deeply or abundantly into a calf's body. The records of other cows and calves give similar data.

POSSIBILITY OF INFECTION THROUGH THE BULL

It is rare for male and virgin cattle to react positively to abortion tests, and it has been pointed out that the bodies of cows do not harbor abortion bacilli elsewhere than in their udders, associated lymph glands, and pregnant uteri. It does happen occasionally that bulls do react when they are tested for abortion disease, and what such reactions may signify remains decidedly questionable; hence, the two following cases may be both instructive and interesting.

Sometime ago the writers found two bulls which reacted when their blood serum was tested with suspensions of abortion bacilli. In one case the reaction was positive in a dilution of 1 to 200 and in the other in a dilution of 1 to 100. Where the bulls got the infection the knowledge of their history does not reveal.

One of the bulls, the one with the higher reaction, was immediately killed and examined. The only lesion found in his body was an abscess involving the epididymis of one testicle, and this abscess was definitely proved to be infected with abortion bacilli. Tests of all other portions of the sexual organs and various other organs of the body failed to reveal abortion bacilli.

Was this apparently healthy bull qualified to serve as an active disseminator of abortion disease? The writers are not ready to answer the question at present.

The other bull was permitted to serve a cow which, according to her history and all tests made, was free from abortion disease. Immediately after the service seminal fluid was recovered from her uterus and injected into a number of guinea pigs, one of which subsequently showed abortion bacillus lesions. Tests are still being carried on with this bull.

RELATION OF THE ABORTION BACILLUS TO THE EMBRYO OR FETUS

A few years ago one of the writers, on the basis of the work on abortion disease, expressed the view that the abortion bacillus seemed to have a peculiar affinity for embryonic tissue. They are still of this opinion, and

it is possible that the disease is in fact primarily a disease of the embryo or fetus rather than of its mother. The mother, to be sure, is the source of infection. Possibly, however, if a large enough number of virulent abortion bacilli are poured into her body from her udder, antibodies of sufficient potency may develop in her blood to protect her fetus. Should this prove true, good results in the treatment of infected herds may be expected from injections into the mother, possibly a short time before she conceives or early during pregnancy, of cultures of abortion bacilli; and it is possible in this case that the more virulent the cultures are and the more abundant the material injected the better the results will be.

CONCLUSION

To prevent the further spread of abortion disease, owners of uninfected cattle should be instructed to have careful agglutination tests for abortion disease made of all cattle they propose to introduce into their herds; and owners of infected herds should be taught that aborted fetuses, also the afterbirth and discharge from the vaginas of infected cows, are infected with abortion bacilli and must therefore be disposed of with care.

The treatment of individual cows which have aborted or failed to clean properly after parturition must be left largely to the good judgment of the practicing veterinarian. If the uterus is given a proper chance to heal after it has been damaged by an abortion or a retained afterbirth, the abortion bacilli in it need occasion little worry, as they will rapidly disappear of their own accord, and it is very questionable whether reparative processes are not retarded rather than facilitated by douching with germicidal solutions which are strong enough to kill bacteria in a reasonable length of time, or the length of time during which they may remain undiluted in the uterus. Douching is no doubt good practice, but it is desirable that there be a flooding out, a washing out, a real physical cleaning of the uterus; and this can best be done with solutions which are healing rather than germicidal, soothing and not irritating.