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INFECTIOUS ABORTION IN SWINE

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THIS BULLETIN CONTAINS

The most important facts relating to infectious abortion in swine, which have been established or verified by the researches of this Experiment Station may be summarized as follows:—

1. A *specific* contagious or infectious disease exists among swine which causes the majority of abortions in this species.

2. The cause is identical with or closely related to the micro-organism which causes the majority of abortions in cattle; namely, the Bacterium abortus—Bang.

3. The infection is contained in the dead aborted pigs, afterbirths, uterine discharges and the colostral milk of the infected sows. The organism was isolated from all these sources, and its infectiousness proven.

4. Infected sows which are apparently healthy, and farrow live pigs, also discharge abortion infection in the afterbirths and colostral milk.

5. The abortion disease can be detected in swine by the serological tests —agglutination and complement fixation—by examination of the blood-serum or the colostral milk-serum.

6. Healthy swine contract the disease by eating materials containing the abortion germs: as dead fetuses, afterbirths, milk, or other food contaminated

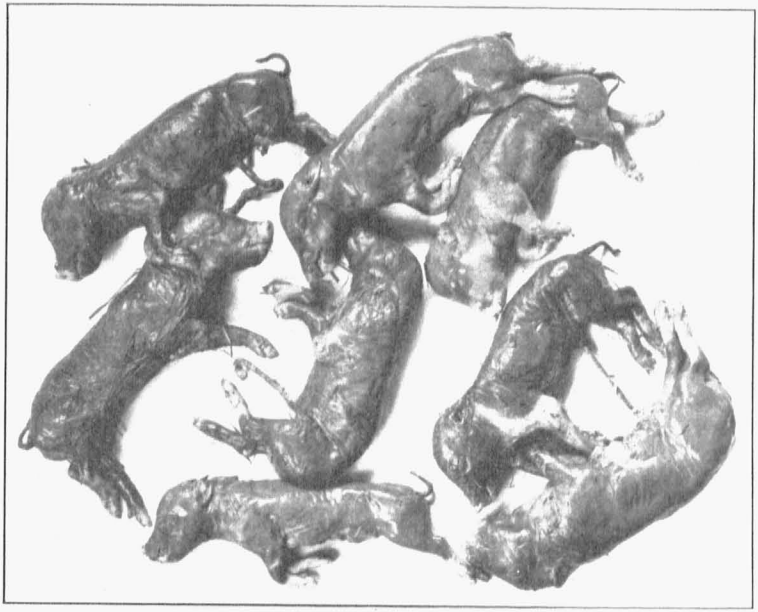

Fig. 1.—Litter of aborted pigs from a $400 purebred sow. This litter of pigs contained the abortion infection (Bact. abortus-Bang) and produced abortion in two other sows, to which a few of the pigs were fed. See fig. 2; p. 20.

with the infection. Transmission by breeding is probable but not definitely proven.

7. Non-pregnant as well as pregnant sows may contract the disease.

8. The herd boar is susceptible and may contract the disease by association with infected sows—but whether by copulation or by ingestion has not been established.

9. Suckling pigs of infected dams react to the serological tests for abortion disease. Some newborn pigs show the reaction before sucking but the majority only after sucking.

10. The abortion germs of cattle (Bact. abortus—Bang) inoculated into pregnant swine have caused abortion, and the development of the specific blood reaction.

11. The blood serum of abortion-infected cattle reacts to the swine abortion antigen.

12. Pregnant sows, in close association with a herd of abortion-infected cattle, aborted; and the infected animals of both species reacted to the same serological test.

13. Sexually mature sows, as a rule, retain the abortion infection indefinitely; and react persistently to the serological tests.

14. Infected sows which have aborted, and continue to react, may farrow full term living pigs at the next gestation. Some, however, become either temporarily or permanently sterile. And some farrow half developed dead fetuses with living, fully developed pigs.

15. Healthy abortion-free progeny can be reared from infected sows bred to an infected boar by isolation of the pigs after weaning to prevent reinfection.

16. Control measures. Apply the abortion test to all the mature breeding animals in the herd, and to recently purchased animals. Isolate the aborters and reactors. Disinfect thoroughly.

17. Vaccination is of doubtful value and probably detrimental.

Infectious Abortion In Swine

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INTRODUCTION

Occasional reports of abortion among swine have come to this department for many years, but apparently not until the past few years has this trouble given sufficient concern to the swine raisers to demand veterinary aid and scientific investigation. Definite data are not available to show whether there has been an actual large increase in the number of abortions and the number of infected herds, or whether this impression is the result of economic conditions which led to the fuller reporting of swine diseases. But it is certain that the increased interest in purebred swine and the higher values prevailing in recent years have made swine raisers more reluctant to send an aborting sow or "shy breeder" to the fattening pen, and have caused them to seek aid for the restoration of these animals to usefulness as breeders. The same considerations have caused them to seek information concerning measures to keep their herds free from the disease.

To meet the needs for fuller information concerning the causes of abortion among swine, and how it may be prevented, a study of this disease was taken up by the Experiment Station; and although these researches are not yet finished, sufficient definite information has been established to justify a report on the progress of the work; and to give some of the conclusions that will be of practical value to the swine breeders and veterinarians.

PRELIMINARY STUDIES

In the summer of 1916 an opportunity came to test blood samples of a few purebred sows that had been purchased at a bred sow sale in one state, and had aborted within a few weeks after arrival at the farm of the purchaser in another state. The test applied was the same that was in routine use in the laboratory for the diagnosis of infectious abortion in cattle. Positive results were obtained.

These results suggested a close relationship or identity of abortion disease in cattle and swine, and led to the experimental use of a number of swine in supplementing the investigations which were in progress on cattle abortion. The inoculation of swine with laboratory cultures of the organism (B. abortus—Bang) which was regarded as the specific cause of infectious abortion in cattle, caused abortion in some of the experimental swine and also produced the positive reacting substances in the serum of others. During this time, blood samples were received from three other breeders of purebred swine. The samples from two of the herds gave positive reactions, while the sample from the other herd was negative.

SYSTEMATIC RESEARCH

The occurrence in 1919 and early part of 1920 of serious outbreaks of abortion in three separate herds of swine within easy reach of the veterinary laboratory supplied appropriate material for a more systematic investigation of this disease among swine. Besides other outbreaks more distant, which were investigated to the extent of making the diagnostic blood test, and securing clinical data, brought the total number of herds investigated for abortion disease up to 30; of which 26 were found to be infected. The essential facts which have been developed or verified in these researches and which furnish a basis for practical measures of prevention and eradication of the infection are given in the succeeding pages.

We will first consider the nature of abortion, its causes, diagnosis, transmissibility and various manifestations; and follow with definite recommendations for handling infected herds and for protecting healthy herds.

DEFINITION OF ABORTION

Abortion is a lack of proper development of the fetus, due to any cause which seriously interferes with its nutrition, and results in its death. As a rule the dead or non-viable fetus is expelled from the uterus; and this is the visible sign of abortion. The expulsion of the fetus, however, does not always occur at the time of its death. The dead fetus may be retained and mummified and expelled at the full gestation period, along with apparently healthy well-developed pigs. On the other hand nonviable living pigs are sometimes farrowed prematurely and die soon after birth. In other cases interference with the nutrition of the fetuses may not be sufficient to cause their death, and, although farrowed prematurely, they may live. These cases are referred to as "premature births," although the causes operating may be the same as those which in other cases produce death of the fetuses.

CAUSES OF ABORTION

The causes of abortion fall into two groups; the non-infectious, and the infectious or microbic causes; and the latter may be further classified as specific and nonspecific causes.

Non-Infectious Causes.—To this class belong the accidental causes such as direct injuries to the uterus, or other severe injury or shock to the mother, which seriously affects the uterine and placental circulation, and interferes with the nutrition of the fetuses. Any serious illness of the mother may in like manner affect the vitality of the fetus, and result in abortion. Toxic plants or drugs such as ergot have an abortifacient action. Malnutrition of the fetus from lack of essential mineral elements and vitamines, from improper feeding of the mother, is believed to be responsible in some cases for abortion.

Non-Specific Bacterial Causes.—The ordinary wound infection bacteria, pus formers, etc., may occasionally gain access to the uterus and cause abortion, and particularly sterility, either temporary or permanent. The bacteria of chronic diseases, such as tuberculosis, occasionally invade the uterus and produce lesions that cause abortion.

None of the foregoing causes, however, are responsible for large losses from abortion in individual herds. The reaction to the specific blood test for abortion disease, is negative in such cases.

Specific Bacterial Cause.—The researches of the Experiment Station thus far indicate that the great majority of abortions is due to a specific infection communicable from the infected swine to healthy ones. And that the bacterium responsible for swine abortion is closely related to, if not identical with, the Bacterium abortus of Bang, which is responsible for the majority of abortions in cattle.

In 30 herds well distributed over the state, and which were suspected of being infected with contagious abortion, the specific abortion test by complement fixation or agglutination showed positive reactions in 26 herds. In the four negative herds, one herd, of 16 sows, had had no abortions; but three of the sows had failed to settle after their last farrowing, and the owner feared that they had become infected with abortion disease. From another herd only one blood sample was examined. This was from a sow which had aborted, but as no other cases were subsequently reported, it is probable that this was a case of accidental abortion. The other two lots examined had been infected the previous year but were non-reactors when last tested. The clinical history of the sows which showed the positive reactions to the abortion test was added evidence which justified the diagnosis of specific abortion disease in the positive reacting cases.

Isolation and Identification of the Specific Organism.—In herds of swine where the clinical history indicated the presence of an abortion disease due to an infectious cause, transmissible from animal to animal, a bacterium was isolated a number of times, by appropriate laboratory technique, from the fetuses, afterbirths, and colostral milk of aborting sows, which corresponds to the Bacterium abortus of Bang, or germ of cattle abortion, in morphology, cultural characters, serological reactions, and pathogenic action on guinea pigs. Moreover, pure cultures of the bacterium have produced the specific blood reactions, and abortions, when fed to non-reacting, pregnant sows. (See illustration, Fig. 6) When the bacterium is used as an antigen in testing blood samples of sows and cows which have aborted, a positive reaction is shown by complement fixation and agglutination; while samples from healthy sows and cows are negative to the same bacterial antigen. The close relation or identity of the bacteria from the two species is further indicated by the production of the specific abortion reaction in the blood of swine by inoculation with the cattle abortion bacteria, which also produced abortion in some cases. Moreover, in field observations, abortions were reported in cattle and swine on the same farm. Reports of such occurrence came from three different farms. In one case an aborted calf was fed to the hogs; and abortion resulted in some of the pregnant sows. Blood tests were not made in this case. In another case several purebred sows were exposed to a cow which had aborted, and abortion followed in the sows. A blood test of the latter showed a positive reaction with the B abortus antigen of bovine origin. A blood sample could not be obtained from the cow, as she had been sold for slaughter. On a third farm, abortions occurred

among the swine and cattle which had run together in the same fields and feeding lots. A blood test of the aborting animals in both species gave a positive reaction by complement fixation.

The further experiment of feeding non-reacting, pregnant heifers with the swine abortion bacteria will be carried out. But whether the diseases in cattle and swine are identical or not, the work done with swine, in the opinion of the writers, is conclusive as to the specificity of the organism obtained from the aborting sows, as the cause of the majority of cases of abortion in swine.

TRANSMISSION OF INFECTIOUS ABORTION

Sources of Infection.—The bacterium abortus occurs in the aborted fetuses, the afterbirths, the uterine discharges, and the colostral milk of aborting sows.

The infection also occurs in the afterbirths, uterine discharges, and colostral milk of infected sows which farrow living pigs, after having once aborted. This has been verified in a sufficient number of cases to justify the statement that practically all positive reactors discharge abortion infection at farrowing time.

Modes of Transmission.—The disease may be contracted through the mouth and alimentary tract. Healthy, non-reacting pregnant sows became reactors and aborted after being fed fetuses and afterbirths from positive reacting sows which had aborted. Moreover, the bacterium abortus was recovered from the dead pigs and colostral milk of sows which were infected by feeding. (See figs. 2-3.)

The probabilities are that swine abortion is spread more frequently by the reacting sow, at the time of abortion, and at time of farrowing, by ingestion of infection by the healthy pregnant sows, than by any other means.

As the milk of reacting sows contains abortion infection the possibility of the suckling pigs acting as infection carriers and contaminating the food of non-reacting pregnant sows should not be overlooked. The suckling pigs sometimes vomit an overfeed of milk. Transmission by copulation is considered in succeeding paragraphs.

Susceptibility of the Boar to Abortion Infection; and Spread of the Disease by Service.—The boar is susceptible to systemic infection, and shows a positive reaction to the specific serological tests. Four herd boars in service in the same number of infected herds, were positive reactors to the abortion test. Two of these boars had disease in one of the testicles. Whether these boars contracted the disease by copulation or by ingestion of the infection, by nosing and licking the soiled parts of an infected sow was not determined. Two healthy, non-reacting gilts when bred to one of these boars did not contract an active infection, with a persistent positive reaction. One of the gilts however, showed two isolated reactions, and the other a single reaction. Both farrowed living pigs which were non-reactors. One of these gilts also had a mummified pig. Two other experimental boars which were non-reactors were bred to reacting sows. Both became permanent reactors. Whether they became infected by the act of copulation, or whether the reacting sows were discharging infection during the heat period, and the boars became infected by nosing and lick-

ing the tail and vulva, was not determined, but that the boar can contract systemic infection by cohabitation with infected sows at the oestrual period appears probable. These two boars did not come in contact with gross infection, such as exposure to a sow which had recently aborted.

Susceptibility of Unbred Sows.—The pregnant condition is not essential to infection. Unbred sows have contracted the disease from cohabitation with infected aborting sows. Six gilts in a herd in which abortions had occurred showed a postive reaction to the abortion test, and the history of these cases indicate that they contracted the disease from cohabitation with infected aborting sows, probably from eating bits of an afterbirth, or portions of an aborted pig. A feeding experiment upon a non-reacting unbred sow with B. abortus cultures of porcine origin produced a positive reaction.

Susceptibility of Young Pigs.—The blood serum of young pigs farrowed by immune abortion-reacting mothers shows a positive reaction to the serological tests at time of birth or soon thereafter, and the reaction persists for a variable period in different litters. In 11 litters under experiment, four pigs in one litter of six had become negative in 19 days after birth, and the other two soon after, while in another litter the reaction persisted in two of the pigs for 102 days, or longer.

It will be recalled that the Bacterium abortus is found in the bodies of aborted pigs, and the possibility exists that the *living* pig may in some instances become infected in utero, and that the reacting bodies are produced by the pig as the result of active infection before birth; but the opportunities for infection of the pig after its birth also occur from the presence of the B. abortus in the colostral milk. These researches, moreover, show the presence of the specific reacting bodies in the blood serum and colostral milk of the mother, and the possibility exists that the reaction of the pig's serum in some cases, may be due in part if not wholly, to the presence of *absorbed* antibodies.

The young animal in most instances appears to destroy the infection or at least to eliminate the reacting bodies, in from three to fifteen weeks. (This phenomenon has also been observed in calves dropped by abortion-infected cows.)

Thus far no reinfection of pigs that have become negative to the abortion test has occurred. One gilt, from a lot which was retained for further experiments, was still negative when she had arrived at sexual maturity and was bred. While sufficient data upon this point is not yet available, the indications are that healthy, non-reacting progeny can be reared from abortion-infected mothers, which have become regular breeders, and that the disease can be eliminated from the herd by quarantine and ultimate slaughter of the infected mothers. The elimination of abortion infection from cattle herds by such methods has been demonstrated to be feasible, and without sacrificing valuable breeding animals, and the same is probably feasible in the case of swine.

Persistency of Infection in Mature Sows.—Some mature sows which have once aborted retain the infection for a considerable time, if not through life. In one lot of eight experiment sows, which aborted from

natural infection, monthly tests have been made for 18 months; and they have remained persistent reactors, although seven of the number have farrowed living litters of pigs. Our experimental records, however, show that some mature sows lose the reaction, and presumably the abortion infection. (Like phenomena are observed in cattle herds affected with abortion disease. Some cows are persistent positive reactors, some are variable, and others become permanently negative.) The udder, moreover, is a favorite habitat for the B. abortus organism in both species.

MEASURES OF PREVENTION AND CONTROL

The facts which have been presented in the foregoing pages suggest practical procedures for the control and eradication of abortion disease in swine herds, and the measures in general are those which apply to the prevention and control of all other infectious or contagious diseases, namely; an early and accurate diagnosis, isolation and proper control of infection carriers and the destruction of the virus by the application of effective disinfection measures. To this should be added the special care and treatment which devolves upon the veterinary practitioner in applying proper surgical and medical measures that individual cases may require: such as the removal of retained afterbirths, dead pigs, and purulent materials, from the uterus, to prevent a chronic metritis and sterility.

Handling a Suspected Herd.—When a sow aborts in a herd, isolate the sow promptly. Assume that the abortion is infectious. This may save several other sows from aborting. Put the aborting sow in small quarters to prevent distribution of the infection over a large area. Remove the other hogs temporarily from the grounds where the abortion occurred. The case may turn out to be due to some accidental cause, but the prudent breeder will apply the preventive measures without awaiting a laboratory test to determine the exact nature of the abortion, for he knows that if the case is of an infectious character, the greatest danger period is at the time the sow is discharging the infection. Hence the necessity for removing the infected animal from the herd and the removal of other hogs from the grounds which may be infected.

Disinfection.—This is the second measure to apply, and this should be done without delay. The aborted pigs and afterbirths should be destroyed by burning or burying deeply, adding quick-lime. The straw of the farrowing bed should be burned if feasible, or disinfected by thorough saturation with a 4 to 5 per cent Compound Cresol solution or other good disinfectant. The farrowing cot or pen where the sow aborted should be well saturated with the same disinfectant. Scatter freshly slaked lime freely over the grounds of the smaller lots that were occupied by the sow when she aborted.

If the abortion occurs on a large pasture, endeavor to find the bedding place, and burn the litter and portions of the fetuses and afterbirths that have not been eaten by the aborting sow or other hogs in the field. Spray the contaminated bedding place, and the grounds immediately adjacent, with an ill smelling coal-tar disinfectant that will be sufficiently distasteful, to prevent swine from eating for awhile over the infected ground. If the pas-

tures are not needed immediately, swine and cattle should be kept away for a few weeks, or the smaller area which was grossly infected may be fenced in temporarily. The liberal use of freshly slaked lime or pulverized quicklime over a small infected area will be helpful. It is not probable that sufficient infection would be spread on the grounds of a large pasture to infect other sows, except at the farrowing place. Some sows, however, abort without making a bed and may drop a dead pig and afterbirth in the open field. Hence the advisability of removal of other hogs from the field for a time.

DIAGNOSIS OF INFECTIOUS ABORTION

Serological or "Blood Test" (Agglutination and Complement Fixation) —It is sometimes advised in dealing with disease to first make the diagnosis before applying any medical measures, but that is not always practicable, and delay in applying the simple preventive measures mentioned may prove to be a serious neglect. But there need not be much delay in having the specific abortion test made. The Veterinary Department of the Agricultural Experiment Station makes these tests free of charge for the veterinarians and breeders, if blood samples from the suspected sows are drawn and sent in proper condition. Two serological tests are used in this laboratory, the agglutination method and the complement fixation test. The latter is preferable on account of its greater accuracy and is more largely employed in this laboratory.

It is advisable to test not only the sow which has aborted, but all the other mature breeding sows; since an immune sow, which is not suspected, may be a carrier and distributor of the infection. If the tests should show the aborting sow and other sows to be reactors, the reacting sows should be put in permanent quarantine away from the non-reactors. They should not be permitted to mix again with the non-reactors.

Drawing Blood Samples.—Only a small quantity of blood is required to furnish enough serum for the laboratory test. A two-drachm homeopathic vial answers well as a container for the blood. The blood can be obtained from a small cut in the marginal vein of the ear. The blood is allowed to drip from the margin of the ear into the vial until it is two-thirds full. The cork is replaced and the vial is properly labeled with a number to indicate the animal from which the sample was drawn. The vial is then set aside until the blood has clotted firmly before packing and mailing to the laboratory. The samples can be sent safely by parcel post, if properly packed in layers of cotton.

The blood samples can sometimes be obtained more easily from the tail by cutting off a small bit at the end, or by nicking one of the lateral blood vessels on the under side of the tail about midway between the tip and the root.

Interpretation of the Blood Test.—A positive reaction is evidence that the animal is infected with the bacterium abortus, or specific germs of abortion disease, and is very liable to abort; although some animals are sufficiently resistant to carry their litters full term, and drop living and apparently healthy pigs. The abortion infection is able to localize in the

udder and lymph glands, as well as in the uterus, and in some cases it does not produce sufficient disturbance in the uterus to cause an abortion, although the percentage of cases of abortions that do occur in the positive reactors, is sufficient to justify looking upon the disease as a specific abortion disease, and the test as a specific diagnostic test.

When the reaction to the blood test is negative, this can usually be relied upon as evidence that the sow is free from the abortion infection. But there are occasional exceptions, due to conditions which temporarily interfere with the reaction in an infected animal. In the sow which has very recently aborted, the blood test is sometimes negative. The reasons for this are not very clear, and to the layman it would seem at this particular time the reaction should be strongest. But when we consider that the reaction in the suspected animal is dependent upon the presence of free antibodies (immune bodies), and not on the amount of infection, a plausible explanation may be given by assuming that at the time the abortion occurs there is a maximal quantity of infection present, and that this infection or antigen has combined with all the reacting substances present in a fixed condition, which prevents the visible reaction in the laboratory test.

When a negative reaction occurs in testing a sow which has recently aborted, that sow should still be kept on the suspected list, and isolated from other sows until a re-test has been made, since in our experimental work we have found that some abortion infected sows have shown a negative phase extending from a week or ten days before aborting or farrowing, to a like period after dropping the pigs. Hence a wrong conclusion could be drawn if the blood sample from an aborting sow should show a negative reaction during this period. It is always well, however, to make a test as soon as possible after an abortion has occurred, since a considerable number of aborting sows will show the positive reaction at time of abortion. If it is convenient to milk out a sample of the colostrum at the time the sow aborts, a test of the colostral serum will show the positive reaction, even when the blood serum does not. In our experimental work this has been verified a number of times.

ULTIMATE DISPOSAL OF INFECTED SOWS

Handle to Quickly Eradicate the Disease.—The question arises what shall be done with the reactors? That will depend upon the special value of each animal. As a general rule, it is advisable to fatten and sell to the butcher all abortion-infected sows which are not of special value and desirable to retain for the perpetuation of special blood lines, or exceptional individual qualities. Every reasonable effort should be made to get rid of the disease as quickly as possible; and the fattening pen will prove a valuable aid in the rapid eradication of infectious abortion in swine, and in some cases will be the most economical procedure.

Do Not Sacrifice Valuable Animals.—It is not necessary to sacrifice animals of special value which have aborted, as the great majority of these will breed again and farrow good litters of vigorous pigs, which by proper

isolation after weaning can be reared free of abortion infection. Of eight aborting sows on experiment which the blood test showed to be infected with specific infectious abortion, and which were removed from the main herd, seven subsequently farrowed living litters of pigs which were apparently healthy.

Some abortion infected animals are however, slow to settle when bred again, on account of the uterine inflammation which existed at the time of abortion, and which in some cases persists for a considerable period. Such handicaps render it desirable to get rid of the disease as quickly as possible rather than to resort to immunization which retains the infection, and is liable to cause temporary or permanent sterility. Appropriate treatment by the veterinary practitioner will lessen the liability to sterility in the aborting sows.

Surgical and Medical Treatment.—Some sows which abort will clean themselves and conceive at the next heat period. But others develop a pyometra or purulent inflammation of the uterus, from retention of a portion of an afterbirth or a dead pig. (See figure 6.) The uterus in such cases becomes infected with pus organisms, and a more or less persistent whitish discharge results. Some of these cases will in time clear up, and the animal will conceive. But it is bad practice to breed a sow repeatedly which has a continuous or intermittent purulent discharge, as they will not conceive until the uterus is free from the irritating cause, and the inflammation has subsided. It may be necessary to introduce an irrigating tube into the uterus and wash out the offending cause and inflammatory products. This is not an easy matter, even for the veterinarian, on account of the narrowness of the cervical passage, and the curved and sacculated form of the horns of the uterus. The layman cannot safely carry out this surgical treatment; he is likely to do more harm than good. But with proper instruments and with due care and patience, the veterinarian can render good service in some of these cases. (See figure 6.) The use also of a uterine stimulant such as Yohimbin may prove helpful in cleaning out the offending matters, and restoring the uterus to a healthy condition. The iodide of potash is a useful remedy in the constitutional treatment of purulent infections. The dosage and the intervals and repetitions of administration of these medicines will depend on the individual cases; and the judgment of the attending veterinarian who examines the case is always the safest guide in the use of drugs.

Some cases are beyond surgical and medical aid, and will remain permanently sterile, on account of the injuries which the ovaries, oviducts and uterus have suffered from the inflammation which has existed. A positive diagnosis of the hopeless cases is sometimes difficult or impossible, and the cause of sterility is found only at the time of slaughter of the animal. The good judgment of the breeder and of his veterinary advisor must decide when the brood sow under treatment should go to the fattening pen.

When veterinary aid cannot be secured and the breeder must rely upon his own resources, resort to simple, warm saline douches is recommended in the treatment of brood sows showing a whitish, purulent discharge. A solution made by adding a tablespoonful of pure table salt to a gallon of

hot water will prove safer, and more useful in the hands of the herdsmen than disinfectants. The improper use of disinfectants has caused permanent sterility in breeding animals. The saline solution is non-irritant and serves the good purpose of washing away the accumulations in the vagina, and if used at a proper temperature may prove helpful in promoting healthy reactions in the cervix and horns of the uterus. The temperature of the solution should be warm enough to stimulate the tissues, but not hot enough to cause injury. The tubing or syringes and vessel containing the solutions should be properly sterilized so as to avoid introducing outside contamination. The use of a 3 or 4 percent solution of creolin, lysol or compound cresol solution to disinfect the vulva, tail and posterior parts of the sow should not be overlooked. A gallon or more of the salt solution should be allowed to flow into and out of the vagina, and the tube should be introduced well forward into the vagina. The use of strong pressure, as with a force pump, which may force the fluid into the uterus and cause an overdistention of the horns has caused fatal results in the hands of an overzealous herdsman. It is easier to force solutions into the uterus than to get them out again, and the irrigation of the uterine horns should be left to the veterinarian who has the skill and proper instruments for that operation.

Quarantine of Reactors.—The breeder should keep in mind the fact that the reacting sows which have once aborted are still infection carriers, even though they may subsequently conceive and farrow living pigs, and that they can distribute abortion infection in the afterbirths and uterine discharges, hence the advisability of quarantining such sows if they are kept for additional litters of pigs.

Care of Pigs from Reacting Sows.—During the lactation period no special care is required beyond that given to the litters of non-reacting sows. But after weaning, the pigs should be separated from the mothers and put on clean grounds away from abortion-infected animals. Most of the pigs will overcome the infection which they had during the early suckling period and will remain free from infection if not exposed when approaching sexual maturity. The blood test should be made on all the pigs before breeding to prevent the retention of a persistent reactor which might prove a permanent carrier and distributor of the infection.

How to Handle the Non-Reactors of the Herd.—When an infected herd has been tested and the reactors removed to other quarters, the premises where the non-reactors are to be kept should be thoroughly disinfected, if they have been exposed to contamination. The hogs should also be sprayed with a good disinfecting solution. A re-test of these non-reactors should be made within three or four weeks, as some of the animals may have been exposed only recently, and the reacting bodies may not have developed in sufficient quantity to show the reaction at the time of the first test. The non-reacting lot should be tested three or four times during the next twelve months or until well assured that no infected animals remain in the herd. As the reaction is prone to develop during the period of pregnancy, if infection exists in the herd, and as the greatest period of danger is at the time of abortion or at farrowing, it is advisable

to test all of the pregnant sows a month or six weeks before their farrowing date, and to isolate those that react. The disinfection of the bedding from the farrowing pens, and from the quarantine pens should not be overlooked; or it should be put where the healthy hogs will not come in contact with it.

Care of the Boar in an Abortion Infected Herd.—The boar which serves abortion-infected sows is liable to become systemically infected, either by service or ingestion of infected discharges; and such boars should not be used on healthy sows, if at all avoidable. As mentioned elsewhere in this article, it is not definitely known whether the boar contracts the disease by copulation, or by ingestion of the infection from licking the soiled parts of the infected sow at time of breeding. But it is advisable to take proper precautions against infection from either of these sources. The disinfection of the tail, rump and vulva of the sow is easily accomplished by using any of the good disinfectants; and to avoid the slight danger of destroying the spermatozoa, from possible contact with disinfectant, the parts which have been disinfected can be sponged over again with water to remove the excess of disinfectant. The thorough drying of the parts with a clean dry towel will probably remove all danger of infecting the boar from the oestrual discharge by ingestion. The douching of the vagina with normal salt solution to cleanse that tract will lessen the danger of contaminating the penis of the boar with abortion infection. Swabbing out the vaginal tract by means of long dressing forceps and a pledget of aseptic cotton is also suggested. As a further precaution against the boar becoming contaminated and carrying infection to healthy sows, his sheath should be well irrigated after serving an infected sow, and before serving a clean sow. The thorough washing of the sheath with the salt solution mentioned is preferable to using disinfectants, since mistakes by the herdsman in using the latter have proven expensive to the breeder. The use of disinfectants strong enough to destroy bacteria are irritant to the tender mucous membranes.

Precautions in Purchase of Breeding Swine.—In purchasing herd boars which have been in service in other herds, it is a prudent procedure for the purchaser to have a blood test made for abortion disease before using the animal on his best sows. These precautions are not so necessary in the case of the purchase of young unused boars; but as the state supplies the laboratory service free of charge for the good of the swine industry, it may prove useful to every breeder who imports a boar, young or old, to have the blood test made. And what has been said in regard to the herd boar is applicable to the purchase of brood sows which have been bred, and are with pig at time of purchase or to open sows which have farrowed one or more litters of pigs. The spread of abortion from herd to herd has probably resulted more frequently from the purchase of infected sows than from infected boars.

Prevention of Infection of Swine from Cattle.—The similarity of the bacterial cause of abortion in swine and in cattle, as well as the similarity in the clinical features of the disease in the two species, has been pointed out; and we have some experimental and clinical evidence of the suscepti-

bility of swine to cattle abortion infection. The presumption that the disease in the two species is inter-communicable is so strong that it justifies the breeder in taking proper precautions to prevent the spread of the disease from cattle to swine or the reverse. The spread of tuberculosis from cattle to swine from eating the droppings of cattle is a fact that is well known; but the infectiousness of abortion in this manner is probably less liable to occur; otherwise it would have been more prevalent in swine. The main source of danger lies in the aborted calves and afterbirths of infected cattle. And the preventive measures consist in the destruction of the infected carcasses. The aborted calves should not be fed to the hogs. Nor should the carcass of an abortion-infected cow which may have died from the effects of a retained afterbirth be fed to the hogs.

The colostral milk of the cow contains the B. abortus organism which our investigations convince us is identical with the B. abortus of swine. It would be prudent therefore to avoid feeding pregnant brood sows the milk from an abortion reacting cow. Some of these possible dangers have not been fully demonstrated, but they are on our experimental program, and a later report will give more definite information in regard to a number of unsettled points.

Vaccination.—It will be well to say something about vaccination, since the question is often asked by swine raisers as to whether there is any vaccine that is effective against abortion in swine.

There has not been sufficient experimental work done by official and financially disinterested investigators to justify a conclusive statement concerning the value of bacterins or vaccines in immunizing swine against abortion. Other phases of the question which are fundamental to this have of necessity first engaged the attention of investigators, as it was of first importance to learn as much as possible about the disease and its cause and how that cause operates, and how it is carried and conserved, as well as its immunizing power under natural conditions. The presentation of this phase of the subject is somewhat difficult on account of the technical nature of the subject of immunity. But since vaccination against swine abortion is already being advocated by commercial producers of bacterins and live vaccines, it will be helpful to the swine breeders to have some explanation of the methods and their possible applicability to the control of abortion in swine.

First what is "bacterin," and how does it act, and is there any danger in its use? Bacterins are laboratory cultures of the disease-producing germs, which have been killed by heating to a proper degree of temperature, or by adding chemical bactericides of appropriate strength. As to their action, it has been found in certain diseases that these dead cultures are very useful in producing a temporary immunity, while in other diseases they are of no practical use; and at best the immunity conferred is of temporary duration. The bacterin or dead cultures of the typhoid organism is perhaps the best example of the useful application of the bacterin inoculations. But, even with this, reinoculation from time to time is necessary if the person is frequently exposed, such as the hospital nurses and

laboratory diagnosticians who handle the living cultures, otherwise they are liable to an acute attack of the disease.

Whether repeated inoculations of the swine abortion bacterins will prove beneficial in preventing sows from aborting their pigs is a matter yet to be determined. There are some strong advocates, among veterinary practitioners, of the use of the abortion bacterins for the prevention of abortion in cattle. This disease however, in both cattle and swine, is of such a nature that the apparent result of any special treatment such as the carbolic treatment, the bacterin treatment, or the live culture treatment may prove deceptive, unless adequate scientific controls are used. And this is never done in private practice, nor has it been done in any official or semi-official tests of these several agents in large herds of cattle. Naturally the owner of the herd is averse to leaving half the herd untreated as experimental checks; and to carefully select for each group, animals of the same age, quality, condition, stage of pregnancy etc., so that an accurate comparison can be made. The comparison also of what will happen the second year, when a certain treatment is given, with what has happened the first year when treatment was not given, or was delayed, is also deceptive, and may give undeserved credit to any treatment that is used; since there is a tendency for animals which have aborted to become more resistant in succeeding years.

A quotation from Dr. Hadley, author of Bulletin 296, Wisconsin Station, will prove of interest on the question of the value or rather lack of value of the bacterins in the prevention of abortion in cattle. And if fuller investigation of these matters show that his opinion is correct, it will probably apply equally to swine abortion, since our experimental evidence seems quite conclusive that the disease is identical in the two species, or so closely related that the same control measures will be applicable. It is also safe to assume that specific measures, like bacterins or vaccines, that are not applicable in the one case will also prove without value in the other. Dr. Hadley in "Questions and Answers" says: Q.—"By whom and on what ground is the use of the dead germs or abortion bacterin advised?" A.—"Many commercial firms engaged in the manufacture and sale of biological products have flooded the market with abortion bacterins. They are the chief exploiters of this product. While bacterins have given good results in certain diseases notably typhoid fever in man, they have been found to have but little or no value as an immunizing agent against contagious abortion in cattle. Some firms claim astonishing results from the use of abortion bacterins, but have no reliable data to substantiate this claim." . . . "We (Hadley) advise farmers not to invest in abortion bacterins of any make, even though the manufacturer goes so far as to guarantee satisfactory results."

Letters on file in this department from cattle breeders, who have had their herds treated by the bacterin method, agree with Dr. Hadley in regard to the lack of satisfactory immunizing value of one dose or even two or three doses of the bacterin, as now employed. The immunity, if any is given, appears to be of short duration. Whether better results may be attained by repeating the doses at intervals from the third to the

end of the eighth month is a question which it may be worth while to have answered. An objection to such use, however, would be the increased expense; and another would be that of producing reactors of non-reacting cows, when perhaps simple isolation of the non-reactors would prevent the animals from becoming infected and from aborting, and not give them and the herd a bad name, if a purchaser should have them tested for abortion disease. The repeated injection of these bacterins however, in a pregnant cow which is already a reactor, and especially one that is carrying the first calf might prove helpful in stimulating the production of the specific immunizing bodies, and if not helpful in this way, the injection of such foreign irritant materials stimulates the production of "leucocytes" or at least increases their activity, and by this means bacteria of any kind that may be harbored in any part of the body may be destroyed by these warriors and scavengers of the body. In considering these theoretical aspects as to possible future usefulness of the "bacterins" in preventing abortion, the reader should keep in mind the fact, that, as the matter stands at present, *irrefutable proof that the bacterins have any material value as a preventive of abortion is lacking.* The bacterins, however, possess one virtue; they are harmless, except that they may produce temporary reaction in non-immune cows, but such reaction would probably in most cases be only temporary. We do not recommend its use in sows.

Living Culture Vaccine.—This vaccine as the phrase indicates consists of the living germs of abortion. The question naturally arises in the mind of a breeder, is it a sensible procedure to infect an animal with the disease germs if one desires to get a clean non-reacting herd? And a sensible answer would be that the use of such vaccine is inadvisable. The claims however, of those who advocate this method is that by this means, and by the vaccination of the *unbred* animals which are not yet infected, most of these will not abort, although exposed to the disease. The data supplied by the reports of the field use of this method in England and in experiments which were made in Germany, and in this country in Wisconsin are not at all convincing as to the value of this method, either as a measure of controlling the disease, or of increasing herd efficiency. The conclusions of those who favor the method are not justified by the data, because the data was not obtained by the use of a sufficient number of appropriate controls. This method has not come into use for swine and there are valid reasons for avoiding this method.

Our knowledge of the action of the abortion germs, both in cattle and swine show the probability of making *permanent* infection carriers of the animals infected unless these animals are quite young. It is certainly true that in most diseases the active infection of the animal with the living germs of the disease stimulates a greater production of immune bodies than the bacterins; but the large use of the living cultures is liable to multiply the infection carriers, and prove harmful to the livestock industry of the country. Let us imagine what might have resulted at the close of the war, if the health officers of the United States Army, who at the beginning of the war enforced the vaccination of every soldier with

the typhoid bacterins, had conceived the notion that the soldier boys should have a more durable immunity against typhoid fever than was given by the bacterin treatment, and had ordered that every soldier, before his final discharge, should be inoculated with the living cultures of the typhoid bacteria. These soldiers if they had recently been fortified by the regular vaccination would probably have suffered no serious illness from the living typhoid germs, and perhaps a considerable number would ultimately have overcome the infection completely, and eliminated the germs from their bodies. But a small percent at least would have become permanent carriers and would have spread the disease to the civil population. Nearly every one has heard of the New York servant girl, "Typhoid Mary," who although apparently healthy herself, spread the disease to a large number of families where she had been employed. The same thing is likely to happen from the large use of the living cultures of abortion disease in the treatment of herds of cattle and swine, for our investigations show that a considerable number of the animals which become infected with this disease remain reactors for a considerable time, and many of them during the remainder of their life. And that the living germs are discharged in the afterbirths and in the colostral milk of the apparently healthy, immune animal, and may infect non-immune animals which are exposed to them at farrowing time.

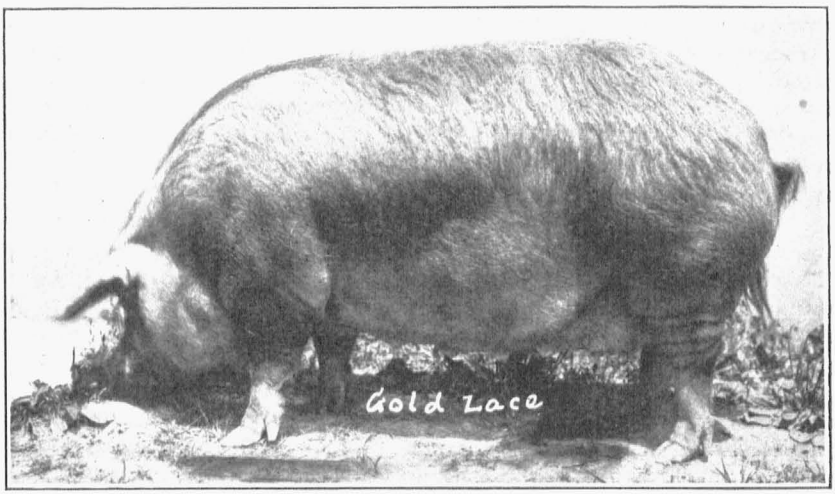
The large question which concerns the breeders is that of protecting the industry and not lessening its efficiency by the multiplication of "abortion Mary's," which will certainly lessen the general efficiency of cattle and swine breeding, from the spread of the disease through traffic to herds which are now clean, and by the increase in the number of non-producers or sterile animals.

It should also be kept in mind that cows which have aborted from *natural infection*, which probably stimulates a stronger immunity than is possible by artificial methods, are not proof against subsequent abortions; they may abort again after calving normally one or more times. The acquired immunity therefore is not an absolute protection. Whether swine will prove more durably immune has not been determined. But there does not appear to be any special reason for attempting to give healthy swine an active immunity by inoculating them with the live abortion germs. Besides, the treatment of sterility in swine is more difficult than in cattle, on account of the smaller size of the genital organs, and the danger of making some of the most valuable sows sterile, by inoculating them with the live cultures, should deter breeders from attempts to immunize healthy sows by this method.

Infectious abortion in swine can, however, be eradicated from any herd by the use of the blood test for diagnosis, by the isolation of infected animals, and by the disinfection measures which have been recommended; moreover, the carrying out of these measures will in the end be less burdensome than to keep the disease in the herds through the use of the live culture vaccinating method.

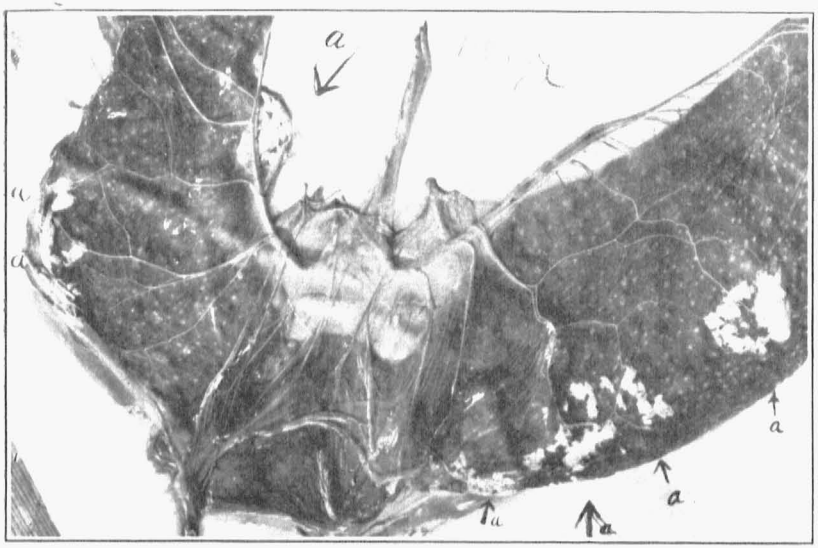
APPENDIX

In the succeeding pages are illustrations and discussions of a number of experimental cases of infectious abortion in swine.



Experiment Sow No. 35, Gold Lace, Infected by Eating Aborted Pigs. (Fig. 2.)—This purebred Duroc sow was a negative reactor to the blood test for abortion disease, had been a regular breeder and was pregnant. She was fed a few aborted pigs from a positive reactor, with the result that she developed a positive reaction and aborted. Bacterial cultures were obtained from her colostral milk and from her dead pigs. These cultures in turn produced infection and abortion when fed to other non-reacting pregnant sows carrying their first litter of pigs. (See also Figs. 1, 3 and 4.)

An Afterbirth from Sow "Gold Lace." (Fig. 3.)—This afterbirth with others was recovered from "Gold Lace" at the time she aborted the litter of pigs mentioned elsewhere. The specimen shows pathological changes at the arrow points "a". These white deposits are located in the capillary net work. The material is of a tough consistency and glistening white, looking like white enamel paint. The location and character of the material suggest a deposit of fibrin following a serous transudation from the capillaries. In other specimens the beginning and intermediate stages of this formation have been observed; namely, a clear watery or jelly-like deposit, and in others material of the same character in which a cloudiness

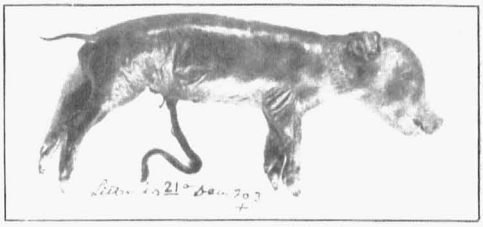


and specks of white occur. Whether these deposits have any relation to abortion infection has not been determined. An effort to grow the B. abortus organism from this material has not succeeded. The placental cotyledons and membrane in the immediate neighborhood showed no distinct disease changes such as a yellowish purulent exudate as is observed in the afterbirths of cattle. The exceedingly minute size of the placental cotyledons in the sow may however, account for the absence of a large quantity of purulent material in the afterbirths of the aborting sow. Fresh membranes however, from sows which have aborted, show yellow patches from which a small quantity of yellowish cellular material can be scraped.

The numerous small round white spots shown in the figure are the placental cotyledons or cups in which the minute buttons or uterine cotyledons were imbedded. In the submucous layer small oval lymphoid bodies occur normally, and may be observed in the figure lying along the course of the blood vessels. These lymphoid bodies were apparently much enlarged in some of the infected afterbirths examined.

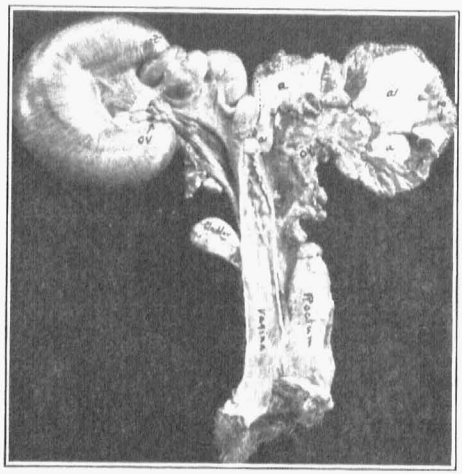
The B. abortus organism has been isolated from the afterbirths of aborting and reacting sows—hence may infect healthy swine if eaten.

Effect of Feeding B. Abortus Cultures (Fig. 4—Aborted Pig, Litter 21 a)—"Gold Lace" Strain. Dam No. 203. Gilt, first litter—field bred—date and sire unknown. **Experiment.**—Serological test for abortion antibodies—negative. Fed B. abortus cultures derived from sow Gold Lace. **Result.**—Gilt developed positive reaction for B. abortus antibodies, and later aborted a litter of dead, immature, hairless pigs. Exact stage of gestation not known, but compare Fig. 4 with Fig. 5. The latter represents a healthy full term new born pig which was slaughtered for experimental work and comparisons. Demonstration of infection in sow and aborted litter.—The colostral milk of the sow gave a positive reaction for abortion antibodies, and yielded B. abortus cultures by inoculation of guinea pigs. The stomach contents of two aborted pigs of this litter also yielded B. abortus cultures by inoculation of guinea pigs.



Healthy New Born Pig (Fig. 5. Litter 22 for Comparison).—This pig was farrowed by Sow No. 7, a non-reactor to the "abortion test," which had been bred to a reacting boar "Real Goods." The pig was killed a few hours after birth for study and comparison with the aborted litter, and to determine whether a reacting boar may infect the progeny through the ovum by infected spermatozoa without infecting the dam. The blood serum and colostral milk of the dam were both negative. The blood of the pig was also negative to the "abortion test." The liver and spleen were cultured, and tissue emulsions of these organs were inoculated into guinea pigs but without positive results. This case serves the additional purpose of a check, showing the improbability that the aborted litter (21a) might have contracted the infection from the unknown male in the field-breeding, instead of through the laboratory cultures from the experiment sow "Gold Lace." (Besides, the validity of the so-called "Colle's law," applying to the progeny of syphilitic fathers, has now but little foundation; and it can be safely assumed, until disproved, that the young abortion-infected pigs must have abortion-infected dams.)

Uterus from Experiment Sow 204. (Fig. 6.)—This gilt was a pen mate of Sow 203, and was also pregnant, and a non-reactor to the abortion test. She was fed a small quantity of abortion germs derived from experiment sow "Gold Lace," and developed a positive reaction. Her farrowing was abnormal—two pigs were dead and four pigs, although alive, died in a few days. The sow became ill from septic condition of the uterus, but recovered from the acute symptoms. A whitish purulent discharge from the vulva was observed. The sow was slaughtered 58 days after farrowing, to study conditions of the uterus. A fragment of the skull bone of a fetus was found in the right horn of the uterus, as indicated in the figure by the arrow "b"—"b". The mucosa was reddened, and considerable thick white pus was present as indicated at the points "a"—"a". In the left horn at the point "x" in the figure, the uterine canal was obliterated for a short distance, as the result of inflammation. The inflammatory products which collected in the apical half of the uterine horn could not escape into the vagina, and had caused considerable distention of this portion of the uterus. An oozing of infected fluid through the oviduct had evidently occurred; as a fibrinous coagulum was attached to the ovary.

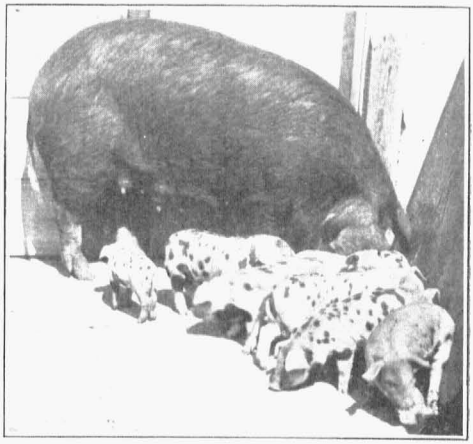


The lymph nodes in adjacent structures were edematous or dropsical. Purulent fluid was found in the left horn, when cut open. No special effort was made to isolate the B. abortus organism, in this case, beyond making a few tube cultures on glycerin agar; the septic condition made it inadvisable to inoculate guinea pigs. Besides the abortion organism had been recovered from the pen mate 203 and from her litter of dead pigs.

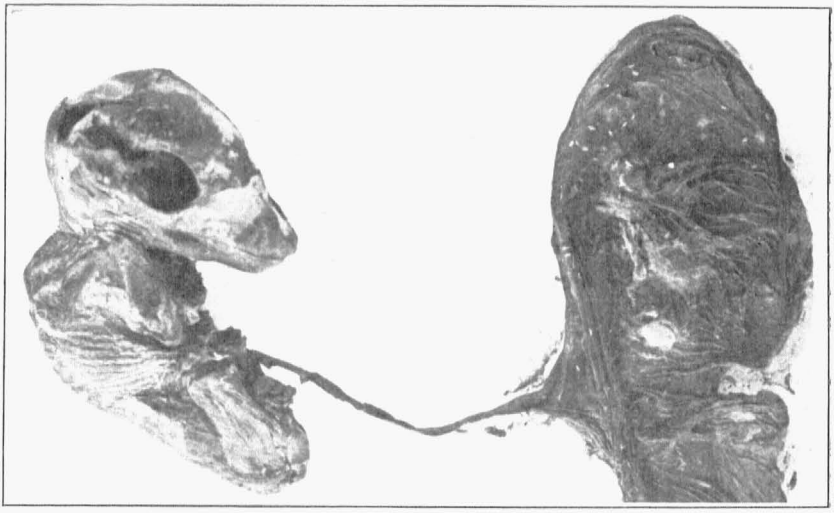
Two organisms which were probably secondary invaders were grown from the uterine fluids and pus. From the right horn a pure culture of the bacillus suisepticus was obtained; and from the left horn a growth of B. proteus.

This case is instructive, from the clinical point of view, as showing the sequels of abortion infection that are sometimes responsible for sterility. It is evident that in this particular case nothing could have been done, two months after farrowing, to restore the sow to usefulness as a breeder, The exploration of the uterine horns, at the time of farrowing, to remove dead pigs and to clean out the cavity would probably have prevented the conditions found at slaughter.

Experiment Sow No. 85 (Fig. 7.)—This purebred Poland China sow aborted a litter of pigs. The serological laboratory test for infectious abortion showed a positive reaction. The sow was later bred to a Duroc boar; and at full term she dropped eight living pigs and one shriveled mummy (Fig. 8) Seven of the living pigs were normal in size, the other was a runt. All did well. From the colostral milk pure cultures of the B. abortus were obtained. The young for a time, therefore, sucked infected milk. The young animals, however, as a rule, overcome the infection and become non-reactors about weaning time or soon thereafter.

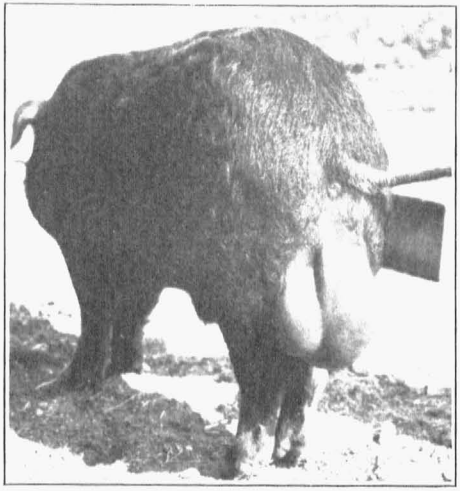


Mummy from Abortion Infected Sow No. 85 (Fig. 8).—Some sows have the remarkable power of carrying in the uterus both dead and living

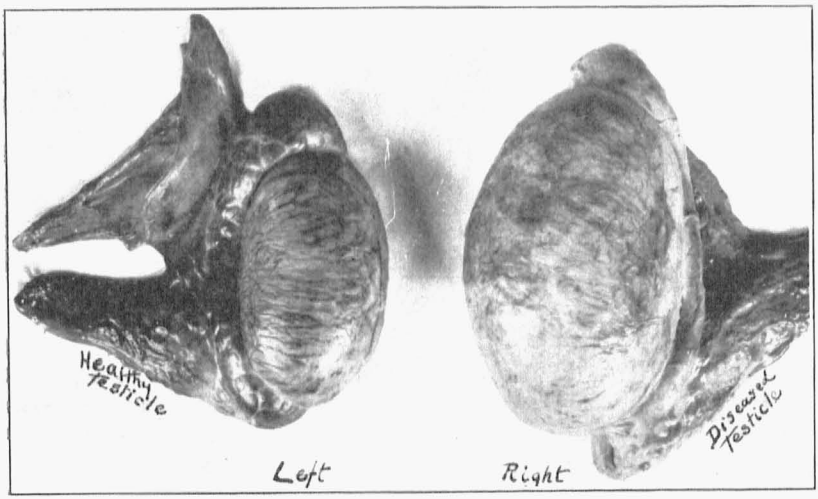


pigs for a considerable time. The encapsulation of each fetal pig in its own membrane apparently prevents or retards the spread of local infection in some cases from the dead fetus to the healthy ones. The mummy, and living pigs, farrowed at the same time by Sow 85 is a case in point. Sow 85 was an abortion-infected sow. But whether the mummified pig died from abortion infection was not determined. The specimen was not obtained in a condition suitable for bacteriological study.

Poland China Experiment Boar (Fig. 9).—A reactor to "abortion test". This boar was from an infected herd in which several sows had aborted and which showed a positive reaction to the blood test for infectious abortion. This young boar had served some of the infected sows. Considerable enlargement of the right testicle is shown; and the blood test showed a positive reaction for abortion disease. The boar was castrated. Figures 10 and 11 show a comparison of size of the removed testicles, and the surface appearance of cross sections.



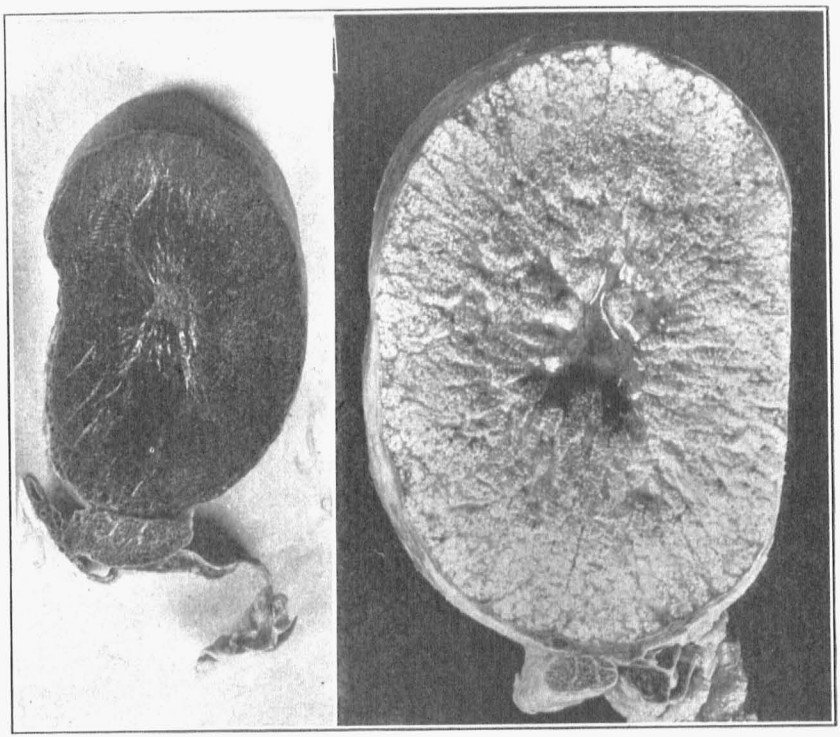
Testicles of Experiment Boar (Fig. 10).—Left testicle healthy, normal in size shows outline of blood vessels distinctly, surface smooth and glisten-



ing. Right testicle considerably enlarged. Surface roughened from inflammatory adhesions, blood vessels indistinct. (Compare Fig. 11).

Cross Section of Testicle of Experiment Boar (Fig 11.).—The illustrations are considerably reduced from natural size. The figure at left shows the surface of a cross section through the middle of the healthy testicle. There was nothing abnormal in the appearance of this organ. This gland was functional and the boar would probably have been able to propagate with this one testicle.

The testicle at the right, on cross section, showed a marked contrast with the healthy organ, in color and density, being white and as firm as a section of hard cheese. The surface presented a somewhat granular



appearance, although the tissue was not crumbly, but held together firmly. The tubules in cross section showed distinctly over the greater part of the surface. The appearance was as if all the tubules had been greatly distended with milky spermatic fluid and then firmly congealed. This testicle was not functional; no spermatic fluid was present.

In specimens from two other reacting boars, a cystic condition of the diseased testicle was also found. Portions of the testicular substance had dissolved and were replaced by clear serous fluid, or a translucent jelly-like coagulum.

RESEARCH REFERENCES

The experimental researches on infectious abortion in swine are very few, as compared with those on cattle abortion. The only research paper on this subject that was mentioned in the reference indexes, at the time the investigations reported herein were begun, was that of Good and Smith of the Kentucky Agricultural Experiment Station. This was published in the Journal of Bacteriology, Vol. 1, 1916. The research related to the etiology of the disease; and the conclusion reached was that the Bacterium abortus (Bang) was the causative agent. The same conclusion had been reached in 1904 by J. Traum in the pathological laboratory of the U. S. Bureau of Animal Industry, in the examination of an aborted swine fetus. Mention is made of this in a brief paragraph in the Report of the Chief of the Bureau for the fiscal year ending June 30, 1914. The matter, however, was not properly indexed and was overlooked by Good and Smith and others. Mention was made of it recently by Dr. Traum, now of the California Experiment Station, who at the time was connected with the Department at Washington. The work appears not to have gone beyond the routine diagnosis of a pathological specimen which had been sent to the laboratory. No systematic research into the nature of the infection in swine was reported.

In addition to the brief accounts which the authors of this bulletin have made in the Annual Reports of the Missouri Agricultural Experiment Station and in the Poland China Journal, a few other experimental researches have been reported during the past year or more. Such as have come to our knowledge are listed herewith, for the benefit of students who wish to study other researches on the subject.

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