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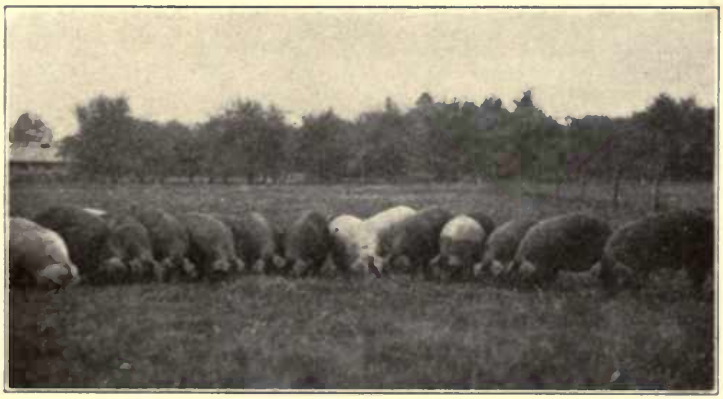
STUDIES ON PORCINE INFECTIOUS ABORTION

By Robert Graham, I. B. Boughton, and
E. A. Tunnicliff



URBANA, ILLINOIS, MARCH, 1930

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Illustration on Cover.—Each of the sows shown in the picture on the cover of this bulletin aborted one or more times and repeatedly gave positive agglutination tests of Brucella Traum. The boar of the herd, like the sows, proved infected. There are no clinical symptoms that enable the owner or veterinarian to diagnose this disease. While abortion often occurs in infected sows, many carry their litters for the full term. In breeding herds where the disease is suspected, the agglutination test is recommended.

STUDIES ON PORCINE INFECTIOUS ABORTION[a]

By Robert Graham, I. B. Boughton, and E. A. Tunnicliff[b]

Sporadic outbreaks of abortion in swine have occurred in Illinois for many years. The first important loss from this disease came to the attention of the Illinois Experiment Station in 1917, tho cultural and animal inoculation tests of the aborted fetuses failed to establish conclusively the nature of the disease. In this outbreak a paratyphoid infection was encountered, which apparently was secondary to intestinal manifestations in the sows. Three years later (1920) abortions in sows were reported in several Illinois herds. Aborted materials from one large herd at this time yielded evidence of a specific abortion infection which resembled the bovine abortion bacillus. Reports of aborting sows in other herds prompted a preliminary survey of the disease on different farms to determine the extent of the infectious type of the malady.

A study of different sporadic outbreaks of swine abortion in Illinois suggested that the specific infection, tho an important factor, was not the exclusive cause of abortion in all herds. In small herds aborting sows of common breeding were generally fattened and sold, making it often impossible to obtain satisfactory material for investigational work. Aborting sows in purebred herds, however, were not so promptly marketed. When valuable breeding sows aborted, an opportunity was presented to make bacteriologic studies of the aborted fetuses, fetal membranes, and vaginal discharges. At the same time samples of colostra and blood from aborting sows were tested for the presence of specific abortion agglutinins.[c]

Following the isolation of Brucella-like organisms from aborted materials in 1920 scarcely a farrowing season, during the past nine years, has passed without the infectious type of swine abortion coming

[a]A popular discussion of the prevention and control of infectious abortion in swine is contained in Circular 271 of this Station, revised June, 1927.

[b]Robert Graham, Chief in Animal Pathology and Hygiene; I. B. Boughton and E. A. Tunnicliff, formerly Associates.

[c]The bacteriologic findings and blood tests in different aborting herds as well as in breeding animals at time of slaughter have confirmed the occurrence of a specific type of abortion in swine and also abortions due to other factors. A herd that yielded positive (bacteriologic and serologic) evidence of abortion in 1920 was found to harbor the infection in 1929, suggesting the chronicity of the disease. In this herd abortion had subsided and had not been observed for five years until three sows aborted and one boar that suffered from orchitis proved infected at autopsy.

to the attention of the authors. In the spring of 1929 more than the usual number of sporadic outbreaks of swine abortion were reported by veterinarians and swine breeders. Upon examination, some of the important losses proved to be associated with the swine abortion organism.

The recognition of the specific type of abortion in swine in 1920 prompted an experimental study of the disease in guinea pigs, gilts, and heifers. Guinea pigs inoculated subcutaneously developed lesions

FIG. 1.—PORCINE ABORTION IN GUINEA PIG

A healthy guinea pig that was fed Brucella Traum from aborted guinea-pig fetuses. The causative organism was regained in pure cultures.

involving the lymphatics, liver, and spleen that were more progressive than lesions induced by bovine strains of Brucella. Abortion in pregnant guinea pigs invariably followed subcutaneous injection of cultures. Porcine strains encountered in different Illinois herds have proved consistently pathogenic for guinea pigs. This character is still regarded as an aid in distinguishing the porcine and bovine types of Brucella. All porcine strains isolated by direct culture as well as by guinea-pig inoculation have grown in open plates or tubes on plain nutrient agar without lowered oxygen tension or an increase of carbon dioxid in the atmosphere.

Artificial exposure of gilts and sows by feeding, by subcutaneous and intravenous inoculation, and by intravaginal installation of cultures did not in all cases cause pregnant animals to abort, but without exception the agglutination titre became distinctly positive. The experimental abortifacient character of the porcine strains, however, has been established by exposing healthy gilts, but all artificially exposed pregnant gilts in the Illinois experiments did not abort.

A heifer injected intravenously with a culture of the porcine strain of the Brucella organism aborted and later died of septic metritis. Another heifer that was allowed to come in contact with positively reacting gilts and sows for a period of six weeks failed to reveal any evidence of abortion infection as judged by her breeding record and repeated agglutination tests. On the other hand, two of three heifers kept in the same lot with five positively reacting sows during the farrowing period showed suspicious agglutination reactions three months later.

In an effort to obtain information regarding the prevalence of the disease in swine, as judged thru the presence of agglutinins in the blood sera, 1,011 blood samples from old sows slaughtered at Chicago were tested in dilutions of 1 to 50 and 1 to 100. Of the group 5.6 percent were positive, while of 975 gilts 4.41 percent gave positive reactions. The percentage of positives in 1,034 barrows was 3.38.

Evidence to support the contention that the porcine type of the disease may become established in cows was suggested in the results of injecting three heifers subcutaneously with porcine cultures and later regaining the organism from the udder of one of the inoculated animals. The possibility of the porcine strain entering the udder thru natural channels is also suggested in the results of repeated examinations of the milk from eight naturally infected cows. One of the cultures isolated from the milk reveals some of the characteristics of the porcine type.

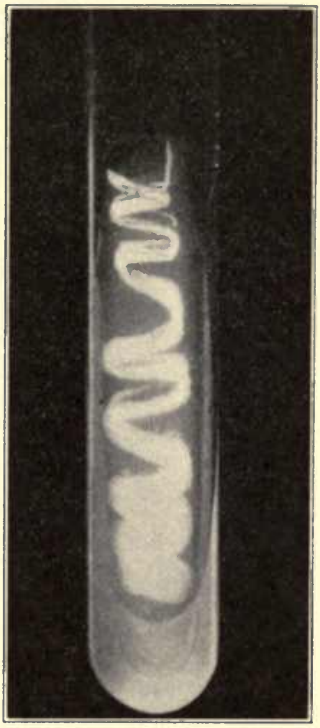

FIG. 2.—BRUCELLA TRAUM

The swine strain of Brucella grows luxuriantly on agar in air. Lowered oxygen tension is not advantageous to its growth.

The presence of specific Brucella agglutinins has been detected in human patients showing febrile symptoms, as well as in others with an indefinite or obscure history of the disease. While the evidence points to the pathogenic significance of the porcine Brucella in man,

there are as yet many unanswered questions regarding the swine and human infections.

It is the purpose of this bulletin to report investigations conducted on the infectious type of swine abortion with particular reference to

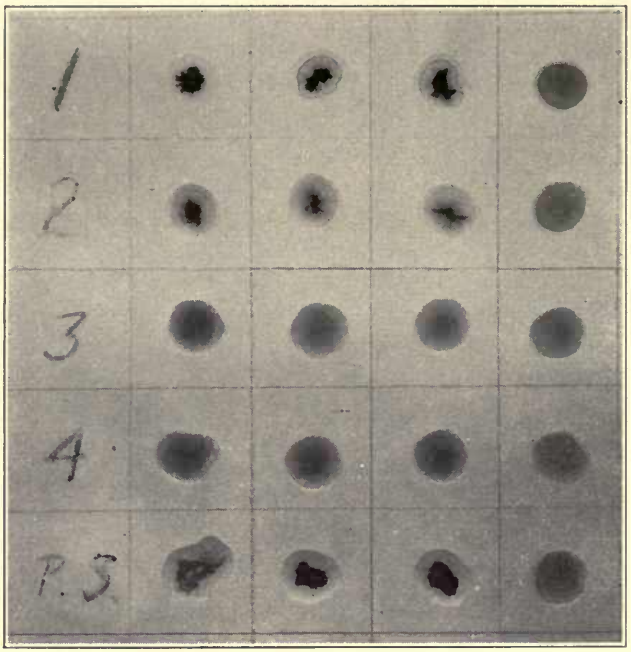

FIG. 3.—RAPID AGGLUTINATION TEST

The presence of abortion in swine can be recognized by testing the blood of each animal. Negative and positive results are shown in the above illustration. From left to right .02, .01, and .005 of the blood serum of the animal to be tested are mixed with .1 cc. of the porcine abortion organism. The antigen control without blood serum is at the extreme right. In the left-hand column is the identification of the blood samples, i.e., "1," "2," "3," and "4." Samples 1 and 2, showing clumping of bacterial suspension, with the antigen control unchanged, are positive, or reactors, to the test; while 3 and 4 in the various serum dilutions are unagglutinated and therefore negative. The last sample, labeled "P. S.," is known positive serum.

the location of the causative factor in the bodies of both naturally and artificially infected animals, and to record the preliminary results obtained from vaccines as a possible preventive measure.

In view of the fact that wide differences of opinion exist with respect to the correct nomenclature for the Brucella organisms, the

authors will follow the practice of the Illinois Undulant Fever Committee[23*] until more evidence has been presented, using "Brucella Traum" for the porcine type and "Brucella Bang" for the bovine type.

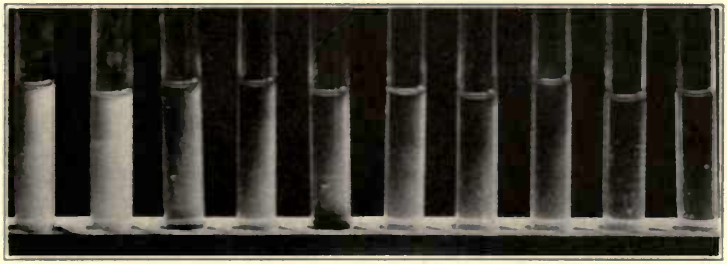

FIG. 4.—STANDARD TUBE AGGLUTINATION TEST

By the use of this test, as well as the rapid agglutination test, sows or boars harboring infectious abortion can be detected. The two cloudy tubes at the left are noninfected or healthy, while the eight tubes at the right show the mixture of blood serum and the bacterial suspension of the abortion organism agglutinated or clumped in varying degrees. Agglutination or clumping of the bacterial suspension by the serum of the animal indicates the presence of the infection in the animal. There is no other disease in swine that will produce the agglutinins for the abortion organism; therefore a positive result in the rapid or standard tube test is definite evidence that the animal is or has been infected. In the experiments discussed in this bulletin the standard test was used in the initial investigations and later supplemented by the rapid method. At the present time the rapid test is used in applying the agglutination test, supplemented in doubtful specimens by the standard method.

REVIEW OF LITERATURE

As early as 1914 Traum,[30*] of the Federal Bureau of Animal Industry, reported the isolation of the genus Brucella from the stomach contents, liver, and kidney of an aborted pig fetus. Many cows aborted in the herd from which Traum's swine specimens were received. The bacteriologic findings of Traum have been confirmed by several investigators, including Good and Smith[9*] in Kentucky (1917), Hagan[13*] (1917) of New York, Hayes and Traum[16*] (1920) of California, Doyle and Spray[7*] (1920) of Indiana, Schlegel[25*] of Germany (1920), Connaway, Durant, and Newman[5*] of Missouri (1921). The latter investigators report that abortion in swine was experimentally produced by feeding abortion cultures isolated from cattle, but Huddleson[15*] (1921) of Michigan failed to infect swine, as judged by abortion, by feeding cow's milk which contained abortion organisms.

Hadley and Beach[12*] (1922) in Wisconsin reported the occurrence of abortion in swine traceable to an organism of the Brucella genus

but biologically different from the bovine type. Artificial exposure of pregnant gilts by these authors showed that the average period of time from exposure to the act of abortion was 23.2 days. They found that young pigs were highly resistant, and that porcine abortion vaccines in a limited number of animals seemed to reduce the incidence of abortion. No evidence of infection carriers was found in their vaccinated animals.

Traum, Schroeder and Cotton, and others recognized cultural and pathogenic characters in the porcine strains which differentiated them from the bovine strains. The carrier feature of the disease in swine was first studied by Hayes[15]* of California (1922). In his investigations the porcine strain was isolated from the udder of an artificially infected sow three months after farrowing. The testicles of 17 artificially infected male pigs were examined with negative results.

Weeter[32]* (1923), of the University of Chicago, in studying 435 sow blood samples collected on the killing floors of Chicago packing establishments found 9 percent positive to the agglutination test in a dilution of 1 to 100. Of 190 blood specimens from barrows, 5 or 2.6 percent were positive in a dilution of 1 to 200. From the nongravid uteri of 3 sows in 389 examined, the porcine strain was isolated.

McAlpine and Slanetz[24]* (1927) of Connecticut studied the difference between the porcine and bovine strains, and concluded thru metabolic studies that the porcine type is different from the bovine type, and that the strains isolated from man suffering from undulant fever display the characters of the porcine group. These authors also recognize that cows may become infected with the porcine variety should they come into close contact with infected swine. Such a conjecture suggests that cattle may be in more danger of contracting the porcine type than swine are of contracting the bovine type. In view of these observations the suggestion that the porcine type might possess advantages in the form of a vaccine for cattle as immunizing agents seems unwarranted until more evidence is obtained regarding the pathogenic properties of the porcine type for cattle.

Possible Relation of Swine Abortion to Undulant Fever

A résumé of the reported investigations on infectious porcine abortion over a period of several years suggests a rather widespread distribution of a chronic infection which is recognized as a potentially dangerous disease to the swine industry, while more recent investigations of Huddleson[19]* (1926), Carpenter and Merriam[4]* (1926), and Carpenter[2]* (1927), suggest the possible significance of the porcine type to public health.

Evans first surmised the possible relation of the abortion organism of cattle to undulant fever in man, and classified the meletensis-abortus group under the genus Brucella, after Bruce, who discovered the cause of Malta (undulant) fever in man. The genus Brucella of Evans recognized the goat, cow, and swine strains.

At the present time the consensus of opinion seems to be that the porcine type is a possible source of undulant fever in man in the middlewestern states. It has been shown by various investigators, such as Hayes and Traum,[16*] Cotton,[6*] Schroeder and Cotton,[26*] Hadley and Beach,[12*] Hayes,[15*] and Smith,[28*] that the porcine strains are more pathogenic for experimental animals than the bovine strains. Whether this is true in the case of Brucella types isolated from undulant fever patients remains to be definitely proved by future studies, but the evidence at this time tends to support this contention. In Illinois, Hull[22*] has observed that cases of undulant fever in man have occurred in localities that have the largest swine population.

All the strains of Brucella obtained from human sources by McAlpine and Slanetz[24*] of the Connecticut (Storrs) Station, belonged in the porcine group. These workers found that the biological characters of the swine and human strains were more nearly related than those of the bovine and human. For instance, the human and porcine strains utilized from 4 percent to 18 percent glucose, increased the non-protein nitrogen, and produced very little free ammonia, while those of bovine origin used very little if any glucose, decreased the non-protein nitrogen, and produced large amounts of free ammonia. They also noted that porcine and human strains were inhibited or unaffected by carbon dioxid, while the bovine strains required carbon dioxid for initial growth.

Huddleson,[20*] in studying the characters of the Brucella genus, found that the porcine group was inhibited by methyl violet in a dilution of 1 to 100,000, by basic fuchsin in a dilution of 50,000, but not by thionin in a dilution of 50,000. The bovine group was inhibited by thionin in a dilution of 1 to 50,000, while the caprine group was not inhibited by any of these dilutions of dyes. He also found that the Brucella organisms could be divided into groups according to their hydrogen sulfid production. The porcine group produced a considerable amount of gas over a period of four days, the bovine group a considerable amount for two days, while the caprine group failed to produce any detectable amount of gas.

In addition to the biological characteristics of the porcine and human strains of Brucella, McAlpine and Slanetz[24*] call attention to

the fact that the "history and distribution of various human cases in the United States lends some support" to the theory that the porcine type is the causative factor in the spread of the abortus infection in man. Their data show that the undulant fever incidence is much higher in states where the swine industry is large. This does not necessarily mean that the majority of cases are contracted directly from swine, however, for it has been proved by Hadley and Beach,[12*] Schroeder and Cotton,[27*] and Carpenter and King,[3*] that porcine strains may readily infect cattle and become established in the mammary glands, where they may be eliminated with the milk.

In his differentiation of the species of the genus Brucella, Huddleson[20*] finds a lower percentage of porcine strains than McAlpine and Slanetz,[24*] yet his results point toward the porcine type as an important etiological agent in undulant fever. Out of 96 strains isolated from cows he found that 8 belonged to the porcine type; of 75 strains isolated from man, 15 were porcine, while all the strains isolated from swine were of the porcine type. All of Huddleson's strains which were isolated from cases of undulant fever in Michigan resembled the bovine abortus species, and those sent from cases outside of Michigan, with two exceptions, resembled the porcine species. Huddleson tested the virulence of the Brucella organisms by feeding monkeys and found that the porcine type was more pathogenic than the bovine regardless of the source of isolation.

Further evidence in behalf of the possible relation of the porcine type to undulant fever in man has recently been presented by Hardy[14*] (Iowa, 1925). He reports the isolation of Brucella-like organisms from 43 cases of undulant fever of which 29 were of the porcine type. Smith[28*] likewise places Brucella types isolated from human sources in the porcine group. His investigations are summarized as follows: "We must, therefore, be prepared to look for the source of human infections in the bacillus of swine abortion, provided the caprine type is not in evidence."

Smith[29*] also holds the porcine type "largely responsible either directly in the handling of swine or raw pork or indirectly when the swine bacillus is introduced into the cow's udder in one of several ways."

Evans,[8*] Blake and Oard,[1*] Viviani,[31*] and other investigators cite cases which support the contention that man may, by contact with infected animals or as a result of wound infection, suffer from the porcine type of infection.

PORCINE ABORTION TRACEABLE TO DIFFERENT CAUSES

In aborting herds coming to the attention of the authors the clinical, bacteriologic, and serologic findings suggest that abortion in swine, aside from the infectious type, may occur as a sequel to other diseases. Sows suffering from cholera, pneumonia, bronchitis, or enteritis may abort or give birth to weak, unthrifty litters. Such herds upon examination invariably prove negative to the agglutination test for the infectious type of porcine abortion caused by Brucella Traum. Abortion in sows or gilts traceable to other diseases often causes weakness and emaciation of the animals, while the death rate in such herds suggests the severity of a disease independent of abortion infection. In sick herds, apparently healthy sows that farrow normally sometimes fail to supply milk in quantities sufficient to nurse their litters.

Five severe outbreaks of abortion in swine, the causes of which were not determined, have been observed by the authors. The history of the herds, as well as the examination of aborted materials and of blood samples from aborting sows, failed to indicate the character of the malady. The general health of the aborting animals appeared normal. Likewise the ration seemed properly balanced and wholesome, tho the possibility of a transitory dietary disturbance as the result of toxic or harmful substances in the feed was recognized as a possible cause. In one herd, where abortions occurred from unestablished causes (1928), it appeared that a sleet storm might have been a predisposing factor. The pregnant sows which aborted in rapid succession had been a few days before in a lot that was covered with a thin layer of icy sleet. The slippery footing might have been responsible for injuries which terminated in abortion.

Swine abortions coming to the attention of the authors, even tho due to different causes, have appeared suddenly and often have occurred in rapid succession, but they have displayed little or no tendency to recur in a serious form on the same farm, even when aborting animals were rebred. One infected herd under observation has harbored the disease for nine years, tho few of the sows have aborted since the initial outbreak.

Infectious Type

The specific infectious type of abortion in swine, as judged by symptoms and gross pathologic lesions in the placenta, is not distinguishable from abortions due to other causes. Often the first symptom noticed is the expelled fetus, tho a discharge may precede abor-

tion. The discharge continues from one to four weeks following abortion. A large number of aborting animals in a herd suggests the presence of the infectious type of the disease, yet herds harboring the infectious type may suffer but a mild loss following the initial outbreak. Causes of abortion other than a specific infection may apparently be responsible for severe losses.

Abortions in infected herds have occurred and disappeared rather abruptly and in subsequent breeding seasons aborting sows that were rebred frequently farrowed normal litters. The abortion rate may be higher in gilts than in old sows, tho pregnant animals of all ages

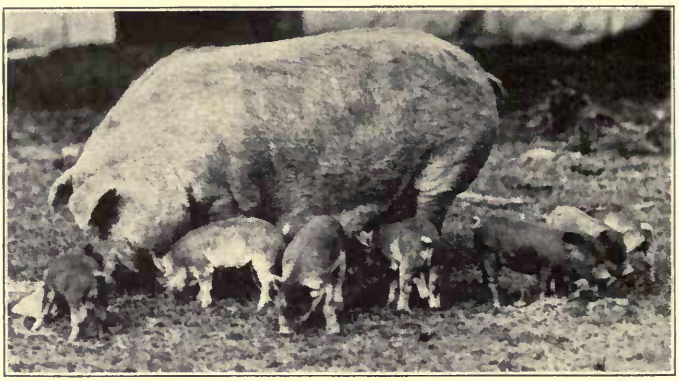

FIG. 5.—AN ABORTION INFECTED SOW THAT GAVE BIRTH TO A NORMAL LITTER OF PIGS

have aborted. In one lot of forty gilts practically all aborted from the infectious type of the disease (1926), while a large number of mature sows on the same farm farrowed normally. The following year none of the sows on that farm aborted. In this respect the course of the disease differs quite markedly from the disease in cattle, which displays a tendency to recur year after year. There can be little doubt, however, that the infectious agent is harbored indefinitely in aborting sows or in the male reproductive organs.

Preventive Measures

Prompt isolation and segregation of aborting sows is recommended as a control measure, yet it must be recognized that in initial outbreaks many animals may be infected before the owner is aware of the disease. Sanitary measures are effective if applied before the infection spreads thruout the herd. As in cows, infected sows may develop a tolerance to the abortion infection and carry their young

for the full term. Since the infectious type of abortion may be present in a herd without manifesting itself in definite symptoms, it is suggested that newly purchased bred sows or gilts be held in quarantine until after farrowing and then tested for abortion. Males should be tested before being employed for breeding purposes.

SPREAD OF INFECTIOUS PORCINE ABORTION

The infectious type of swine abortion is generally introduced into a herd thru the purchase of infected animals. Bred gilts and sows

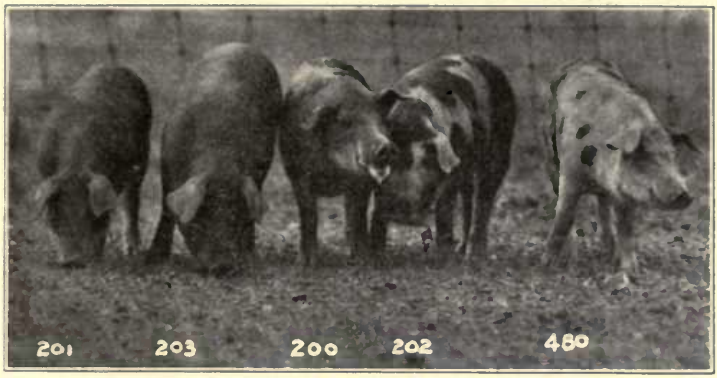

FIG. 6.—SHOTES IN AN ABORTION HERD THAT PROVED POSITIVE TO THE SERUM AGGLUTINATION TEST

The dams of these pigs were infected naturally with porcine infectious abortion.

may be infected and show no symptoms. The diagnosis of infectious abortion in swine by the agglutination test may not be accurate if the sows have been or are being fed milk from abortion-infected cattle. Independent of positive agglutination tests in swine receiving milk from abortion-infected cattle, the organism has been isolated from aborted materials in five herds in Illinois since 1920. These results confirm the existence of the infectious type of abortion as reported by Traum,[30*] Good and Smith[9*] of Kentucky; Hayes and Traum[16*] of California; Doyle and Spray[7*] of Indiana; Schlegel[25*] of Germany; Connaway, Durant, and Newman[5*] of Missouri; Hadley and Beach[12*] of Wisconsin; Hayes[15*] of California; and Weeter[32*] of Illinois.

Infected Animals May Farrow Normally

In one group of aborting sows that suffered from the infectious type of the disease it was observed that a majority of the infected sows subsequently farrowed healthy litters and showed no clinical evidence of the disease notwithstanding a positive agglutination test.

The possibility of animals breeding normally and yet being carriers of the disease, first suggested by Hayes,[15*] is supported not only by

FIG. 7.—BARROWS IN AN ABORTION INFECTED HERD

These animals (eight months old) gave a positive serum agglutination test at the time they were marketed.

field observations of the authors, but also by the results of bacteriologic examinations of the colostrum and vaginal discharge of experimentally infected gilts that farrowed normal litters.

The number of sows that actually abort would appear therefore to be an inaccurate index to the extent of the disease in a herd. The

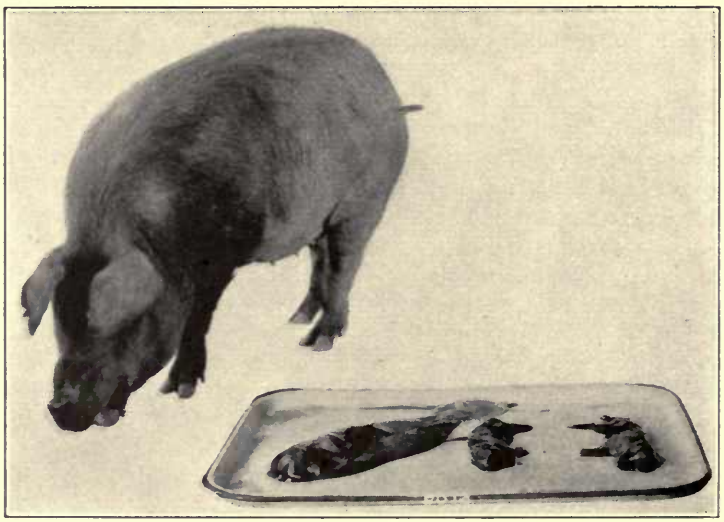

FIG. 8.—ABORTED FETUSES

This sow (2012) suffered from porcine infectious abortion. From the fetuses pure cultures of Brucella Traum were obtained.

chronic character of the disease, unaccompanied by abortion, has for many years provided an unsuspected opportunity for infection to spread from herd to herd thru apparently normal tho infected animals.

INFECTIVE CHARACTER OF BRUCELLA TRAUM

The first investigational studies of infectious abortion in swine at the Illinois Station dealt with the infective character of Brucella Traum isolated from aborted pig fetuses. Cultures of Brucella Traum

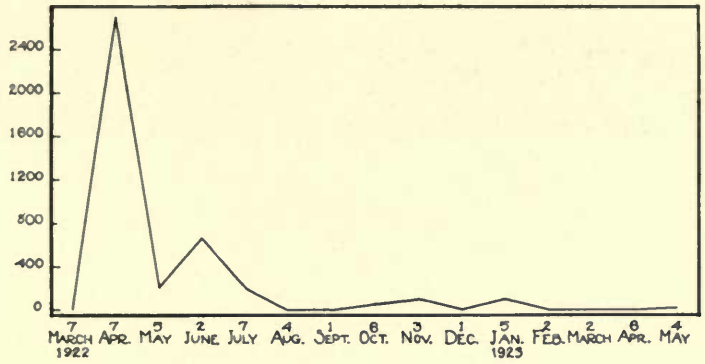

FIG. 9.—AGGLUTINATION REACTION OF GILT AFTER RECEIVING INTRAVENOUS INJECTION OF BRUCELLA TRAUM

Healthy Gilt 2061, at the age of 7 months, was treated with Brucella Traum injected intravenously on March 24, 1922. This gilt farrowed 6 healthy pigs on October 10, 1922, and 8 healthy pigs on April 2, 1923. At farrowing time Brucella Traum was not demonstrated in colostrum or fetal membranes.

Agglutinations

1922		*1922*		*1922*		*1923*	
March 7	Neg.	July 7	1–200	Oct. 27	1–200	Feb. 9	Neg.
March 24	Neg.	July 15	1–100	Nov. 3	1–100	Feb. 16	1–100
March 31	1–10000	July 22	Neg.	Nov. 10	1–500	Feb. 25	Neg.
April 7	1–2700	July 28	1–50	Nov. 17	1–100	March 2	Neg.
April 14	1–1000	Aug. 4	Neg.	Nov. 24	Neg.	March 9	1–50
April 21	1–200	Aug. 11	1–400	Dec. 1	Neg.	March 16	Neg.
April 28	1–50	Aug. 18	1–200	Dec. 8	Neg.	March 23	Neg.
May 5	1–200	Aug. 25	1–20	Dec. 15	1–100	March 30	Neg.
May 12	1–200	Sept. 1	Neg.	Dec. 22	1–50	April 6	Neg.
May 19	1–200	Sept. 8	1–50	Dec. 29	1–50	April 13	Neg.
May 26	1–666	Sept. 15	1–50	*1923*		April 20	Neg.
June 2	1–666	Sept. 22	Neg.	Jan. 5	1–100	April 27	1–20
June 9	1–1000	Sept. 29	Neg.	Jan. 12	1–20	May 4	1–20
June 16	1–1000	Oct. 6	1–50	Jan. 19	1–50	May 11	1–50
June 23	1–1000	Oct. 13	1–20	Jan. 26	1–20	May 18	Neg.
June 30	1–500	Oct. 20	Neg.	Feb. 2	Neg.	May 25	Neg.

isolated from the internal organs of aborted fetuses and fetal membranes proved capable of producing abortion when fed or injected intravenously into pregnant gilts. While all experimental gilts exposed by feeding or intravenous injection gave a positive agglutination reaction, some farrowed normal litters. Sows infected via the

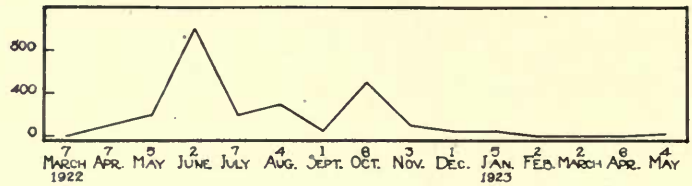

FIG. 10.—AGGLUTINATION REACTION OF GILT AFTER BEING FED BRUCELLA TRAUM

Healthy Gilt 2060 at the age of 7 months was fed Brucella Traum on March 25, 1922. On October 13, 1922, this gilt farrowed 1 dead and 8 healthy pigs, and on April 7, 1923, 5 healthy pigs. At farrowing time Brucella Traum was not demonstrated in colostrum or fetal membranes.

Agglutinations

1922	*1922*	*1922*	*1922*	*1923*
March 7....Neg.	June 9....1–2500	Sept. 1....1–50	Dec. 1.....1–50	Feb. 25.....Neg.
March 24...Neg.	June 16...1–1250	Sept. 8....1–50	Dec. 8.....1–50	March 2.....Neg.
March 31...1–100	June 23...1–1250	Sept. 15...Neg.	Dec. 15....1–50	March 9.....1–20
April 7.....1–100	June 30...1–1666	Sept. 22...Neg.	Dec. 22....Neg.	March 16....Neg.
April 14....1–500	July 7.....1–200	Sept. 29...Neg.	Dec. 29....1–100	March 23....Neg.
April 21....1–100	July 15....1–50	Oct. 6.....1–500	*1923*	March 30....Neg.
April 28....1–200	July 22....Neg.	Oct. 13....1–1000	Jan. 5....1–50	April 6.....Neg.
May 5.....1–200	July 28....1–100	Oct. 20....1–1250	Jan. 12.....1–100	April 13.....Neg.
May 12.....1–200	Aug. 4....Hemol.	Oct. 27....1–400	Jan. 19.....Neg.	April 20.....Neg.
May 19.....1–200	Aug. 11...1–500	Nov. 3....1–100	Jan. 26.....1–20	April 27.....1–20
May 26.....1–500	Aug. 18...1–666	Nov. 10...1–400	Feb. 2.....Neg.	May 4.....1–20
June 2.....1–1000	Aug. 25...Neg.	Nov. 17...1–100	Feb. 9.....1–20	May 11.....1–20
		Nov. 24...1–400	Feb. 16....1–20	May 18.....Neg.
				May 25.....1–50

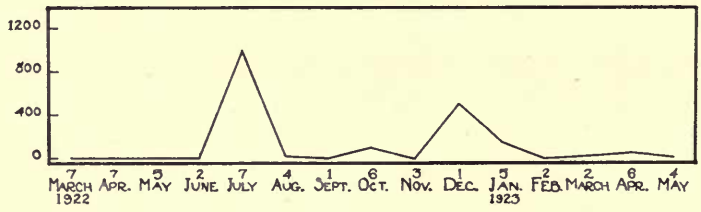

FIG. 11.—AGGLUTINATION REACTION OF GILT AFTER RECEIVING INTRAVAGINAL INJECTION OF BRUCELLA TRAUM

Healthy Gilt 2059 at the age of 7 months was injected intravaginally with Brucella Traum on June 15, 1922, and bred fifteen minutes later. On October 7, 1922, this gilt farrowed 2 dead and 6 live pigs, and on May 20, 1923, 14 live pigs. At farrowing time Brucella Traum was not demonstrated in colostrum or fetal membranes.

Agglutinations

1922	*1922*	*1922*	*1923*
March 7.....Neg.	Aug. 18.....1–500	Nov. 24.....1–100	Feb. 25.....Neg.
April 7.....Neg.	Aug. 25.....Neg.	Dec. 1.....1–500	March 2.....1–20
May 5.....Neg.	Sept. 1.....Neg.	Dec. 8.....1–500	March 9.....1–100
June 2.....Neg.	Sept. 8.....Neg.	Dec. 15.....1–200	March 16.....1–50
June 16.....Neg.	Sept. 15.....Neg.	Dec. 22.....Neg.	March 23.....1–20
June 23.....1–50	Sept. 22.....Neg.	Dec. 29.....1–100	March 30.....Neg.
June 30.....1–500	Sept. 29.....Neg.	*1923*	April 6.....1–50
July 7.....1–1000	Oct. 6.....1–100	Jan. 5.....1–100	April 13.....1–50
July 15.....1–200	Oct. 13.....1–50	Jan. 12.....1–50	April 20.....Neg.
July 22.....1–500	Oct. 20.....1–400	Jan. 19.....Neg.	April 27.....Neg.
July 28.....Neg.	Oct. 27.....1–200	Jan. 26.....1–50	May 4.....1–20
Aug. 4.....1–20	Nov. 3.....Neg.	Feb. 2.....Neg.	May 11.....1–20
Aug. 11.....1–400	Nov. 10.....1–100	Feb. 9.....1–50	May 18.....1–50
	Nov. 17.....1–100	Feb. 16.....1–50	May 25.....Neg.

vagina at the time of breeding likewise reacted to the agglutination test, while cows and horses inoculated with Brucella Traum gave positive agglutination reactions.

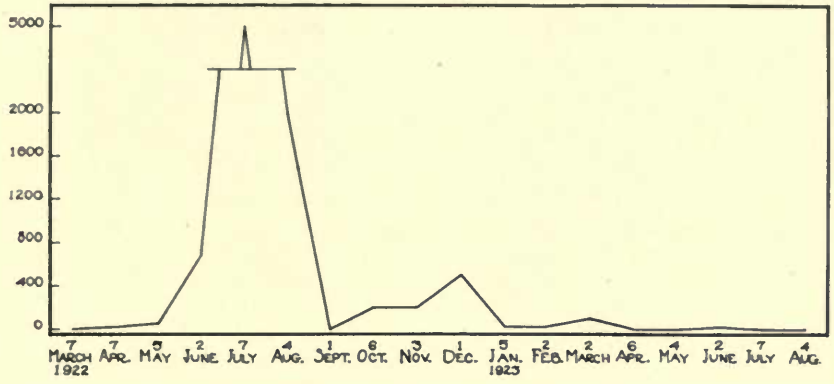

FIG. 12.—AGGLUTINATION REACTION OF BOAR AFTER BEING FED BRUCELLA TRAUM

Healthy Boar 2058 at the age of 7 months was infected by being fed live culture Brucella Traum on March 24, 1922. When the animal was killed on August 23, 1923, Brucella Traum was isolated from the bulbo-urethral gland and seminal vesicles.

Agglutinations

1922	*1922*	*1922*	*1923*
March 7.....Neg.	July 28.....1-5000	Dec. 8.....1-500	April 13.....Neg.
March 24.....Neg.	Aug. 4.....1-2000	Dec. 15.....1-50	April 20.....Neg.
March 31.....Neg.	Aug. 11.....1-500	Dec. 22.....Neg.	April 27.....Neg.
April 7.....1-20	Aug. 18.....1-666	Dec. 29.....1-50	May 4.....Neg.
April 14.....1-100	Aug. 25.....1-500	*1923*	May 11.....1-100
April 21.....1-50	Sept. 1.....Neg.	Jan. 5.....1-20	May 18.....Neg.
April 28.....1-20	Sept. 9.....Neg.	Jan. 12.....1-50	May 25.....1-100
May 5.....1-50	Sept. 15.....Neg.	Jan. 19.....Neg.	June 2.....1-20
May 12.....Neg.	Sept. 22.....Neg.	Jan. 26.....Neg.	June 9.....Neg.
May 19.....1-20	Sept. 29.....Neg.	Feb. 2.....1-20	June 16.....Neg.
May 26.....1-100	Oct. 6.....1-200	Feb. 9.....1-50	June 23.....Neg.
June 2.....1-666	Oct. 13.....Neg.	Feb. 16.....Neg.	June 30.....Neg.
June 9.....1-2500	Oct. 20.....Neg.	Feb. 25.....Neg.	July 7.....Neg.
June 13.....1-1666	Oct. 27.....1-500	March 2.....1-100	July 14.....Neg.
June 23.....1-1250	Nov. 3.....1-200	March 9.....1-200	July 21.....Neg.
June 30.....1-2500	Nov. 10.....1-500	March 16.....1-200	July 28.....Neg.
July 7.....1-5000	Nov. 17.....1-500	March 23.....Neg.	Aug. 4.....Neg.
July 15.....1-5000	Nov. 24.....1-500	March 30.....Neg.	Aug. 18.....1-50
July 22.....1-1000	Dec. 1.....1-500	April 6.....Neg.	

The results of artificially exposing animals to cultures of Brucella Traum are graphically illustrated in Figs. 9 to 18.

Antigenic Value of Live and Dead Cultures

Live and killed cultures of Brucella Traum producing agglutinins following subcutaneous injection in sows are illustrated in Fig. 16. The injection of old, dead cultures was followed by a higher initial agglutination titre, but the live cultures subsequently produced a still higher titre. A single feeding of Brucella Traum to 22 male pigs 45 days old yielded evidence, as judged by the agglutination test,

that young pigs are quite resistant. The agglutination reaction remained low. Twenty-two pigs gave an average weekly agglutination reaction which varied from 0 to positive in a dilution of 1 to 22 following feeding of the culture (Fig. 18).

Infected Boars Potential Spreaders

The possibility of boars spreading Brucella Traum was suggested in the isolation of the abortion organism from the bulbo-urethral

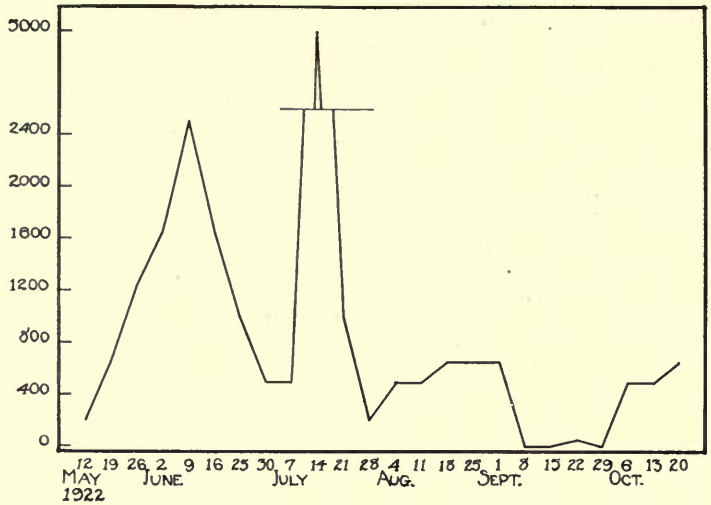

FIG. 13.—AGGLUTINATION REACTION OF COW AFTER RECEIVING SUBCUTANEOUS INJECTION OF BRUCELLA TRAUM

A brindle cow was treated May 5, 1922, with a 48-hour culture of Brucella Traum injected subcutaneously. She gave birth normally to a bull calf on October 18, 1922.

Agglutinations

1922		*1922*		*1922*		*1922*	
May 12	1–100	June 23	1–1000	Aug. 4	1–500	Sept. 15	Neg.
May 19	1–666	June 30	1–500	Aug. 11	1–500	Sept. 22	1–50
May 26	1–1250	July 7	1–500	Aug. 18	1–666	Sept. 29	Neg.
June 2	1–1666	July 14	1–5000	Aug. 25	1–666	Oct. 6	1–500
June 9	1–2500	July 21	1–1000	Sept. 1	1–666	Oct. 13	1–500
June 16	1–1666	July 28	1–200	Sept. 8	Neg.	Oct. 20	1–666

glands and seminal vesicles of an actively breeding boar, following infection by feeding (Fig. 12). This boar, immediately preceding slaughter, reacted negatively to the agglutination test. A nonreacting sow (2063) was served by the boar. Twenty-three days following the first service, this sow reacted to the agglutination test. The possibility of infection from other sources could not be eliminated, but inasmuch as the reproductive organs of this boar yielded pure cultures of Brucella Traum, the potential danger of males with infected reproductive organs is suggested (Fig. 14).

Relation of Brucella Bang and Brucella Traum

The porcine and bovine abortion organisms appear serologically and morphologically indistinguishable. On nutrient agar, porcine strains grow more abundantly than bovine strains and have a tendency to produce a yellowish pigment. The similarity of the two organisms, together with the wide prevalence of the disease in cattle, suggested the possible transmission of Brucella Bang from cattle to swine by association or thru the feeding of infected milk or aborted fetuses. This suspicion, however, has not been substantiated by the history of outbreaks or by bacteriologic findings. Abortion in heifers has been induced by the intravenous injection of the porcine abortion organisms, while a heifer allowed to associate with infected sows

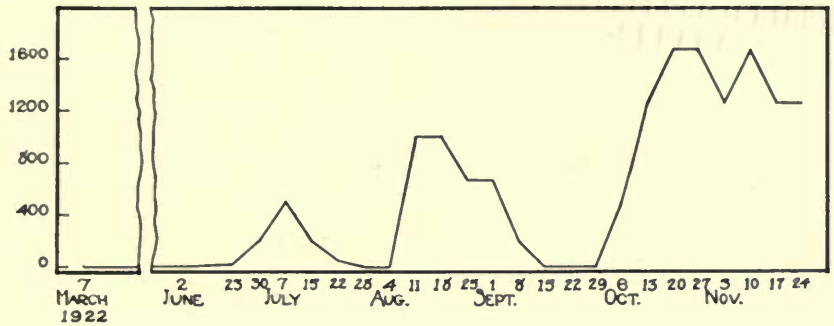

FIG. 14.—AGGLUTINATION REACTION OF GILT EXPOSED TO BRUCELLA TRAUM BY BREEDING TO INFECTED BOAR

Healthy Gilt 2063 at the age of 7 months was bred on June 7 and July 28, 1922, to a male which had been infected March 24, 1922, by being fed Brucella Traum.

Agglutinations

1922	*1922*	*1922*	*1922*
March 7.....Neg.	July 15.....1–200	Sept. 1.....1–666	Oct 20.....1–1666
April 7.....Neg.	July 22.....1–50	Sept. 8.....1–200	Oct. 27.....1–1666
May 5.....Neg.	July 28.....Neg.	Sept 15.....Neg.	Nov. 3.....1–1250
June 2.....Neg.	Aug. 4.....Neg.	Sept. 22.....Neg.	Nov. 10.....1–1666
June 23.....1–20	Aug. 11.....1–1000	Sept. 29.....Neg.	Nov. 17.....1–1250
June 30.....1–200	Aug. 18.....1–1000	Oct. 6.....1–500	Nov. 24.....1–1250
July 7.....1–500	Aug. 25.....1–666	Oct. 13.....1–1250	Dec. 5.....Sold

gave a suspicious agglutination reaction yet did not abort. The possibility that cattle may become carriers of porcine abortion as the result of continuous association with swine was studied without obtaining positive evidence of the danger. Heifers have been experimentally confined in lots with reacting sows at the time of farrowing and for six months thereafter without communicating the infection.

Abortion in swine resulting from association with aborting cows or from the feeding of milk from aborting cattle has not been observed to any extent on dairy farms where this type of exposure has been provided.

The feeding of cows' milk containing the abortion organism to gilts for several months without producing abortion was reported by Huddelson.[21*] Similar results were obtained in one experiment conducted at the Illinois Station. Seven pregnant nonreacting gilts were

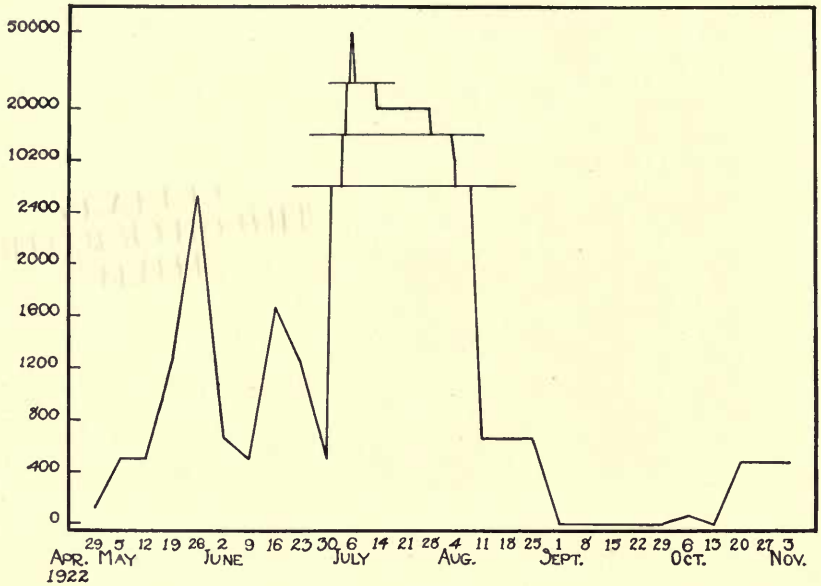

FIG. 15.—AGGLUTINATION REACTION OF SOW TO REPEATED SUBCUTANEOUS INJECTIONS OF BRUCELLA TRAUM

Sow 2080 farrowed 2 healthy pigs on April 16, 1922. She was bred on May 12, 1922, and rebred May 31, 1922. Treatments: March 13, 1922, fed fetuses. April 21, ¾ of one 48-hour agar slant of Brucella Traum killed by heating for 15 minutes at 65° C. injected. April 28, 1 48-hour agar slant heated 15 minutes at 65° C. injected. On the following dates the number of 48-hour agar slants, live culture, injected were as follows: May 5, 1; May 12, 1½; May 19, 2; May 26, 3; June 2, 4; June 9, 5; June 16, 6; June 23, 7; June 30, 8; July 6, 9; July 14, 10; July 21, 11; July 28, 12; Aug. 4, 13; Aug. 11, 14.

Agglutinations

1922	*1922*	*1922*	*1922*
April 28.....1–100	June 16.....1–1666	Aug. 4.....1–10000	Sept. 22.....Neg.
May 5.....1–500	June 23.....1–1250	Aug. 11.....1–666	Sept. 29.....Neg.
May 12.....1–500	June 30.....1–500	Aug. 18.....1–666	Oct 6.....1–50
May 19.....1–1250	July 6.....1–50000	Aug. 25.....1–666	Oct. 13.....Neg.
May 26.....1–2500	July 14.....1–20000	Sept. 1.....Neg.	Oct. 20.....1–500
June 2.....1–666	July 21.....1–20000	Sept. 8.....Neg.	Oct. 27.....
June 9.....1–500	July 28.....1–20000	Sept. 15.....Neg.	Nov. 3.....1–500

fed infected milk each day, beginning one month after breeding and continuing until farrowing time. Two gallons of a composite sample of milk taken from ten abortion-infected cows were fed each day. By guinea-pig inoculation the milk was shown to be infected. Abor-

tion did not occur in any of the seven gilts receiving infected cows' milk, while animal inoculation and bacteriologic examination of the fetal membranes and colostra at farrowing time proved negative to Brucella Traum.

Similar negative results were encountered in gilts which were fed milk from infected cows that had been injected subcutaneously with porcine abortion strains.

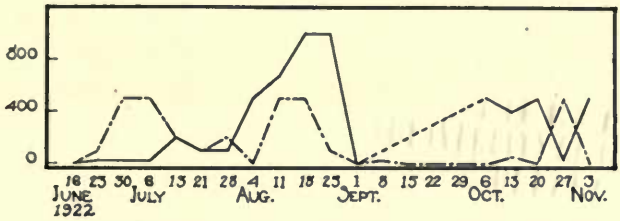

FIG. 16.—AGGLUTINATION REACTIONS OF TWO GILTS FOLLOWING SUBCUTANEOUS INJECTIONS OF LIVE AND KILLED CULTURES OF BRUCELLA TRAUM

Healthy Gilts 2035 and 2079, at the age of one year, were given subcutaneous injections of Brucella Traum. Reaction of Gilt 2035 is shown by the continuous line; of Gilt 2079, by the broken line.

Treatments

1922	*Gilt 2035, 1 agar slant live culture*	*Gilt 2079, 1 agar slant, dead culture*
June 16	66–day growth	108–day growth
June 23	73–day growth	71–day growth
June 30	75–day growth	107–day growth
July 6	48–day growth	34–day growth
July 13	93–day growth	131–day growth
July 21	108–day growth	127–day growth
July 28	130–day growth	134–day growth

Agglutinations

1922	*G. 2035*	*G. 2079*	*1922*	*G. 2035*	*G. 2079*	*1922*	*G. 2035*	*G. 2079*
June 16	Neg.	Neg.	Aug. 4	1–500	Neg.	Sept. 22		Neg.
June 23	1–20	1–100	Aug. 11	1–666	1–500	Sept. 29		Neg.
June 30	1–20	1–500	Aug. 18	1–1000	1–500	Oct. 6	1–500	Neg.
July 6	1–20	1–500	Aug. 25	1–1000	1–100	Oct. 13	1–400	1–50
July 13	1–200	1–200	Sept. 1	Neg.	Neg.	Oct. 20	1–500	Neg.
July 21	1–100	1–100	Sept. 8	[1]	1–20	Oct. 27	1–20	1–500
July 28	1–100	1–200	Sept. 15		Neg.	Nov. 3	1–500	Neg.

([1]From September 1 to October 6 no weekly readings were made for Gilt 2035.)

Since subcutaneous and intravenous injections of pregnant gilts with virulent saline suspensions of Brucella Traum, as well as the feeding of porcine abortion cultures, have not consistently produced abortion, negative results in swine receiving Brucella Bang in milk may not be conclusive, and it would seem probable that the underlying facts regarding the intercommunicability of Bang abortion disease of cattle to swine can be determined only by more extensive studies. It is apparent that Bang's disease in cattle is not usually communicated to swine, yet until more evidence is available it is not advisable to ignore the possible danger of spreading infectious abortion from cattle to swine and vice versa.

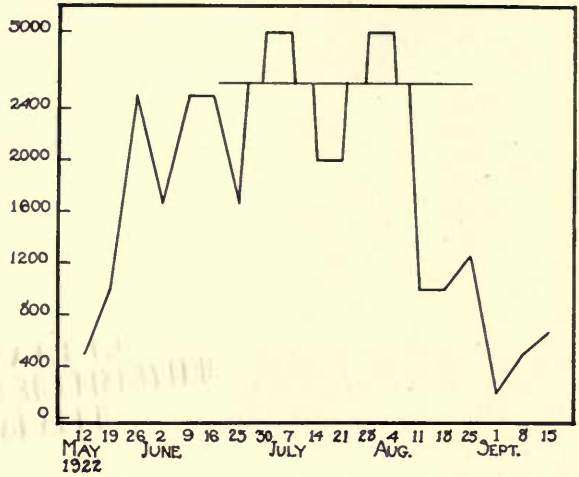

FIG. 17.—AGGLUTINATION REACTION OF FILLY AFTER RECEIVING INTRAVENOUS INJECTION OF BRUCELLA TRAUM

Treatments: May 5, 1922, 1 48-hour live culture was injected. On the following dates agar slants, in the numbers indicated, were injected. May 12, 1; May 19, 1½; May 26, 2; June 2, 3; June 9, 4; June 16, 5; June 23, 6; June 30, 7; July 7, 8; July 14, 9; July 21, 10; July 28, 11.

Agglutinations

1922	*1922*	*1922*	*1922*
May 5.....1–20	June 9.....1–2500	July 14.....1–2000	Aug. 18.....1–1000
May 12.....1–500	June 16.....1–2500	July 21.....1–2000	Aug. 25.....1–1250
May 19.....1–1000	June 23.....1–1666	July 28.....1–5000	Sept. 1.....1–200
May 26.....1–2500	June 30.....1–5000	Aug. 4.....1–5000	Sept. 8.....1–500
June 2.....1–1666	July 7.....1–5000	Aug. 11.....1–1000	Sept. 15.....1–666

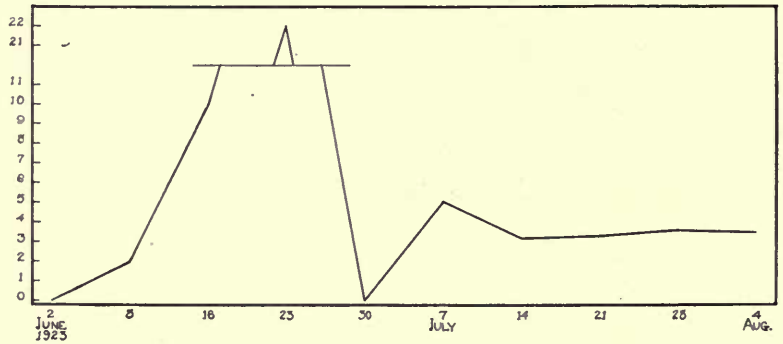

FIG. 18.—AGGLUTINATION REACTIONS (WEEKLY) OF TWENTY-TWO MALE PIGS, JUNE 2 TO AUGUST 4, 1923

Pigs 2949 to 2070, from 45 to 93 days old, with one exception, were each fed 1 agar slant of old culture Brucella Traum on June 1, 1923.

Average Agglutinations

1923	*1923*	*1923*	*1923*	*1923*
June 2.....Neg.	June 16.....1–10	June 30.....Neg.	July 14.....1–3.1	July 28.....1–3.5
June 8.....1–2	June 23.....1–22	July 7.....1–5	July 21.....1–3.3	Aug. 4.....1–3.5

Normally Farrowing Sows as Carriers of Brucella Traum

In a group of 17 aborting sows, abortions occurred as early as three weeks after breeding, tho the majority took place between the fourth and twelfth weeks of pregnancy. Ten of the aborting sows farrowed normal litters in the first pregnancy following abortion. Four of the sows aborted two consecutive times. One sow, after aborting in the spring of 1920, farrowed normally in the fall and aborted during the next period of pregnancy in the spring of 1921. Two of the original aborting sows repeatedly failed to conceive and were regarded as

FIG. 19.—PURERBED CHESTER WHITE SOW WHICH ABORTED MARCH, 1920
On September 10, 1920, this sow farrowed 6 healthy and 4 weak and dead pigs. Abortion bacilli were present in the internal organs of the dead pigs.

nonbreeders. The result of monthly agglutination tests on aborting animals (Table 1) indicated that some of these sows probably remained actively infected and were potential spreaders of the disease for many months. This suspicion was further supported by the breeding records of four sows (of the experimental herd) that aborted the second time and one sow that farrowed normally in the fall of 1920 and aborted in the spring of 1921.

The presence of Brucella Traum in the fetal membranes and colostra of normally farrowing sows that were experimentally fed or injected intravenously with the organism prompted an examination of the fetuses and fetal membranes of 23 normally farrowing sows in an infected herd.* One fetal membrane was too badly contaminated

*All fetuses and fetal membranes were delivered immediately to the laboratory. The fetuses were washed in tap water and the skin was dissected back over the thorax and abdomen, care being taken not to open the thoracic and abdominal cavities. The fetuses thus exposed were flamed thoroly. The thoracic and abdominal walls were removed with sterile instruments in order to expose the heart and stomach. The parts exposed were again flamed. The heart

TABLE 1.—MONTHLY AGGLUTINATION TEST OF ABORTING SOWS IN EXPERIMENTAL HERD AT ILLINOIS STATION

Identification			Date bred 1919–20	Month aborted 1920	Monthly agglutination tests										Date farrowed and number of pigs	Date aborted and number of pigs
Sow No.	Age yrs.	Breed			Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.		
13	1½	Hamp.	11–30–19	Mar.	+	+	+	+	+	+	+	−	−	−	9–7 (7 live, 4 dead)	.....
3	1½	D. J.	11–12–19	Feb.	+	+	+	+	+	+	+	+	+	−	.....	7–25 (8 dead)
2012																
66	1½	D. J.	12– 8–19	Feb.	+	+	+	+	+	+	+	+	−	+	9–2 (9 healthy)	.....
60	4	D. J.	1– 4–20	Feb.	+	+	+	+	−	+	+	Died	..	..	.....	9–28 (12 dead)
77	2½	D. J.	12– 7–19	Jan.	−	+	+	−	−	−	−	−	−	+	9–4 (10 healthy)	.....
6	2	L. Y.	11–13–19	Jan.	+	+	+	+	−	−	+	−	+	+	9–4 (11 healthy)	.....
6	2½	D. J.	11–12–19	Mar.	−	+	+	−	+	+	−	+	+	+	9–12 (11 healthy)	.....
15	1	C. W.	.....	Mar.	+	+	+	+	+	+	+	+	+	+	9–16 (6 healthy, 4 weak and dead)	.....
60-a	1½	D. J.	12–28–19	Mar.	−	+	+	+	+	+	−	+	+	−	9–14 (12 healthy)	.....
14	1½	D. J.	1–19–20	Mar.	+	+	+	+	−	+	+	+	+	+	.....	.....
14	5	C. W.	2– 7–20	Mar.	+	+	−	−	−	−	−	−	+	−	9–19 (3 healthy)	.....
X-a	3	C. B.	3–13–20	Mar.	−	+	+	−	−	+	−	+	+	−	9–7 (7 healthy)	.....
7	1	D. J.	12– 9–19	Mar.	−	−	−	+	+	+	+	+	+	−	.....	.....
93	2	P. C.	11–22–19	Mar.	+	+	+	−	+	+	−	+	−	+	9–12 (5 healthy)	.....
66	3	D. J.	1–28–20	Mar.	+	+	+	+	−	+	+	+	+	+	12–14 (5 healthy, 1 immature)	7–23 (Sow ate pigs)
11	5	C. W.	12–28–19	Apr.	−	−	−	+	−	−	−	−	−	−	.....	7–28 (Sow ate pigs)

(+) Positive. Agglutination .01 cc. of serum to .1 cc. of antigen. Incubated 24 hours at 37.5° C. Porcine and bovine antigen gave similar results.
(−) Negative.

to be examined. Only one sow of this group had previously aborted, tho during 1920-21, other sows in the herd had given birth to litters prematurely.

Brucella Traum was not isolated in direct cultures from the fetal membranes of any sow of this group. Guinea pigs inoculated with emulsions of the fetal membrane failed to show lesions of abortion infection, and spleen cultures from the inoculated guinea pigs were negative to the organism. However, the serum of one guinea pig injected with fetal membrane 2174 completely agglutinated Brucella Traum in a dilution of .02. In nine instances the blood and colostra of the sows at the time of farrowing gave complete agglutinations in a dilution of .02, altho the abortion organism was not demonstrated in the fetal membranes. The blood sera of guinea pigs injected with fetal membrane 2106 gave complete agglutination in a .01 dilution (Tables 2 and 2A). Bacteriologically all sows of this group gave negative evidence of the presence of abortion infection, but serologically (thru guinea-pig inoculation) evidence of infection was obtained in two instances (Tables 2 and 2B).

Location of Brucella Traum in Infected Animals

Examination of Nonlactating Mammary Glands. In a few sows that aborted following artificial infection, an examination of the colostra gave positive serologic and bacteriologic evidence of the presence of Brucella Traum. This fact suggests that the udder might commonly, as in abortion-infected cows, serve as the reservoir of the organism, as pointed out by Hayes.[15]* Examination was made of fourteen inactive mammary glands from spontaneously and artificially

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and stomach were punctured with a sterile pipette and about one-half cubic centimeter of the contents was streaked on agar slants or plates. Heart blood was also obtained for agglutination tests with Brucella Traum.

The fetal membranes usually arrived with the serous surface exposed and the mucous surface (fetal placenta) inward. Material for planting was obtained with a sterile platinum loop or forceps after the external covering was thoroly flamed and a small area was smeared by means of a hot spatula. When fetal membranes were received inverted, material was obtained for planting from the serous side or from blood in the large vessels. Plain agar, 2 percent glycerin agar, and 1 percent dextrose agar titrated pH 6.9 were used as culture media. Some specimens were planted on plates and placed in a 10-percent carbon dioxid atmosphere, but the majority of the specimens were cultured on slants and then sealed with melted paraffin. All cultures were incubated at 37° C.

Guinea pigs were inoculated intraperitoneally with emulsions of the fetal membranes and with composite heart blood and stomach contents of the dead pigs submitted. Three to four weeks following injection, the guinea pigs were etherized and autopsied. Under strict aseptic precautions, pieces of spleen about the size of a pea were carefully streaked over the surface of agar slants. The tubes were sealed and incubated at 37° C. The blood of these guinea pigs was subjected to the agglutination test. The technic outlined gave positive results in materials known to be infected, both in direct cultures and in inoculated pigs

TABLE 2.—EXAMINATION OF FETAL MEMBRANES AND DEAD PIGS FROM SOWS IN ABORTION-INFECTED HERD

No.	Date 1922	Material	Results of examination				Source of material						
			Direct culture	Aggl. fetus blood	Guinea-pig inoculations			Sow No. and age	History			Agglutination of sow		
					Autopsy	Cultures (spleen)	Aggl. blood		Previous abortion	Live pigs	Dead pigs	Blood	Milk	Recheck blood
2037 (a)	3–4	Dead pig (a)	Heart sterile Stomach 1 tube G + spreader	Negative	3–29 Spleen slightly enlarged, very friable. Liver, few small white spots	Sterile	Negative	D. J. 1 3 yr.	No	11	2	Negative	Negative	Negative 4–28
2037 (b)	3–4	Dead pig (b)	Staphylococcus Saprophytes	Negative	3–29 No gross lesions	Sterile	Negative							
2038	3–4	Fetal membranes	Staphylococcus Saprophytes	....	3–24 No gross lesions	G + rod resembling *B. mesentericus*	....							
2039 (a)	3–4	Dead pig (a)	G + short rods *Staphylococcus albus* No growth in sugar	Negative	3–29 Spleen slightly enlarged	Sterile	Negative	D. J. 93 3 yr.	No	11	2	.05	Negative	Negative 4–7
2039 (b)	3–4	Dead pig (b)	Staphylococcus Molds	Negative	3–29 No gross lesions	Sterile	Negative							
2040	3–4	Fetal membranes	G + *Staphylococcus albus* Diploids G + Coccus	....	Died	G − rod	....							
2041 (a)	3–4	Pig (a)	Sterile	Negative	Died 3–9 No gross lesions	Sterile	Negative	P. C. 33 5 yr.	No	6	2	Negative	Negative	Negative 4–8
2041	3–4	Pig	Sterile	Negative	.....	.....	....							
2042	3–4	Fetal membranes	Spreader	....	Pregnant 4–18 No gross lesions	*B. coli* *Staphylococcus albus*	Negative							

TABLE 2.—EXAMINATION OF FETAL MEMBRANES AND DEAD PIGS FROM SOWS IN ABORTION INFECTED HERD—*Continued*

No.	Date 1922	Material	Results of examination					Source of material						
			Direct culture	Aggl. fetus blood	Guinea-pig inoculations			Sow No. and age	History			Agglutination of sow		
					Autopsy	Cultures (spleen)	Aggl. blood		Previous abortion	Live pigs	Dead pigs	Blood	Milk	Recheck blood
2053	3–7	Fetal membranes	Too contaminated for bacteriologic examination	....	.....	.....	....	D. J. 13 5 yr.	No	2	0	.02	.002	Negative 4–7
2054	3–7	Fetal membranes	G + diploids Staphylococcus	....	3–30 Spleen enlarged Follicles very prominent	Sterile	Negative	D. J. 78 4 yr.	No	15	3	.05	Negative	Negative 4–7
2066 (a)	3–8	Dead pig (a)	Fine growth G + rods with short, rounded ends	Negative	3–31 Spleen slightly enlarged. Follicles visible	Sterile	Negative							
2066 (b)	3–8	Dead pig (b)	Fine growth G + rods with short, rounded ends	Negative	3–31 No gross lesions	Colon-like organism	Negative							
2066 (c)	3–8	Dead pig (c)	Mixed cultures G + rods and chains	Negative	Died 3–20 Pneumonia	*B. coli*	....							
2055	3–7	Fetal membranes	Staphylococcus Coccus	....	3–30 Spleen small Follicles visible	Sterile	Negative	C. W. 14 7 yr.	3–7 1922	6	1	.05	....	+.05 5–3
2056	3–7	Dead pig	Saprophytes Staphylococcus	Negative	3–10 Spleen large, numerous good-sized gray areas, liver friable	Sterile	Negative							
2068	3–8	Fetal membranes	G − rod, short plump bacillus G + large rod	....	3–31 Spleen enlarged	Sterile	Negative	D. J. 9 (Telling) 4 yr.	No	8	0	Negative	Negative	Negative 4–7
2083 (a)	3–8	Dead pig (a)	G + large rods	Negative	3–31 Spleen slightly enlarged	Sterile	Negative	Berk. 3 2 yr.	No	4	3	Negative	Negative	....
2083 (b)	3–8	Dead pig (b)	G − short plump rods often in pairs	Negative	3–31 No gross lesions	Sterile	Negative							
2083 (c)	3–8	Dead pig (c)	Large coccus G + short bacilli	Negative	3–31 Spleen slightly enlarged, follicles rather prominent	Sterile	Negative							

TABLE 2.—EXAMINATION OF FETAL MEMBRANES AND DEAD PIGS FROM SOWS IN ABORTION INFECTED HERD—*Continued*

No.	Date 1922	Material	Results of examination					Source of material						
			Direct culture	Aggl. fetus blood	Guinea-pig inoculations			Sow No. and age	History			Agglutination of sow		
					Autopsy	Cultures (spleen)	Aggl. blood		Previous abortion	Live pigs	Dead pigs	Blood	Milk	Recheck blood
2084	3–8	Fetal membranes	G + tetrads, large and in fine colonies Small G + staphylococcus	....	3–31 Spleen slightly enlarged, follicles very prominent	Sterile	Negative	Berk. 3 2 yr.	No	4	3	Negative	Negative	....
2085	3–10	Pig	*Staphylococcus albus*	Negative	4–3 Splenic follicles slightly enlarged	Sterile	Negative	D. J. 5 1 yr.	No	11	1	Negative	Negative	Negative 4–28
2086	3–10	Fetal membranes	*Staphylococcus albus* G + rod spreader	....	4–3 Spleen rather small. Follicles slightly visible	Sterile	Negative							
2087	3–10	Fetal membranes	G − rods G + spreader rods *Staphylococcus aureus*	....	4–4 Splenic follicles visible	Sterile	Negative	P. C. 3 4 yr.	No	6	0	Negative	Negative	Negative 5–17
2091	3–11	Fetal membranes	*Staphylococcus albus*	....	4–3 No gross lesions	Sterile	Negative	D. J. 99 4 yr.	No	10	0	.05	Negative	.05 5–3
2106	3–13	Fetal membranes	Mixed staphylococci G + plump rods, moist growth	....	4–4 Splenic follicles visible	Sterile	Negative	D. J. 16 2 yr.	No	8	0	.01	....	.01 5–3
2114	3–15	Fetal membranes	G + rods *Staphylococcus citrius*	....	4–10 Spleen slightly enlarged. Follicles prominent. Some necrotic areas in liver	Sterile	Negative	Hamp. 5 1 yr.	No	8	0	Negative	Negative	Negative 4–28
2124	3–16	Fetal membranes	*B. subtilis*	....	4–10 Spleen slightly enlarged. Follicles rather prominent	*B. coli*-like colony	Negative	Berk. 19 2 yr.	No	4	3	Negative	Negative	.02 4–28
2125 (a)	3–16	Dead pig (a)	G + cocci in fine spreading growth	Negative	4–10 Spleen slightly enlarged. Follicles rather prominent	Sterile	Negative							
2125 (b)	3–16	Dead pig (b)	Fine spreading growth	Negative	4–10 Spleen slightly enlarged. Follicles rather prominent	Sterile	Negative							
2143	3–20	Fetal membranes	Sterile	....	4–18 No gross lesions	G + plump rod	Negative	D. J. 2	No	12	1	....	....	.05 5–3

TABLE 2.—EXAMINATION OF FETAL MEMBRANES AND DEAD PIGS FROM SOWS IN ABORTION INFECTED HERD—*Continued*

No.	Date 1922	Material	Results of examination					Source of material						
			Direct culture	Aggl. fetus blood	Guinea-pig inoculations			Sow No. and age	History			Agglutination of sow		
					Autopsy	Cultures (spleen)	Aggl. blood		Previous abortion	Live pigs	Dead pigs	Blood	Milk	Recheck blood
2152	3–22	Dead pig	*B. coli*	Negative	Died 3–30 Spleen slightly enlarged	Sterile	Negative	Hamp. 10 1 yr.	No	10	1	Negative	Negative	Negative 4–28
2153	3–22	Fetal membranes	*B. coli* *Staphylococcus citrius*	....	4–3 Spleen large, follicles prominent	Sterile	Negative							
2163	3–25	Dead pig	Long rod-like *B. mesentericus* G − rod; fine, delicate growth	Negative	4–18 No gross lesions	Sterile (liver)	Negative	Berk. 10 6 yr.	No	7	1	.05	Negative	.02 4–28
2164	3–25	Fetal membranes	*B. coli* *B. subtilis* G + tetrads or sarcina, in bluish growth. Fine micrococcus	....	4–18 No gross lesions	G + diplococcus G − coli-like bacilli	Negative							
2174	3–29	Pig and fetal membranes	G + spreader, fine	Negative	4–26 Spleen follicles enlarged	Sterile	.02	D. J. 66	No	0	8	.05	Negative	Negative 5–17
2175 (a)	3–29	Dead pig (a)	Sterile	Negative	Composite of 2175 injected into 2 guinea pigs 4–26 No gross lesions	Sterile	Negative							
2175 (b)	3–29	Dead pig (b)	Sterile	Negative										
2175 (c)	3–29	Dead pig (c)	Sterile	Negative										
2175 (d)	3–29	Dead pig (d)	Sterile	Negative										
2175 (e)	3–29	Dead pig (e)	Sterile	Negative										
2175 (f)	3–29	Dead pig (f)	Sterile	Negative										

TABLE 2.—EXAMINATION OF FETAL MEMBRANES AND DEAD PIGS FROM SOWS IN ABORTION-INFECTED HERD—*Concluded*

No.	Date 1922	Material	Results of examination					Source of material						
			Direct culture	Aggl. fetus blood	Guinea-pig inoculations			Sow No. and age	History			Agglutination of sow		
					Autopsy	Cultures (spleen)	Aggl. blood		Previous abortion	Live pigs	Dead pigs	Blood	Milk	Recheck blood
2193	4–2	Fetal membranes	*B. coli* *Staphylococcus albus*	....	None made	.....	....	P. C. 30 2 yr.	No	12	3	Negative	Negative	.02 5–17
2195	4–3	Fetal membranes	G + coccus	....	None made	.....	....	C. W. 17 4 yr.	No	8	2	.02	....	....
2196 (a)	4–4	Small pig born alive (a)	Staphylococcus	Negative	4–26 No gross lesions	Sterile	Negative							
2196 (b)	4–4	Large pig injured by sow (b)	Sterile	Negative	4–26 No gross lesions	Sterile	Negative							
2230	4–5	Fetal membranes	*Staphylococcus albus.* G + rod	....	4–26 No gross lesions	Sterile	Negative	P. C. Meharry 5 yr.	No	4	8	Negative	Negative	Negative 5–17
2231 (a)	4–5	Small pig (a)	*Staphylococcus albus.* G + rod G − bacilli bipolar	Negative	4–26 No gross lesions	*Staphylococcus albus*	Negative							
2231 (b)	4–5	Large pig (b)	Sterile	Negative	4–26 No gross lesions	Sterile	Negative							
2259	4–7	Fetal membranes	G + diplococci in fine bluish growth	....	5–8 No gross lesions	Sterile	Negative	D. J. 96 1 yr.	No	7	1	.02	None	Negative 5–17
2260	4–7	Dead pig	G + diplococci in fine bluish growth	Negative	5–8 No gross lesions	Sterile	Negative							
2356	4–20	Fetal membranes	Sterile	....	5–18 No gross lesions	Sterile	....	D. J. 76 4 yr.	No	5	9[1]			Negative 5–30
2357 (a)	4–20	Dead pig (a)	Sterile	Negative	5–18 No gross lesions	Sterile	Negative							
2357 (b)	4–20	Dead pig (b)	Sterile	Negative	5–18 No gross lesions	.....	....							

[1]Mashed.

TABLE 2A.—EXAMINATION OF FETAL MEMBRANES AND DEAD PIGS FROM NORMALLY FARROWING SOWS IN AN ABORTION-INFECTED HERD

(Part of data summarized from Table 2)

Sows without history of abortion	22
Live pigs farrowed	169
(Average 7.6 per litter)	
Dead pigs farrowed	50
Bacteriologic examination	
Fetal membranes examined	21
Fetal membranes too badly contaminated to examine	1
Fetal membranes sterile	2
Organisms isolated from fetal membranes:	
Brucella Traum	0
Staphylococcus	11
Saprophytes	1
Gram-positive diploids	2
Coccus	1
Gram-positive tetrads	2
Gram-positive rods	7
Gram-negative rods	2
B. subtilis	2
B. coli	3
Micrococcus	1
Gram-positive coccus	2
Gram-positive diplococcus	1
Dead pigs examined	31
Pigs sterile on culturing	12
Pigs badly contaminated	0
Organisms isolated from dead pigs:	
Gram-positive spreader	2
Staphylococcus	6
Saprophytes	2
Gram-positive rods	6
Molds	1
Gram-negative rods	2
Coccus	1
Gram-positive bacilli	1
Gram-positive coccus	1
Spreader	1
B. coli	1
B. mesentericus	1
Gram-negative bacilli bipolar	1
Gram-positive diplococcus	1
Inoculation of guinea pigs	
Injected with emulsions of fetal membranes	19
Died following injection	1
Showing no gross lesions of abortion	17
Fetal membranes not examined bacteriologically or by animal inoculation	3
Spleens sterile on culture	12
Organisms isolated:	
Gram-negative rod	1
Gram-positive rod	2
B. coli	2
Staphylococcus	1
Gram-positive diplococcus	1
Gram-negative coli-like bacilli	1
Injected with composite of blood and stomach contents of fetuses	26
Died following injection	3
Showing no gross lesions of abortion	24
Spleens sterile on culturing	22
Organisms isolated:	
Staphylococcus	1
B. coli	2
Serologic examination	
Sows negative to agglutination test with Brucella Traum antigen	11
Sows positive to agglutination test with Brucella Traum antigen	9
Sows giving complete agglutination in .02 or less dilution of Brucella Traum antigen	4
Fetuses positive to agglutination test of heart blood	0
Fetuses negative to agglutination test of heart blood	31
Guinea pigs injected with—	
Emulsion of fetal membranes, negative to agglutination test	15
Fetal blood and stomach contents, positive to agglutination test	1
Fetal blood and stomach contents, negative to agglutination test	23

infected sows.* The artificially infected sows of this group were exposed by subcutaneous injection as well as by feeding. The presence of the infection following exposure was determined by the agglutination test.

The direct cultures from these fourteen mammary glands failed to yield Brucella Traum. Guinea pigs injected subcutaneously with a saline emulsion of the udder tissue were killed 20 to 25 days later and examined at autopsy. Blood samples of the inoculated guinea pigs were subjected to the agglutination test, and the organs of the guinea pigs were examined for gross lesions of abortion. Cultures

*At autopsy the mammary gland was removed *en masse*, with the abdominal fat and skin intact, and taken to the laboratory. The fat of the abdominal wall was removed with sterile instruments in order to expose the gland. After searing the gland surface thus exposed, two separate portions of the gland were seeded on the surface of agar slants with sterile instruments. The cultures were sealed and incubated at 37° C. for seven days. Many small separate pieces of each gland were ground in a sterile mortar and injected into guinea pigs. Two guinea pigs were injected with each mammary gland sample (Table 3).

were also made from the liver and spleen of these animals. With two possible exceptions, lesions of abortion infection were not detected macroscopically in the inoculated guinea pigs. Udder specimens 642 and 671 produced suspicious lesion in the spleen of guinea pigs, yet direct cultures failed to reveal the presence of Brucella Traum. The agglutination test of the blood of guinea pigs injected with emulsions of udder tissues 588, 644, and 671 gave positive evidence of abortion agglutinins. Sow 2035 had been injected subcutaneously with Brucella Traum 156 days previous to the time the udder was examined. Sows 2475 and 2729 had been exposed 165 and 210 days previous, respectively. Since Brucella Traum was not isolated in direct cultures from

TABLE 2B.—EXAMINATION OF FETAL MEMBRANE AND DEAD PIG FROM THE ONE PREVIOUSLY ABORTING SOW (C.W.14) IN ABORTION-INFECTED HERD
(Part of data summarized from Table 2)

Animals involved	
1 sow with previous history of abortion, farrowing 6 live pigs and 1 dead pig	
Bacteriologic examination	
Organisms isolated from fetal membrane, which was neither sterile nor badly contaminated:	
Brucella Traum	0
Staphylococcus	1
Micrococcus	1
Organisms isolated from fetus, which was neither sterile on culture nor badly contaminated:	
Brucella Traum	0
Unidentified saprophytes from heart blood	1
Staphylococcus	1
Inoculation of guinea pig	
Injected with emulsion of fetal membrane	1
Inoculation of guinea pig (concluded)	
Died following injection	0
Showing no gross lesions of abortion	0
Spleen sterile on culturing	1
Injected with composite of blood and stomach contents of fetus	1
Died following injection	0
Showing no gross lesions of abortion	1
Spleen sterile on culturing	1
Serologic examination	
Sow was positive to agglutination test with Brucella Traum antigen in .05 dilution.	
Fetus was negative to agglutination test of heart blood.	
Guinea pig injected with emulsion of fetal membrane was negative to agglutination test.	
Guinea pig injected with fetal blood and stomach contents was negative to agglutination test.	

the udder tissue or by guinea-pig inoculation, the evidence regarding the inactive udder as a reservoir for Brucella Traum was limited to positive serologic tests in guinea pigs following the injection of mammary tissue.

Examination of Testes. A study of the carrier feature of the male reproductive organs of pigs that had been exposed to Brucella Traum gave more definite results. For this experiment 118 pigs were divided into five groups of 19, 21, 30, 38, and 10 respectively. Group 1 was fed with Brucella Traum, and Groups 2, 3, 4, and 5 were injected intravenously. At intervals of 14, 21, 38, and 45 days some of the pigs in each group were castrated and the testes were placed in sterile petri dishes and delivered to the laboratory for examination. The tunica vaginalis propria was removed after having been seared with a hot spatula, and small bits of the testicular tissue were seeded on plain agar, while a saline suspension of the same tissue from each pig was macerated in a sterile mortar and injected into guinea pigs.

Fourteen days following exposure, 20 pairs of testicles from the different groups were cultured and injected separately into guinea

TABLE 3.—EXAMINATION OF NONFUNCTIONING MAMMARY GLANDS OF SOWS

Udder identification			Results of examination					Source of material					
				Guinea-pig inoculations				Sow identification				Exposure	
No.	Date	Pigs in uterus	Direct culture	No.	Autopsy	Cultures	Agglutination	No.	Mark	Weight	Age	Date 1922	Method
										lbs.	*yrs.*		
588	11–20–22	No	Sterile	1825 1633	12–14–22 No gross lesions	Sterile	.01	2035	L	266	2	6–16	Live culture subcutaneous
778	1– 1–23	No	Sterile	1139 591	1–24–23 No gross lesions	Sterile	Negative	2079	L	220	2	6–16	By association
642	11–27–22	Yes	Sterile	1223 1636	12–18–22 Suspicious lesions No gross lesions	Sterile	Negative	2134	R L	330	2	4–15	Fed live culture
669	12– 5–22	Yes	Sterile	1017 1013	12–24–22 No gross lesions	Sterile	Negative	2136	R L	300	2	3–17	By association
904	1–18–23	No	Sterile	1889 1495	2–6–23 No gross lesions	Sterile	Negative	2265	L R	215	2	4–18	By association
777	1– 1–23	No	Sterile	1963 1679	1–18–23 No gross lesions	Sterile	Negative	2318	R	220	2	4–15	Live culture intravenous
643	11–27–22	No	Sterile	....	12–18–22 No gross lesions	Sterile	Negative	2319	R	320	2	4–15	Fed live culture
644	11–27–22	No	Sterile	....	12–18–22 No gross lesions	Sterile	.01	2475	L	340	2	6–14	By association
587	11–20–22	No	Sterile	1801 1632	12–14–22 No gross lesions	Sterile	Negative	2080	L R	309	2	3–13	Fed aborted fetuses
903	1–18–23	No	Sterile	1520 1050	2–8–23 No gross lesions	Sterile	Negative	2135	L	210	2	3–15	Live culture intravenous
902	1–18–23	No	Sterile	1506 1036	2–6–23 No gross lesions	Sterile	Negative	3205	OPC	380	2	3–12	Sporadic abortion
700	12–12–22	No	Sterile	1453 1753	1–17–23 No gross lesions	Sterile	Negative	3207	Spot	460	2	3–12	Sporadic abortion
670	12– 5–22	No	Sterile	1962	Died 12–6–22 Sepsis	.....	.....	2063	53	300	1	6–27	By copulation
671	12– 5–22	No	Sterile	1918 1227 1732	Died 12–7–22 Sepsis 12–24–22 No gross lesions Suspicious lesions	Sterile Sterile	Negative .002	2729	98	230	1	7–28 5–8	By association

TABLE 4.—EXAMINATION OF LYMPH GLANDS AND SPLEEN OF PIGS FOR BRUCELLA TRAUM

Pig No.	Weight	Infection	Autopsied	Body lymph glands	Visceral lymph glands	Spleen
	lbs.		*days*			
3676	60	Fed Brucella Traum	30	Brucella Traum	Brucella Traum	Brucella Traum
3526	26	Fed Brucella Traum	80	Negative	Brucella Traum	Negative
3521	15	Fed Brucella Traum	80	Brucella Traum	Negative	Negative
3515	25	Fed Brucella Traum	80	Negative	Brucella Traum	Negative
13	..	Natural infection	..	Negative	Brucella Traum	Negative
3512	27	Fed Brucella Traum	80	Negative	Brucella Traum	Negative
3507	23	Fed Brucella Traum	80	Negative	Brucella Traum	Negative

TABLE 5.—EXAMINATION OF EPIDIDYMI OF ARTIFICIALLY INFECTED PIGS

Identification		Results of examination					Source and history				
			Guinea-pig inoculations				Pig identification			Treatment 6–1–23	Date castrated
No.	Date examined 1923	Direct culture	No.	Autopsy	Culture	Aggl.	No.	Sex	Birth		
2949	6–15	Negative	901 758	7–5 No gross lesions	Negative	Negative	P. C. 7–1	M	4–17	Fed 1 slant Brucella Traum	6–15
2950	8–1	Negative	73 839	8–22 No gross lesions	Negative	Negative	P. C. 7–3	M	4–17	(do.)	8–1
2951	7–7	Negative	848 786	7–30 No gross lesions	Negative	Negative	P. C. 7–2	M	4–17	(do.)	7–30
2952	6–21	Negative	608 74	7–16 No gross lesions	Negative	Negative	P. C. 7–5	M	4–17	(do.)	6–21
2953	6–15	Negative	417 997	7–5 No gross lesions	Negative	Negative	D. J. 65–4	M	3–21	(do.)	6–15
2955	8–1	Negative	551 961	8–22 Spleen slightly enlarged	Negative	Negative	H. 13–2	M	3–30	(do.)	8–1
2956	7–21	Negative	58 853	8–13 Spleen enlarged Liver necrotic	Negative	Negative .02	H. 13–6	M	3–30	(do.)	7–21
2957	6–26	Negative	575 794	7–26 No gross lesions	Negative	Negative	H. 13–1	M	3–30	(do.)	6–26
2958	8–1	Negative	931 675	Died 8–12 Spleen slightly enlarged	Negative	Negative	H. 13–8	M	3–30	(do.)	8–1
2960	7–7	Negative	667 844	7–30 Spleen enlarged	Negative	Negative	H. 30–5	M	3–22	(do.)	7–7
2962	6–21	Negative	653 668	7–16 No gross lesions	Negative	Negative	H. 30–6	M	3–22	(do.)	6–21
2963	7–21	Negative	54 66	8–13 Spleen slightly enlarged	Negative	Negative	H. 4+3−7	M	3–26	(do.)	7–21
2968	7–28	Negative	781 787	8–6 Spleen enlarged	Negative	Negative	D. J. 22–3	M	4–7	(do.)	7–28
2969	7–28	Negative	766 937	8–18 Spleen slightly enlarged	Brucella Traum	.01	D. J. 71–6	M	4–7	(do.)	7–28
2970	6–26	Negative	782 780	7–18 No gross lesions	G − rod	Negative	D. J. 75–7	M	4–2	(do.)	6–26

pigs. One testicle yielded Brucella Traum in cultures. Other guinea pigs injected with the different saline suspensions of testicular tissue yielded negative results. Twenty-one days following exposure, 21 pairs of testicles from the five groups were cultured and injected into guinea pigs. Brucella Traum was found in one testicle on direct culture, altho guinea pigs injected with the testicular emulsion yielded negative results. Thirty-eight days following exposure, 21 pairs of testicles from the five groups were cultured and injected into guinea

FIG. 20.—MULTIPLE ABSCESS OF TESTICLE AND EPIDIDYMUS OF BOAR CAUSED BY BRUCELLA TRAUM

Tho the animal gave a positive blood test and repeatedly failed to impregnate sows, there was no visible enlargement of either testicle. Chronically enlarged testicles in male hogs are frequently traceable to infection with the abortion organism. Such infected animals are potentially dangerous in the spread of the disease.

pigs. Direct cultures in all cases proved negative, but Brucella Traum was isolated from the spleen of four guinea pigs inoculated with testicular tissue. The positive specimens came from the infected pigs in the first four groups. Forty-five days following exposure, 43 pairs of testicles from the five groups of exposed pigs were examined for Brucella Traum. The testicles from one pig in Group 3 gave positive cultures, and the injection of a testicular tissue of one pig in Group 1 into a guinea pig yielded positive cultures from the spleen.

The agglutination test of the blood of the pigs made 30, 60, and 90 days after castration showed that some animals continued to agglutinate Brucella Traum for a period of 90 days following castration.

The results of examining testes of artificially infected pigs suggest that the testes may harbor Brucella Traum for 14 to 45 days after exposure even tho no gross lesions are manifested.

Examination of Lymph Glands and Spleen. Seven pigs weighing 15 to 60 pounds infected naturally as well as by fed cultures were killed after intervals of 30 to 80 days for examination of the lymphatic

glands and spleen for Brucella Traum. Two of the seven pigs yielded cultures from the body lymph nodes, six from the visceral lymph glands, and one from the spleen. One pig proved positive in the body visceral lymph glands as well as the spleen, while five of the pigs yielded positive cultures via guinea pigs from visceral lymph glands only. One pig proved positive in body lymph glands only (Table 4).

Examination of Epididymi. The positive findings in testes, lymph glands, and spleen of young pigs artificially infected with Brucella Traum suggested the possible localization of the organism in the accessory reproductive organs. Fifteen male pigs farrowed in March and April, 1923, were fed Brucella Traum on June 1. Fourteen to 16 days later these animals were castrated and the epididymi were cultured and injected into guinea pigs. All epididymi proved negative with the exception of 2969 (Table 5). At autopsy one of the guinea pigs (937) injected with this specimen, showed lesions of abortion in the spleen. Agglutination test of the blood serum of this pig was positive, while Brucella Traum was isolated from the spleen.

Altho no gross lesions were found in the epididymi examined, the positive serologic and bacteriologic findings suggested that the epididymi of young pigs, as well as testes, body and visceral lymph glands, and spleen, may temporarily harbor Brucella Traum.

Presence of Brucella Traum in Bulbo-Urethral Glands and Seminal Vesicles of an Actively Breeding Boar.[10*] On March 24, 1922, a grade Duroc-Jersey boar (2058) seven months old was fed one agar slant of a freshly isolated porcine strain of Brucella Traum. Two consecutive agglutination tests, with an interval of 17 days preceding the feeding of the abortion organism, indicated that the animal was probably free from abortion infection. Two weeks after the feeding, agglutinins appeared in the blood serum of the boar, and four months after feeding, agglutination was complete in a dilution of .0002.

The agglutination tests were continued weekly from the date of exposure until August 18, 1923 (Fig. 12). The titre declined to negative in September, 1922, and following mild fluctuations suggestive of occult infection, returned to negative in April, May, June, July, and August, 1923. The decline in the agglutinating titre of the blood serum of the boar indicated the probability of recovery notwithstanding the fact that certain evidence pointed to the service of this boar as a possible factor in the transmission of abortion infection to Sow 2063. The source of the infection in one sow was suggested by positive reaction to the agglutination test following breeding on neutral ground at the time the boar (2058) was reacting strongly to the agglutination test.

Other sows bred to the same boar (2058) were exposed to abortion infection thru other channels, and information could not be obtained thru the breeding records to suggest clearly the active role of the boar

in transmitting the disease at the time of breeding. In order to secure evidence which might throw light on the possible relation of the boar to the transmission of abortion infection in Sow 2063, the boar was slaughtered and the genito-urinary organs were examined pathologically and bacteriologically for the presence of Brucella Traum. No gross pathologic lesions of infectious abortion could be detected. Saline suspensions of testicular tissue, epididymi, bulbo-

FIG. 21.—LIVER OF GUINEA PIG SHOWING LESIONS OF BRUCELLA TRAUM INFECTION

Guinea pigs injected with cultures of Brucella Traum or tissues containing this organism show marked necrotic lesions in the liver, spleen, and lymph glands.

urethral glands, prostate glands, seminal vesicles, synovial joint fluid, and synovial fluid of the tendon sheaths were each injected subcutaneously into two healthy guinea pigs. The guinea pigs were placed in separate cages and were killed 21 days later. The blood serum from each guinea pig in diagnostic dilutions was mixed with abortion antigen and incubated at 37° C. After three weeks the inoculated guinea pigs were autopsied and examined for lesions of abortion. Cultures from the spleen and the liver were also made on plain agar.

The sera of guinea pigs which had received the saline tissue emulsion of bulbo-urethral glands and seminal vesicles reacted positively to the agglutination test, and the spleens of these pigs showed lesions typical of abortion. Pure cultures of Brucella Traum were isolated from the splenic tissues of these guinea pigs. The saline emulsions of testes, epididymi, prostate glands, synovial joint fluid, and synovial fluid of tendon sheaths, when injected into guinea pigs, gave negative bacteriologic, pathologic, and serologic findings. The presence of Brucella Traum in the accessory organs (bulbo-urethral glands and

seminal vesicles) of an actively breeding male suggests the part which an infected male might play in the spread of abortion infection among swine even tho reacting irregularly or negatively to the agglutination test. The boar (2058) in question gave a negative weekly reaction from September 1 to September 29, and from March 23 to May 4, and again from June 9 to August 11 (Fig. 12).

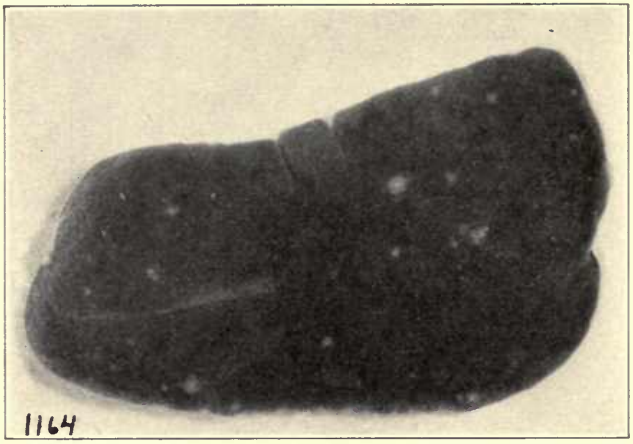

FIG. 22.—LESIONS OF BRUCELLA BANG IN SPLEEN OF GUINEA PIG

The above spleen was removed from a guinea pig six weeks after injection with 2 cc. of a suspension of Brucella Traum grown on an agar slant.

Examination of Uteri and Ovaries. Six sows were slaughtered and the ovaries and uteri examined for Brucella Traum in September, 1923. Four of these animals had been artificially infected by the subcutaneous injection of cultures of the organism; two of the four had been given a second injection of the virus approximately eleven months after the first exposure. The other two had contracted the infection thru association with infected animals.

The reproductive organs of each animal were removed at the time of slaughter and brought to the laboratory. Three of the uteri were gravid. The surface of the uterus was washed with tap water and then flamed before opening with sterile instruments. The stomach contents of the fetuses and the amniotic fluid were injected subcutaneously into guinea pigs. Saline emulsions of the uterine mucosa from the three nongravid uteri and the ovaries of four of the sows were macerated in sterile saline solution and injected into guinea pigs. The uterine mucosa of sows Duroc-Jersey 7, Hampshire 3, and Hampshire 13, upon injection into guinea pigs, gave positive serologic or bacteriologic evidence of Brucella Traum, while the ovarian tissues of sows Hampshire 13, Duroc-Jersey 66, and Hampshire 3 also proved

positive. The location of the abortion virus in the nongravid uterine mucosa and the ovaries of a pregnant sow may be regarded as somewhat at variance with the location of the virus of abortion disease in cattle (Table 6). These findings confirm the observations of Weeter[32*] on the presence of the organism in the nongravid uterus.

In November of the same year four artificially infected sows of another group were slaughtered, and their ovaries and uteri were examined for Brucella Traum. Three of these sows had been infected at least twenty months prior to the examination, two by the subcutaneous injection of cultures and one by intravaginal injection. One sow had been infected by association, as judged by the serum agglutination test. The same technic of examining the uterine mucosa and ovaries by animal inoculation as in the first group was carried out. The mucosa of gravid and nongravid uteri of sows Duroc-Jersey 73 and Duroc-Jersey 22, respectively, were found to harbor Brucella Traum (Table 7).

Five artificially infected sows, 9907, 9908, 9909, 9910, and 9911, were slaughtered in December, 1923, and the uteri and ovaries were examined for Brucella Traum. One sow had been fed virulent porcine abortion cultures nineteen months prior to the time of slaughter and on two other occasions had been given an intravenous injection of the same cultures. Two sows that contracted the disease naturally also received an intrauterine injection of Brucella Traum.

Of the remaining sows one had been infected by an intravenous injection and the other by a subcutaneous injection. Later both were injected with cultures into the uterus just before breeding. The uterine mucosa and ovarian tissue of these sows proved negative to Brucella Traum (Table 8).

Monthly Agglutination Tests of Vaccinated and Unvaccinated Pigs

In an experiment designed to test the carrier feature of Brucella Traum in young pigs, monthly agglutination tests were made on one group of pigs of which eleven were vaccinated and eleven remained unvaccinated. The abortion vaccine was given subcutaneously. The vaccinated pigs showed a positive agglutinating titre about one month following treatment. A similar reaction was observed in the unvaccinated group two to four months later. The character of the reactions in the two groups were comparable, but the vaccinated pigs reacted to the agglutination test more promptly. They showed an average maximum of agglutination reaction six months after treatment, with a secondary elevation of the agglutination curve two months following the initial rise. Three months previous to farrowing, the agglutination reaction was negative in the vaccinated pigs (Fig. 23). Unvaccinated pigs allowed to associate with the vaccinated pigs apparently contracted the disease. Each gave a positive agglutination reaction three

TABLE 6.—EXAMINATION OF UTERI AND OVARIES OF INFECTED SOWS

Case No. and Sow No.	Artificial infection		Organs examined	Guinea-pig inoculations 9–10–23					
	Date	Brucella Traum		No.	Saline suspension injected subcutaneously	Date of autopsy 1923	Results of inoculations		
							Gross lesions	Agglutination guinea-pig sera	Bacteriologic examination
113 (H. 3)	6–30–22 5–25–23[1]	1 cc. agar culture 2955 subcutaneous. 1 agar slant 2012 in uterus 5 minutes before service	Nongravid uterus	251 71	Uterine mucosa	10–1 10–1	Spleen enlarged None	.05 .02	Brucella Traum Not cultured
118 (H. 13)	6–30–22 5–25–23[2]	1 cc. agar culture 2955 subcutaneous. 1 agar slant 2012 in uterus 5 minutes before service	Nongravid uterus	6 257	Uterine exudate	10–1 10–1	Spleen swollen, necrotic spots on liver Spleen swollen, necrotic spots on liver	.002 .002	Brucella Traum Brucella Traum
117 (P. C. 4)	5–24–23	1 cc. agar culture 2012 subcutaneous	Gravid uterus	871 269	Stomach contents of 4 fetuses	10–1 10–1	None None	Negative Negative	Not cultured Not cultured
116 (D. J. 9)	Not known	Infected by association[3]	Gravid uterus	862 741	Amniotic fluid and stomach contents of fetuses	10–1 10–1	None None	Negative Negative	No growth No growth
114 (D. J. 66)	Not known	Infected by association[3]	Gravid uterus	256 4	Amniotic fluid and stomach contents of fetuses	10–1 10–1	None None	Negative Negative	No growth Not cultured
112 (D. J. 7)	5–24–23	1 cc. agar culture 2012 subcutaneous	Nongravid uterus	548 270	Uterine mucosa	10–1 10–1	None Spleen slightly enlarged	.05 .002	Not cultured Brucella Traum
123 (D. J. 66)	Not known	Infected by association[3]	Ovaries	543 874	Macerated ovaries	10–1 10–1	Few necrotic foci on liver Spleen enlarged, necrotic foci, liver and spleen	.002 .002	Brucella Traum Brucella Traum

TABLE 6.—*Concluded*

Case No. and Sow No.	Artificial infection		Organs examined	Guinea-pig inoculations 9–10–23					
	Date	Brucella Traum		No.	Saline suspension injected subcutaneously	Date of autopsy 1923	Results of inoculations		
							Gross lesions	Agglutination guinea-pig sera	Bacteriologic examination
122 (H. 3)	6–30–22 5–25–23[1]	1 cc. agar culture 2955 subcutaneous. 1 agar slant 2012 in uterus 5 minutes before service	Ovaries	76 5	Macerated ovaries	10–1 10–1	None None	Negative Negative	Brucella Traum Brucella Traum
115 (D. J. 66)	Not known	Infected by association[3]	Fetuses	21 265	Stomach contents of 1 dead, 2 live pigs	Died 9–12 Died 9–12	.....	.....	.....
121 (D. J. 7)	5–24–23	1 cc. agar culture 2012 subcutaneous	Ovaries	258 17	Macerated ovaries	10–1 10–1	None None	.05 Negative	Not cultured Not cultured
120 (H. 13)	6–30–22 5–25–23[2]	1 cc. agar culture 2955 subcutaneous. 1 agar slant 2012 in uterus 5 minutes before service	Ovaries	539 853	Macerated ovaries[4]	10–1 10–1	Spleen swollen, necrotic foci on liver Spleen swollen, necrotic foci on liver	.002 .05	Brucella Traum Brucella Traum

[1]Sow H. 3 rebred 6–11–23. [2]Sow H. 13 rebred 6–18, 7–18, and 8–3–23 [3]Natural infection as indicated by serum agglutination test. [4]Cystic ovaries.

TABLE 7.—EXAMINATION OF UTERI AND OVARIES OF INFECTED SOWS

Case No. and Sow No.	Artificial infection		Organs examined	Guinea-pig inoculations 11–21–23						
	Date	Brucella Traum		No.	Saline suspension injected subcutaneously	Date of autopsy 1923	Results			
							Gross lesions	Agglutination guinea-pig sera	Bacteriologic examination	Agglutination of culture
5961 (D. J. 74)	3–24–22 9–29–22 8–28–23	Live culture 2103 subcutaneous. 1 live culture 2012 intravenous, 1 culture 3312 injected in sheath of boar 5 minutes before service	Nongravid uterus	635	Uterine mucosa	Died 11–23–22	Pneumonia. Spleen and liver normal	Negative	Coccus	.....
			Slightly catarrhal	527		12–12	None	Negative	No growth	.....
5962 (D. J. 3)	5–24–22 8–28–23	1 cc. 2012 subcutaneous, 1 culture 3312 injected in sheath of boar 5 minutes before service	Nongravid uterus	115	Uterine mucosa	Died 11–24	None	Negative	*B. coli*	.....
				41		Died 12–7	Spleen swollen. Necrotic spots on liver	No blood	.....	.....
5963 (D. J. 22)	5–25–23	Infected by association. 1 agar slant 2012 injected in uterus 5 minutes before service	Nongravid uterus	534	Uterine mucosa	12–12	None	.005	Brucella Traum	.002
				368		12–12	None	.005	Brucella Traum	.002
5964 (D. J. 73)	6–15–22 8–25–23	5 cc. agar slant 3036 in vagina, 1 culture 3312 injected in sheath of boar 5 minutes before service	Gravid uterus	515	Uterine mucosa	12–12	None	Negative	Brucella Traum	.002
				769		12–12	None	Negative	No growth	.....
5965 (D. J. 74)	3–24–22 9–29–22 8–28–23	Live culture 2103 subcutaneous. 1 live culture 2013 intravenous. 1 culture 3312 injected in sheath of boar 5 minutes before service	Ovaries	302	Macerated ovaries	12–12	Spleen enlarged	Negative	.....	.....
				47		12–12	None	Negative	No growth	.....
5966 (D. J. 3)	5–24–22 8–28–23	1 cc. 2012 subcutaneous. 1 culture 3312 injected in sheath of boar 5 minutes before service	Ovaries	311	Macerated ovaries	12–12	None	Negative	No growth	.....
				494		12–12	None	Negative	No growth	.....
5967 (D. J. 22)	5–25–23	Infected by association. 1 agar slant 2012 injected in uterus 5 minutes before service	Ovaries	133	Macerated ovaries	Died 12–3	None	No blood	No growth	.....
				550		12–12	None	Negative	.....	.....
5968 (D. J. 73)	6–15–22 8–25–23	5 cc. agar slant 3036 in vagina, 1 culture 3312 injected in sheath of boar 5 minutes before service	Ovaries	198	Macerated ovaries	Discarded 12–10	None	No blood	.....	.....
				16		12–12	None	Negative	G+ short rod	.....

TABLE 8.—EXAMINATION OF UTERI AND OVARIES OF INFECTED SOWS

Case No. and Sow No.	Artificial infection		Organs examined	Guinea-pig inoculations 12-14-23						
	Date	Brucella Traum		No.	Saline suspension injected subcutaneously	Date of autopsy 1924	Results			
							Gross lesions	Agglutination of guinea-pig sera	Bacteriologic examination	Agglutination of culture
9907 (71)	3-24-22 9-29-22 5-25-23	Fed live culture 2103. 1 culture 2012 intravenous. 1 agar slant 2012 in uterus 5 minutes before service	Gravid uterus	133 501	Uterine mucosa	1-4 1-4	Spleen enlarged None	Negative Negative	No growth No growth	Negative Negative
9908 (75)	3-24-22 9-28-22 5-25-23	Live culture 2103 intravenous. Live culture 2012 intravenous. 1 agar slant 2012 in uterus 5 minutes before service	Nongravid uterus	801 964	Uterine mucosa	1-4 Died 12-25-23	None	Negative	No growth	Negative .....
9909 (P. C. 7)	5-24-22 5-25-23	1 cc. 2012 subcutaneous. 1 agar slant 2012 in uterus 5 minutes before service	Nongravid uterus	112 512	Uterine mucosa	1-4 1-4	Follicles prominent in spleen None	Negative Negative	No growth No growth	Negative Negative
9910 (D. J. 65)	5-26-23	Infected by association. 1 agar slant 2012 in uterus 5 minutes before service	Nongravid uterus	825 823	Uterine mucosa	1-4 1-4	Spleen hemorrhagic None	Negative Negative	No growth No growth	Negative Negative
9911 (H. 4 +3)	5-26-23	Infected by association. 1 agar slant 2012 in uterus 5 minutes before service	Nongravid uterus	806 136	Uterine mucosa	1-4 1-4	None None	Negative Broken	No growth No growth	Negative Negative
9912 (71)	3-24-22 9-29-22 5-25-23	Fed live culture 2103. 1 culture 2012 intravenous. 1 agar slant 2012 in uterus 5 minutes before service	Ovaries	821 850	Macerated ovaries	Died 12-31-23 1-4	..... None	..... Negative	..... No growth	..... Negative
9913 (75)	3-24-22 9-28-22 5-25-23	Live culture 2103 intravenous. Live culture 2012 intravenous. 1 agar slant 2012 in uterus 5 minutes before service	Ovaries	835 814	Macerated ovaries	1-4 1-4	None None	Negative Negative	No growth No growth	Negative Negative
9914 (P. C. 7)	5-24-22 5-25-23	1 cc. 2012 subcutaneous. 1 agar slant 2012 in uterus 5 minutes before service	Ovaries	807 819	Macerated ovaries	1-4 1-4	None Liver enlarged and discolored	Negative Negative	No growth No growth	Negative Negative
9915 (D. J. 65)	5-26-23	Infected by association. 1 agar slant 2012 in uterus 5 minutes before service	Ovaries	802 849	Macerated ovaries	1-4 1-4	None None	Negative Negative	No growth No growth	Negative Negative
9916 (H. 4+3)	5-26-23	Infected by association. 1 agar slant 2012 in uterus 5 minutes before service	Ovaries	123 975	Macerated ovaries	Died 12-30-23 1-4	.....	.....	.....	.....

months following exposure, but the dilution was relatively low. The agglutination curve was similar to that displayed by vaccinated pigs. The development of agglutinins was prompt in vaccinated pigs, while unvaccinated exposed pigs showed similar reactions 90 days following

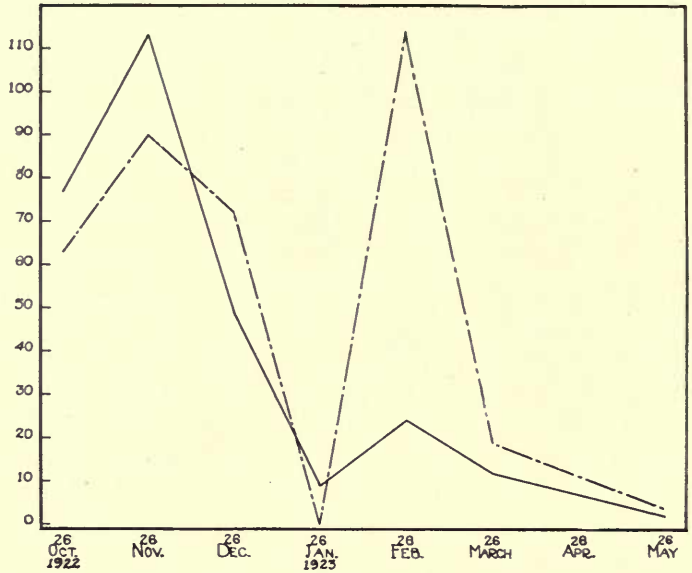

FIG. 23.—AGGLUTINATION REACTIONS (MONTHLY) OF ELEVEN VACCINATED AND ELEVEN UNVACCINATED PIGS, OCTOBER 26, 1922, TO MAY 26, 1923

Pigs PC-4, DJ-34, PC-7, DJ-6, DJ-32, DJ-7, DJ-11, DJ-3, PC-23, PC-11, and DJ-4 were infected subcutaneously with Brucella Traum at the time of weaning, May 24, 1922. Pigs DJ-66, DJ-65, DJ-63, DJ-92, PC-41, PC-66, DJ-22, DJ-15, DJ-95, PC-32, and DJ-9 were associated with infected pigs. The vaccinated and unvaccinated pigs were kept in the same lot. Reaction of the vaccinated pigs is shown by the continuous line; of the unvaccinated pigs, by the broken line.

Average Agglutinations

1922	*Vaccinated*	*Unvaccinated*	*1923*	*Vaccinated*	*Unvaccinated*
Oct. 26	1–77	1–63	Feb. 26	1–24	1–114
Nov. 26	1–113	1–90	March 26	1–12	1–19
Dec. 26	1–49	1–77	April 26	.....	.....
1923			May 26	1–1.8	1–4
Jan. 26	1–9	Neg.			

contact with the vaccinated group. As in other instances, the titre in young pigs following exposure was not high, and it gradually receded and often disappeared. In the unvaccinated pigs 9.9 percent aborted, while of the vaccinated group showing the early agglutination reaction all farrowed normally (Fig. 23).

Brucella Traum in Vaccinated Pigs. In an effort to determine the relation of a vaccine prepared from Brucella Traum following

subcutaneous injection of gilts, to the carrier feature of the disease, three groups of young pigs following weaning in the infected herd were placed at the disposal of the Animal Pathology division each year from 1921 to 1924. The vaccine consisted of a porcine culture isolated from an aborted pig fetus, grown in nutrient agar and suspended in sterile saline. For three consecutive years approximately one-half of the female pigs (Duroc-Jersey, Poland China, and Hampshire) at two to three months of age were treated with abortion vaccine. Untreated female pigs selected from the same litters as the vaccinated pigs were kept in the same lots under similar conditions. In November and December the gilts were bred to boars of their respective breeds. At the time the gilts farrowed in March and April the fetal membranes and aborted pigs were examined for Brucella Traum, while the blood and milk of the vaccinated gilts at farrowing time were subjected to the agglutination test.[11*] A recheck of the blood of the gilts by the agglutination test was made one to two months after farrowing. The technic used in examining these specimens was the same as that used in the examination of fetuses and fetal membranes from normally farrowing sows described on page 199.

Examination of Fetal Membranes of Vaccinated and Unvaccinated Gilts, 1921-22. In 1921, ten female pigs were injected with Brucella Traum live vaccine at weaning time. Eleven unvaccinated female pigs were placed with the vaccinated pigs. In November and December the gilts were bred and at the time of farrowing, March and April, 1922, fetal membranes and aborted fetuses were examined for Brucella Traum. None of the vaccinated gilts aborted. Two of the 88 pigs in ten litters, or 2.27 per cent, were born dead. Nine fetal membranes from the vaccinated group (1921-22) upon direct culture proved negative. The negative bacteriologic findings in direct cultures were confirmed by guinea-pig inoculation, while the presence of agglutinins in the blood of the inoculated guinea pigs could not be demonstrated three weeks later at the time of autopsy. Blood samples obtained from three gilts at the time of farrowing or within two months after farrowing showed a low titre for Brucella Traum. Bacteriologic evidence that the vaccinated gilts became carriers was not demonstrated in a single vaccinated animal. The vaccine apparently exerted no ill effect upon the prolificacy of the gilts, as an average of 8.6 live pigs per litter were farrowed (Tables 9 and 9A).

In the unvaccinated control group three of the eleven gilts aborted. A total of six fetal membranes were examined by direct culture and animal inoculations for Brucella Traum, with negative results. One fetal membrane was too badly contaminated to be examined. Ten fetuses were examined, five of which were obtained from one of the three aborting gilts, and from each of these five fetuses Brucella Traum was isolated by direct culture of the internal organs. In the

TABLE 9.—GILTS VACCINATED AT WEANING TIME, EXAMINED AT FARROWING
(Vaccinated in July, 1921. Bred in November and December, 1921. Farrowed in March and April, 1922)

No.	Date 1922	Material	Results of examination					Source of material						
			Direct culture	Aggl. fetus blood	Guinea-pig inoculations			Gilts	History			Agglutination of sow		
					Autopsy 1922	Cultures (spleen)	Aggl. blood		Vaccine 1921	Live pigs	Dead pigs	Blood	Milk	Recheck blood 1922
2036	3–4	Fetal membranes	Staphylococci in fine colonies. No growth in dextrose, lactose, or saccrose. Diploid forms	....	3–29 Spleen slightly enlarged. Follicles quite prominent	Sterile	Negative	D. J. 33	July	6	0	Negative	None	....
2067	3–8	Fetal membranes	Badly contaminated	....	3–30 Follicles of spleen very prominent	Sterile	Negative	P. C. 6	July	7	0	Negative	Negative	Negative 4–7
2144	3–20	Fetal membranes	*B. coli* communior *Staphylococcus albus*	....	4–18 No gross lesions	Sterile	Negative	D. J. 5	July	11	0	Negative	Negative	+.05 6–13
2150	3–22	Fetal membranes	All tubes sterile	....	4–18 Spleen twice normal size, congested; liver with numerous pinpoint necrotic areas. Abdominal lymphatics enlarged	Sterile	Negative	O. P. C.	July	5	0	Negative	Negative	Negative 5–13
2256	4–7	Fetal membranes	G − rods rather long G + large rods	....	5–8 No gross lesions	Sterile	Negative	O. D. J.	July	6	0	Negative	None	+.02 5–17
2257	4–7	Fetal membranes	Sterile	....	5–8 No gross lesions	Sterile	Negative	D. J. 40	July	6	1	Negative	None	Negative 5–17
2258	4–7	Dead pig	G + sporulating rods and other saprophytes. Stomach sterile	Negative	5–8	Sterile	Negative							
2278	4–10	Mummified fetus	Sterile	....	5–8 No gross lesions	Sterile	Negative	D. J. 1	July	10	0	+.05	None	Negative 5–17
2283	4–12	Fetal membranes	Too badly contaminated for culture	....	Died 4–14 Peritonitis	.....	....	D. J. 33	July	12	0	+.05	None	Negative 5–7
2317	4–14	Fetal membranes	Too badly contaminated for culture	....	5–8 No gross lesions	Sterile	Negative	D. J. 19	July	12	1	Negative	....	+.05 5–7
2321	4–15	Fetal membranes	Sterile	....	5–8 No gross lesions	Sterile	Negative	D. J. 99	July	11	0	+.05	Negative	Negative 5–17

TABLE 10.—GILTS NOT VACCINATED AT WEANING TIME EXAMINED AT FARROWING
(Bred in November and December, 1921. Farrowed in March and April, 1922)

No.	Date 1922	Material	Results of examination					Source of material						
			Direct culture	Aggl. fetus blood	Guinea-pig inoculations			Gilts	History			Agglutination of sow		
					Autopsy 1922	Cultures (spleen)	Aggl. blood		Vaccine	Live pigs	Dead pigs	Blood	Milk	Recheck blood 1922
2115	3–15	Fetal membranes	G + rods Streptococci Diploid forms	....	4–10 Spleen slightly enlarged. Spleen follicles rather prominent	1 colony *Staphylococcus albus*	Negative	P. C. 30[1]	No	7	2	.02	Negative	+.02 4–28
2116	3–15	Pig (a)	Heart—1 tube, sterile 1 tube, saprophytes and staphylococcus. Stomach—*Staphylococcus albus*	Negative	Died 3–20	*Coli communis* in heart	.....							
2116	3–15	Pig (b)	Heart—1, tube, sterile 1 tube, staphylococci. Stomach—*Staphylococcus aureus*. G + rod; acid and gas in dextrose and lactose	Negative	4–10 Spleen slightly enlarged. Spleen follicles rather prominent	Sterile	Negative							
2081 A	3–13	None submitted	.....	....	.....	.....	.....	P. C. 13	No	0	Ab. 3–12–22	.002	None	Negative 4–7 +.05 6–13
2081 B	....	None submitted	.....	....	.....	.....	.....	P. C. 33	No	0	Ab. 2–12–22	....	....	+.005 6–13
2081 C	3–13	None submitted	.....	....	.....	.....	.....	P. C. 63	No	7	0	.002	.005	....
2090	3–11	Fetal membranes	3 tubes, spreader. 1 tube, *Staphylococcus albus* and cocci	....	4–3 Spleen slightly enlarged. Follicles very prominent	Sterile	Negative	P. C. Best	No	8	0	.05	Negative	Negative 4–28
2102	3–13	Aborted pig	Brucella Traum	Negative	4–3 Subcutaneous ulcer at point of injection Spleen 3 times normal size. Liver full of white spots	Sterile	+.0005	P. C. 33	No	0	Ab.	.005	Negative	Negative 5–3 +.005 6–13
2103	3–13	Aborted pig												
2104	3–13	Aborted pig												
2105	3–13	Aborted pig												
2105 A	3–13	Aborted pig												

[1]Changed to P. C. 31.

TABLE 10.—GILTS NOT VACCINATED AT WEANING TIME EXAMINED AT FARROWING—*Concluded*

No.	Date 1922	Material	Results of examination					Source of material							
			Direct culture	Aggl. fetus blood	Guinea-pig inoculations			Gilts	History			Agglutination of sow			
					Autopsy 1922	Cultures (spleen)	Aggl. blood		Vaccine	Live pigs	Dead pigs	Blood	Milk	Recheck blood 1922
2107	3–13	Fetal membranes	Sterile	....	4–4 Spleen normal size Follicles very visible	Sterile	Negative	H. 2	No	6	2	Negative	Negative	+.05 6–13
2108 (a)	3–13	Dead pig	Heart—mixed cultures of large coccus and G + short rod. Stomach—sterile	Negative	4–4 Spleen normal size Follicles visible Pericarditis	Sterile	Negative							
2108 (b)	3–13	Dead pig	G + short, plump bacilli. Stomach—mixed cultures of *Staphylococcus albus, aureus,* and rods	Negative	4–4 Spleen normal size Follicles visible	Sterile	Negative							
2167	3–27	Fetal membranes	Sterile	....	4–18 No gross lesions	Colon-like organisms	Negative	D. J. 40	No	8	0	Negative	Negative	Negative 5–3
2254	4–6	Fetal membranes	Too badly soiled for bacteriological examination	....	.....	.....	.....	P. C. 3	No	9	0	Negative	Negative	Negative 5–17
2468	4–24	Fetal membranes	Colon-like species	....	5–18 No gross lesions	Sterile	Negative	D. J. 59	No	3	0	+.05	+.01	+.05 5–30
2634	5–2	Fetal membranes	All sterile	....	5–25 Spleen white areas size of pea in several places. Slightly enlarged	G − large rods abundant growth, no gas in sugar	Negative	O.D.J.	No	9	1	None	Negative	+.02 5–30
2635	5–2	Dead pig	*Staphylococcus citreus, albus,* and other contaminators very plentiful	Negative	5–25 No gross lesions	G + large coccus	Negative							

TABLE 9A.—EXAMINATION OF FETAL MEMBRANES AND DEAD PIGS FARROWED BY GILTS INJECTED WITH LIVING CULTURE BRUCELLA TRAUM

(Vaccinated in July. Bred in November and December, 1921. Materials obtained in 1922. Part of data summarized from Table 9)

Gilts vaccinated	10
Gilts aborted	0
Live pigs farrowed	86
(Average 8.6 pigs per litter)	
Dead pigs farrowed	2
Bacteriologic examination	
Fetal membranes examined	9
Sterile on culturing	3
Badly contaminated	3
Organisms isolated from fetal membranes:	
Staphylococci in fine colonies	1
Staphylococcus albus	1
B. coli	1
Gram-negative long rod	1
Gram-positive large rod	1
Diploid forms	1
Fetuses examined	2
Mummified	1
Sterile on culturing	1
Organisms isolated from fetuses:	
Gram-positive sporulating rod and other saprophytes	1
Inoculation of guinea pigs	
Injected with emulsions of fetal membranes	9
Died of peritonitis following injection	1
Showing no gross lesions of abortion	7
Spleens sterile to cultural methods	8
Injected with fetal blood and stomach contents	2
Showing no lesions of abortion	2
Spleens sterile to cultural methods	2
Serologic examination	
Vaccinated gilts:	
Negative to agglutination at time of farrow	10
Positive to agglutination at time of farrow	0
Guinea pigs injected with:	
Fetal membrane emulsions, negative to agglutination test	8
Stomach contents and fetal organs, negative to agglutination test	2

TABLE 10A.—EXAMINATION OF FETAL MEMBRANES AND DEAD PIGS FROM UNVACCINATED GILTS ON INFECTED PREMISES IN ASSOCIATION WITH VACCINATED GILTS OF TABLE 2

(Materials obtained in 1922. Part of data summarized from Table 10)

Gilts not vaccinated	11
Gilts aborted	3
Live pigs farrowed	57
(Average 7.1 per litter, not including aborting sows; average litter of all sows 5.2 live pigs)	
Dead pigs farrowed	5
Bacteriologic examination	
Fetal membranes from nonaborters examined bacteriologically	6
Fetal membranes from nonaborters too badly soiled for examination	1
Fetal membranes sterile on culturing	3
Organisms isolated from fetal membranes:	
Streptococcus	1
Gram-positive rods	1
Diploid forms	1
Staphylococcus albus	1
Cocci	1
B. coli	1
Fetuses examined	10
Organisms isolated from fetuses:	
Staphylococcus albus	3
Saprophytes	1
Staphylococcus aureus	2
Gram-positive rod	1
Brucella Traum	5
Gram-positive short rod	1
Coccus, large	1
Gram-positive, short, plump bacilli	1
Staphylococcus citreus	1
Inoculation of guinea pigs	
Injected with emulsions of fetal membranes	6
Showing no gross lesions characteristic of abortion	6
Spleens sterile on culturing	3
Organisms isolated from above guinea pigs:	
B. coli	1
Inoculation of guinea pigs (concluded)	
Staphylococcus albus	1
Gram-negative large rod	1
Injected with fetal blood and stomach contents	6
Died following injection	1
Showing no lesions characteristic of abortion	
Spleens sterile to cultural methods	
Organisms isolated from guinea pigs' spleens by cultural methods:	
Gram-positive large coccus	1
B. coli	1
Serologic examination	
Gilts not vaccinated, negative to agglutination test at time of farrowing:	
Blood negative	5
Milk negative	7
Gilts positive to agglutination test at time of farrowing:	
Blood positive	4
Milk positive	2
Gilts for which samples were not obtained:	
Blood	2
Milk	2
Guinea pigs injected with fetal membrane emulsions, negative to agglutination test	6
Fetuses examined, negative to agglutination test	10
Fetuses examined, positive to agglutination test	0
Guinea pigs injected with:	
Fetal blood and stomach contents, negative to agglutination test	4
Fetal blood and stomach contents, positive to agglutination test	1

TABLE 11.—GILTS VACCINATED AT WEANING TIME EXAMINED AT FARROWING
(Bred in November and December, 1922. Farrowed in March, April, and May, 1923)

No.	Date 1923	Material	Results of examination					Source of material						
			Direct culture	Aggl. fetus blood	Guinea-pig inoculations			Gilts	History			Agglutination of sow		
					Autopsy 1923	Cultures (spleen)	Aggl. blood		Vaccine 1922	Live pigs	Dead pigs	Blood	Milk	Recheck blood
1508	2–28	Vaginal swab	G − rod G + coccus	Negative	3–21 No gross lesions	Sterile	Negative	P. C. 4	May	5	0	Negative	Negative	Negative 3–28
1643	3–5	Fetal membranes	None	....	3–26 No gross lesions	Sterile	Negative	P. C. 23	May	9	0	Negative	Negative	Negative 4–5
1762	3–19	Fetal membranes	G − rod G + coccus	....	4–9 No gross lesions	Sterile	Negative	D. J. 4	May	9	0	Negative	Negative	Negative 4–19
1764	3–19	Vaginal swab	G − rod G + coccus	....	4–9 No gross lesions	Sterile	Negative	D. J. 11	May	8	0	Negative	Negative	Negative 4–19
1956	4–3	Fetal membranes	G + coccus G + small rod G − medium rod	....	4–24 No gross lesions	Sterile	Negative	P. C. 11	May	10	0	.05	....	Negative 5–3
2046	4–10	Vaginal swab	G + coccus-like staphylococcus	Negative	5–1 No gross lesions	G + coccus	Negative	D. J. 7	May	1	9[1]	Negative	Negative	Negative 5–10
2047	4–10	Fetal membranes	G + staphylococcus G − short plump rod G − coccus G + coccus	....	5–1 No gross lesions	Sterile	Negative	D. J. 6	May	8	1	Negative	Negative	Negative 5–10
2194	4–17	Fetal membranes	G + coccus G − small rod G + large rod	Negative	5–8 No gross lesions	Sterile	Negative	P. C. 7	May	5	0	Negative	Negative	Negative 5–17
2573	5–9	Fetal membranes	G − coccus	Negative	5–30 No gross lesions Spleen slightly enlarged and spotted white	Sterile	Negative	D. J. 3	May	10	0	Negative	Negative	....

[1]Death was due to exposure.

three aborting gilts the presence of the abortion organism was suggested by positive agglutination tests of either blood or milk at the time of abortion (Tables 10 and 10A).

Examination of Fetal Membranes of Vaccinated and Unvaccinated Gilts, 1922-23. During the month of May, 1922, nine female pigs (Duroc-Jersey and Poland China) approximately two months old were injected subcutaneously with porcine abortion vaccine. Eleven unvaccinated pigs of the same age were allowed to associate with the vaccinated pigs until farrowing time. These gilts, both vaccinated and unvaccinated, were bred to boars of their respective breeds during November and December, 1922. None of the nine vaccinated gilts aborted; ten pigs were born dead.

TABLE 11A.—EXAMINATION OF FETAL MEMBRANES AND VAGINAL SWABS FROM GILTS INJECTED WITH LIVING CULTURE BRUCELLA TRAUM

(Vaccinated in May, 1922. Bred in November and December, 1922. Materials obtained at time of farrowing in March, April, and May, 1923. Part of data summarized from Table 11)

Gilts vaccinated	9	*Inoculation of guinea pigs*	
Gilts aborted	0	Injected with emulsions of fetal membranes	12
Live pigs farrowed	65	Showing no gross lesions of abortion	12
(Average 7.2 per litter)		Spleens sterile to cultural methods	12
Dead pigs farrowed	10	Injected with emulsions of vaginal swabs	6
		Showing no gross lesions of abortion	6
Bacteriologic examination		Spleens sterile to cultural methods	5
Fetal membranes examined	6	Organisms isolated:	
Fetal membranes not cultured	1	Gram-positive coccus	
Organisms isolated from fetal membranes:		*Serologic examination*	
Gram-positive coccus	4	Vaccinated gilts:	
Gram-negative coccus	2	Negative to agglutination test at time of farrowing	
Gram-positive small rod	1	Giving suspicious reaction to agglutination test at time of farrowing	1
Gram-negative rod	4	Guinea pigs injected with:	
Gram-positive large rod	1	Fetal membrane emulsions, negative to agglutination test	12
Gram-positive staphylococcus	1	Vaginal swab emulsions, negative to agglutination test	6
Vaginal swabs examined	3		
Organisms isolated from vaginal swabs:			
Gram-positive coccus	3		
Gram-negative rod	2		

Fetal membranes and vaginal swabs from the nine vaccinated gilts were examined for Brucella Traum in March, April, and May, 1923. Direct cultures, as well as guinea-pig inoculations of suspensions of these materials, proved negative, while the agglutination tests of the blood and milk of these sows, at time of farrowing, with one exception gave no evidence of the presence of Brucella Traum agglutinins. The vaccinated group averaged 7.2 live pigs per litter. The blood of the sows was rechecked thirty days later, with negative results (Tables 11 and 11A).

Similar materials from the control or unvaccinated group, including blood and milk, were examined at the time of farrowing. One of the eleven unvaccinated gilts, Poland China 41, aborted and gave a positive agglutination test. Poland China 32 at the time of farrowing also gave a positive agglutination test with blood and milk sera. Eighty-one live pigs and eight pigs born dead, exclusive of the five

TABLE 12.—GILTS NOT VACCINATED AT WEANING TIME EXAMINED AT FARROWING
(Bred in November and December, 1922. Farrowed in February, March, and April, 1923)

No.	Date 1923	Material	Results of examination						Source of material						
			Direct culture	Aggl. fetus blood	Guinea-pig inoculations				Gilts	History			Agglutination of sow		
					No.	Autopsy 1923	Cultures (spleen)	Aggl. blood		Vaccine	Live pigs	Dead pigs	Blood	Milk	Recheck blood
1507	2–28	Vaginal swab	G − small rod G + coccus *Staphylococcus aureus*	Negative	1455 1878	3–21 No gross lesions	Sterile	Negative	D. J. 63	No	5	0	Negative	Negative	Negative 3–28
1715	3–9	Aborted fetuses	*B. coli*	....	1335 1341	3–30 No gross lesions	Sterile	Negative	P. C. 41[1]	No	0	5	.002	None	Negative 4–9
1716	3–9	Fetal membranes	G − small rod G + short rod Spore forms Staphylococci	....	1503 1349	3–30 No gross lesions	Sterile	Negative	P. C. 32	No	6	0	.005	.01	Negative 4–9
1719	3–10	Fetal membranes	*B. coli* Large aerobic spore forming clostridium	....	....	4–1 No gross lesions	Sterile	Negative	P. C. 66	No	8	0	Negative	Negative	Negative 4–10
1735	3–14	Fetal membranes and 4 dead pigs	G + coccus G − small bacillus	Negative	1534 1578	4–5 No gross lesions	Rods in long chains G + coccus G − small rod	Negative	D. J. 66	No	8	1	Negative	Negative	Negative 4–14
1763	3–19	Vaginal swab	G + coccus G − rod	....	1586 1347	4–9 No gross lesions	Sterile	Negative	D. J. 15	No	8	0	Negative	Negative	Negative 4–19
1809	3–21	Fetal membranes	G + coccus G − coccus G + rod	Negative	1527 1541	4–11 No gross lesions	G + coccus G − rod Sterile	Negative	D. J. 65	No	9	1	Negative	Negative	Negative 4–21
2025	4–6	Vaginal swab	.....	....	....	4–27 No gross lesions	Sterile	Negative	D. J. 95	No	8	2	Negative	None	Negative 5–6

[1]Aborted.

TABLE 12.—*Concluded*

No.	Date 1923	Material	Results of examination						Source of material						
			Direct culture	Aggl. fetus blood	Guinea-pig inoculations				Gilts	History			Agglutination of sow		
					No.	Autopsy 1923	Cultures (spleen)	Aggl. blood		Vaccine	Live pigs	Dead pigs	Blood	Milk	Recheck blood
2041	4–7	Fetal membranes and 2 dead pigs	G − rod and G + coccus G + coccus	Negative	741 738 77 451	4–28 No gross lesions	Sterile	Negative	D. J. 22	No	8	2	Negative	Negative	Negative 2–7
2135	4–11	Fetal membranes	G + coccus G − medium rod	....	852 856	Died 4–13 Septicemia	.....	....	D. J. 92	No	16	0	Negative	Negative	Negative 5–11
2291	4–20	Fetal membranes and 2 dead pigs	G + staphylococcus. Spore bearing rod	Negative	....	Not examined	.....	....	D. J. 9	No	5	2	Negative	Negative	Negative 5–20

TABLE 12A.—EXAMINATION OF FETAL MEMBRANES, VAGINAL SWABS, AND DEAD PIGS FROM UNVACCINATED GILTS ON INFECTED PREMISES IN ASSOCIATION WITH VACCINATED GILTS OF TABLE 4

(Materials obtained in 1923. Part of data summarized from Table 12)

Gilts not vaccinated	11
Gilts aborted	1
Live pigs farrowed	81
(Average 8.1 per litter)	
Dead pigs farrowed	8
Pigs aborted	5
Bacteriologic examination	
Fetal membranes examined	7
Organisms isolated from fetal membranes:	
Gram-negative rod	3
Gram-positive rod	2
B. coli	1
Gram-positive coccus	4
Gram-negative coccus	1
Gram-positive staphylococcus	1
Gram-negative small bacillus	1
Aerobic	1
Spore-forming clostridium	1
Spore-bearing rod	1
Staphylococcus	1
Other spore forms	1
Vaginal swabs examined	3
Organisms isolated from 2 vaginal swabs:	
Gram-negative rod	1
Gram-positive coccus	2
Gram-positive rod	1
Staphylococcus aureus	1
Fetuses examined	1
Organisms isolated:	
B. coli	1
Inoculation of guinea pigs	
Injected with emulsions of fetal membranes	12
Showing no gross lesions of abortion	10
Died following injection	2
Inoculation of guinea pigs (concluded)	
Spleens sterile on culturing	7
Organisms isolated:	
Gram-positive coccus	2
Gram-negative small rod	2
Rods in long chains	1
Injected with emulsions of vaginal swabs	5
Showing no gross lesions of abortion	5
Spleens sterile on culturing	5
Injected with composite organs of fetuses	2
Showing no gross lesions of abortion	2
Spleens sterile on culturing	2
Serologic examination	
Unvaccinated gilts:	
Blood negative to agglutination test at time of farrowing	9
Milk negative to agglutination test at time of farrowing	8
From which milk samples were not obtained	2
Blood positive to agglutination test at time of farrowing	2
Blood positive to agglutination test at time of farrowing	2
Milk positive to agglutination test at time of farrowing	1
Guinea pigs injected with:	
Fetal membrane emulsions, negative to agglutination test	10
Vaginal swab emulsions, negative to agglutination test	5
Composite fetal organs emulsion, negative to agglutination test	2

pigs aborted by one sow, were farrowed by the sows in this group, an average of 8.1 live pigs per litter (Tables 12 and 12A).

Examination of Fetal Membranes of Vaccinated and Unvaccinated Gilts, 1923-24. On June 2, 1923, sixteen gilts (Poland China, Duroc-Jersey, Hampshire, Chester White, and Berkshire breeds) two to four months old were vaccinated. The live porcine abortion vaccine was injected subcutaneously. Fifteen unvaccinated gilts of the same age and breeds were allowed to associate with the vaccinated pigs. The gilts were bred in November and December, 1923. Because of an outbreak of bronchitis in the herd during the winter, eight of the vaccinated gilts and three of the unvaccinated gilts died. In March and April, 1924, three of the vaccinated gilts farrowed a total of 24 pigs. The fetal membranes of these gilts, the four fetuses and ovaries of Chester White 3, which died, and the uterus and ovaries of Duroc-Jersey 46 were examined for Brucella Traum by inoculation of guinea pigs. The results were negative (Tables 13 and 13A).

Similar materials from the unvaccinated group were injected into guinea pigs, while the blood and milk of the sows were subjected to the agglutination test, with negative results. One gilt in this group aborted, but no evidence of the presence of Brucella Traum could be found. Seventy-one live pigs and three dead pigs were farrowed by

TABLE 13.—EXAMINATION OF FETAL MEMBRANES, FETUSES, UTERI, AND OVARIES FROM GILTS INJECTED WITH LIVING VACCINE. GILTS VACCINATED AT WEANING TIME, EXAMINED AT FARROWING

(Bred in December, 1923. Farrowed April, 1924)

No.	Date 1924	Material	Results of guinea-pig inoculations				Source of material						
							Gilts	History			Agglutination of sow		
			No.	Autopsy	Cultures (spleen)	Aggl. blood		Vaccine 1923	Live pigs	Dead pigs	Blood	Milk	Recheck blood
42231	4-1	Uterus and ovaries	229	4-23 No gross lesions	.....	Negative	D. J. 46	Sept.	0	0	None	None	None
44166	4-8	Fetal membranes	765 759	4-25 No gross lesions	Sterile	.....	D. J. 2	Sept.	7	0	Negative	Negative	Negative
45234	4-12	Fetal membranes	409 415	Died 4-18 No gross lesions Died 4-16 No gross lesions	....	....	P. C. 49	Sept.	7	0	Negative	None	Negative
36322	3-10	Fetal membranes	196 188	Died 3-16 No gross lesions Died 3-15 No gross lesions	....	....	H. 99	Sept.	10	0	Negative	Negative	Negative
45482	4-17	Liver of 4 fetuses	763 760	5-5 No gross lesions	.....	Negative	C. W. 3[1]	Sept.	....	....	Negative	None	Negative
45483	4-17	Ovaries	752 493	Died 4-24 No gross lesions 5-5 No gross lesions	.....	Negative							

[1]Died 4-17-24; 4 pigs in uterus.

TABLE 14.—GILTS NOT VACCINATED AT WEANING TIME EXAMINED AT FARROWING
(Bred in December, 1923. Farrowed in February, March, and April, 1924)

No.	Date 1924	Material	Results of guinea-pig inoculations				Source of material						
			No.	Autopsy 1924	Cultures (spleen)	Aggl. blood	Gilts	History			Agglutination of sow		
								Vaccine	Live pigs	Dead pigs	Blood	Milk	Recheck blood
32207	2–27	Fetal membranes	239 718	Died 2–29 No gross lesions Died 3–19 No gross lesions	Sterile	.....	D. J. 92	No	10	0	Negative	Negative	Negative
45550	4–18	Vaginal swab	766 606	5–8 No gross lesions	.....	Negative	P. C. 13	No	4	0	.05	Negative	Negative
36323	3–10	Fetal membranes	171 205	Died 3–11 No gross lesions Died 3–12 No gross lesions	.....	.....	P. C. 96	No	8	0	Negative	Negative	Negative
39605	3–21	Ovaries	0 707	4–10 No gross lesions Died 3–24 No gross lesions	.....	Negative	D. J. 96[1]	No	....	....	None	None	None
		Fetal membranes	653 221	4–10 No gross lesions Died 3–31 No gross lesions	.....	Negative							
		Fetal liver and stomach contents	377 0	4–10 No gross lesions	.....	Negative							
40213	3–22	Fetal membranes	220 639	Died 3–26 No gross lesions 4–12 No gross lesions	.....	.....	H. 13	No	4	1	Negative	Negative	Negative
40214	3–22	Fetal membranes	385 153	Died 3–23 No gross lesions 4–12 No gross lesions	.....	.....	P. C. 30	No	6	1	Negative	None	Negative

[1]Died of hog cholera 3–21–24; 10 normally developed fetuses in uterus.

TABLE 14.—*Concluded*

No.	Date 1924	Material	Results of guinea-pig inoculations				Source of material						
			No.	Autopsy 1924	Cultures (spleen)	Aggl. blood	Gilts	History			Agglutination of sow		
								Vaccine	Live pigs	Dead pigs	Blood	Milk	Recheck blood
45785	4–22	Uterus and ovaries	724 390	5–14 No gross lesions 5–14 Spleen swollen	.....	Negative	D. J. 33[1]	No	....	....	Negative	None	Negative
		Uterine mucosa	485 691	5–14 No gross lesions	.....	Negative							
45235	4–12	Fetal membranes	408 410	5–8 No gross lesions Died 4–18 No gross lesions	.....	.....	P. C. 99	No	5	0	Negative	None	Negative
41120	3–26	Fetal membranes	361 359	4–15 No gross lesions Died. No gross lesions	.....	.....	P. C. 23	No	8	0	Negative	.05	Negative
44165	4–8	Fetal membranes	767 769	4–25 No gross lesions	.....	Negative	P. C. 40	No	9	0	Negative	Negative	Negative
42786	4–4	Vaginal swab	498 396	Died 4–11 No gross lesions 4–26 No gross lesions	Sterile	.....	H. 6[2]	No	0	....	Negative	None	Negative
46593	4–28	Vaginal swab	3029 3095	Died 4–30 No gross lesions Died 5–2 No gross lesions	.....	.....	P. C. 38	No	8	1	Negative	None	Negative
46594	4–28	Fetal membranes	4419 4405	5–26 No gross lesions Died 5–5 No gross lesions	.....	Negative	H. 3	No	9	0	Negative	None	Negative

[1]Sterile. [2]Aborted and ate fetuses.

TABLE 13A.—EXAMINATION OF FETAL MEMBRANES, FETUSES, UTERI, AND OVARIES FROM GILTS INJECTED WITH LIVING CULTURE BRUCELLA TRAUM

(Vaccinated in September, 1923. Bred in December, 1923, and farrowed in April, 1924. Part of data summarized from Table 13)

Gilts vaccinated	5
Gilts aborted	0
Live pigs farrowed	24
(Average 4.8 per litter)	
Dead pigs farrowed	0
Fetuses in uterus at death of sow	4
Bacteriologic examination	
Fetal membranes examined	3
Uteri examined	1
Ovaries examined	2
Fetuses examined	4
Inoculation of guinea pigs	
Injected with fetal membrane emulsion	6
Died following injection	4
Showing no gross lesions of abortion	6
Injected with fetal liver emulsion	2
Showing no gross lesions of abortion	2
Injected with uterine and ovarian emulsion	1
Showing no gross lesions of abortion	1
Inoculation of guinea pigs (concluded)	
Injected with ovarian emulsion	2
Died following injection	1
Showing no gross lesions of abortion	2
Spleen cultures showing no growth	2
Serologic examination	
Guinea pigs injected with:	
Fetal membrane emulsions, negative to agglutination test	None made
Uterine and ovarian emulsions, negative to agglutination test	1
Ovarian emulsion, negative to agglutination test	1
Fetal liver emulsions, negative to agglutination test	2
Vaccinated gilts:	
Negative to agglutination test at time of farrowing	4
Not tested	1

TABLE 14A.—EXAMINATION OF FETAL MEMBRANES, VAGINAL SWABS, UTERI, OVARIES, AND FETUSES OF UNVACCINATED GILTS ON INFECTED PREMISES IN ASSOCIATION WITH VACCINATED GILTS OF TABLE 6

(Farrowed in 1924. Part of data summarized from Table 14)

Gilts not vaccinated	13
Gilts aborted	1
Live pigs farrowed	71
(Average 5.9 per litter)	
Dead pigs farrowed	3
Fetuses in uterus at death of sow	10
Bacteriologic examination	
Fetal membranes examined	9
Vaginal swabs examined	3
Uteri examined	1
Organisms isolated from above sources:	
B. coli	1
Pasteurella	1
Ovaries examined	2
Fetuses examined	10
Inoculation of guinea pigs	
Injected with fetal membrane emulsions	18
Died following injection	10
Showing no gross lesions of abortion	18
Injected with vaginal swab emulsion	6
Died following injection	3
Showing no gross lesions of abortion	6
Injected with uterine and ovarian emulsion	2
Showing no gross lesions of abortion	2
Injected with uterine mucosa emulsion	2
Showing no gross lesions of abortion	2
Injected with ovarian emulsion	2
Inoculation of guinea pigs (concluded)	
Died following injection	1
Showing no gross lesions of abortion	2
Injected with fetal liver and stomach-content emulsion	2
Showing no gross lesions of abortion	2
Spleen cultures sterile	3
Serologic examination	
Guinea pigs injected with:	
Fetal membrane emulsions, negative to agglutination test	5
Vaginal swab emulsions, negative to agglutination test	2
Uterine and ovarian emulsions, negative to agglutination test	2
Uterine mucosa emulsions, negative to agglutination test	2
Ovarian emulsions, negative to agglutination test	2
Fetal liver and stomach-content emulsions, negative to agglutination test	2
Unvaccinated gilts:	
Negative to agglutination test at time of farrowing	11
Giving suspicious reaction	1
Not tested	1

these sows, while ten healthy fetuses were found in the uterus of one sow at the time of slaughter (Tables 14 and 14A).

Summary of Results in Vaccinated and Unvaccinated Gilts, 1921-24. The carrier feature of Brucella Traum in 24 gilts given porcine abortion vaccine was not detected by direct culture of the fetal membranes and fetuses, or by guinea-pig inoculation at time of farrowing. In cases where fetal membranes were not available vaginal swabs, uteri, and ovaries were examined. The negative findings suggest that

young pigs possess considerable resistance to the Brucella Traum vaccine. None of the vaccinated gilts aborted.

The unvaccinated or control animals included a total of 35 gilts that were kept with the vaccinated gilts. Five of the unvaccinated control gilts exposed in this manner aborted. Therefore, it appears in the Illinois experiments that the vaccine administered to pigs two to four months of age, two or more months before breeding, had a tendency to reduce the number of abortions during the first pregnancy, tho continuous association of unvaccinated gilts with vaccinated gilts tended to perpetuate abortion in the unvaccinated group. The animals in these experiments were not available for observation during the second or third pregnancies, and the abortion rate over a period of years in the vaccinated and unvaccinated animals was not determined. Vaccinated and unvaccinated gilts were not examined at the time of slaughter for Brucella Traum. The permanent carrier feature in these animals, therefore, could not be determined. Altho the value of vaccination as a means of controlling infectious porcine abortion is suggested, the results herein reported do not justify the use of living culture vaccine in the control of this disease except for experimental purposes. In fact it seems undesirable to employ living vaccine in a herd of aborting swine unless a large portion of the herd has previously suffered from the infectious type of the disease as established by accurate laboratory methods.

SUMMARY AND CONCLUSIONS

1. Abortion in swine on Illinois farms has occurred sporadically over a period of many years. The infectious type of the disease was recognized in Illinois in 1920. Following initial outbreaks in different herds in which sows and gilts abort, the incidence of abortion generally subsides. In other words, the disease loses rather than gains momentum after the initial storm, and infected sows generally farrow normally in subsequent pregnancies. The benign clinical manifestation of the disease does not necessarily imply recovery, for infected animals may harbor the infection indefinitely and serve in the capacity of spreaders at time of farrowing. Infected boars are also a potential source of danger at time of breeding.

2. Field evidence of a convincing character has failed to show that abortion disease in cattle spreads to swine. By experimentally exposing swine, this supposition was not materially altered. On the other hand, the susceptibility of a pregnant heifer, as judged by abortion and positive agglutination test, suggests the danger of Brucella Traum invading cattle.

3. Outbreaks of abortion in swine in Illinois coming to the attention of the authors are also traceable to non-infectious causes. Bru-

cella Traum is responsible for one type of the disease. Other types of abortion encountered, aside from those due to injury or violence, appear related to febrile diseases; while in other cases the cause or causes of abortion could not be established.

4. Gilts suffering from infectious abortion may, with few exceptions, continue to react to the agglutination test but farrow normally in subsequent pregnancies.

5. Abortion in healthy gilts or sows may occur following the feeding of the porcine abortion organism, but some pregnant sows and gilts following exposure may farrow normally. A positive agglutination reaction was consistently observed in healthy gilts and sows following the injection or feeding of Brucella Traum. Males, including barrows, react the same as gilts.

6. Cows, horses, guinea pigs, and rabbits may be artificially infected, as judged by the agglutination test. Young pigs are highly resistant, as judged by the mild response and rapid decline of the agglutination titre following exposure. The infection may persist, however, in young pigs for several weeks.

7. Abortion in swine traceable to Brucella Traum can be accurately diagnosed by isolation of the infecting agent. Serologic tests are also helpful in diagnosis, provided animals to be tested are not being fed infected cow's milk.

8. The porcine type of Brucella organism resembles the bovine strain morphologically and serologically, but can generally be distinguished by its luxuriant growth and yellow pigment in old agar cultures. Experimental infection of a heifer by intravenous injection with porcine strains was followed by abortion. Field observations and exposure of pigs by feeding naturally and artificially infected cow's milk fail to provide definite proof that Brucella Bang of cattle is a common etiologic factor in infectious abortion in swine. Two different pathogenic types of the abortion or Brucella organism in cattle and swine are thus suggested.

9. In normally farrowing sows in one spontaneously infected herd Brucella Traum could not be demonstrated in the afterbirth or dead fetuses, yet emulsions of these tissues following subcutaneous injection into guinea pigs occasionally produced in these animals specific agglutinins for Brucella Traum. Since the blood sera or colostra in nine of the sows at the time of farrowing completely agglutinated Brucella Traum in a dilution of .01 to .02, the passive transmission of agglutinins by the material injected into guinea pigs seems probable.

10. Direct cultures of the nonlactating mammary glands of sows reacting positively to the agglutination test failed to yield Brucella Traum. Negative results were also obtained by inoculating guinea pigs with emulsions of the mammary tissue. Occasionally the guinea pigs inoculated with the mammary gland emulsion developed specific agglutinins for Brucella Traum.

11. Brucella Traum was present in the testicular tissue of young pigs 14 to 45 days after artificial exposure by feeding or intravenous injection. The pigs yielding positive cultures showed slight or no agglutinins to Brucella Traum. No gross pathologic lesions in testes harboring Brucella Traum were observed in young pigs experimentally infected.

12. Brucella Traum was demonstrated in the epididymi of pigs 14 to 16 days after feeding the organism. The agglutinins in the blood serum of pigs were slight or imperceptible. Gross lesions were not observed in the epididymi yielding positive cultures.

13. Brucella Traum was encountered in the bulbo-urethral glands and seminal vesicles of an actively breeding boar seventeen months after the feeding of the organism. Such findings suggest that males harboring the infection in the reproductive organs might play an active part in the spread of the disease at the time of breeding.

14. The body and visceral lymphatic glands and spleen of young pigs artificially infected by feeding yielded positive evidence of Brucella Traum 30 to 80 days later. The agglutinin titre for Brucella Traum in the blood sera of these pigs was not characteristic of the infection.

15. The nongravid uteri and ovaries of sows harbored Brucella Traum for a period of six to twenty months following subcutaneous or intravaginal injection. Other animals that yielded positive uterine or ovarian cultures were exposed by feeding or by association with infected animals. The frequency of a uterine or ovarian infection was not determined, but in the animals at the authors' disposal, the nongravid uteri frequently harbored the infection. The colostrum in aborting and normally farrowing infected sows also yielded Brucella Traum.

16. Pigs ten to twelve weeks old injected subcutaneously with Brucella Traum vaccine showed a low average agglutination reaction extending over a period of approximately six months, followed by a secondary curve of shorter duration lasting approximately two months. Uninoculated control pigs in the same pen showed a comparable average primary and secondary agglutination curve with comparable maximum titre to Brucella Traum. The average maximum agglutination titre of the vaccinated pigs preceded the maximum agglutination reaction of the contact control or unvaccinated pigs approximately 90 days.

17. Unvaccinated pigs which were allowed continuous association with pigs of the same age that received live vaccine probably contracted abortion infection thru association. This suggests the importance of segregation of vaccinated pigs.

18. None of the 24 pigs vaccinated at weaning aborted, nor was evidence regarding the danger of abortion carriers in the pigs injected

with living culture vaccine found in fetal membranes and dead fetuses of pigs vaccinated at the time the first litters were born. Direct cultures and guinea-pig inoculations were negative. The vaccinated gilts also gave a negative agglutination test at the time of farrowing, nine months following vaccination. Materials from the vaccinated and unvaccinated gilts were examined from the first litters and it is possible that the results of subsequent pregnancies and examinations of the vaccinated animal might not coincide with the findings in the first farrowing period.

19. Of 35 control, or unvaccinated, pigs of the same age that were kept with the vaccinated pigs, 5 aborted during the first pregnancy, while none of the 24 pigs receiving the vaccine aborted. Further breeding records for the vaccinated and unvaccinated gilts were not available. Since the agglutinin titre of the blood of pigs in each group shows that both vaccinated and unvaccinated pigs become infected, it is apparent that the delivery of healthy litters by the vaccinated group may be related to time of exposure to the virus of the disease. In the unvaccinated group initial positive agglutinins appeared ninety days later than in the vaccinated group, and obviously during pregnancy. The same danger of infection either from natural exposure or by vaccination has been observed in pregnant cattle.

20. The possible danger of living culture vaccine was suggested by the occurrence of abortions among the control, or unvaccinated, gilts that were associated with the vaccinated pigs. Approximately 14 percent of the unvaccinated gilts aborted. The results of the agglutination test in the case of the unvaccinated gilts also suggest the possibility of infection being spread by vaccinated animals. It therefore appears that the use of living vaccine, while of apparent immunizing value when administered to young pigs, may spread infection to unvaccinated animals.

21. Investigations conducted by various laboratories during the past three years give results which support the possible relation of Brucella Traum to undulant fever in man. Such results prompt the cautious handling of aborted materials by attendants and the segregation of infected animals preparatory to fattening for market in order to reduce the danger of direct infection to man, as well as indirectly thru gaining entrance to cattle, where it might become lodged in the udder and thus be transmitted to man.

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