

ECONOMIC LOSSES DUE TO BRUCELLOSIS
IN A VACCINATED HERD

by

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INTRODUCTION

Brucellosis no doubt continues to be one of the most important diseases in the livestock industry. The great financial losses resulting from this disease are still frequently not recognized by many dairymen and farmers with small herds. It is doubtful whether experienced and even purebred breeders are aware of all the losses encountered, as brucellosis attacks in many ways that frequently are not spectacular in nature or immediately visible and as a result are overlooked or minimized.

Today there is no doubt that no other disease is responsible for greater losses to the dairy industry than the infections which center around the reproductive organs. The outstanding infection or disease of these organs being that caused by the organism Brucella abortus.

Mohler and Traum (43) in 1911 made the following statement.

From the viewpoint of economic importance, infectious abortion of cattle ranks second only to tuberculosis, and in certain sections of the country even supersedes the latter in the monetary loss at occasions. Aside from the loss of the calf, the loss occasioned by the reduction in milk supply, together with the failure to conceive for several months or forever after the abortion, and the frequency of retained placenta, has made the disease the bane of dairymen and stock raisers.

The exact financial loss can not be even approximately estimated, it can safely be stated that the direct loss reaches into the millions, while the potential loss is likewise enormous and unestimatable.

The Special Committee of the United States Livestock Sanitary Association (49) has made a final estimate of around \$90,000,000. for the yearly losses suffered by the cattle industry because of

brucellosis (every effort has been made to lean heavily toward the conservative side).

Many livestock men and veterinarians are of the opinion that additional and beneficial protection or resistance is gained by calfhood vaccinated animals if they are exposed to infection or reactor cattle, when a recession of the blood titer occurs following vaccination.

This report is submitted as additional data on losses due to brucellosis in dairy cattle in which a calfhood vaccination program was in effect with some reactors left in the herd while they were profitable in so far as milk production was concerned.

The losses due to brucellosis will be considered as:

1. Loss in milk production
2. Loss of calves
3. Losses in a cow herd
 - a. Breeding efficiency and sterility
 - b. Reactors in vaccinated and nonvaccinated animals

The second part of this report deals with a study of the longevity of the resistance created or engendered by vaccination of calves with Bureau of Animal Industry Brucella abortus strain 19 when these animals are exposed as adults to natural infection.

REVIEW OF LITERATURE

Loss in Milk Production

In studying the relation of abortion to milk loss Rich (47) observed that in two groups of heifers from the same sires, fourteen of which aborted and fourteen which had normal parturition, give an interesting comparison of production in the first lactation. The aborting group averaged 1,308 pounds of milk less than the group having normal parturition. This is a 16 per cent decrease in production of the infected group. The same author reported a 22.5 per cent lowered production in a herd with 71 cows aborting. This figure was determined by using a normal parturition following the abortion period.

White et al. (54) reported that there was a 22.2 per cent decrease among 13 head calving before 215 days and a decrease of 12.3 per cent among 14 head calving between the 215th and 265th day. In combining these two groups, a 16.6 per cent decrease resulted in milk production.

Simms et al. (48) report a 28 per cent decrease in milk production during a three year period. These studies showed that even though the infected cows carried their calves full time, their production of milk and butter fat was not up to the expected normal. Rich (47) too has reported that cattle reacting to brucellosis without aborting have a lowered milk yield than negative cows. He reported a 6 per cent increase in favor of the negative group. These figures were based on

life time records on a herd of 12 reactors and a group of negative animals of the same number.

Fritz and Barnes (22) reported a 28 per cent decrease in one herd and a 22 per cent decrease in another herd.

In addition the following workers have published data in regard to milk yield losses resulting from abortions. Graham and Thorp (25) reported a 22 per cent decrease in milk yield. Minett and Martin (41) report a 10 per cent decrease in milk production. Hooper (35) in studying the premature calving found that an early abortion, 152 days, will slightly stimulate the milk flow, while a late abortion, 239 days, augments it considerably but in neither case like that of normal calving. He reported a 35 per cent decrease in milk yield in the brucella infected group.

Loss of Calves

The calves from brucellosis infected cattle are in most cases highly susceptible to pneumonia and scours. Graham and Thorp (25) state that this susceptibility is due to lowered vitality from the abortion infection and as a result are more susceptible to these infections. Smith et al. (49) report a 15 per cent calf loss in brucella infected herds. Rich (47) working in Minnesota reported a calf loss of 16.8 per cent in a total of 974 pregnancies.

Simms et al. (48) reported both difficult breeding and abortions reduce the percentage of live calves per year from the infected animals. The average number of live calves per year from 36 infected head was 22 calves. In other words, there was one live calf per cow each 19.6 months. During the same four years there was an average of 19.75 calves per year from an average of 23 nonreactors. This represents one live calf per cow each 13.4 months.

Losses in Cow Herd

Breeding Efficiency and Sterility. Sterility as a result of brucellosis may vary in different herds due to the method of handling and treatment of the infected animal. The writer from field experience has observed that the percentage of sterility cases may be very low in infected animals if given proper treatment and care; whereas, in animals that do not receive proper treatment and care the percentage of sterile cases and difficult breeders may at times be very high.

Graham and Thorp (25) report that sterility varies and may be as high as 45.3 per cent in infected animals.

Udall (53) reports that among the positives the failures are three times those of the negative and low group.

Retained placenta is a common complication following abortion which if not properly handled may be followed with a metritis, salpingitis, and oopharitis; which may terminate

in difficult breeders, and sterility.

Eichhorn and Crawford (20) state that it has frequently been observed in herds with brucellosis that a cow which has aborted may have to be served three or more times before she conceives. The cause of this in many instances is the inflamed condition of the uterus. When the uterus is inflamed, no doubt a change in the pH of the vagina occurs, and the discharge which accompanies inflammation is so viscid that it retards the movement of the sperm and when putrefactive substances are present due to other bacteria, the sperm may be rapidly destroyed. It should be apparent, therefore, that aborting cows should be given a rest of at least three months before being bred, to allow the uterus to return to a normal condition.

White et al. (54) observed that reactor animals require 2.09 services per cow before conception while the negative group required 1.82 services per cow. Rich (47) states that the productivity of reactor cattle is one year shorter than noninfected cattle. In concluding the loss from the effects of abortion on breeding efficiency, it may be stated that the main financial losses come from aborting cows being more uncertain breeders and a higher per cent becoming sterile.

Smith et al. (49) points out that brucellosis free cattle calve every 11.5 months, infected cattle calve on an average of every 20 months and one out of every five cows aborting

will become sterile. The disease with the breeding trouble, sterility and mastitis it produces, increases the needed replacements by about 30 per cent. Birch et al. (5) gave the breeding efficiency of recent reactor cattle as 54.5 per cent, chronic reactors as 76.38 per cent and clean cattle as 86.8 per cent.

Reactors in Vaccinated and Nonvaccinated Animals. Many studies have been made of brucellosis in cattle caused by Brucella abortus. From these studies attempts have been made to prevent the spread of brucellosis from animal to animal as well as to man.

Immunization against Bang's disease in cattle is by no means a recent attempt. Bang (1) wrote of immunizing cattle to this disease in 1897 and published his experiments on vaccination with dead and living cultures of Brucella abortus. Some of his results with living cultures were encouraging. In 1914 Stockman (51) reported similar results and agreed with Bang that living cultures were of greater value than bacterins in producing resistance to this disease. They based their conclusions on a series of 493 treated animals in which the abortion rate was 6.5 per cent as compared with 432 controls in which the abortion rate was 23.4 per cent.

Giltner et al. (23) in 1916 reported discouraging results with their experiments. Huhtala (37) of Finland reported similar results with biological preparations in 1931.

Huddleson (36) in 1924 reported that a culture of Brucella abortus has been obtained which has lost its disease producing properties for guinea pigs, that is, lesion production and abortion. That 141 animals have been treated and indications are that it has lost its disease producing properties for the bovine and that some degree of immunity follows its inoculation.

Smith and Little (50) in 1917 were among the first to study vaccination in this country. They reported in 1923 that infection may be eradicated by the destruction of all infected animals and resistance can be increased through the use of vaccination. They used two live virulent cultures as vaccines and were able to show marked improvement in the lowering of the abortion rate.

Buck and Creech (9) working in the Bureau of Animal Industry conducted vaccination experiments in the field on 1,141 animals in various herds and also on 23 animals at the laboratory. Of 772 unbred cows and heifers vaccinated with Brucella abortus, 13.1 per cent terminated their later pregnancies by aborting while 369 animals used as controls had an abortion rate of 17.7 per cent. Of the smaller group, eight heifers and three cows were vaccinated subcutaneously with abortion vaccine when nonpregnant, four heifers received abortion bacterin, and six heifers and two cows served as controls. All animals were exposed by feeding material

containing Brucella abortus. Ten of the eleven vaccinated produced normal calves. In the group of four receiving bacterin two aborted and also seven of the eight controls aborted.

Hadley (26) in 1921 had come to the conclusion that the abortion vaccine has a decided immunizing value, especially for cattle of certain groups. The vaccinated cattle showed a decrease in both abortion rate and the sterility rate. The vaccine had little value when administered to open cows that had aborted, whereas, open cows that had not aborted most gratifying results were obtained. The experiments of Hart and Carpenter (34) clearly demonstrated the value of living cultures of Bacterium abortus in preventing abortion in the vaccinated animals when subjected to identical infection that produced abortion in the controls. Lubbehusen et al. (38) reported on 42 pregnancies in the vaccinated group in which 8 or 19 per cent aborted, whereas in the control group 66 pregnancies occurred in which 19 or 28.7 per cent aborted.

Fitch and Boyd (21) concluded from their experiments that immunizing agents will not solve all the difficulties or reduce the economic losses incident to infection with Bacterium abortus Bang to a desirable minimum. One must therefore look for other means of control to diminish such losses.

It was soon realized that by the injection of a vaccine consisting of a virulent strain of Brucella abortus, although conferring considerable resistance to the disease, was attended with considerable danger. Hart and Traum (33) reported that after administering such a vaccine that ten out of sixteen open lactating cows were eliminating the organism in the milk.

The above report led investigators to produce an avirulent strain of vaccine. Giltner et al. (24) used an avirulent strain on a large number of animals in the field. Of 1,212 animals vaccinated, 3.6 per cent aborted while 1,258 animals used as controls had an abortion rate of 18.4 per cent. These experiments were conducted on groups of all ages.

Buck (7) concluded that it is possible by the subcutaneous administration of abortion vaccine during calthood, to engender in bovines an immunity to Bacterium abortus infection that is readily demonstrable during their first pregnancies. The immunity afforded by early vaccination, possibly somewhat reinforced by Bacterium abortus ingestion exposures, seems to continue through second gestation.

The experiments of Cotton and Buck (10) proved very encouraging to make further tests along similar lines.

The same authors (11) in 1932 came to the conclusion that by selecting strains of Brucella abortus of proper virulence for vaccine preparation and by confining the use of vaccine largely to unbred animals, possibly virgin heifers

at near breeding age, immunization may be perfected to the point where in many herds it may be found to serve a useful purpose in reducing abortion losses and assisting herdowners gradually to eliminate the disease without at the same time being a menace to human health.

Cotton, Buck and Smith (13, 14, 15) concluded in continued experiments with avirulent strains of Brucella abortus from which strain 19 was selected as the most promising, and that calves should be vaccinated between the ages of 4 to 6 months, to avoid prolonged serum agglutination titer.

This procedure as outlined by these men has been generally accepted and is practiced to control brucellosis today. This Bureau of Animal Industry strain 19 Brucella abortus is an avirulent strain which is thought to build up an increased resistance in the animal against the entrance of the virulent form of Brucella abortus.

The use of avirulent strains of Brucella abortus in field herds was reported in 1936 by Meyer and Huddleson (40). They concluded that the vaccinated animals showed a higher degree of resistance than nonvaccinated, but observed that 10 per cent of the injected animals failed to develop sufficient immunity to last for a period of one year.

Cotton and Buck (12) reported that of 772 unbred cows and heifers in one herd which were vaccinated, 13.1 per cent subsequently aborted. Of 369 animals as controls 17.7 per

cent aborted. In another herd over a ten year period, 149 heifers were vaccinated and 83 left as controls. The abortion rate in the vaccinated animals was 5.1 per cent and in the controls 17.9 per cent.

Further results on vaccination with Bureau of Animal Industry strain 19 was reported by Hardenbergh (27). In the vaccinated group there were 7 abortions or 5.6 per cent out of 124 terminated pregnancies. Of these only three or 2.4 per cent were apparently caused by Brucella infection. In the control group there were four abortions out of 64 terminated pregnancies or 6.2 per cent, all four were apparently due to Brucella infection.

Field vaccination was undertaken in a large scale beginning in 1934.

In England McEwen (39) with field immunization reported that Brucella abortus infection of the vaccinated animals fell to a negligible quantity during the second and third years of vaccination and the results encouraging in so far as no attempts were made to control the disease by hygienic measures. He reported 4 per cent infection in 109 vaccinated animals at the end of the first year, 2 per cent in 90 the second year, and no infection the third year in 38 head; whereas in the controls he reported 5 per cent in 98 head the first year, 19 per cent the second year in 73 head and 24 per cent the third year in 29 head

Buck et al. (8) gave further results of vaccination in 1938. Five animals vaccinated during calfhood gave birth to vigorous calves and were negative to the agglutination test at time of calving. Of the seven controls three expelled weak calves, and four healthy calves. Brucella abortus was isolated from two of the weak calves and one from the healthy calves.

Haring (29) recorded the results of Bureau of Animal Industry strain 19 on 641 calves and heifers and of 1,001 pregnancies of these animals there was an abortion rate of 3.9 per cent. He also reported that the vaccine has proved to be useful in eradicating brucellosis from a badly infected dairy herd having 44 per cent infection. The disease completely disappeared following a six year program of heifer and calfhood vaccination; during which time the diseased cows were permitted to remain in the herd until economically useless.

Wight (55) reported in 1939 that since 1936, there were 13,000 calves vaccinated between 5 and 7 months of age, and that the results continued to be encouraging.

Tompkins (52) reported the results of 391 pregnancies in which 16 abortions occurred during three gestation periods.

Mohler et al. (44) reported on 8,182 calves vaccinated, in which the abortion rate was 1.6 per cent, during three pregnancies, which could be attributed to brucellosis. He

also gave figures on another group of 44 vaccinated animals in which 2.3 per cent aborted and gave positive results to blood tests.

Birch (3) in a progress report gave the following figures, out of 35 vaccinated animals at the end of the first pregnancy 2.8 per cent aborted whereas in 23 controls 26 per cent abortion occurred. In the second pregnancy out of 29 vaccinated no abortions occurred, whereas 25 per cent abortion occurred in 16 controls. He further pointed out that as the effects of the vaccine wears off the drift is towards a higher susceptibility.

Haring and Traum (30) were able to demonstrate Brucella abortus in 13.8 per cent of the abortions, and they concluded that less than 15 per cent of the abortions and still births in vaccinated animals were caused by brucellosis. The same authors (31) in 1941 reported that vaccination with strain 19 has given a high degree of protection as indicated by controlled experiment and by a 94.1 percentage of full term calves in vaccinated animals in field trials among affected herds.

Haring (28) used strain 19 vaccine on 93 heifers in a dairy herd affected with brucellosis. For a period of four years, the results have been apparently beneficial in retarding the spread of the disease.

Rabstein and Welsh (45) reported ten abortions or 1.5

per cent out of a total of 640 calvings over a three year period in which 172 cows having had one calf, 90 having had two calves; 48 having had three calves; 26 having had four calves, and 8 having had five calves. They further pointed out that the percentage of reactors has been reduced from an average of 36.2 to 8 per cent during this period.

Bonyng (6) reported a 0.72 per cent failure in vaccinated animals, in other words 4 animals became positive to the agglutination test out of 550 replacements.

Mohler (42) in a report released by the Bureau of Animal Industry stated that there were 195 abortions or 1.1 per cent of 17,608 calvings that could be attributed to brucellosis according to the test. These figures were taken over a six year period.

Rabstein (46) carried on a calfhood vaccination program in herds where the infection rate has ranged from 25 per cent to 100 per cent, yet in no herd has the percentage of abortions in the vaccinated animals due to brucellosis exceeded 1.5 per cent. Birch et al. (4) in studying the immunity created by vaccination of calves with strain 19 reported 53.34 per cent infection in 45 vaccinated animals and 66.67 per cent infection in 33 controls. These experiments included animals with one pregnancy up to including six pregnancies.

Haring and Traum (32) in analyzing 1,005 parturitions

in animals vaccinated as calves 4 to 8 months, concluded that the abortion due to Brucella abortus was 0.9 per cent.

Edwards et al. (19) in England from their experiments concluded that Bureau of Animal Industry strain 19 confers a substantial degree of immunity in cattle against a virulent infection applied 35 weeks after vaccination.

Delez (17) in 1937 administered two doses of living cultures in calfhood and observed that a placental resistance developed to Brucella abortus infection as indicated by the number of living calves obtained in his experiment.

Crawford (16) reported on the calves in 260 heavily infected herds which had been calfhood vaccinated, and of 8,182 pregnancies during the first 4½ years, 96.2 per cent were normal and 3.8 per cent resulted in abortion. Of the latter 58.7 per cent were in cows negative to the blood test which reduced the percentage of abortions due to Bang's disease to 1.6 per cent.

Beach et al. (2) in their experiments subjected 23 animals vaccinated as calves and 6 vaccinated as young adults with Bureau of Animal Industry strain 19 to a virulent strain of Brucella abortus in the third and fourth gestation period. Each of the 10 controls aborted following exposure. Among those vaccinated as calves there were 12 cows which aborted, 2 with living weak calves and 9 with calves born alive at

full term. Among those vaccinated as young adults, there were 2 animals with living, but weak calves, 3 with normal calves and one which aborted.

Delez (18) in 1940 studied the duration of immunity of Bureau of Animal Industry strain 19 through two gestations on 13 heifers. Nine were vaccinated and 4 served as controls. The vaccinated and controls delivered full term calves the first pregnancy but two of the control calves were born dead. Following exposure in the fifth and sixth month of the second gestation, six principals delivered living calves. Two others delivered living calves in the middle of the eighth month and one early in the ninth month of gestation. Brucella abortus was demonstrated in three of the animals that calved prematurely. Two controls dropped dead calves and one a live calf in the eighth month of gestation. The fourth aborted in the seventh month of pregnancy. Brucella abortus was demonstrated in three of the controls.

SOURCE OF DATA

The data used in this study were taken from the records of the Kansas State College dairy herd.

The records of the college herd were very complete. Data were available for production, calving and abortion, breeding, testing and vaccination of all animals to Bureau of Animal Industry strain 19.

The herd has been kept under the same conditions as to feeding, housing, milking, and management, therefore all the records presented are comparable.

In selecting nonreactor cattle for comparison with reactor cattle in milk production, all the cows except two were from the same sires. These animals selected were therefore closely related genetically. Cattle of the same ages were selected as nearly as possible as well as the same breed. Every effort was made to reduce individual error to a minimum. Minett and Martin (41) have pointed out that loss from disease presents inherent difficulties owing to the numerous factors which influence the milk yield of cows. Corrections have to be made in the first place for age, as judged by the number of calvings, length of dry period, service period (interval between calving and next effective service) and month of calving. They further point out that comparisons of yield can only be made with animals of the same breed, living under the same conditions of animal husbandry and being milked by the same system. After all these conditions have been satisfied it has to be remembered that other diseases and disease conditions have a bearing on the issue. Finally there are practical obstacles arising through sale, death or sporadic illness of animals whose milk records are desired.

One can readily understand why that in the past no exact and at the same time complete and extensive observations have

been published as to the economic losses due to brucellosis in a vaccinated herd.

HERD HISTORY

The college herd consists of approximately 65 to 70 head of cattle in production. These consist of four breeds: Holstein, Ayrshire, Jersey and Guernsey. The herd has been closely confined in small dry lots and as a result close contact of individuals existed at all times. The only cattle that were put out on pasture were the dry cattle and pregnant heifers during the summer months. Calves and heifers were kept separate from adult cattle except when heifers were bred and diagnosed pregnant they were then placed with the dry cows. The lots have fair drainage as well as the pastures.

The cows and heifers calve in maternity stalls and are confined until discharges have disappeared. The calves were removed after the first few days and placed in the calf barn and fed by buckets. These calves were tested before six months and vaccinated when six months of age. They were retested after vaccination to determine if a post vaccinal titer had developed. Blood tests were continued at frequent intervals throughout the life of the individuals.

The herd has been blood tested since 1929 to present date. There never was an outbreak of brucellosis until 1943. The herd had been clean throughout all these years with the

exception of an occasional animal developing a positive titer. These were immediately removed from the herd. When the outbreak occurred a calfhood vaccination program was undertaken and later the entire herd was vaccinated when losses continued due to brucellosis.

Loss in Milk Production

In the study of the college dairy herd from 1940 to 1950, it was found that there were eight cows that were reactors to the agglutination test, with production records following normal calving on parturition and following an abortion. Table 1 shows the daily average production for ten months and the total production for 305 days. Two animals 386A and 167A failed to complete a second lactation of 305 days. This table shows a wide range in the per cent decrease following an abortion. The greatest per cent decrease in milk production was 47 per cent. One animal produced a higher milk yield, 2 per cent, following an abortion than following a normal parturition. The greater number of abortions occurred in the second and third gestation period. This per cent decrease in milk yield is less than reported by most other workers (22, 25, 35, 47, 48). The milk yield for lactation period following an abortion for the eight head was 13 per cent greater, or a total of 11,063 pounds of milk more than the lactation following an abortion.

Table 1. Average monthly milk yield of eight cows before and after abortion.

| | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th | 9th | 10th | 1305 : Decrease: Per cent days: pounds : decrease | |
|------|------|------|------|------|------|------|------|------|------|------|--|-------|
| 124A | 38.9 | 55.4 | 54.4 | 53.3 | 49.0 | 46.0 | 43.3 | 42.1 | 40.6 | 36.7 | 13,781 | 9.6 |
| | 24.6 | 47.1 | 48.4 | 46.3 | 41.3 | 40.9 | 38.5 | 37.3 | 36.2 | 37.0 | 12,436 | |
| 129A | 28.6 | 35.6 | 34.8 | 36.5 | 31.8 | 28.2 | 29.7 | 27.6 | 23.6 | 18.6 | 8,718 | +188 |
| | 29.4 | 43.5 | 40.9 | 34.6 | 30.4 | 27.2 | 25.7 | 23.0 | 20.3 | 14.8 | 8,896 | +2.0 |
| 114A | 56.5 | 60.6 | 61.0 | 60.5 | 54.7 | 50.8 | 43.3 | 41.3 | 38.2 | 36.8 | 15,004 | 6.9 |
| | 51.0 | 66.9 | 65.5 | 58.0 | 52.0 | 42.5 | 39.4 | 37.1 | 29.0 | 26.3 | 13,958 | |
| 391A | 26.5 | 28.1 | 25.2 | 23.3 | 21.2 | 18.7 | 17.2 | 16.3 | 16.5 | 15.8 | 6,294 | 8.0 |
| | 22.0 | 25.4 | 22.4 | 20.8 | 18.4 | 16.4 | 18.9 | 18.0 | 13.3 | 17.5 | 5,785 | |
| 386A | 23.7 | 31.7 | 33.2 | 26.5 | 23.6 | 23.4 | 23.3 | 24.5 | 23.9 | | 6,026 | 02.6 |
| | 34.1 | 36.0 | 29.3 | 33.9 | 31.1 | 27.1 | 23.1 | 21.6 | 17.1 | 9.9 | 6,024 | |
| 219A | 43.4 | 47.7 | 45.7 | 41.3 | 39.4 | 37.8 | 27.4 | 26.6 | 18.2 | 11.9 | 9,928 | 47.0 |
| | 23.6 | 29.9 | 31.5 | 27.0 | 23.0 | 24.7 | 23.9 | 19.4 | 13.2 | 10.6 | 5,306 | |
| 139A | 35.4 | 40.4 | 38.3 | 38.0 | 37.7 | 35.5 | 33.1 | 35.0 | 35.9 | 34.5 | 11,094 | 2.0 |
| | 23.4 | 49.4 | 46.8 | 42.7 | 36.2 | 35.2 | 39.3 | 35.4 | 30.7 | 25.8 | 10,830 | |
| 167 | 59.1 | 67.5 | 58.6 | 50.1 | 39.6 | 30.1 | 19.6 | 3.8 | | | | 35.0 |
| | 56.2 | 44.7 | 36.3 | 27.8 | 21.2 | 8.3 | 9.2 | 4.6 | 2.4 | | 9,844 | 3,463 |
| | | | | | | | | | | | 6,381 | |

Abortion occurred in the following lactation: 124A 2nd lactation, 245 days; 114A 3rd lactation, 236 days; 391A 2nd lactation, 228 days; 386A 2nd lactation, 255 days; 219A 5th lactation, 212 days; 139A 2nd lactation, 253 days; 167A 4th lactation, 163 days; 129A 2nd lactation, 236 days.

It was further possible to select twelve cows which furnished 19 lactations before becoming positive to the agglutination test and aborting, and 19 lactations after abortion.

Table 2. Milk yield before and after infection.

| | Number of ani- mals | Number : of lac- tations | Total milk pro- duction | Average : milk pro- duction | Per cent decrease |
|-----------------------|---------------------------|--------------------------------|-------------------------------|-----------------------------------|-------------------------|
| Prior to infection | 12 | 19 | 179,888 | 9,468 | |
| After abortion | 12 | 19 | 167,427 | 8,812 | 6.9 |
| Difference | | | 12,461 | 656 | |

The decrease in milk production was 656 pounds per lactation after abortion or a 6.9 per cent decrease in milk production.

In studying this herd it was also possible to select twenty head of cows which were reactors and compare them with an equal number of clean cattle. For each reactor it was possible to select, with the exception of three, clean or nonreactor females from identical sires and almost same approximate ages.

In selecting such animals it was felt that individual variance would be at a minimum and as mentioned before (41) these are all factors that must be considered in arriving at the loss in milk yield due to disease if accurate results are

to be expected. It was therefore possible to compare the milk yield, breeding or settling efficiency, calf yield and number of retained placentae from these two groups.

Table 3. Comparison of these two groups.

| Group | : : Number: : cows | :Total: : cow :years: | :Lacta- : tions | : Total : : milk : : yield | : Average : : milk : : yield | : Per : cent : decrease |
|------------|--------------------------|--------------------------|--------------------|----------------------------------|------------------------------------|-------------------------------|
| Negative | 20 | 115 | 67 | 636,400 | 9,499 | |
| Positive | 20 | 117 | 67 | 567,246 | 8,466 | 10 |
| Difference | | | | 69,154 | 1,033 | |

It will be observed that the total number of cow years is almost identical and the number of lactations are the same of each group. This being due to the fact that two of the negative group became infected with lymphocytoma and were lost early in this study.

The average milk yield being 1,033 pounds less per lactation or a 10 per cent decrease for the reactor group. This figure too is lower than that reported by other workers (22, 25, 35, 42, 47) with the exception of Minett and Martin (41).

It was possible by cultural methods to demonstrate the presence of Brucella abortus in fourteen of the animals in the reactor group.

Loss of Calves

The records show that there were 23 calves lost due to abortion in the 67 lactations of the reactor group and only 4 calves lost in the negative group during the same time, Table 4. There were 26 abortions but three of the calves born prematurely lived (228, 253 and 245 days). There were 3 premature calvings in the negative group but these animals were all negative to the agglutination test and the losses cannot be attributed to Brucella abortus infection. This is a loss of approximately 35 per cent of the calf crop of the infected group, and only a 6 per cent loss in the negative group.

Table 4. Calf losses in reactor and negative groups.

| Group | :Number: :cows | :Lactations | :Abor- :tions | :Retained: :placenta | :Calves: :lost | :Calves: :raised | :Per cent :raised |
|----------|-------------------|-------------|------------------|-------------------------|-------------------|---------------------|----------------------|
| Reactor | 20 | 67 | 26* | 16 | 23 | 44 | 65 |
| Negative | 20 | 67 | 3 | 2 | 4** | 63 | 94 |

* 3 calves born premature but lived (228, 253 and 245 days).
 ** 1 calf dead at birth full term.

Losses in Cow Herd

Breeding Efficiency and Sterility. The breeding efficiency of the reactor group was 3 services per cow and the negative group was 2.5 services.

There were 16 retained placentae in 67 gestations in the reactor group which had to be removed manually while there were only 2 or 3 per cent in the negative group. One can readily see why the per cent of sterility is higher in reactor cattle when such complications follow abortions. Furthermore it was necessary to treat 15 of the aborting cows 20 times before they conceived and only 7 of the negative group.

The average dairyman can tolerate the loss of a calf but when he encounters difficulty in settling a cow he becomes quite concerned because he not only disrupts his milk production schedule but also stands to loose the cow as a nonbreeder.

These are all factors which add considerable expense to milk production in herds with brucellosis.

Vaccinated and Nonvaccinated Animals. During this same period of study on milk production there were 175 calves at six months of age vaccinated with Bureau of Animal Industry strain 19 vaccine. Prevaccinal tests were conducted on all the calves prior to vaccination. Post vaccinal tests were conducted on all vaccinated calves to determine if titer developed as a response to the vaccine. These animals in most

instances were blood tested every six to eight weeks and all became negative to the blood test following vaccination with the exception of a few that were revaccinated at a later date with an additional dose of strain 19.

Out of a total of 173 animals that were calfhood vaccinated there were 27 animals that became reactors or positive to the agglutination test after coming into production. Ten of the 28 animals aborted and in each case the blood titer became positive before or about the time of abortion. The other animals were disposed of at the time the blood test became positive. Eight of the high producing animals have been maintained in the herd.

There were 59 adult animals, heifers and cows, that were clean or negative to the agglutination test and not vaccinated. Forty-four of these animals became infected and were positive to the agglutination test, Table 5. In other words, 74 per cent of the clean animals became infected with Brucella abortus. Following this outbreak the entire herd was vaccinated with Bureau of Animal Industry strain 19.

Table 5 shows the year and number of vaccinated animals that became reactors and also the number of negative or clean animals that became positive to the agglutination test.

Table 5. Number of reactors in herd 1943 to 1949.

| Year | : Number of calfhood : : vaccinated animals : becoming positive | : Number of nonvaccinated : : animals becoming : positive |
|-------|---|---|
| 1943 | 0 | 13 |
| 1944 | 0 | 12 |
| 1945 | 0 | 17 |
| 1946 | 6 | 1 |
| 1947 | 12 | 1 |
| 1948 | 9 | 0 |
| Total | 27 | 44 |

Table 6. Number of calves vaccinated each year and the number of positive animals by the agglutination test after they came into production.

| Year | : Number of calves : : vaccinated six : months of age | : Number of cows vaccinated : : as calves becoming reactors : to agglutination test | : Per : : cent in- : : fected |
|-------|---|---|-------------------------------------|
| 1943 | 24 | 5 | 21 |
| 1944 | 18 | 7 | 29 |
| 1945 | 39 | 9 | 23 |
| 1946 | 33 | 6 | 18 |
| 1947 | 36 | 0 | 0 |
| 1948 | 23 | 0 | 0 |
| Total | 173 | 27 | |

Table 7. Calfhood vaccinated animals that became infected.

| Animal: | Date | Date of | : | Date | Date | : |
|---------|----------|-------------------|-----|------------|-----------|---------|
| number: | of birth | pre-vaccinal test | : | vaccinated | broke | Titer |
| 122A | 1-14-43 | 7-23-43 | neg | 7-23-43 | 10-11-47 | 1-200 |
| 123A | 1-22-43 | 7-23-43 | neg | 7-23-43 | 3-3-48 | 1-200 |
| 124A | 3-23-43 | 7-23-43 | neg | 7-23-43 | 6-11-47 | 1-200+ |
| 128A | 12-4-43 | 7-14-44 | neg | 5-10-44 | 12-6-48 | 1-400 |
| 129A | 2-14-44 | 7-22-44 | neg | 8-9-44 | 3-4-47 | 1-200+ |
| 130A | 2-14-44 | 8-4-44 | neg | 8-9-44 | 9-30-46 | 1-200+ |
| 133A | 7-2-44 | 12-8-44 | neg | 1-5-45 | 1-9-47 | 1-100 |
| 136A | 8-2-44 | 12-8-44 | neg | 12-8-44 | 12-6-47 | 1-200 |
| 137A | 9-1-44 | 4-25-45 | neg | 5-24-45 | 12-17-46 | 1-200 |
| 139A | 11-28-44 | 4-25-45 | neg | 6-13-45 | 10-11-47 | 1-200 |
| | | | | 4-13-46 | | |
| 152A | 2-14-46 | 7-19-46 | neg | 7-19-46 | 9-22-48 | 1-400 |
| 254A | 12-11-44 | 4-25-45 | neg | 6-13-45 | 12-6-47 | 1-200 |
| | | | | 8-1-45 | | |
| | | | | 4-13-46 | | |
| 354A | 9-13-42 | 3-12-43 | neg | 4-29-43 | 12-17-46 | 1-200 |
| 361A | 1-30-44 | 5-22-44 | neg | 7-12-44 | 6-11-47 | 1-100 |
| 372A | 6-9-42 | 12-8-44 | neg | 1-5-45 | 10-17-46 | 1-200+ |
| 376A | 4-1-44 | 10-20-44 | neg | 10-20-44 | 9-30-46 | 1-200 |
| 377A | 1-25-46 | 7-19-46 | neg | 7-19-46* | 7-13-48 | 1-1600 |
| | | 10-1-46 | neg | 10-1-46 | | |
| 379A | 4-25-44 | 10-20-44 | neg | 10-20-44 | 12-17-46 | 1-100 |
| 380A | 4-28-44 | 10-20-44 | neg | 10-20-44 | 3-9-48 | 1-200 |
| 386A | 11-24-44 | 4-25-45 | neg | 4-25-45 | 10-11-47 | 1-100+ |
| 388A | 2-14-45 | 4-25-45 | neg | 8-1-45 | 6-11-47 | 1-200+ |
| 391A | 5-17-45 | 10-25-45 | neg | 11-3-45 | 6-11-47 | 1-200+ |
| 392A | 5-28-45 | 10-25-45 | neg | 1-9-46 | 12-6-48 | 1-1600+ |
| 397A | 1-25-46 | 7-19-46 | neg | 7-19-46* | 7-13-48 | 1-1600 |
| 451A | 9-1-42 | 3-9-45 | neg | 4-29-43 | 3-10-48 | 1-400 |
| 465A | 6-16-44 | 1-22-45 | neg | 1-22-45 | 5-5-48 | 1-2000+ |
| 472A | 1-3-46 | 7-19-46 | neg | 7-19-46* | 9-30-46** | 1-100 |

† Aborted.

* Dead vaccine.

** Anamnestic test.

The average duration of resistance to brucella infection under field conditions in the 27 animals vaccinated as calves at six months of age, was 2 years and 9 months, Table 7. In other words 15.5 per cent of the calfhooed vaccinated animals with Bureau of Animal Industry strain 19 became susceptible to brucella infection under field exposure. These results offer additional data that by exposing vaccinated animals to reactors or field infection does not increase the resistance or immunity of the vaccinated animals when they become adults. These results offer additional evidence that it is not advisable nor profitable to keep reactor cattle on the same premises when a vaccination program is used to eliminate or control Bang's disease.

DISCUSSION

It is fairly obvious why such wide variations have been reported in the milk loss or per cent decrease in brucellosis infected dairy cattle when one examines Tables 1, 2 and 3. Hooper (35) has pointed out that the milk flow is not greatly stimulated in early abortions whereas in later abortions the milk flow is greatly stimulated. Therefore when the milk yield is studied this factor must be considered. Minett and Martin (41) have also pointed out factors which must be taken into consideration in determining the milk loss due to disease such as brucellosis. These studies support these investigators

that the per cent decrease in milk yield due to brucellosis is approximately 10 per cent when these factors are considered.

The dairyman today is required by the dairies to produce the same quantity of milk from month to month throughout the year if he is to receive the greatest financial returns from his milk. It is therefore evident that it is of the greatest importance that he does not encounter abortion, difficult breeding, and sterility in his herd if he is to maintain an even flow of milk throughout the year.

The per cent of sterility no doubt is higher in the average infected herd as experienced from three years of field work in a milk shed than was encountered in these studies due to the excellent cooperation between the School of Veterinary Medicine and the Department of Dairy Husbandry. As mentioned previously when abortions are properly handled and treated the per cent of sterility may at times be very low.

When these results are analyzed, the average dairyman with a herd that becomes infected with brucellosis, may expect the following losses: a 10 per cent decrease in milk production, 30 per cent calf loss, 20 per cent increase in the number of retained placentae and the difficult breeders increased by 45 per cent over that of a negative or clean herd.

SUMMARY AND CONCLUSIONS

The records of 8 cows with a normal parturition and followed by an abortion, show a 13 per cent decrease in milk production for that period, compared with the normal period.

The records of 12 cows which furnished 19 lactations before becoming reactors and also furnished 19 lactations after aborting, show a decrease of 656 pounds of milk per lactation or a decrease of 6.9 per cent.

The records of 20 reactors and an equal number of clean cows whose sires were identical and approximately the same ages show a lowered production of 10 per cent or 1,033 pounds of milk less per lactation for the aborting group.

The calf losses for the reacting group of 20 cows were 35 per cent, whereas the losses for the negative group were 6 per cent. There were 26 abortions in the reactor group and only 3 in the negative group.

It was necessary to manually remove 16 placentae in 67 lactations for the reactor group and only 2 for the negative group with the same number of lactations.

The breeding efficiency of the reactor group was 3 services per cow and the negative group required 2.5 services per cow.

There were 15 cows of the reactor group which required sterility treatment before conceiving and only 7 of the negative group.

Abortions occur in animals that have been calfhood vaccinated with Bureau of Animal Industry strain 19 when exposed to field infection.

There seems to be a variation in susceptibility or resistance to invasion of field infection of Brucella abortus.

The duration of resistance to brucellar infection in calfhood vaccinated animals under field exposure appears to be approximately two years and nine months in this herd. Evidence is submitted indicating that exposure of calfhood vaccinated animals as adults does not appear to be of any beneficial value in creating additional resistance or immunity to infection with brucella organisms.

Calfhood vaccination alone will not control brucellosis. Every available means, as: careful and intelligent management, especially with regard to testing, isolation or removal of reactors, adequate sanitation, use of maternity stalls, vaccination and introduction of replacements, must be intelligibly exercised in order to control this devastating disease in the livestock industry.

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