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The Abortion Problem in Farm Live Stock

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DEPARTMENT OF ANIMAL PATHOLOGY AND HYGIENE



THE UNIVERSITY OF NEBRASKA
COLLEGE OF AGRICULTURE
EXPERIMENT STATION
LINCOLN

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THE ABORTION PROBLEM IN FARM LIVE STOCK

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INTRODUCTION

Animal husbandry is for its success fundamentally dependent on efficient reproduction and the preservation of its young stock. Not only are losses among the latter a prolific source of direct economic damage, but they also tend to create an equally serious disadvantage of a more indirect nature. Losses of young animals, unless a reduction of our live stock population can be tolerated, necessitate the setting aside of a larger number of females for purely reproductive purposes than would be required if such losses were not a factor. Our national needs of food and clothing and our agricultural progress and prosperity do not permit material reductions in the number of our farm animals and hence we are compelled either to compensate for the losses of young animals by increasing our breeding operations or to attack the problem by preventive measures. There are reasons, the discussion of which lies outside the scope of this publication, which compel us to give to disease prevention the preference as a means of solving our problem. From an economic as well as from a hygienic standpoint, it is the soundest policy to follow.

In the minds of many people the problem associated with the preservation of young animals begins with their birth. This view is erroneous, because even the prenatal existence of an animal is beset by many dangers. A young animal thus should be the object of hygienic care from the moment it is conceived; even before that event its safety might well be given consideration. The loss by death of the unborn animal or fetus materially alters its relation to its dam. From an object of the most ingenious care lavished on it by the maternal organism it becomes changed to a mere foreign body often of a very noxious nature and the womb casts it out if it is at all capable of such a perfectly defensive and legitimate act.

This casting out of a dead or at least abnormal fetus we call abortion. It constitutes the culminating accident in a process set into motion by disease or injury. To the breeder it is its

most conspicuous feature, and its more or less constant occurrence among live stock warrants us to speak of the abortion problem.

It is the purpose of this publication to lay before our Nebraska breeders such information on the subject as can be gathered from the more recent literature and from observations in the field and the laboratory.

THE RELATION BETWEEN FETUS AND DAM

Before engaging in an examination of the abortion problem as we meet it on our farms, it will no doubt be profitable to take a glimpse at the relations existing between the pregnant female and its unborn young. The latter, designated as embryo during its earlier stages and as fetus during the later ones, takes its origin from the union of the egg cell formed in the female with the fertilizing elements of the male. This union renders cell multiplication possible and by a series of cell divisions and groupings the formation of the young animal is brought about and completed.

During this process the embryo or fetus must derive all sustenance from the maternal body. It requires food and oxygen, and necessarily the waste products from its own body must be eliminated. The needs of the fetal body are precisely those of the adult body; the difference lies merely in the manner of supplying them. While the latter is compelled to provide for its own sustenance and is endowed with the means to accomplish this, the former is dedicated to a purely parasitic existence until the fateful event of birth. For this purpose it is provided with a most adequate equipment. This consists of temporary structures in the form of membranous coverings lying in a more or less intimate contact with or attachment to the wall of the uterus.

We speak of those structures as the fetal membranes, while the special means of attachment to the uterine wall are known as the fetal placenta. They are purely fetal structures and develop from the same source as the embryo or fetus itself. They are, as it were, a scaffolding used in the building of the new individual. With its birth they become superfluous and are cast off as the so-called afterbirth.

The blood supply of the fetal membranes and placenta is derived from the fetus, which has a circulation of its own not at all connected with that of the mother in a direct manner. The vessels of the membranes are branches of the arteries

and veins of the navel cord, which is the connecting medium between the fetus and its membranes, while the outermost one of the latter brings about the necessary contact with the maternal body.

While in its essentials the manner of contact with the mother is quite similar, there are great differences in its arrangement and methods of attachment.

Contact with and attachment to the maternal body is brought about by means of the penetration into the uterine wall of small conical projections arising from the outer fetal membrane. Each of those projections is called a villus. It has a rich supply of capillary blood vessels and by its penetration into the substance of the uterine wall the capillary vessels of the villus lie in the closest contact with those of the uterus. The proximity of the two sets of capillaries is so close and their vessel walls are so thin that it is possible for certain substances to pass from one set to the other and *vice versa* by a process known as osmosis.

It is in this manner that the fetus receives nearly all of its nutriment and oxygen from the circulation of the dam, while by the same route it yields to the latter such waste products as are formed during its life processes and which are then eliminated along with those arising in the maternal body itself.

The villi growing from the external surface of the outer fetal membrane, which is known as the chorion, may at first be nothing more than simple conical projections. They penetrate into the uterine wall in a manner comparable to that by which a growing root enters into the soil. They become larger and branched as pregnancy advances.

The arrangement and method of attachment of the fetal placenta varies considerably in the different animal species.

In the case of swine and horse, the fetal placenta takes the form of simple villi distributed over the surface of the chorion. In other species, such as cattle and sheep, the villi also occur over the entire surface of the chorion, but they are not evenly distributed and are concentrated in definite groups or areas, appearing as special structures to which the name of cotyledon has been given. In the dog and cat the fetal placenta is confined to a limited area, which surrounds the fetal sack like a girdle. Another form of fetal placenta is the one in the shape of a disk such as is seen in the rabbit and man.

In the animal species mentioned, with the exception of the horse and swine, the mucous membrane of the womb lying in contact with the fetal placenta also presents special features,

in the form of characteristic structures which receive the villi and their branches. Such structures are known as the maternal placenta. Especially in cattle and sheep they are extremely well developed and are represented by the mushroom like bodies to which the membranes of the fetus are attached and which are designated as caruncles.

THE GENERAL CAUSES UNDERLYING ABORTION

From what has been stated above it will be quite apparent that, while the fetus is in reality a distinct individual, its welfare must be closely associated with the proper functioning of the maternal body and that noxious factors present in the latter may damage it so far as the fetal placenta is incapable of refusing them admittance to the fetal circulation or so far as the placenta itself may be injured by them. In this respect the relation of the fetus to its mother is somewhat comparable to that of an internal parasite to its host.

When reference is made to the fetus it should be understood that this term includes all the temporary structures, such as fetal membranes and the placenta. Those are an integral part of the unborn animal and should never be looked upon as something detached from it.

Any damage to the fetal placenta and interference with its contact and normal relation to the maternal placenta or uterine wall jeopardizes the welfare, health, and life of the fetus proper. This damage, interrupting the food and oxygen supply or the elimination of waste matters of and from the developing animal, may cause its death. Death may likewise result from the action of germs operating within the body of the fetus.

Death or serious damage to the fetus usually results in its being cast out, and this act is spoken of as abortion. This is somewhat distinct from the expulsion of a live fetus before term, which is usually known as premature birth.

In accordance with what is stated above, abortion must not be looked upon as a disease by itself but as a result of disease or damage to the fetus. It represents the removal of something which has become useless in nature's plans, the dead or doomed fetus. It may also be looked upon as an act making for the safety of the mother.

THE SPECIAL CAUSES OF ABORTION

All causes or disturbances leading to abortion and their mode of action are not fully understood. Attempts to classify them have been made, altho classification remains imperfect.

The following types of abortion are recognized: (1) abortion due to mechanical injury, (2) abortion following acute infections in the mother, (3) abortion due to poisons, (4) abortion due to dietary insufficiencies, (5) abortion due to specific infection.

The latter group probably comprises more than 99 per cent of all abortions occurring. Those abortions resulting from the action of certain bacteria are often known as infectious or contagious abortions and will probably continue to be thus named in spite of the fact that the name fails to give expression to what actually takes place in the uterus of the animal involved.

It is not impossible that there occur in each animal species distinct bacteria the presence or activity of which leads to fetal death and abortion. In the following discussion of the abortion problem, only the type of infection responsible for the preponderating number of abortions will be given consideration.

THE ABORTION PROBLEM IN CATTLE

ABORTION CAUSES

Specific infection leading to abortion in cattle is widespread in all cattle growing countries and has assumed such proportions that it has become one of the most urgent problems in live stock sanitary practice. It is the direct cause of enormous financial losses: 1st, thru the deaths of the aborted calves; 2nd, thru interference with milk and meat production; 3rd, thru its compelling the breeders of the country to maintain a greater number of breeding animals than would otherwise be necessary for the recruiting of their herds; and 4th, thru those sequels of abortion which affect the breeding efficiency of cows.

It is more than probable that the number of cattle abortions which are not due to specific infection is so small as to be practically without economic importance. Therefore when abortions do occur it is always safest to assume them to be the result of infection and not of accidents or similar causes.

The cause of cattle abortion in nearly all cases is a germ which is known as the abortion bacillus of Bang, being so called after the scientist who discovered it and who first

proved its relationship to the disease. While in occasional outbreaks of abortion other germs may play a part, that part is considered to be so small that the following remarks on cattle abortion in this publication pertain exclusively to the abortion resulting from infection by the Bang organism. This is justified by the fact that, as already stated, this organism is the cause of mischief in practically all outbreaks, while furthermore the preventive measures recommended would also be largely applicable in the few outbreaks in which some other type of infection is playing a part.

THE SELECTIVE ACTION OF THE INFECTION

It can serve no useful purpose to describe here the bacteriologic characteristics of the Bang bacillus, but it will be all the more essential to study its relation to cattle, to ascertain how it travels, how it enters the animal body, what it does there, and how it again finds its way to the outside.

In the case of infection with Bang's bacillus, so far as it results in damage, we are confronted with a problem which cannot be compared with any presented by most other diseases. This is principally due to the fact that there are always two animals associated with the infection, each with an entirely different behavior in regard to it, and to the further fact that one of those animals is situated within the body of the other one, upon which it is dependent for sustenance.

The maternal body, while it serves as host to the infection and provides it with a suitable place of abode, is in no way damaged by it. In cattle, during postnatal life, the abortion bacillus cannot be regarded as disease producing. In mature cattle no disease damage can be shown which can be primarily charged to the Bang bacillus. In the many cases in which the writer injected enormous masses of abortion bacilli into nonpregnant cattle nothing resulted which could be interpreted as disease. It is true that in bulls lesions have been found which contained the abortion bacillus, but there is as much reason to believe that those organisms came to those areas and could remain there by reason of some previous damage as there is reason to think that the bacilli caused the lesions.

Infection with abortion bacilli thus causes no actual disease in mature cattle and when we follow the custom of referring to it as a cattle disease it should be understood that it pertains particularly to unborn cattle.

The relation of the unborn calf or fetus to the germ of Bang is quite different from that of the adult bovine. The

bacillus actually produces disease and tissue damage in the fetus, which is highly susceptible to the infection, which cannot defend itself against it, and which is bound to be destroyed by it unless it comes about so late in fetal life that the young animal by a birth at normal term can escape before its lines of communication with the dam's body are cut by the disease.

That the primary seat of damage is the placenta does not change the fact that infection by the Bang germ results in a disease peculiar to the unborn and not in a disease of the adult. The latter merely acts as infection carrier, a function which does not involve the adult in disease risks directly due to the bacillus Bang.

Risk there is, of course, when abortion takes place, but this risk is of an entirely different nature and is of a secondary character.

It is this two-animals-in-one complication which causes the abortion problem to be so particularly resistant to solution.

THE DISTRIBUTION OF THE INFECTION

It is by no means possible to explain in all cases how the abortion infection enters a herd which has previously been exempt from trouble. Inasmuch as the germ of Bang is an obligate parasite or, in other words, is always dependent upon the animal body for its propagation and increase, it can be readily seen that there must come about direct or indirect contact with infected animals before a previously healthy herd can become involved in the disease.

For this, of course, many avenues are open; and inasmuch as animals may be the carriers of the infection for a long time, it is usually very difficult to retrace the route along which the infection travelled.

In many cases this has, however, been done, and then it was found that newly purchased stock, outside cows, bred to the herd bull, or animals returning from stock shows or sales, proved to be the carriers of the initial infection. In a more indirect manner the infection may be introduced when the Bang bacillus is contained in feedstuffs which in some manner have become contaminated. Inasmuch as the germ can be commonly found in the milk of infected cows, it is evident that milk or milk products brought to a farm without previous sterilization, to be used for feeding, may prove to be the vehicle of infection. Other feeds may serve the same purpose, but milk is, no doubt, the one most to be feared in this connection.

The infection may adhere to the hands, garments, and utensils of persons who have been in contact with aborting animals or with animals which have recently aborted. Such persons coming in contact with other cattle may also serve as distributors of the disease.

THE PORTALS OF INFECTION ENTRANCE

In a disease which is so markedly associated with the reproductive function, it is not surprising that the genital organs were for a long time looked upon as the portal thru which the infection enters the maternal body. In the light of experimental results obtained and observations made during more recent years, this mode of entrance no longer figures as prominently as it once did, as the means by which an animal became infected. It must, however, still be considered as among the possibilities, and it should not be forgotten that several investigators have induced abortions experimentally by inserting infectious material into the vagina of pregnant animals. Altho some very competent investigators minimize, if they do not deny outright, the part played by the bull during service as a transmitter of the infection, it would at this time be folly to disregard its possibility. Such a mode of infection may not be as common as it was once considered to be, but in the practical management of the disease it will always be better not to take chances with a possibly infected bull.

Bulls may be themselves infected and eliminate the Bang organisms with their semen. In such a case their blood will show the same specific reaction as that of the infected cow. They may also be infected without eliminating germs. All this depends, of course, on the seat of the infection within their bodies. It is further possible that bulls will be merely soiled with infectious material. In such a case the infection adheres to the external genitals, for example, as a result of serving cows with infectious vaginal discharge. Such a contamination may not result in a lasting infection of the male, but he might transmit infection to the next cow he serves. Whether this danger be small or great, it should as yet not be disregarded.

The most common avenue by which the infection enters the body is the digestive canal. The possibility of this mode of entrance has been proved by numerous experiments and it is all the more probable under natural conditions, because not only does it afford opportunity for the acquisition of larger amounts of infectious materials than would be the case in vaginal infection, but entrance of bacilli into the uterus via

the digestive system and the blood stream can be more readily accomplished than by the vaginal route. It is thus more than probable that the majority of all cases acquire their infection thru the drinking of infected milk or thru the eating of feed, fodder, or bedding which had become soiled by aborted calves, afterbirths, or the uterine discharges of cows which have recently aborted. Attention must further be called to the tendency of one cow to devour the afterbirth of another one and the danger attendant on this habit.

Another possible point of entry has more recently been pointed out, and that it thru the teat canal. It is well known that infected cows are apt to harbor the Bang bacillus in their udders and that from there it is commonly expelled with the milk. This being the case, the possibility of the germ being transmitted from cow to cow on the hands of the milkers must be conceded, altho it does not seem likely that it plays an important part in the dissemination of the disease.

THE LOCATION OF THE INFECTION

After the abortion germs have entered the body, the paths followed by them and their wanderings thru organs and tissues are difficult to trace. This is especially so because the bacilli cannot be found outside of a number of very definite locations.

Those locations are probably the only places in the body in which the infection can maintain itself, altho its occasional occurrence in other parts must be tentatively accepted.

The places in the body in which the abortion bacilli maintain themselves, in which they increase in numbers, or for which they have a particular predilection are (1) the fetal placenta, membranes, fluids, and body organs; (2) the cow's udder and its lymphnodes; and (3) certain portions of the male reproductive organs.

FETAL TISSUES THE MOST VULNERABLE

The most favorable place for the abortion bacilli is the contents of the pregnant uterus and there they are particularly attracted by the fetal tissues. It does not appear from any evidence now available that the nonpregnant uterus has any special attraction for the Bang organism or that the latter will find conditions there which are at all suitable to its well-being. The fetal tissues which form within the uterus, on the other hand, appear to be the ones in which abortion bacilli thrive best and in which they can manifest their disease-producing qualities. The infected pregnant uterus, no doubt, fur-

nishes the principal source of infection. No sooner has abortion taken place and the uterus thus cleared itself of the medium so suitable to the Bang bacillus than the infection commences to disappear from that organ. Investigations upon which considerable reliance can be placed revealed the fact that three weeks after abortion the uterus no longer showed evidence of the infection. It appeared further that two months represent about the longest period during which abortion bacilli can maintain themselves in the empty uterus. Intrauterine infection is thus entirely dependent on pregnancy or on the presence of fetal tissues. To the nonpregnant uterus the abortion bacillus appears to be entirely harmless.

THE UDDER AS INFECTION RESERVOIR

Cows involved in abortion disease were found to frequently harbor the Bang bacillus in their udders and it is quite probable that the udders of practically all cows which actually abort are at least temporarily infected.

It does not appear that the infected udder is damaged by the presence of the abortion bacilli. The latter apparently find in the udder conditions suitable for their growth.

Multiplication within the udder proceeds but slowly and is not to be compared with that which takes place in the tissues belonging to the fetus. The bacilli are, however, reproduced in sufficient abundance to appear in the milk either periodically or constantly.

How long the udder may remain infected cannot be stated with great clearness. There is a tendency to persist indefinitely. One investigator reports one case in which the udder infection endured from the time of its discovery until the cow died, seven years later, and some others in which it persisted from one to four years.

Exit with the milk is not the only way by which the bacillus may leave the udder. Its having been found in the lymph nodes which receive the lymph drain from the udder indicates that the germs may travel with the lymph and blood streams away from the udder. This occurrence may indicate how an infected udder may serve as a more or less permanent reservoir for the infection. When the infected udder belongs to a nonpregnant animal, the bacilli which escape into the lymph or blood vessels probably succumb during their migration thru the body, as no suitable place of abode is offered to them. In the case of the pregnant animal the migrating bacilli finding their way to the uterus will not be slow to invade the fetal tissues, which are so remarkably suitable for their growth,

and to bring about there the changes ultimately responsible for the death of the fetus.

THE INFECTION IN THE BULL

The fate of abortion bacilli in the bull is not so well understood. In the opinion of the writer the bulls in infected herds take in the Bang organisms with contaminated food and otherwise just as much and as often as the cows do. Inasmuch as the body of the bull has nothing to offer which compares with the udder and pregnant uterus as suitable media in which to grow and thrive, the invading germs sooner or later perish. If enough of them are introduced or if the infection is of frequent occurrence, they will, of course, cause the blood to eventually show the characteristic reactions peculiar to Bang's disease.

In some cases, however, it appears that the abortion bacillus may become localized in the body of the bull. In most cases of this kind described, the testicles or the seminal vesicles were involved. They occurred in such lesions as abscesses, softened areas, and inflammatory centers. Whether some previous infection or damage to those tissues fitted them as abodes for the Bang bacillus or whether the latter was actually responsible for the changes mentioned cannot be said with certainty at this time. True it is, however, that the tissues of the bull have occasionally been found to be invaded by the Bang bacillus. It also appears to be true that in some instances this organism was shown to be eliminated from the body with the semen. So far as present indications show, however, there does not seem to be a great volume of evidence which compels one to recognize this source of infection as being a very formidable one. The actual infection of the bull, as described in the preceding sentences, must not be confounded with the soiling of some part of the body surface of the bull with infectious material. The two conditions are of an entirely different nature.

THE DAMAGE TO THE FETAL TISSUES

As already indicated, the only tissues which are prone to be damaged by the Bang bacillus are those belonging to the fetus and more particularly that part of the fetus which constitutes the fetal membranes and the fetal placenta. The latter especially offer the best medium of growth and it is in them that the disease-producing qualities of the germs are most manifest. It does not appear that the maternal placenta is primarily involved, but disease of the so intimately con-

nected fetal placenta cannot progress very far without also bringing about changes in the maternal structures placed in direct contact with the affected areas.

Examination of the parts concerned at the time of the maximum degree of infection will commonly reveal the fact that, while a varying number of the cotyledons still present their normal red, reddish-brown, or dark red color, many others will show a yellowish red or dirty yellow discoloration. When the fetal and maternal placenta are separated, the villi present a bloodless, gangrenous appearance and the space between them is often filled with a yellow, purulent material in which flakes of fibrin may be observed. In others there may be present a watery or mucous exudate, which separates the villi more or less and which may be either clear or cloudy enough to suggest pus. In the space situated between the outer surface of the chorion and the wall of the uterus of the infected cow, accumulations of a viscid exudate mixed with fibrinous or purulent material may be found.

The manner in which the lesions are distributed shows a considerable degree of variation. In some animals nearly all the cotyledons present the changes mentioned more or less conspicuously. In other cows, healthy and diseased cotyledons occur in distinct groups; and while in one part of the uterus they have a perfectly normal aspect, they present in another marked evidence of disease. Even in the same cotyledon normal and diseased portions may occur side by side.

The fetuses proper may also show some degree of variation in the evidence of disease as they belong to different cows. In some no changes can be observed even if the cotyledons are badly diseased. In others the body cavities are filled with a bloody, serous fluid and there is a dropsical condition in the connective tissues under the skin. In a number of cases such organs as the stomach, the intestines, and the spleen may present abnormal changes.

Cases occur in which the fetus presents evidence of decomposition and putrefactive decay, while more rarely the dead fetus instead of being expelled is retained and becomes mummified.

HOW THE INFECTION LEAVES THE BODY

The manner in which the Bang bacillus leaves the body of the infected animal is of the utmost importance in its bearing upon the solution of the abortion problem. From a sanitary point of view the veritable exodus of enormous numbers of abortion bacilli at the time that the infected fetus is expelled

is no doubt of the greatest moment. Then the thoroly infected mass comprising the fetus proper, its membranes, placentae, and fluids is thrown out of the body and is not infrequently permitted to contaminate premises, pastures, feed, and water in a most profuse manner. At the time of abortion the greater part of all the infection carried by the dam and its fetus is thus more or less suddenly eliminated. It would, however, be a serious mistake to believe that this explosive exodus of bacilli takes place only during actual abortion. In this connection it must not be forgotten that the infection does not constantly lead to abortion, because infected cows may calve normally and yet by this act set free great numbers of germs. In infected herds thus the cow which does not abort as well as the one that does must be given attention on account of the possibility just mentioned.

While the expulsion of the fetus is accompanied by the exit of the greater part of the bacteria present, the latter continue to be discharged from the uterus for a number of weeks after calving or aborting.

The udder, likewise serving as an infection reservoir, is responsible for the fact that the Bang bacilli may also leave the body with the milk. This elimination cannot be compared with that which takes place during the emptying of the infected pregnant uterus. The escape of bacilli with the milk, altho more persistent, does not provide the overpowering number which make an actual abortion so formidable as a source of further mischief. While the bacilli in milk are, of course, a potential danger to clean animals and herds, they are not apt to be a very prolific source of infection for mature cattle unless unusual conditions are present.

Indirectly such milk may also play a part in the dissemination of infection. When fed to calves the latter may become the means of scattering bacilli with their bowel discharges and this avenue of elimination must also be given consideration.

Lastly the escape of the bacilli with the semen of infected bulls must be mentioned as one of the means by which the infection can escape from the body of a host.

THE INFECTION OUTSIDE THE BODY

There is but little information which shows how long abortion bacilli may remain alive when once removed from the animal body. Experimental evidence which tends to throw light on this question indicates that the Bang bacillus contained in placentae will not survive much beyond four months,

but that carefully preserved in culture tubes it may retain its vitality as long as three years. There are, however, so many influences active under natural conditions that it seems futile to attempt to draw hard and fast lines regarding the existence of the abortion germ when outside the animal body.

SEXUAL MATURITY AND INFECTION

The susceptibility of cattle to infection with Bang bacillus increases with the approach of sexual maturity. Blood tests made with the blood of calves born of infected mothers frequently give positive reactions during the first weeks of their lives. Those reactions soon change to negative ones, and this occasionally in spite of the fact that they are nourished with milk derived from infected udders. These observations tend to show that the calf or young bovine prior to sexual maturity is not a very suitable host to the abortion infection. With the approach of sexual maturity, however, or with its attainment, the bacillus will find in the bovine animal opportunity to maintain itself, in the nonpregnant animal in the udder alone, and in the pregnant one both in udder and in the uterine contents.

THE TIME OF ABORTION

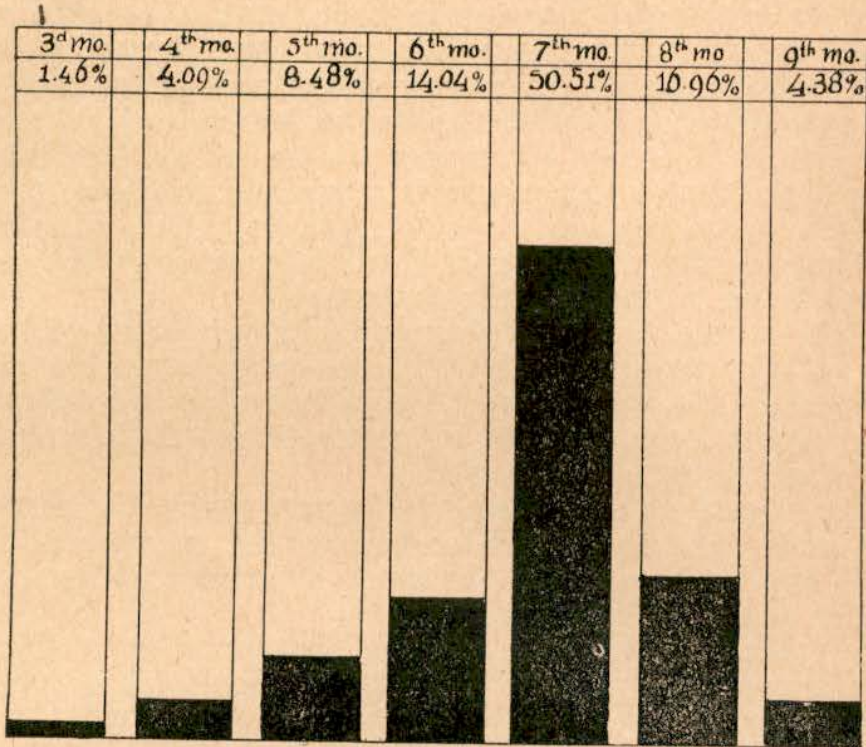
When infection with the Bang bacillus actually leads to such damage as results in the death of the fetus and its expulsion, a certain period necessarily elapses between the induction of the disease and the actual occurrence of the abortion. This space of time has been called the period of incubation. It is probable that in infections with the abortion bacillus this term should mean something entirely different from the period which closes with the actual abortion inasmuch as the latter act is more a sequel of infection than a symptom of it.

The time elapsing between the initial infection and the expulsion of the fetus is not readily to be determined. It probably ranges between one month and the duration of the full period of gestation.

Abortions are apt to occur during any stage of pregnancy, but the great majority are observed between the fourth and the eighth month of pregnancy. It appears that the seventh month shows the greatest number of abortions.

The following graph, projected from the data published by Zwick and Zeller, indicates how in a large number of abor-

ting animals the abortions are distributed over the gestation period.



Per centum of abortions occurring during the different months of pregnancy. (Graph projected from figures published by Zwick and Zeller.)

There is a tendency of heifers to abort during an earlier stage of pregnancy than cows which have raised calves before they became infected or which have sustained previous abortions. It is probable that the time of infection and the virulence and amount of the same exercise a greater influence on the time of abortion than the stage of fetal development does.

ABORTION PHENOMENA

When as a result of infection by Bang's bacillus the life of the fetus has been either destroyed or seriously impaired, the impending expulsion of the uterine contents is commonly manifested by certain preliminary symptoms. Those signs simulate the ones which announce the approach of a normal parturition. The external genitals become swollen and a glary thick mucus may be discharged from the vagina. The udder swells or "springs" as it is often called, preparatory to the function of milk secretion. The flanks become sunken in and the ligaments of the pelvis soften.

The actual expulsion of the fetus is but rarely accompanied by any difficulty. When the abortion takes place during the earlier stages of pregnancy the fetus is expelled while enclosed in its membranes; but when the expulsion takes place at a later period, the membranous sack is ruptured and the fetus proper expelled first to be followed later by the membranes, which are then commonly spoken of as "afterbirth." In this type of abortion, there is a marked tendency for the afterbirth to be retained, a circumstance which should not fail to engage the attention of those interested in the health and well-being of the animals concerned.

On the whole, the cow aborting does not seem to be the worse for the experience, but the untimely expulsion of the fetus renders the animal most liable to certain complications which express themselves in such results as septic inflammation of the uterus, sterility, etc.

After abortions occurring late in pregnancy, the secretion of the udder shortly before and after the expulsion of the fetus is apt to assume the character of colostrum as seen in the cases of normal parturition.

The milk soon becomes normal and in animals aborting late in pregnancy may be secreted in desirable quantities. Animals aborting early in pregnancy, however, may become dry, altho this is by no means sure to occur.

Cows which abort without retaining the afterbirth for any length of time soon recover and will conceive again when bred. A number of animals continue to abort at each succeeding pregnancy a number of times, and more particularly so when they are bred during the heat periods immediately after the abortion. Many animals will, however, carry their calves to normal time after one or more abortions and they may even do so while they continue to carry the infection.

The retention of the afterbirth is a very common sequel to the abortions resulting from specific infection. In fact, it is so common that herds in which this retention is of frequent occurrence may be suspected of harboring abortion infection, whether actual abortions do occur or not. The retention of the afterbirth is often responsible for secondary infections which destroy the animal's capacity for reproduction and is one of the most common causes of sterility subsequent to abortion.

INFECTION BEHAVIOR

The behavior of the Bang infection in herds is subject to considerable variations. In some herds more than half the cows will abort during a certain year and then the disease will

decline so that during the next gestation periods the calf crop may reach an almost normal proportion.

Or, after a few abortions, none more occur and the disease disappears completely. In other herds the toll of calves lost by abortion may not be very high, but the losses recur from year to year. It is always difficult, if not impossible, to foretell what course the disease may take in a given herd and how long it will continue to do damage. This pertains especially to herds in which the disease is not opposed by any preventive measures, in which the infection has practically free range, and into which new stock is frequently being introduced. It is possible that the variations in the behavior of the disease in herds is associated with differences in herd management and breeding practices.

PERSISTENT INFECTION CARRIERS

Among infected cattle, whether they have aborted or not, there is always a considerable proportion of animals which will continue to harbor the infection for long periods, years even. It is not always certain that the organisms carried by such animals continue to be possessed of a degree of virulence which would render such animals particularly dangerous. Such animals, however, may abort after having carried a number of calves in a normal manner. This may be due to new infection, but in the absence of evidence pointing to the contrary such animals must be regarded as sources of mischief and there is certainly good reason for not introducing such virus carrying cows into infection free herds.

RECOGNITION OF THE INFECTION

The existence of such animals and the importance of knowing whether an abortion is due to specific infection or not has directed the investigational activities quite early into attempts to secure some reliable and specific method by which the prompt diagnosis of the infection can be made. Such a diagnosis is now quite possible in more than one way. The changes in the fetal envelopes and placenta as described above may serve as a guide toward correct conclusions after an abortion has taken place.

The recognition of the Bang bacillus in the fetus and its membranes accurately establishes the true nature of the infection. This method, however, is only of practical value when a bacteriologic laboratory is near at hand, and even then the results of such examinations are often miscarried by the fact that the degree of contamination or putrefaction in

the materials submitted interferes with or hinders the isolation of the organism.

For general purposes, the so-called blood tests, even if they are by no means perfect, may be regarded as being the most useful. As a result of infection with the abortion bacilli, there form, in the animal body, substances which can bring about well defined reactions when brought in contact with the bacilli as the latter are grown in the laboratory or with certain products of the organisms.

Two such tests are in use for the detection of the infection by the Bang bacillus. They are called the agglutination test and the complement fixation test.

For the purpose of either of these tests a small quantity of the animal's blood is drawn into a sterile bottle by inserting a hypodermic needle into the jugular vein. (For the preparation of blood specimens for laboratory examination see Nebraska Agricultural Experiment Station Circular 16.) The bottles are properly labelled so as to correspond with the number of the cow whose blood is contained within. The samples are then forwarded to a laboratory prepared to undertake the required examination. In Nebraska, the Department of Animal Pathology and Hygiene, College of Agriculture, can undertake the examination of a limited number of such specimens.

When a test made with the blood of a given animal yields a positive reaction, this must be accepted as evidence that the animal is at the time carrying infection or has been doing so at some time prior to the test. It never means that an animal will abort or has aborted and neither does it mean the contrary. Neither will a negative test result permit the interpretation that the animal involved will not abort. The result of the test merely establishes the fact that in the animal contact was made with the Bang bacillus and that the latter entered the tissues, whether it remained there or not.

The blood tests are valuable means, however, to ascertain the absence or presence of specific infection in a given herd and yield a fairly accurate picture regarding the extent of the distribution of the infection.

In view of the fact that so many cows remain infection carriers for very long periods, the tests have become more valuable than they were thought to be before this feature of infection carrying became better known. At least one investigator has conclusively shown that by means of the agglutination test a herd can be cleaned from infected cattle, if the test

be undertaken at definite intervals and cows giving a positive reaction be immediately removed. The tests are perhaps most useful when used in connection with new cattle which are to be introduced into an infection free herd.

IMMUNITY OR RESISTANCE

It is a matter of common observation that the abortions due to the Bang infection have, in the herds involved, a tendency to disappear. Many animals belonging to such herds abort only once, and subsequent abortions become more rare with succeeding pregnancies. Stated in other words, the infection is self-limited and is inclined to disappear gradually, at least so far as the occurrence of abortions is concerned. There are authorities who deny such a self-limiting nature of the disease and who claim that the disappearance of the infection is rather more apparent than real. No doubt the behavior of the disease may show marked variations in different herds. The fact remains, however, that in a great number of herds in which for some time the calf crop has been considerably reduced on account of abortions, the losses decline and the calves, born fully developed and healthy, again approach the normal number.

This phenomenon is generally considered to be evidence of an immunity or a resistance to the infection on the part of the animals which have been exposed to it. No doubt something akin to immunity or to an immunity reaction may have some relation to this aspect of the case, but the fact that such so-called immune animals continue to remain infected with the Bang bacillus and after two or three pregnancies with normal termination again abort as a result of infection is somewhat disturbing to the conception of an absolute protective immunity.

The propriety of speaking of a cow's immunity might be further questioned on the ground that it does not appear that her tissues are at all actively involved in the infection. It is not to be doubted that there form in the cow's tissues or body liquids specific antibodies, which may be antagonistic to the invading organisms, but those are not constantly sufficient to destroy them. The persistence with which an animal remains a virus carrier may be looked upon as evidence in support of this contention. The function of the maternal animal thus is that of a virus carrier, a reservoir of an infection which is of no consequence to her *per se*.

On the other hand, the fetus is always vulnerable to the infection. It is doubtful whether it can receive from the ma-

ternal circulation sufficient protection by immune substances to escape serious consequences to its tissues when once the Bang bacillus invades them. It is highly probable that even in the so-called immune cow the fetal tissues are as susceptible to the damage caused by the disease as in the recently infected one. The best that a so-called immune cow can do for her fetus is to prevent virulent bacilli from invading the uterus contents.

It is not altogether impossible that a rather complex biologic process is involved in the instance named above and if so that this process has not yet been exposed by experimental research.

When it is assumed that the fetus and the structures which essentially belong to it are always in a state of high susceptibility, no matter in what sort of a cow they may be situated, how can the fact that cows, constantly infected, carry their calves to full term be accounted for? How may we further account for the cessation of abortions in herds which formerly were disastrously afflicted and in which many animals continue to carry the infection?

In the absence of experimental data of an exact nature, those questions can only be approached by hypothesis at this time. As already stated, the explanation nearest available is that of a simple protective immunity developed by the once infected cow. This may be objected to because a cow may fail to abort one or more times, in spite of the fact that she constantly harbored the infection, and then abort again. It must be granted that a virus carrying animal may be immune enough to protect her susceptible fetus from harm, but then she may be expected to do so permanently, while her immunity is being sustained by the constant presence of the infection. That this is not always the case may be due to unexplainable increases in the number of the bacilli or to increases in their virulence in the face of which the cow's defense of her fetus is inadequate or to unknown fluctuations in the amount of protective substances available for the purpose.

The phenomenon described may be interpreted in another manner, however. It is quite possible that it is to be entirely ascribed to a loss of the disease producing qualities of the organisms carried by the permanently infected cow. Fluctuations in virulence are by no means an uncommon feature in many disease producers and there is experimental evidence that the abortion bacillus is not an exception to this rule. It is highly probable that the virulence of this organism is

especially maintained by sojourn in fetal tissues. All observers are practically unanimous in pointing out the extreme infection danger caused by recently aborted material, and this danger is as apt to be associated with greater virulence of the bacteria as with their extraordinary numbers in such cases.

By vegetating in the tissues of the nonsusceptible cow, this virulence may be lost merely thru the temporary absence of the favorite culture medium furnished by fetal structures; or, what is still more probable, the immunity mechanism of the cow has an attenuating influence on the pathogenic powers of the bacteria. It is conceivable, as long as the latter are subjected to this influence to the extent that they become increasingly incapable of causing mischief, even in the fetal structures, that at the same time their powers of multiplication may become correspondingly impaired.

In spite of all obstacles of this nature, the attenuated organisms may find their way into the fetal structures of a new pregnancy and there gradually recuperate their power of causing actual disease. When this occurs at a period not too close to the time of normal termination of the pregnancy, abortion may occur again as a result.

It is, however, by no means certain that the resumption of abortion in a presumably immune cow is always due to the original infection. The writer remembers instances of such cows aborting when introduced into some other herd in which abortions were taking place at the time and some other instances of their aborting without leaving the herd after newly purchased animals lost their calves shortly after arrival. It is highly probable thus that the recurrence of abortion must be ascribed to a new infection by germs directly obtained from freshly aborted materials, or, in other words, that those highly virulent organisms could find entrance to the fetal structures before they could be attenuated or otherwise acted upon by the protective substances of the presumably immune cow. Once arrived in the fetal placenta, they are no longer subject to the influence of the dam's immunity to an extent sufficient to prevent mischief.

To what extent these views or any one of them are or is in accordance with the facts is for further experimental inquiry to decide. The fact that the animals of no herd are safer from the recurrence of abortion than the ones belonging to one into which no new animals are introduced lends some support to the latter hypothesis being the more satisfactory one.

THE FUTILITY OF ABORTION CURES

Many remedies against abortion have been recommended, many "sure cures" are on the market. When such remedies were tried under adequately controlled conditions, they proved to be utterly worthless and there is the best reason to believe that the "sure cures" are no better. When consideration is given to what actually happens in abortion infection, no results other than negative can be expected from drug medication. Whatever good results have apparently been obtained from medicinal treatment must be entirely credited to the tendency of the disease in certain outbreaks to disappear spontaneously.

A frequently asked question may also be disposed of at this juncture, and that is: What can be done to ward off abortion in an infected or presumably infected animal? The answer is: Absolutely nothing. Progressive infection of the placenta leading to death of the fetus cannot be arrested by any medical, surgical, or biological procedure now known.

THE VALUE OF PREVENTION

When the abortion problem is to be faced, our entire dependence must be placed on preventive measures and management aiding such features of the disease and such defensive functions of the animal body as tend to restrict the progress of the infection.

THE MANAGEMENT OF THE CLEAN HERD

In dealing with the abortion problem the first consideration must be given to the infection free herd. It is altogether too common that breeders never give a thought to the abortion problem until the disease has invaded their herds. As a matter of fact, abortion infection like tuberculosis is a problem of all owners of breeding stock and if they are not actively engaged in eradicating it from their herds they should, for the sake of their own profit and progress, be vigilant against its introduction.

Certain barriers should be thrown around the abortion free herds. Before a new animal is introduced into the herd its assured freedom from infection should be thoroly challenged. The best means of doing so is by a blood test, some two weeks after the arrival of the animal concerned, which, pending the test, should be kept segregated from the herd. When such a test is not practicable, the animal should be kept in isolation until her calf is born in a normal manner.

If in the buying of new stock preference can be given to young, unbred heifers, this should be done, if at all feasible.

Owners of infection free herds should not permit their herd bulls to be used for the breeding of outside cows, even if some authorities minimize the part played by the male as an infection spreader. Freedom from infection is too valuable an asset to be jeopardized by taking liberties with the herd bull. Bull associations are particularly urged to keep the bull in mind as a possible means to disseminate the disease. The least that can be done in this direction is the disinfection of the bull both before and after service. In order to accomplish this the sheath should be irrigated with a weak antiseptic solution (one half per cent liquor cresolis compound in warm water) by introducing a common horse catheter attached to an irrigator as far as possible into the sheath. The tuft of hair near the opening of the sheath should be kept clipped quite short, and previous to irrigation the lower part of the abdomen should also be washed with a mild antiseptic.

Bull associations should be informed by blood tests in regard to the distribution of the infection among the herds belonging to the members. If circumstances require such an arrangement, separate bulls should be kept for clean and reacting herds.

Common or public pastures should not be patronized by breeding stock, and all other forms of promiscuous contact with other cattle should be avoided.

Care must be exercised in the use of outside milk products on the premises where breeding cattle are being kept. The best precaution is to pasteurize such types of feed.

In addition, stable cleanliness and clean methods of handling the cattle, their feed, and all that comes in contact with them must be looked upon as very useful in the prevention of this infection.

Some of the measures taken when dealing with infected cattle also have a place in the management of the disease free herd. This refers particularly to isolation of all parturient animals in the so-called maternity stable.

THE MANAGEMENT OF THE INFECTED HERD

The problems presented by the infected herd, as a rule, vary somewhat in accordance with the extent of the prevailing infection.

The abortion menace in all good herds places emphasis on the importance of good herd management. The latter certainly includes a well kept breeding record of all animals.

The owner should know of each animal when a normal calving may be expected. It also includes a more or less close supervision of all animals, so that the pregnant cow showing signs of approaching abortion may be at once safely segregated. This fact alone is of the highest importance because the act of abortion is accompanied by the escape of an enormous amount of infection. When the first aborting cow can be isolated so that the contamination of an entire stable or part of a pasture can be prevented it becomes possible to destroy the infective material in an extremely effective manner.

The aborted fetus and the afterbirth as well as the bedding are to be carefully removed, without bringing those materials in contact with anything else. They are best destroyed by burning but when this is not possible they should be buried deeply, preferably at a place not frequented by any cattle. The infected afterbirth passed in the pasture or on the range is a most serious menace to the breeding efficiency of a herd, owing to the likelihood that it will be eaten by some of the other cows.

The next step is to disinfect the stable in which the abortion has occurred, and this must not be done in a perfunctory manner. The soiled exterior of the cow must also be carefully cleaned and disinfected and all utensils used in the removal of the aborted material, such as shovels, manure forks, wheelbarrows, and the like, must be included in the process.

It was once thought that disinfection of the interior of the uterus was a valuable means of destroying the germs remaining in this organ and thus of assisting the animal in getting rid of the infection. The importance of the uterine irrigation is no longer emphasized for the reason stated, but there is frequently a better reason for this form of treatment and that is the prevention of the consequences of secondary infections which may ultimately result in sterility.

The danger is always present and to be feared when the afterbirth is being retained and this is of common occurrence in abortions of the kind under consideration. As the breeding efficiency of the aborting cow is at stake whenever an afterbirth is being retained, a few words on this subject may not be amiss, even at the risk of unduly lengthening this discussion.

Dealing with the afterbirth is by no means so simple a matter as it often appears, and its injudicious, unskillful, or incomplete removal is fraught with danger to the cow, and the writer is painfully aware that many good cows are ruined

annually by amateurish tampering with the afterbirth. A good authority on this subject once advised that if one is not perfectly skilled in this manipulation, the best thing to do is to leave it alone. Thus if a good veterinarian can be secured for this work, this should be preferred, and particularly so in the case of a very valuable breeding animal.

Unless it is quite certain that all of the afterbirth came away with the fetus, the uterus of the aborting cow should always be explored by hand in order to make sure that none has been retained. A part only may have been passed and the retention of the remainder will not differ in its consequences from that of the whole.

When all or part of the afterbirth has to be taken away there is no special urgency to do so within the first 48 hours after the abortion. At the end of this time, however, the removal should be undertaken.

After placing the cow in a suitable position, the parts involved as well as the hands and arms of the operator should be thoroly cleaned. The hand and arm are then inserted into the vagina and the uterus. When the latter is partially closed so as to prevent the hand from entering freely, the opening should be slowly dilated by arranging the fingers into a cone, which is then very gentle and gradually pressed thru the narrow passage. The long nozzle of an irrigator is then passed into the uterus along the operator's arm and the uterine cavity flushed or partially filled with a weak antiseptic solution. A carbolic acid solution composed of one part of the antiseptic to two hundred parts of warm water and well mixed is strong enough for the purpose.

After this is done, the protuding part of the afterbirth is grasped by the disengaged hand and gentle traction applied to it. The hand within the uterus can now begin to loosen the fetal placenta from its attachments to the uterine wall. Each one of the cotyledons must be given attention and be carefully peeled loose from the mushroomlike caruncles until they all have thus been detached. The entire mass now comes away, and after carefully exploring the entire cavity for remnants still adhering, the uterus can be given its final flushing. A very weak solution of iodine in water (one part of iodine to one thousand parts of water is strong enough), used in abundance, is quite suitable for the purpose. This irrigation may be repeated from day to day if the persistence or foul character of the vaginal discharge renders it advisable.

The cow which aborted should remain in isolation at least

until all evidence of discharge has disappeared. In herds in which abortions are common and in which their occurrence is particularly costly, provision may be made for stable facilities, so that all parturient animals, either normally so or prematurely, can be isolated whenever a normal birth or an abortion is impending. In aborting herds no distinction needs to be made between the two because of the fact that even in apparently normal births a large amount of infection may be scattered about. Such maternity stables, as they are called, are a most valuable asset in the management of an aborting herd. Any infection can be promptly confined and destroyed there and the general stable or even a pasture can thus be kept free from infection danger.

Cows which aborted should not be bred again until some two or three months after the event. The longer the breeding is delayed, the better the chance that the succeeding pregnancy will terminate normally.

If it is possible to remove the pregnant animals to some noninfected stable or pasture immediately after the first abortion has occurred, it may be the means of a considerable degree of protection. It should never be forgotten that the infection danger in a stable or pasture is always greatest after a recent abortion.

In some cases it may be advisable to sell the first aborting cows to the butcher, but when the disease has once gained a foothold in a herd the best policy is to keep such animals and to deal with them in accordance with the plan mapped out above. When no animals are sold and none are bought the abortions are apt to disappear on their own account because of the so-called immunity or because of the gradual attenuation of the infection. Such herds offer less difficulty in ridding them of abortion than the others in which there is a constant going and coming of breeding stock. None of the first cows aborting in a herd should be sacrificed, however, until the entire infection status of the herd has been revealed by a blood test.

In the aborting herd the bull should be managed in the manner already indicated, while all that has been said regarding stable sanitation and cleanliness in the protection of the clean herd is to be even more urgently considered in this case. The contact between cow and bull should be limited to the time of service only.

In the management of an infected herd it should be borne in mind that calves born from infected cows or calves sucking

such cows are apt to have introduced into their digestive organs a varying number of Bang bacilli, which they may cast off again by means of their bowel discharges. It hence becomes a matter of prudence to keep all calves in infected herds away from pregnant animals. Because of the frequent occurrence of the Bang infection among swine, it is further advisable to prevent any contact between pregnant cattle and brood cows.

There is no doubt that the application of the blood test may furnish valuable assistance in the management of abortion infection. Whenever it can be done, blood tests should be made of all breeding animals as soon as an abortion occurs.

In its very beginning an outbreak may be checked by the elimination of the one or more animals which show positive infection. In such a case the elimination by slaughter of a few animals would be an entirely rational procedure. A blood test of all breeding animals in a herd is certainly the best means of obtaining prompt information regarding the extent of infection present.

By means of the blood tests, infected herds may be divided into reacting and nonreacting animals and each group managed as an entirely separate herd. Such a method can probably only be applied to specially selected herds of great value and where the required segregation can be scrupulously carried out. Its usefulness has been demonstrated but there has not yet accumulated a volume of experience which warrants recommending it for every outbreak. There can be no question, however, of the propriety of giving this method careful consideration when an abortion outbreak is to be managed.

The fact that there develops in herds infected with the Bang bacillus a resistance either identical with or akin to immunity has been the guiding reason for the many experiments made during the last two decades in the hope that a practical means of immunization might be found. It may be said that those experiments are still in progress. A brief review and interpretation of the data thus far obtained will no doubt be of interest to our breeders and farmers.

Artificial immunity against the Bang infection has been attempted with three distinct preparations, namely, immune serum, killed cultures, and living cultures. The consensus of the opinions of disinterested investigators and of impartial observers points toward failure on the part of serum and killed cultures, often sold under the name of bacterins, to pro-

duce in the animals inoculated a degree of immunity of practical importance.

On the other hand, there is good experimental evidence that with the use of living cultures abortions in infected herds may be materially reduced. There is, however, no evidence which shows that by their use the infection can be entirely eradicated.

The results obtained by the use of living cultures furthermore show extreme variations, ranging from a reduction of the abortions to a mere five per cent of the pregnant animals to a frank increase over the ones shown before the vaccination. It is pointed out that the use of living virulent organisms as vaccine is associated with the great danger of scattering infection and that the method will rather promote infection than suppress it. There is a maze of opinions on the subject, which is apt to leave the breeder's mind in a state of confusion. It may be well therefore to attempt an examination of the evidence on the subject and to draw such conclusions as this may warrant.

The live culture vaccine method consists in the injection of enormous numbers of abortion bacilli in the nonpregnant animal, not less than two months before admitting her to the bull. Injection into pregnant animals would, of course, be liable to be followed by infection of the fetus and subsequent abortion.

The practice depends on the theory that the bacilli injected will so speed up the production of protective substances and so increase their quantity that the vaccinated cow can achieve the protection of her fetus during the coming period of gestation; or, that instead of acquiring her protective qualities or immunity by natural infection during pregnancy and often at a cost of one or more abortions, all this is brought about within a short space of time when there is no fetus to be risked.

When we analyze the various discussions and statements regarding the method, we find that there is perfect accord on the point that it has no place in herds which are not infected. In fact, in such herds the method would be dangerous on account of the infection hazard involved. Owners of such herds, then, will act to their best interests when they follow the sound doctrine of leaving well enough alone.

It is not clear that those who counsel against the use of live cultures as immunizing agents always refer to infection

free herds. If they do they are sound in their position. It is not altogether certain that their position is different when they oppose the method in infected herds for the same reason, but we have seen no evidence brought forward which conclusively shows that in such herds actual damage was done by the method. On the other hand, competent and experienced observers point out that in infected herds, in which the animals eliminate infection already, the additional bacteria would not make a material difference in the general situation. In addition it may be pointed out that there is no certainty that the injected bacteria would be scattered about unless they actually caused abortions.

The breeder interested in this question must not forget that the term "infected" as applied to herds does not always designate an identical situation. A herd in which two or three animals have aborted is not to be compared with one in which three-fourths of all animals are involved in the infection, yet both are infected herds. If the use of live culture vaccines is instrumental in the dissemination of infection, it must be conceded that in the type of infected herd first mentioned the consequences may be serious and the results entirely contrary to those hoped for, while in the other type of herd the infection danger might not be materially increased.

Another objection to the live culture vaccination is based on the fact that in the treated herds the incidence of apparent or real sterility is materially increased. This coincidence has been observed on several occasions, but a constant relation between the vaccination and sterility has not been proved and has, in fact, been somewhat disproved by the more recently concluded experiments in Germany. In the report in which those experiments are related it is frankly stated that no sterility could be associated with the method.

When all the evidence is weighed it appears that all attempts at the immunization of cattle against the Bang infection must be regarded as experiments. It must be admitted, however, that the method of vaccination with live cultures is being credited with bringing about the desired results by some highly competent investigators and that in special cases its use could be tentatively countenanced. Its promiscuous use must be emphatically discouraged, owing to the infection hazards which might be associated with it. Under no circumstances should the method find employment in infection free herds, and only in herds presenting an overwhelming degree of infection may its use be considered and then not without a

previous survey of the herd by means of the blood tests and always under the supervision and control of persons thoroly trained in subjects of this sort.

Furthermore, there is no reason to believe that even in the event that this method should prove to be of practical value it would render sanitary herd management superfluous. In this there must be no relaxation and especially should the treated herd be guarded against the introduction of new virulent infection. It is not likely that the susceptibility of the fetus to this infection will ever be removed or lowered by any method and that the immunity barriers erected by the dam for its preservation may not be invulnerable or capable of withstanding the assaults of the highly virulent organisms derived from a recently aborted fetus.

THE ABORTION PROBLEM IN SWINE

THE CAUSE

Abortion in swine has been observed for many years, but only during the last four or five years has its occurrence been so frequently observed as to attract more or less general attention.

Especially in the states where swine raising is being most extensively practiced have abortions been distressfully common. In Nebraska, also, the infection resulting in abortion has caused havoc in many herds.

It is possible that like in the case of cattle this infection is not always to be ascribed to one and the same germ, but so far as this question has been given attention by this Experiment Station there can be no doubt that in the great majority of outbreaks the abortion bacillus of Bang could be associated with disease resulting in the loss of unborn pigs. More extensive investigations in other states have yielded the same results and there seem to be ample reasons to regard this germ as the almost universal cause of the trouble and to leave other factors out of the consideration, at least at this time.

It is quite possible that the germs obtained from swine and those derived from cattle show some slight variety differences, but it must not be forgotten that among the many strains of abortion bacilli isolated from cattle certain variations in their growing peculiarities and infection proclivities are also observed. It is true that thus far we have become acquainted with only exceptional instances in which contact with aborting cattle herds appeared to be associated with the disease in

swine. In the hands of some investigators the infection of swine with the bacilli of bovine origin failed to produce abortion while in other cases such a result was obtained. Infection of cattle with the bacilli obtained from swine resulted similarly; but it appears that abortion in cattle can be more readily induced with swine organisms than abortion in swine with the bovine infection. In view of the fact, however, that those various observations are but few in number, great importance cannot be attached to them. For practical purposes it is safer at this time to look with apprehension upon direct contact between pregnant sows and abortion infected cattle and between pregnant cattle and swine among which abortions have occurred.

The abortion bacillus of Bang has been isolated from the stomach, heart, liver, and navel cords of aborted pigs as well as from the afterbirth and the uterine discharge and colostrum milk of aborting sows. Furthermore, the blood serum of the latter commonly causes the characteristic reactions with abortion bacilli originating from both cattle and swine with a striking impartiality. Those facts seem to be sufficient warrant to look upon the Bang bacillus as being always identical whether found in cattle or in hogs.

THE MANNER OF INFECTION

So far as our own present knowledge of the abortion problem in swine permits conclusions to be drawn, it is highly probable that the behavior and progress of the infection is quite similar to the one pertaining to cattle.

The usual avenue by which the germ enters the sow is that furnished by the mouth and digestive system. Contaminated feed or the aborted fetuses and afterbirths of other sows (or cattle) are apt to convey the disease. This contamination may take place in many ways, but no doubt one of the principal sources is the uterine discharge of the sow which has recently aborted. This may even come about in an indirect manner, thru the agency of sucking pigs, which take in the germs with the milk of their dams altho the latter may have farrowed in a perfectly normal manner and at the proper time. It must not be forgotten that a sow may be infected and carry the germs in her milk and still give birth to healthy pigs at the end of a normal gestation period. In such pigs the bacilli may pass thru the intestinal canal and, contained in the dung, may soil food and water from which susceptible, pregnant sows may partake. No doubt one of the most certain

ways in which sows infect themselves is by the eating of aborted pigs and afterbirths. The custom of keeping several brood sows in one and the same lot or yard, which prevails on most of our farms, offers ample opportunity for this mode of infection. One sow aborts and several if not all of the others devour the cast-off material. This probably explains why in so many instances the greater part of the sows on a given farm abort within a short space of time.

While infection by the ingestion of virulent material is without doubt the most common, the possibility of the disease being contracted by sexual contact cannot be excluded even if there is but little known about this phase of the subject. Results experimentally obtained indicate that the boar may be a factor in the transmission.

Boars have been found which carried the infection or which by blood test were shown to have been infected by the abortion germs, and this fact should not be overlooked when dealing with the abortion problem. How such boars became infected is not definitely known, but in all probability the mode of infection in the male does not differ materially from that in the female.

THE RESULTS OF INFECTION

While unbred sows may contract the infection and abort after they become pregnant, there is evidence to show that pregnancy greatly increases the infection chances. Infection taking place does not always result in abortion, but especially in gilts the danger is a considerable one.

The stage of gestation at which abortion is apt to take place is subject to great variations and it is probably safe to assume that it may take place at any time during the whole period. One investigator reports that in infected herds sows aborted as early as twenty-four days and as late as ninety days after having been bred. The same investigator found that the average time elapsing between the introduction of the infection and the occurrence of the abortion was slightly more than twenty-three days.

The act of abortion does not differ materially from that of a normal birth. When it takes place early in pregnancy, there may be no warning of its impending. The sows abort, often entirely unobserved, and do not seem to suffer any bad consequences as a result. A vaginal discharge, often of a brief duration, may be all that shows that something abnormal has happened. When the abortions occur at a more advanced

stage of the gestation, preliminary signs, such as enlargement of the udder and swelling of the external genitals, may be in evidence. In some instances the sows may show slight illness, dullness, and reduced appetite for two or three days prior to abortion. As a rule the fetuses are expelled without much effort and this is promptly followed by the afterbirths.

The retention of the latter is less common in sows than in cattle altho it occasionally occurs. In most cases there is a vaginal discharge for a week or more, and with its disappearance there is but little to show that the pregnancy was abnormally terminated.

There are cases, on the other hand, when as a result of secondary infection the uterus becomes seriously diseased; the sow becomes thin and may even succumb. In such cases the discharge is apt to persist and subsequent sterility must be expected.

Opinions differ as to what happens subsequent to actual abortion. On the one hand it is asserted, on apparently good ground, that the disease is self-limited and that immunity develops to a sufficient degree to render the following pregnancy safe. It is also stated that the chances of a sow aborting during the subsequent and later pregnancies are quite remote. It has been said, on the other hand, that instances may be encountered in which the results were not so favorable. So far as observations in Nebraska indicate, it seems probable that the disease will not maintain itself for long periods in the same herd. The disease may appear suddenly, bring about the destruction of a major part of the pig crop, and then disappear completely from the herd involved. Such a course, while occurring in many outbreaks, is, however, not always to be expected and in some herds a greater or smaller number of abortions may occur from year to year. The tendency of the disease to "wear itself out," as farmers often express it, can, however, not be denied.

INFECTION ORIGIN

The question of how the disease becomes introduced into a herd cannot be definitely answered at this time. A bovine source of infection must always be given consideration, altho the introduction of pregnant sows from infected herds has been shown to be a more prominent source of danger. The feeding of slaughter house offal and milk products from unknown sources must also be given consideration in this connection.

THE RECOGNITION OF THE INFECTION

A question of much practical importance which confronts the breeder dealing with abortion among his brood sows relates to the recognition of the disease. Abortion from any cause presents no features which distinguish it from that due to specific infection. It is true that the careful and skilled observer may recognize in the cast-off placenta certain lesions which are similar to the ones seen in cattle and are evidence of infection. But owing to the nature of the placenta these changes are not so pronounced and may be entirely overlooked. At least they do not furnish a constant and reliable indication of specific infection.

In the laboratory it is possible to demonstrate the Bang bacillus in aborted material; but inasmuch as this material is so commonly grossly contaminated or even decayed, bacteriologic examinations frequently terminate in failure.

From the breeder's standpoint there is just one safe attitude which he may take with reference to the recognition of the disease, and that is to regard every abortion in his swine as being the result of the Bang infection and to act accordingly until the contrary can be proved.

Of material assistance in the diagnosis of the disease are the agglutination and complement fixation tests made with the blood serum of the suspected sows or of those belonging to the same herd. These tests are similar to the ones used in the disease in cattle and have the same shortcomings and advantages. They will show—in at least a large portion of the sows in a given herd—either that they are actually infected or that they were so within a certain length of time. The tests cannot be relied upon to determine beforehand whether or not a sow will abort. Some sows giving a positive reaction will carry their pigs until a normal farrowing time while others without reacting may abort. In spite of those disadvantages the tests are valuable aids in determining the actual condition of the herd and may assist in the rational management of the outbreak and in the prevention of the introduction of the disease into clean herds.

When blood tests are to be made, it is particularly advisable to include all animals of breeding age in a given herd, because by doing so a comprehensive view of the entire situation is at once obtained.

For the collection of the blood samples, vials of no less than half-ounce capacity should be used. They and their stoppers should be perfectly clean and sterile. The blood should

be collected in the cleanest manner possible and the vials should not be filled more than half full. The vials should be properly labeled and numbered in such a manner that the sow from which the sample was taken can be readily identified. The blood can be withdrawn from a small wound made in the edge of the ear or by cutting a small piece from the end of the tail. When a good veterinarian is available he should be entrusted with the task of collecting and caring for the samples. The Department of Animal Pathology and Hygiene, College of Agriculture, University of Nebraska, is prepared to make the tests desired.

PREVENTIVE MEASURES

In the management of the abortion problem in swine the only efforts tending to control the disease are those which aim at prevention. Before discussing the measures which tend to accomplish this, one or two facts should be impressed upon the breeder's mind in order to enable him to keep from wasting time and money in useless efforts. It should be understood that in a herd involved in the infection the abortion of sows already infected may take place or may not take place, but that the final outcome cannot be changed by the use of medicines or drugs. Nor will the administration of medicines or drugs have the least influence in protecting the noninfected sow against the infection.

It should be understood further that at this time there is as yet no good reason to believe that the use of vaccines against swine abortion is indicated in the management of the disease on farms. There is evidence which shows that so-called bacterins are entirely useless, while of the so-called live culture vaccines it can be said that they are as yet entirely in the experimental stage.

It is true that drugged, doped, and vaccinated herds may have ceased to abort, but it is equally true that herds subjected to no treatment at all have done the same thing.

THE MANAGEMENT OF CLEAN HERDS

Both in the disease-free herd and in the infected herd will preventive measures have their place. It may not always be possible to know when a herd should be regarded as disease free, but for practical purposes a herd may be so regarded when none of the sows used for breeding ever have aborted and when for a period of six months no new swine of unknown origin as far as abortion is concerned have been introduced. This definition is not to be regarded as valid in all possible

cases, but it probably suffices to establish a working base. If a more absolute assurance of freedom from infection is desired, this may be obtained by the blood tests referred to above. Under ordinary farm conditions it will, however, but rarely be necessary to resort to it.

In guarding the abortion free herd, our first effort should be against the introduction of infected swine obtained by purchase or otherwise. A certain amount of circumspection on the part of prospective buyers at sales, etc., can certainly be recommended. If sows and gilts sold at sales or otherwise could be previously subjected to the blood test, some very disappointing and discouraging experiences would certainly be prevented. As long as this precaution is as yet not commonly taken, the next best thing to do is to isolate the newly purchased swine until a blood test made in behalf of the buyer, made a couple of weeks after the arrival of the animals, indicates a freedom from infection or until the farrowing of a normal litter at the normal time points to the same condition. But inasmuch as even in the latter case infection cannot absolutely be excluded, a blood test of such animals should be given preference. Female swine returning from shows should be isolated and dealt with in a similar manner.

The identity of the Bang bacillus of cattle and the one of swine or at least their very close relationship renders it prudent to keep sows and gilts intended for breeding away from cattle and cattle yards. If such swine are to be fed with milk or milk products, such feeds should only be offered after pasteurization or sterilization.

An additional element of safety may be secured when pregnant swine, instead of being kept all together in one common lot or pasture, are divided into as many small groups as is practicable. With such an arrangement there is at least less danger of a great number of sows becoming infected by devouring aborted pigs and afterbirths in the event of an abortion actually taking place in one of the groups.

In the prevention of swine abortion, the safeguarding of the disease-free herd always constitutes the most effective means of dealing with the problem.

THE MANAGEMENT OF INFECTED HERDS

When an abortion takes place, safety demands that the accident be ascribed to the results of infection unless the contrary can be clearly proved. In such an event the aborting sow should be at once isolated, preferably in rather close con-

finement and in quarters suitable to subsequent disinfection. At the same time the remaining sows in the same enclosure should be removed to other ground and, if possible, there be divided into as many small groups as at all practicable. This latter measure alone is very apt to save at least some of the litters.

If possible at all, the aborted pigs and afterbirths should be carefully removed and destroyed by burning. If the latter can be done at the place where the infectious material was found, so much the better. All objects which have come in contact with it should be promptly disinfected, and this must never be done in a perfunctory manner.

The isolated sow should remain segregated until all evidence of vaginal discharge has disappeared. If the discharge persists, it is probably a matter of economy to prepare her for the butcher. In such a case, breeding is apt to be futile; and, while the prospect of success by surgical treatment cannot be absolutely excluded, it is always more or less problematic.

The plan as outlined should be executed with all the aborting sows until the end of the farrowing season or until all pregnant sows have either aborted or farrowed normally. If the sows are of no special breeding value, consideration may be given to the advisability of preparing all of them for the market, the aborting ones as well as the exposed ones, and of beginning the next breeding operations with a new set of gilts. It is as yet not possible to foretell accurately what might happen after aborting sows are bred again. In all probability the majority will carry their litters to term, but many of them are apt to remain infection carriers and may be a menace to the gilts to farrow during the next season. It is not particularly urged to dispose of the sows as indicated, but the wisdom of such an action must be seriously considered.

If the sows of the infected herd do have a special breeding value or if it is desirable to keep them for other reasons, it seems advisable to subject all sows set aside for breeding to the blood test. The test has its shortcomings and its indications may leave some questions unanswered, but it cannot be denied that it is capable of rendering efficient help in the management of the infected herd.

In accordance with the results of the blood test the herd can be divided into reacting and nonreacting sows. As an additional precaution a subsequent test some three or four weeks after the first one may be made.

Reacting and nonreacting sows should now be kept strictly separate and different boars, also tested, should be maintained for each group. Both lots should be divided into as many small groups as possible and an effort should be made by proper disinfection, etc., to render their quarters as safe as possible.

The above measures may be supplemented by the further precaution of a blood test of the nonreacting sows from four to six weeks before farrowing time, so that in the event that any of them should then show a positive reaction they could be isolated in order to limit the danger arising from a possible setting free of an abundance of infection material thru the abortion act or thru the farrowing at the normal time.

In devising ways and means for dealing with the abortion problem the situation in each particular herd and its requirements must be studied quite separately. What is intended by the suggestions offered above is the establishment of certain principles which in the light of our present knowledge may serve as a guide in the management of outbreaks of this disease.

THE ABORTION PROBLEM IN HORSES

INTRODUCTION

Abortion in mares has attracted attention for some years in the various horse breeding parts of the world. In this country likewise it has been a serious problem in many sections. Owing to the fact that these abortions so commonly occurred in certain stables and even in many distinct areas of territory the bacterial origin of the disease was suspected quite early. It was soon known as equine infectious or contagious abortion and many investigators have occupied themselves with the problem.

THE NATURE OF THE INFECTION

The early part of the investigation of abortion of mares did not result in establishing the relation of a single definite germ to the causation of the disease and many of the reports indicated that several species of bacteria could be held responsible. Perhaps this is quite in accordance with the actual facts. The later investigations, however, disclosed the fact that in a preponderating number of the outbreaks bacteria belonging to the so-called colon-typhoid group were implicated as the actual cause of the disease. It is not certain that the organisms found, while very closely related, were always the

same. They corresponded in so many details, however, that the organisms came to be spoken of as the equine abortion bacillus. This germ, quite different from the one causing the disease in cattle and swine, may not always be true to type, but in a given stable or outbreak one and the same species was constantly proved to be the cause of the disturbance.

In this country the equine abortion bacillus, allowing for certain variations in its characteristics, is the manifest cause of abortion in mares.

The Kentucky investigations, above all, have established this fact in an abundance of material. When we speak thus of equine abortion, we have in mind the disease of which the equine abortion bacillus is the cause.

CHARACTERISTIC FEATURES OF THE INFECTION

Our knowledge of equine abortion is not as extensive as that of the disease in cattle. This is perhaps due more to the nature of the disease than to the lack of investigational zeal. While in cattle the disease concentrates its mischief on certain special tissues, and maintains itself in the body of the cow for long periods if not indefinitely, the infection in mares is a more general one, takes on the form of a septicemia, interferes more suddenly with fetal nutrition and oxygen supply, and disappears more rapidly and completely from the animals involved.

THE INTRODUCTION OF THE INFECTION

Imperfect as our knowledge may be, there is good reason to believe that the infection is most commonly taken into the body with infected feed and water. Other means of entrance by the equine abortion bacilli must, of course, be reckoned with. It is thus possible that the stallion may infect the mares but it has not yet been proved conclusively that this is at all an important factor in the distribution of the disease. The rather acute behavior of the infection somewhat renders this mode of infection improbable. On the other hand, the sudden occurrence of many abortions in certain studs within a brief space of time speaks for infection thru the digestive organs as well as does the disappearance of the disease observed after a change of location and of feed and water.

THE DAMAGE BY THE INFECTION

Infection with the equine abortion bacillus takes on the nature of a septicemia in which both the infected mare and her fetus become involved with different degrees of intensity.

While the mare, as a rule, suffers only a transitory illness, the fetus, including its membranes, is damaged to the extent of fatality. There is no evidence which shows that the changes, if any be present at all, in the organs of the adult animal have been studied. Apparently no mares have been sacrificed for the purpose of ascertaining what the condition of the various organs is at the time when abortion is impending. In one case the equine abortion bacillus was found with some other germs in the inflamed testicle of a stallion belonging to a stud in which abortions were occurring.

Most of the studies pertaining to the damage done by the infection relate to the aborted fetus and its membranes. The lesions found in those structures point to a very acute disease process, and there is good reason to assume that the fetus proper and its membranes are simultaneously attacked by an overpowering infection and that, unlike in cattle and swine abortion, this infection is not primary to the placenta alone.

The fetal membranes may not show marked disease in some cases, but more often they are found to be involved in severe inflammatory changes. The membranes present a dropsical appearance, and hemorrhages of varying degrees of severity may be observed. The blood derived from the more extensive hemorrhages may have separated the membranes from one another. The chorion or outer membrane is covered with a yellowish slimy substance and the villi of the placenta may be gangrenous and their lighter, dirty, reddish, yellowish, or dirty yellow color may form a sharp contrast with the dark red color of the thickened membrane. The chorion like the navel cord is also commonly found to be gelatinous and permeated with a watery liquid.

In the fetus proper the tissues are dropsical and the body cavities contain either a clear or a cloudy reddish fluid. Stomach and intestines are commonly found to be inflamed. Many of the organs are congested and may present small hemorrhages.

Some observers make mention of a characteristic sour odor of the fetus, the fetal membranes, and the discharge issuing from the vagina of the mare.

THE ELIMINATION OF THE INFECTION

There can be no doubt that, during the evacuation of this thoroly diseased mass from the uterus, there is cast out also an enormous number of equine abortion bacilli. They also will

continue to escape for some time in the fluids discharged from the uterus. There is, however, evidence which indicates that the organisms disappear entirely from the body within a comparatively short period. It is also highly probable that during the time the mare is actually infected the bacteria may also escape with the bowel evacuations and the urine, altho this fact has not been definitely ascertained.

That mares may become such persistent carriers of the equine abortion bacillus as cows may become of the Bang bacillus appears to be quite improbable in the light of our present knowledge of the disease. It appears that the equine abortion bacillus infection is marked by a sudden invasion, a quick assault on the fetus, and an early disappearance.

THE OCCURRENCE OF ABORTION

Pregnant mares infected with the equine abortion bacillus may abort any time during the gestation period. The time of the abortion is more dependent on the time when the infection was introduced than on the stage of gestation. Mares have been observed to abort from the second to the eighth month of pregnancy, while many abortions at an earlier period may have occurred without attracting attention. In artificial infections, the abortions took place in from 10 to 14 days after the introduction of the infectious material.

The abortion frequently takes place without much indication as to what is about to happen. Mares abort and rapidly recover from whatever the results of the act may have been. In other cases the mares show an ill defined illness for a few days. There may be dullness, inappetence, and a moderate increase in the body temperature. In some instances a vaginal discharge of a varying character and a swelling of the udder and of the external genitals serve as a warning as to what is about to happen. There may be a certain degree of stiffness of the hind legs, probably arising from the painful swelling of the udder.

On the whole, the aborting mares recover quickly. There is but little trouble with afterbirth retention, and while for some time a chocolate colored vaginal discharge may persist little harm to the mare comes from the abortion in a direct manner. It must be borne in mind, however, that the uterus after an abortion is particularly vulnerable to a variety of infections and that cases must be managed accordingly in order to prevent what may develop into a fatal septic inflammation of this organ. Here and there reports are encountered which

point to a connection between abortion and sterility, but the latter sequence is not nearly as common in the mare as it is in the cow.

THE RECOGNITION OF THE INFECTION

The recognition of an abortion as being due to a specific infection depends primarily upon the bacteriologic examination of the aborted fetus. Only in this manner may the organism be identified. From an experimental viewpoint blood tests and blood reactions are interesting, but it is doubtful if they have much value as a means of routine diagnosis.

This is largely due to the fact that in various outbreaks different varieties of the equine abortion bacillus may be implicated and that the laboratories cannot always have available cultures with which to undertake successful blood tests for all outbreaks. It further appears that the blood tests, even made with organisms taken from the outbreaks in studs from which the blood is examined, are apt to fail to indicate the infection. No doubt the blood tests may have a value to the investigator, but they cannot be regarded as very useful in field work.

THE MANAGEMENT OF EQUINE ABORTION

The management of equine abortion is entirely dependent on measures of prevention. There is no way to combat or destroy the infection when once it has been introduced into the mare.

General stable hygiene, such as pertains to cleanliness, drainage, and periodic disinfection, will be of material aid in the prevention of this disease as well as in that of many others. The feed used should be guarded against contamination and the water supply should be of unquestioned purity. When a mare shows signs of impending abortion, she should at once be isolated; and after this act has taken place, the fetus and afterbirth should be removed in such a manner that those materials cannot soil the premises or litter.

The same should be done with the bedding of the stall in which the abortion has taken place. Destruction of the materials mentioned is best done by burning. The stall and the utensils used in the handling of the infected materials must be most thoroly disinfected.

If more pregnant mares are present in the stable in which an abortion has taken place, they should be removed to infection free premises, if such is at all possible. In addition, a

complete change of feed and water is highly recommended. When circumstances do not permit the removal of the pregnant mares, or even when this is being done, the entire stable should be subjected to a thoroughgoing cleaning and disinfection. This should be done without delay, because in the management of equine abortion stable disinfection is a very important detail.

The mare which has aborted should remain segregated until all signs of vaginal discharge have disappeared, while in many cases, if not in all, it is advisable to have the uterus washed out by means of some nonirritating antiseptic solution by a skillful veterinarian. Uterine washes may be repeated several times until the closing of the uterine passage renders this operation either difficult or too irritating to the mare. Mares which have aborted should not be bred before two months after the complete disappearance of the vaginal discharge.

In all studs in which abortion has occurred it is advisable to disinfect the external genitals of the stallion immediately before and after each service.

Indications are not lacking that a method of immunization may be very useful in protecting the mares of an infected stud against the disease.

The immunizing agent used for this purpose consists of the killed cultures of the equine abortion bacillus, especially the one which was obtained and isolated from cases in the outbreak concerned. As a rule four separate injections are made at intervals of approximately one week. As the bacteria used in the injections have been killed by heat, the treatment can be applied to pregnant mares. The only harm observed after the injections is an occasional abscess at the point of inoculation.

Attempts to protect mares by means of an immune serum have also been made, but on the whole the results were not particularly successful.

THE ABORTION PROBLEM IN SHEEP

THE NATURE OF THE DISEASE

While in Nebraska there arise but few complaints about abortion in ewes which can be attributed to a specific infection, a few words may be added on the subject of abortion in sheep.

It does not appear from the evidence presented by the lit-

erature on the subject that there occurs in sheep an infection, resulting in abortion, which can be compared with that of cattle and swine caused by the Bang bacillus or with that of the mare produced by the equine abortion organisms.

It is true that ewes in certain flocks abort in large numbers; it is also true that by artificial infection with the Bang abortion bacillus those animals can be caused to abort, and this same organism may cause abortion under natural conditions. Yet it is apparent that neither this organism nor any other can be said to be definitely or constantly associated with substantial losses of unborn lambs.

In the outbreaks which were studied, the bacteria found in a compromising if not a convincing situation belonged to a number of species. From the evidence on hand, one may conclude that mass abortions among ewes are mostly produced by germs, which cause disease in the adults, and that by this disease the lambs perish. In such cases the evolution of the morbid process is somewhat comparable with what happens in pregnant mares when they become infected with the equine abortion bacillus, with this difference, that in sheep there is probably a larger assortment of bacteria which can bring about this result. This type of abortion is described in outbreaks of foot and mouth disease, sheep-pox, catarrhal fever, or hemorrhagic septicemia, while in addition there has been found to be identified with sheep abortion in a few outbreaks the Bang bacillus and in others a so-called vibrio.

THE MANAGEMENT OF SHEEP ABORTION

In the absence of very definite information on this subject it is difficult to undertake the recommendation of specific measures of prevention. In the face of an outbreak of abortions among sheep, thus we can only have recourse to the ordinary sanitary measures. Among those may be included the removal of the pregnant ewes to other range, pasture, lot, or premises, with a complete change of feed and water. The destruction of the aborted lambs and their afterbirths and the segregation of the ewes which did abort or of those which show signs that such an act may be in prospect are all measures of which the usefulness is obvious. If the group of aborting ewes is of small number, they should not again be admitted to the flock but should be prepared for butcher purposes. Disinfection of the sheds and stables and such utensils as were used in the removal of the aborted materials must also be undertaken in a thoro manner.