BULLETIN NO. 37.

Texas Fever Experiments.

UNIVERSITY OF THE STATE OF MISSOURI
COLLEGE OF AGRICULTURE AND MECHANIC ARTS
AGRICULTURAL EXPERIMENT STATION

Co-operating with the

MISSOURI STATE BOARD OF AGRICULTURE.

APRIL, 1897.

CROP REPORT CONTENTS.

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ESTIMATED CONDITIONS OF AGRICULTURE AND LIVE STOCK, APRIL, 1897.

SUMMARY OF CROP REPORTS.	State	Northeast	Northwest	Central	Southwest	Southeast
Wheat, condition with average crop	65	40	70	65	79	71
Wheat, per cent likely to be plowed up	27	52	27	23	12	19
Rye, condition with average crop	79	70	91	80	91	64
Oats, probable acreage compared with 1896	93	89	97	93	91	94
Clover, condition	85	77	93	83	87	84
Apple buds, per cent alive	86	85	89	79	93	85
Peach buds, per cent alive	67	51	62	64	79	81
Small fruit, per cent alive	87	84	90	85	92	85
Strawberries, condition	86	83	87	80	91	88
Horses, condition compared with average	96	97	99	96	96	94
Horses, probable number compared with 1896	90	87	87	90	92	96
Mares, what per cent will drop foals this spring	42	37	38	52	38	46
Cattle, condition compared with average	97	97	99	97	98	93
Fat cattle, number being fed for market compared with 1896	81	91	97	83	67	67
Hogs, number compared with 1896	84	86	84	80	92	80
Pigs, estimated number dropped compared with 1896	86	85	84	88	93	82
Hogs, condition as to disease	84	79	88	76	89	89
Sheep, condition	96	93	100	97	94	95
Sheep, probable number compared with 1896	95	95	99	93	97	89

CROP REVIEW.

Wheat.—The acreage seeded in fall of 1896 was estimated to be the same as that of 1895. The conditions for seeding were not the most favorable, in some localities the ground being too dry, while in others continued rainfall interfered with this work. The seed generally germinated well and the young plant made a promising growth. But the winter was not favorable for the protection of the plant, and repeated freezing at such times as it was not in condition to resist proved disastrous in many localities. Reports for April, 1896, esti-

mated the acreage that wou'd be plowed up at ten per cent of the crop, while the present conditions indicate that twenty-seven per cent of last fall's seeding is dead and the land will be used for other crops. In other words, the acreage of 1895 was placed at 1,550,000 and suffered a reduction the following spring of ten per cent, and for 1896 the estimated acreage is the same, but will be reduced twenty-seven per cent, leaving the acreage for harvesting at 1,130,000 against 1,270,000 for last season.

In some of the southeast counties large tracts are under water and will be a total loss. In north Missouri correspondents from some localities say: "The wheat on hill land is all dead," and others that "wheat on prairie is all dead." A prominent farmer from Linn county, now in office, says "a large per cent of the wheat acreage on his farm is a total loss, and what survives is largely interspersed with streaks and spots of dead wheat." This condition on one farm illustrates, in a general way, the conditions in the State. In some localities the conditions are favorable to a good crop, while in another only removed a short distance, the plant is dead.

The fields that will be permitted to stand for harvest, by reason of the dead streaks and spots and plants scattered promiscuously through the field, promise only sixty-five per cent of an average crop. Favorable conditions for April may, however, improve the outlook, and fields that now appear too thin to give profitable returns may thicken up, and a vigorous growth for the next thirty days may give better results than are now indicated.

Oats.—The continued wet weather has prevented seeding in most localities. The estimated acreage is placed at ninety-three per cent of that of 1896, which would give 1,060,000 acres for this season against 1,140,000 acres for last. But if excessive rainfall continues and seeding can not be done by the

usual time, this estimate of acreage will, no doubt, be materially reduced.

Fruit.—The condition of apple buds and small fruits and strawberries is fairly good and if not injured in the future, promises an abundant crop. Peaches in some localities are all killed, while others in the same county or section promise an average crop. The Northwest section has suffered most severely, with a slight improvement in the Northeast, more pronounced in the Central and promising conditions in the Southwest and Southeast.

Horses are reported in good condition, with a decrease of ten per cent in number since last season. Forty-two per cent of the mares will drop foals against forty-four per cent for 1896. The foals so far produced are strong and vigorous, and but little loss has been sustained from abortion or death of young foals. The price of horses has slightly advanced, the foreign demand increased, and the decrease in number has occurred from the higher grade of animals and the increase in price is largely upon that class.

Cattle.—The number being fed for market has decreased nineteen per cent as compared with 1896, or a decrease in number for the State approximating 150,000 head. Formerly the cattle fed in Missouri were largely produced on our own pastures, but of the cattle now being fed at least forty per cent were brought into the State from the non-infected territory in Kansas, Oklahoma and Texas, and a few from Arkansas. This decline in the production of Missouri feeders is the result of a depressed cattle market that continued over a period of several years, rendering the business unprofitable. Whether present prices will stimulate the breeding of cattle in this State or whether we will find it more profitable to purchase feeders elsewhere and turn off a larger number of finished cattle will,

no doubt, be settled by our feeders and breeders on a basis that promises the largest returns.

Hogs are reported to have decreased sixteen per cent as compared with 1896, and the number of spring pigs fourteen per cent.

Last season it was estimated that fourteen per cent of the hogs died with cholera, and present reports indicate a condition as to health of eighty-four per cent, and there has been an immense mortality among young pigs.

Texas Fever

or

Acclimation Fever.

By John W. Connaway, M. D. C., Veterinarian.

Co-operative experiments on Texas fever were carried on at the Missouri station grounds during the summer of 1896 by the Missouri Experiment Station, the Missouri State Board of Agriculture, and the Texas Experiment Station according to the plans set forth in the following pages.

I. CONFIRMATION OF THE TICK THEORY AS TO THE TRANSMISSION OF TEXAS FEVER.

The tick infestion experiments, as carried out at this station, were not planned with the special aim of confirming the "tick theory"; they formed, as will be seen later, a necessary, though incidental, part of the main experiments of the investigation, viz.: *Experiments to determine the practicability of certain measures in the prevention of Texas fever.* These main experiments were, in fact, based upon the belief that the claims in regard to the tick as the transmitter of the diseases are true.

It has been thought best to give these experiments greater prominence than was originally intended, on account of the doubts that still exist in some quarters in regard to the "tick theory," as they term it. The removal of all doubts in this matter is very essential if we would secure the hearty and intelligent co-operation of all stockmen in aiding the State Board of Agriculture in the enforcement of quarantine regulations and in the disinfection of any part of our territory that may in the future become infected.

These experiments furnish such clean, clear, unmistakable evidence in support of the claim that the ticks transmit the disease, that had no other promising results attended the investigation, this reconfirmation of the work of others, freed as it is from any of the remotely possible objections that might be brought against their work, would have been ample compensation for all the expense incurred.

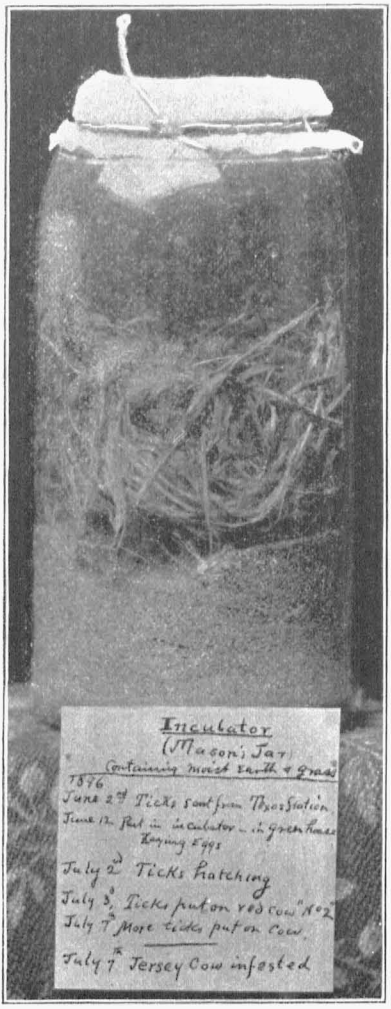

Fig. 1. Method of hatching the young ticks used for infesting the experimental cattle.

Before presenting our own experiments it is proper to introduce at this point a clear statement of the views that are now most generally accepted as to the cause of Texas fever and the mode of its transmission, and also to give a summary of the experimental facts that support these views.

In a special report on "Texas Fever" issued by the Bureau of Animal Industry in 1893 the claims are made:

First. *That the cause of "Texas Fever" is a "blood corpuscle destroying micro-organism," the presence of which in the blood of affected animals can be demonstrated.* Dr. Theobald

Smith, the discoverer (1889) of this micro-parasite, has named it "pyrosoma bigeminum" on account of its pyriform outline and the usual occurrence in pairs within the corpuscle.

Second. *That the transmission of this micro-organism from Southern cattle to native Northern cattle in natural outbreaks is effected by the Southern cattle tick and by this means only.* The credit of first proving this belongs to Dr. F. L. Kilborne, (1889–90).

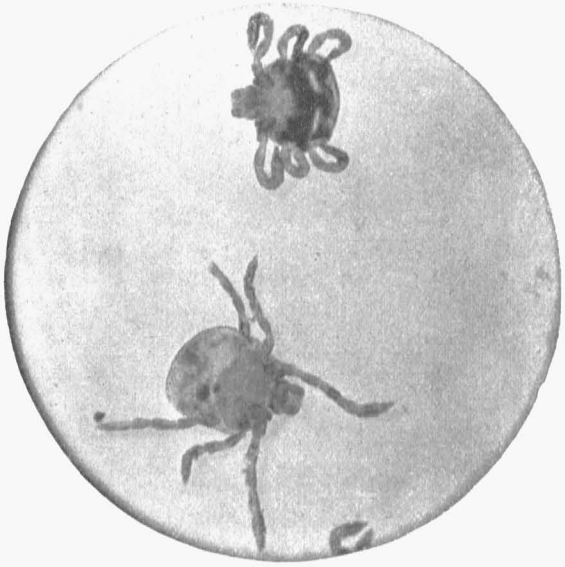

Fig. 2. Larval stage of the Southern cattle tick from photograph of mounted specimen.

(1) The evidence in support of the first statement is in brief, that numerous microscopical examinations showed:

(a) The constant presence of the micro-parasite (pyrosoma bigeminum) in the blood corpuscles of infectious Southern cattle.

(b) The constant presence of the same micro-parasite, but in greatly increased numbers in the blood-corpuscles of native Northern cattle suffering from Texas fever.

(c) The absence of this micro-organism from the blood of healthy native Northern cattle.

(d) The absence from the blood of a diseased animal of other organisms (bacteria), when the examination was made previous to death or very soon after.

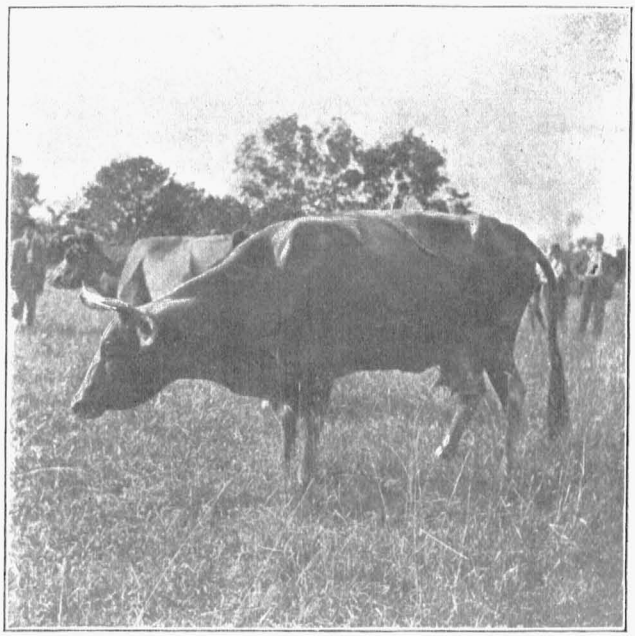

Fig. 3. Jersey cow in foreground, on the 17th day after infesting artificially with ticks, very sick; died on the following day, July 25, 1896. Shorthorn in the background, on 4th day after turning on infected pasture shows no sign of sickness, but died 9 days later.

(e) It was also shown that the intravenous injection of blood from infectious Southern cattle into native Northern cattle resulted in the contraction of Texas fever by the latter. In these cases the presence of the micro-parasite was demonstrated.

(2) The claim that the cattle tick (Boophilus Bovis) is the usual and probably sole transmitter of the above mentioned micro-parasite in natural outbreaks is supported by the following experiments:

(a) Native cattle were exposed for several weeks to Southern cattle, the latter being infested with ticks: Result:

Fig. 4. Jersey cow, Case No. 2. Infested with ticks July 7th, died in 18 days, July 25, 1896.

The natives contracted Texas fever. Young ticks were found upon them. The micro-parasite mentioned was found in the blood.

(b) Native cattle were exposed to Southern cattle from which the ticks had been removed, the ticks having been picked off by hand. Result: Native cattle showed no signs of fever.

(c) A pasture was infested with ticks taken from Southern cattle—no Southern cattle were admitted to the pasture. Native cattle were turned into this pasture. Result: Texas fever and death.

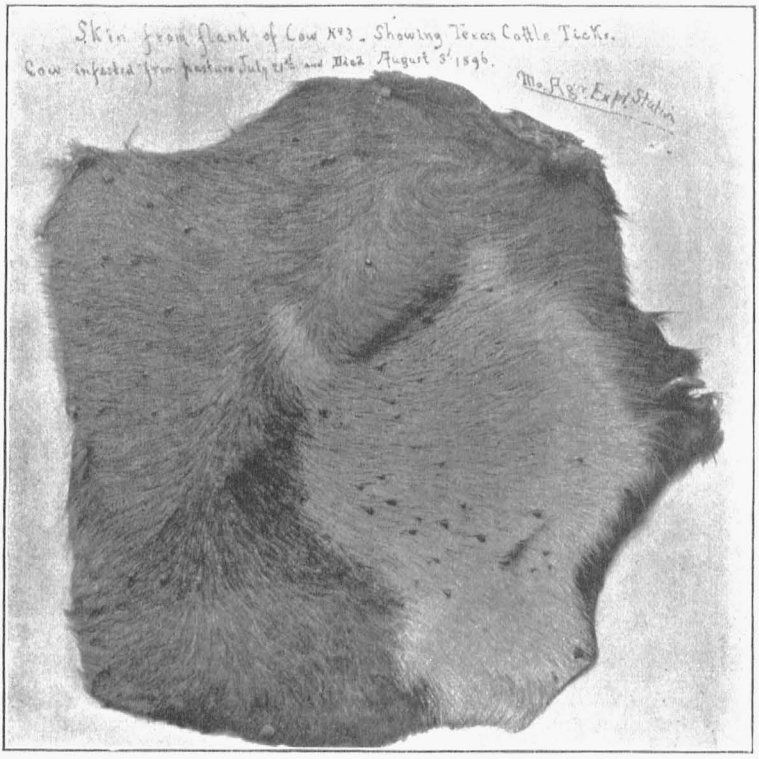

Fig. 5. Portion of skin from flank of cow No. 3, showing the cattle ticks picked up from infested pasture—from photograph; reduced 1-4.

(d) Young ticks hatched artificially from the eggs laid by adult ticks picked from Southern cattle were placed upon native cattle. Result: Texas fever and death. Micro-organism of Texas fever in the blood.

(e) Experiments were made showing that the disease is not transmissible by means of the excretions of Southern cattle.

In the experiments mentioned under (b) the native cattle had every opportunity to become infected from the excretions.

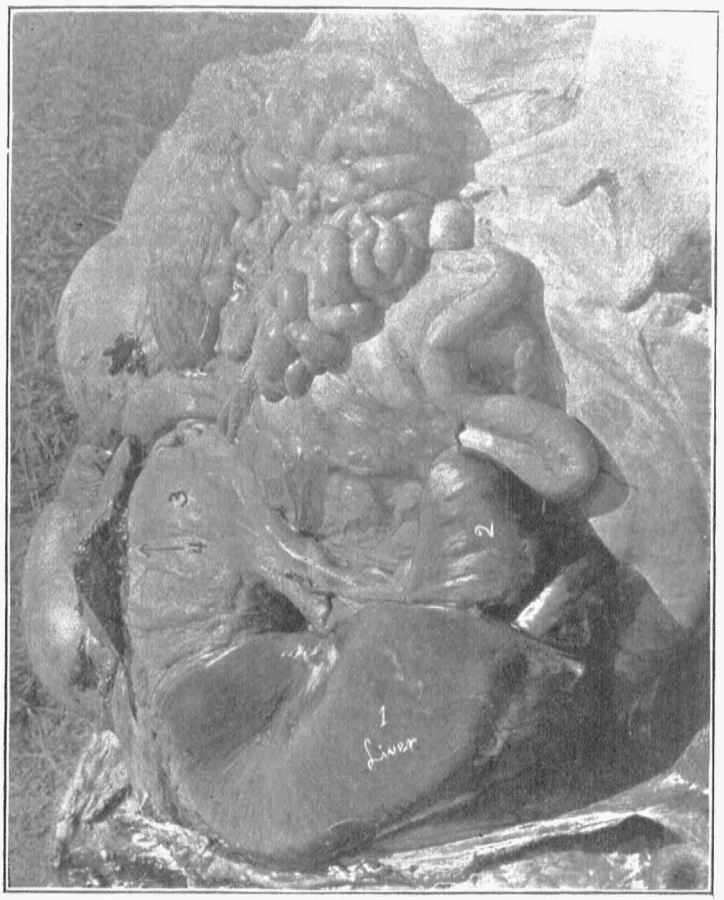

Fig. 6. 1 liver, 2 gall bladder, 3 stomach, arrow from fig. 4 points to the enlarged spleen, which which has been cut across to show thickness.

The above claims have had independent confirmation at the Experiment Stations of our neighboring states, Arkansas and Kansas.

But notwithstanding the quite conclusive nature of the evidence presented by all these experiments, there remain a few investigators who have had some experience with Texas fever, who still doubt the conclusions given above and believe that the experiments mentioned *did not exclude the possibility of infection from other sources than the tick.* Such a thought is evidently in the mind of one who says: "As to the 'tick theory'—we have tested it thoroughly on two cows; *of course by excluding every other source of infection*, and failed to get any effect whatever." What the source of infection in the work of others may be is not mentioned. In regard to the experiments of the United States Bureau of Animal Industry, the thought may be that the infection was carried from infected pens in the neighborhood on the shoes of the investigators and their assistants. It is claimed that the infection of hog cholera can be so transported. This, however, does not dispose of the experiment in which native cattle were exposed with safety to Southern cattle free from ticks.

As to the Arkansas experiments, it would not be impossible for these critics to assert the probability of the Experiment Station being on infected ground. A portion of Missouri, much farther north, was included in the quarantine district only two years ago.

In the Kansas experiments it was not successful in the case of calves, but gave a positive result in the case of a four year old cow. The criticism that would be presented here can not be imagined unless it be that the number of positive results was not sufficient to determine the matter, for it seems that no other source of infection was possible. The critics themselves admit that calves possess some degree of natural immunity. The gross lesions that are described certainly indicate a case of Texas fever.

If the grounds upon which the doubts rest are the hypothetical ones suggested, the experiments carried on here will effectually dispose of them. These experiments were made upon grounds where no Texan cattle had ever been; and upon

which no excretions from Texan cattle had ever been placed. At the time these experiments were made no Texan cattle were in the neighborhood, nor had been for several years. Nor did we have any excretions of Southern cattle at the Experiment Station for experimental purposes. Infection of the grounds from these sources was impossible. This Station is 200 miles or more north of the quarantine line. Cattle trains carrying Southern cattle pass no closer than ten miles to this Station. The results of our tick infestion were all positive. The symptoms and morbid changes were in every instance those seen in typical cases of Texas fever. The number of experimental animals used—three—will doubtless be sufficient, considering the conditions surrounding this experiment.

The details of these experiments are as follows:

METHOD OF SECURING THE YOUNG TICKS.

June 2, 1896. Dr. M. Francis, of the Texas Experiment Station, sent us two dozen or more adult female ticks (Boophilus Bovis—Riley) picked from Southern cattle. These ticks fell into the hands of the entomologist, Dr. Stedman, who kindly placed them in improvised incubators—Mason jars containing moist earth and grass. The mouth of the jar was closed by tying over it a piece of muslin. See figure 1, page 82.

June 12th. A large number of eggs have been laid.

The jar with ticks was removed to the green house to maintain a more uniform temperature.

July 2d. Young ticks hatching out in jar A.

July 3d. *Infested cow with ticks.*

Case No. 1. Red cow, grade Shorthorn, four years old, in good condition. Temperature of cow 101 degrees F. A large number of young ticks were applied to the udder, escutcheon, and back by taking off the muslin cover of the jar and permitting the ticks to crawl out upon the animal.

July 7th. Temperature of the cow 102 degrees F. The young ticks have attached to the skin and have increased in size.

Eggs in jar "B" have hatched; a few ticks from this jar were applied to the belly, chest, and neck of the cow.

July 11th. Temperature of cow 102.6 degrees F. Day warm. Cow looks well.

July 18th. Cow very sick. Temperature 104.1 degrees F. *Bloody urine* was passed, after taking the temperature.

The animal died during the night, fifteen days after the first application of ticks.

Post Mortem Notes: Examination made July 19th, 10 a. m., probably ten or twelve hours after death.

No external injuries; ticks in large numbers on udder, escutcheon, belly, and dewlap. Size of tick, an eighth of an inch long. Connective tissue beneath the skin very yellow.

Abdominal cavity: The fatty apron (Omentum) covering the intestines, very yellow. The (mesentery) membranes suspending the intestines, yellow and dotted over with (petechiae) small blood spots. These spots also seen beneath the external coat of the intestines and beneath the lining membrane of the abdominal cavity.

The *rumen* contained a small quantity of food, and the usual amount of gas. Maniplies impacted.

Fourth Stomach, nothing noted. *Small intestines:* Mucous membranes look healthy. *Large intestines:* Nothing noted. *Liver:* Blood vessels nearly empty. Cut surface very yellow—deeply stained by bile. *Gall bladder:* Full of thick bile. *Spleen:* Enlarged; very much softened; black tarry substance exudes from cut surface; the fibrous tissue easily broken down by the finger. *Fatty tissue* over kidneys very yellow. *Bladder:* Distended with bloody urine. *Flesh* of animal, of good color, but the intermuscular connective tissue had a yellowish tinge.

Chest cavity: Lungs collapsed. They presented no abnormal appearance. *Heart:* Empty and contracted. Blood extravasations under (pericardium and endocardium) the external and internal lining of heart. *Blood:* Fluid and dark colored.

Specimens of the liver, spleen, kidneys, and blood were preserved for microscopic examination.

Mounts from the blood showed bacteria and the Texas fever micro-organism.

CASE NO. 2.

July 7th. Jersey cow, ten years old; condition good, except that one of the quarters of the udder had been spoiled and gave the animal some uneasiness at times. (This cow had previously been infested with young ticks, raised from adult Australian ticks. The result was negative. See record of this on page 138).

July 7th. Temperature of animal 102 degrees F.

Infested the animal with several hundred young ticks from jar "B". (Four days after the infestion of cow No. 1).

July 11th. Temperature of animal 101 degrees F.

July 20th. Cow seemed off feed—reported by farm hand.

July 22d. Temperature of cow 105 degrees F. The day very hot, 94 degrees F., udder slightly distended—vulva shows a mucous discharge. May be in heat. Cow looked more gaunt than a few days previous—was lying down.

July 23d. Temperature of cow at 9 a. m. 107.8 degrees F., at 6 p. m. 107.4 degrees F. The day exceedingly warm, 93 degrees F. Mounts from the blood taken from the ear showed the micro-organism of Texas fever.

The animal lies down most of the time; looks sick; the urine highly colored but not bloody.

July 24th. Temperature at 8 a. m. 105.4 F., at 6:30 p. m. 106.5 degrees F. The animal lying down, gets up when disturbed.

July 25th. Temperature 8:30 a. m. 108 degrees F.; at 4:30 p. m. 105.4 degrees F., gait very unsteady; seems constipated, strains considerably, passed bloody urine this morning; observed by the writer and Mr. Potter, collector for Biological Department. The cow has marked cerebal symptoms; she makes lunges at persons near her. These symptoms became more marked as the end approached. The animal died at 11:30 p. m. and the post mortem was made the following morning at 9 o'clock.

A photograph of this cow was made a few hours before

she died. Cow No. 3 not then sick, also appears in this picture. See fig. 3.

Sunday, July 26th, 9 a. m. The following gentlemen were present at the post mortem: Director Waters, of the Experiment Station; Secretary Rippey, of the State Board of Agriculture; Dr. Stedman, Entomologist of Station; Dr. Smith, Veterinarian of the city; H. A. Lipscomb, M. D.; Chas. Conner, Assistant Agriculturist in Experiment Station.

Post Mortem Notes:

Inspection of exterior: No serious external wound, only a few barb wire cuts made when falling on wire fence at time of death.

Ticks in large numbers on udder, escutcheon inside of hind legs, and on neck.

Subcutaneous fat: More yellow than normal even for a Jersey and shows some extravasation of blood. *Flesh*, healthy in color.

Adominal viscera: The petechiae or blood spots mentioned in case No. 1. are more numerous in this case. They are abundant on the *broad ligaments* of the uterus. This was not noted in the other case. *The liver*. Very yellow from bile injection. Liver more enlarged than in former case. *Spleen:* Shows some enlargement not very marked; the structure, however, is much softened. *Bladder:* full of bloody urine.

Heart: blood clots in the cavities, blood spots as in former case beneath the pericardium and endocardium. *Lungs:* Right lung collapsed and healthy looking, left lung shows hypostatic congestion. The cow was lying on that side when found—probably not a morbid condition. *The pleurae* showed no marked changes.

Microscopical examination of the blood showed motile bodies in the plasma and within the corpuscles. Dr. Lipscomb, the assistant in this work, succeeded in making good drawings of one of the intercorpuscular bodies, showing amoeboid movements. Stained preparations showed the paired pyriform bodies.

Specimens of the liver, spleen, lymph glands, kidneys and salivary glands were preserved.

CASE NO. 3.

July 21, 1896. Shorthorn cow, red color, eight years old, in fair condition as to flesh. The left half of udder slightly distended from retained milk—otherwise in good health. The cow was put in the pasture lot previously occupied by cow No. 1. No ticks were put on this cow; but eight days before, a jar containing a few old and young ticks was emptied on the grass beneath a shed located in this pasture, the object being to determine whether the animal would take up a sufficient number of ticks from the grass to cause death. A few days later the cow broke down two partition fences separating this lot from the lot containing cow No 2. The two animals were left together and had the run of both pasture lots. The two lots contain about two acres.

July 22d. Temperature of cow 103.8 degrees F., respiration rapid, udder distended with milk. The distress of the animal was relieved by emptying the udder. The day was exceedingly warm, 94 degrees F. at 7 p. m.

July 23d. Temperature of cow 102.2 degrees F. at 9 a. m.; 104.8 degrees F. at 6 p. m. The day very hot—93 degrees F. The excessive heat doubtless accounts in part for the cow's high temperature. It is too soon to be affected by Texas fever.

July 24th. Temperature of cow 100.4 degrees F. Weather record 86 degrees F.

July 28th. Temperature of cow, 7 a. m. 103.8 degrees F.; 6:30 p. m. 106 degrees F. Weather record 94.2 degrees F.

July 29th. Temperature of cow, 7 a. m. 104 degrees F.; 6:30 p. m. 106 degrees F. Weather record 94.8 degrees F.

July 30th. Temperature of cow 7 a. m. 104.3 degrees F.; 6:30 p. m. 107.5 degrees F. Weather record 97.1 degrees.

July 31st. Temperature of cow 7 a. m., 106 degrees; 6:30 p. m. 108 degrees F. Weather record 97.2 degrees. Large number of ticks began to show on the animal.

August 1st. Temperature of cow 7 a m. 105.8 degrees F.; 6:30 p. m. 107.8 degrees F. Cow looks dumpish, movements sluggish. The urine shows no tinge of blood. Weather 89.5 degrees.

August 2d. Temperature of cow, 7 a. m. 107 degrees F.; 6:30 p. m. 106.4 degrees F. Sluggish movement. Weather 89.8 degrees.

August 3. Temperature of cow 7 a. m. 106 degrees F. Cow looks very sick. Movements unsteady, lies down much of the time—has become gaunt.

Died at 2:30 p. m., on the thirteenth day after admission to the infested pasture.

Post mortem made at 4 p. m. Drs. Lipscomb and Barnett assisted at the post mortem.

Notes: Inspection of Exterior: Ticks were found on the neck, front legs, escutcheon, udder, flanks, hind legs, more abundant on inner surface.

A portion of the skin from the flank where the ticks were most numerous was cut off and photographed. (See Fig. 5, page 87.) They are not so numerous as in the cases artificially infested. All these tick were picked up from the pasture in the natural way of infestion.

Abdominal viscera: Spleen slightly enlarged, extravasation of blood beneath the capsule, fibrous framework easily broken down, pulp exudes on section through the spleen. *Liver:* Large vessels engorged with blood—bile capillaries injected with bile. Cut surface of liver very yellow. *Gall bladder*, full of thick bile. *Kidney fat* exceedingly yellow. Kidneys look healthy to unaided eye. Bladder distended with bloody urine. The cow during life was not seen to pass bloody urine.

Intestines: Show the same spotted appearance under serous coat as seen in cases No. 1 and No. 2.

Chest cavity and viscera:—Lungs and *pleurae* healthy looking. *Heart* shows extravasation of blood beneath pericar-

dium. Right side distended with blood, left side empty, muscular tissue of heart in the deeper portions looks healthy. *Endocardium* and arch of aorta covered with petechiae. Considerable exudation of lymph tinged with blood, into the areolar tissue around the thoracic aorta.

Specimens of diseased tissues were preserved.

Microscopical examination of the blood shows a breaking up of corpuscles. Many small motile bodies, having a consistency appearently about the same as the corpuscle and size about that of the blood platelet or smaller, and varying in form from sphere to pear-shape, were seen floating free in the plasma Five or six were frequently found in a field (one-twelfth immersion lens No. 4 ocular). Intra corpuscular bodies were also observed.

It is greatly regretted that the temperature record of each of the foregoing cases is not complete. This resulted from circumstances which could not be foreseen. Fortunately, however, the omissions are not vital. The conclusions to be drawn from the experiments would remain the same were these gaps in the records filled up.

It will also be seen that no estimations are recorded of the diminution in the number of corpuscles that occurs in this disease. Here, too, fortunately, such determinations by use of the haemacytometer would have added nothing of practical value, since the cases were of such well marked character as to render the use of this more delicate aid to diagnosis unnecessary. On cow No. 3 an attempt was made to obtain a count of the corpuscles, but the carrying out of such work with an unruly cow for a subject, and in the open air exposed to sun and wind, is much more difficult than is a similar determination at the bedside of the human patient, or in the laboratory. The liability of the introduction of elements of error by the unfavorable conditions, as well as the lack of time on account of the burden of other more pressing duties, led to the abandonment of further attempts to make these determinations.

NO OTHER SOURCES OF INFECTION THAN THE TICK.

The proofs that have been given above will convince the majority of doubting stockmen of the fact that the tick is a very efficient agent in the production of Texas fever; yet they may not be so fully convinced that there are not other sources of infection quite as efficient as the ticks. This is a matter that has been well investigated and the *mass of evidence points to the conclusion that the disease is never transmitted by the saliva, the urine, or the manure*, through the eating of foods contaminated by these excretions. The feet of cattle are not capable of carrying the germs. Nor is it probable that the micro-parasites carried by the ticks can cause the disease when taken into the stomach. Soils, grasses and pond waters of the infectious districts of the Southern states do not cause the disease when fed to cattle.

Feeding experiments by the workers connected with the Bureau of Animal Industry, by Dr. Dinwiddie, of the Arkansas Station, and by this station show very conclusively that the materials mentioned do not contain substances that prove dangerous to the animal when introduced into the alimentary tract.

Some unpublished data connected with the Texas fever work carried on at this station under the direction of the former veterinarian, Dr. Paul Paquin, substantiate this view.

In the fall of 1888, under his direction, the writer made feeding experiments on eight head of cattle, two of which were yearlings, all the others were adult animals. The materials used were: *manures*, fresh and old, *urine*, *hay*, *pondwater*, *soil infusion*, *hoof infusion*, and *tick infusion*. Some of these materials were collected by Dr. Paquin and the remainder sent by Dr. Francis of the Texas Station. The doses were in some cases given as drenches, in others mixed with food.

The results failed to show the slightest evidence that these materials can cause the disease, when taken into the alimentary tract. No marked increase of temperature occurred in a single case.

II. EXPERIMENTS ON THE PREVENTION OF TEXAS FEVER.

(1) DIPPING EXPERIMENTS TO KILL THE CATTLE TICK, AND THE APPLICATION OF THE METHOD TO COMMERCE.

It is evident from what has been presented in the preceding section, that if some effective, cheap, and easy method of destroying the ticks infesting southern cattle without injuring the latter, could be devised, great benefits would accrue to the cattle and farming industry of the whole country; the danger of infecting northern territory in the transfer of these animals would be overcome; a market previously closed would be opened to summer feeders in the north, in seasons when there occurs an abundance of corn and grass and a scarcity of native cattle. This surplus food stuff could be turned quickly to the profit of the farmer. The present necessary though burdensome quarantine regulations would be greatly eased; foreign countries could no longer exclude these animals on the grounds that they are liable to introduce a dangerous disease. Nor should the ultimate extermination of these dangerous parasites. through the general and systematic use of this and other methods, be looked upon as a vain hope; when we consider that a period of existence on the ox (or horse) is an absolute necessity in the life cycle of the parasite. They do not propagate when kept away from the host. The mating of the male and female takes place on the host. Experiments at this station the past summer, show that it is difficult to get these ticks to grow on other animals than cattle and horses. The name of this tick (Boophilus Bovis, "ox-loving") indicates its preference for cattle, and since the experiments of Dr. Dinwiddie of the Arkansas Station showed that the tick loses its virulence when grown on the horse, the disinfection is reduced practically to the application of the method to cattle. The possibility, however, of the progeny of the ticks grown on the horse regaining their virulence when they come again upon cattle should not be overlooked.

The method of disinfecting live cattle which at present comes nearest to fulfilling the required conditions for commercial purposes is the "dipping method," which now has a large use in Texas for a different and double purpose, both humanitarian and economic, that of giving comfort to the animals, and thereby insuring a profit in growth and fat that would otherwise be impossible. On this point Dr. Francis of the Texas experiment station says in one of his publications: "Ticks have become such a curse in this state that we have been compelled to devise some means for their destruction."

The first attempt to determine the practicability of using this method for commercial purposes was made during the past summer.

While the methods of completely ridding the animal of the ticks have not been fully perfected in all details it is believed that the difficulties thus far encountered are not insurmountable. The method has been demonstrated to be cheap, and of easy and rapid application, and so far as this particular experiment is concerned it was practically effective.

The irritating effect of the dip, as shown in this experiment, would be a serious matter were these the usual effects. We feel confident that the essential of nonirritation will be secured for this method.

METHOD OF DIPPING AND DIPS USED.

This part of the work was performed by the Texas Experiment station under the immediate direction of Dr. M. Francis, veterinarian of that station. The following statement concerning the methods of dipping and the solution used has been prepared by Dr. Francis:

"The destruction of these parasites on the bodies of our cattle has engaged a large share of our attention for several years. It is evident that whatever means be adopted, it is of first importance that every tick be reached. This is accomplished by forcing the cattle to swim through a large dipping vat, somewhat similar to the dipping process employed against certain parasites of sheep. The device consists of a large

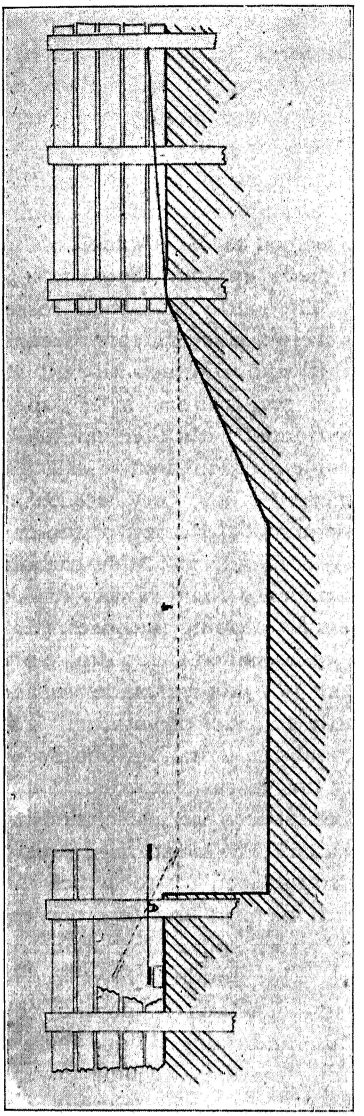

Fig. 8.—Sectional view of dipping vat used by the Texas experiment station.

wooden vat, about ten feet deep and forty feet long, having a working capacity of about five thousand gallons. It is constructed in a large trench so that the lower two-thirds is below the ground line. The entrance is through a narrow chute at the end of which there is provided a trap door balanced over the end of the vat, so that when the animal passes through the chute and arrives on the trap, the latter tilts, and the animal, losing its balance, plunges into the vat. The animal is almost always completely submerged, thus bringing the solution in contact with its entire body. On rising to the surface it swims to the exit, which is provided with a cleated inclined floor to enable it to make its way out and reach an inclined dripping platform where the cattle are detained a short time. This device has a working capacity of about one thousand head per day. It is, perhaps, not desirable to burden this report with the details of the

construction of the vat. A general understanding may be gotten from the accompaning cut, figure 8. Those who are seriously interested in the subject will be provided with plans and dimensions. In our earlier studies of the subject we began testing the different varieties of sheep dips, with the view of finding a suitable and efficient commercial preparation that could be supplied in large quantities and be of uniform quality. We selected a certain one which seemed to be typical of the carbolic acid group. Of this we made up four thousand gallons of a five per cent strength. The cattle were then forced to swim through it. The results were not satisfactory because it irritated the animals considerably and did not kill all the ticks. We also tried other carbolic preparations in a similar manner, but found ourselves confronted with this condition: That some of the ticks would survive solutions that would probably be fatal to the cattle if immersed in it. On one occasion we seriously scalded about ninety animals by using a too concentrated carbolic preparation. We found, also, that carbolic emulsions are very unstable, and undergo changes very rapidly which make them almost worthless for dipping purposes. Our attention was next engaged with an arsenical sheep dip, which we used in a one per cent solution. Of this we made up four thousand gallons and forced cattle to swim through it. This preparation was stable, uniform, and non-irritating, but its action on the ticks was so indifferent that it was discarded. Emulsions of kerosene and decoctions of tobacco were also tried in a small way with no practical results. We next began using oils. The first season we used cotton seed oil to which had been added ten per cent crude carbolic acid and five per cent pine tar. We filled the vat with water and added about one hundred gallons of the oil mixture, which made a layer on the surface of the water three-fourths to one inch in depth. The cattle were forced through the chute and plunged into the vat. On rising to the surface and coming out they became covered with oil, which was exceedingly fatal to the tick without causing any positive injury to the cattle. We noted, however, that such a coating of oil in the vat soon became greatly altered in

appearance and quality, from contact with water which eventually induced us to seek a substitute. We next tried a cheap natural or mineral oil, called "Winter West Virginia." We used this in the same manner as the cotton oil. It bears agitation with water quite well, but it occurs to me that it is not so fatal as the cotton oil to the tick. We sometimes use it alone and sometimes add carbolic acid to it. In some instances we have dipped a bunch of cattle with absolutely perfect results, and sometimes we notice an animal on which the work was imperfect. There is yet a third condition of affairs for which we have no satisfactory explanation. It sometimes occurs that that half grown ticks will be noticed several days after dipping. This has caused us great annoyance and much study. At present we attribute it to the condition of the tick at the time of dipping, viz., that it was moulting. These young ticks sometimes increase in size and may have the appearance of healthy ticks, but we have invariably failed to hatch their eggs, which seem to have been aborted, though the conditions were suitable as proven by eggs of other ticks hatching under same conditions.

This has led us to be somewhat guarded of late, in claiming that one dipping will offer sufficient safeguard against Texas fever, if the dipping processes be adopted on a commercial basis. For purely experimental purposes it may, but in our judgment it would be somewhat risky for general use. It occurs to us then, that if a change in the present Federal regulations be contemplated, it would be wise to require two dippings with an interval of several days. This we believe would be absolutely safe.

Having succeeded to the above extent in finding a suitable means of destroying the ticks on such a scale, it was decided to make the experiment of shipping a lot of dipped Texas cattle to the Missouri Experiment Station, to be confined there under suitable conditions with native Missouri cattle. Through the courtesy of the Secretary of Agriculture permission was granted. It was decided that this should be done in midsummer. After ticks from this locality had been tested in Missouri and had been found capable of transmitting the disease.

Some delay occurred just at this time in finding a lot of cattle bearing a sufficient number of ticks. This compelled us to use a lot of old cows that had become greatly emaciated by suckling calves. Tuesday, August 4th, we dipped ten old cows and one stag in the vat. On the water we had put one hundred gallons of Winter West Virginia oil, with which ten per cent of crude carbolic acid had been mixed. The cattle were greatly irritated by this treatment; a result that was unusual and unexpected. We had previously used the same proportions with no severe results. This result we ascribed to our inability to obtain at the time on the open market crude carbolic acid of uniform quality.

The next day, August 5th, the cattle showed the effects of the dipping by panting, and most of them showed irritation of the eyes. Late in the afternoon of the same day they were driven five miles to the stock pen at Bryan. During the loading the stag became obstinate and refused to enter the car and was left in the pens. So the load consisted of ten cows. Mr. W. D. Clayton, who accompanied the car and represented us at the Missouri Station, reports that the cattle suffered intensely from the heat, dipping and thirst combined, so that two of the cows became exhausted and died in the car and their bodies were thrown out at Parsons, Kansas. It is perhaps worthy to note that just at this time, August 7th, there occurred a period of intense heat. I notice the record at Columbia, Missouri, of that date reads 103.6 F. The car reached Columbia August 8th at 9 a. m. and the further conduct of the co-operative experiment passed to the Missouri Agricultural Experiment station."

OBSERVATIONS ON DIPPED CATTLE AT THE MISSOURI EXPERIMENT STATION.

On the arrival of the dipped Texan cattle at Columbia they were inspected by Director Waters, Dr. White, State Veterinarian, and the writer. The cattle were very much exhausted from the excessive heat, and from lack of water. The weather record shows August 7th, 103.6 F., and August 8th, 103.1

F. These were the hottest days of the summer. The irritant effect of the dipping, as already mentioned by Dr. Francis, was also noted. These effects passed away in a short time after the cattle were put upon a shaded pasture and supplied with an abundance of good running water. The cattle were carefully examined for live ticks. The table given below will show in column, under August 8th, the number found on the day of arrival. The succeeding columns will show that quite a number of live ticks escaped observation and became fully matured. No ticks were observed after August 24th, sixteen days after the arrival of the cattle. The total number of ticks dropped upon the pasture, we may roughly estimate at a hundred; a number certainly sufficient to cause a dangerous infection if all the conditions were favorable. The grounds upon which the experiment was made presented no unfavorable conditions, according to the opinion of Mr. Albert Dean, superintendent of the Western Branch of the Southern Cattle transportation for the Bureau of Animal Industry, who inspected these cattle on August 20th. (A picture of a bit of this ground as well as the cattle is shown in figure 7.) An exposure of native cattle with the Texans for a period of 79 days gave ample time for an infestion of these animals with young ticks hatched from the eggs deposited by the mature ticks dropped on the pasture by the Texans, and the development of Texas fever, but throughout this period not a tick was found on the native cattle, nor could any be found on the Texas cattle after those brought with them had disappeared.

There were thousands of dead ticks, young, and half grown to be seen on each of these animals, showing that the dipping solution is very destructive to these parasites.

Besides the exposure experiment other, experiments in the laboratory made with the ticks indicate that the ticks that escaped destruction are practically harmless. Several of the mature female ticks that were taken from the Texan cattle on the day of arrival, and placed in the laboratory in order to determine whether they would lay eggs, and whether these eggs had suffered any injury from the dipping solution. The

TABLE SHOWING THE NUMBER OF LIVE TICKS FOUND ON THE TEXAN CATTLE ON ARRIVAL, AND THE LATER DEVELOPMENT OF OTHERS THAT WERE NOT THEN SEEN.

(From notes taken by Dr. Lipscomb and Mr. Clayton.)

Animal.	Aug. 8	Aug. 13	Aug. 17	Aug. 18	Aug. 19	Aug. 20	Aug. 22	Aug. 24	Aug. 29
No. 1.	4 live ticks.	Estimated 8 to 10.	.. ....	.....	.. ...	Mr. Albert Dean, of the U. S. Bureau of Animal Industry, inspected the cattle to-day and collected a few ticks.	.....	4 full grown ticks.	Ticks have all disappeared.
No. 2.	5 live ticks.	2 doz. (est.)	.....	.....	.....		.....	.....	
No. 3.	2 live ticks.	8 to 10	.....	.....	.....		.....	No ticks.	
No. 4.	2 live ticks.	No ticks.	A dozen or more sm'll ticks "mated."	... ..	Ticks enlarged		½ doz. full grown	2 full grown ticks.	
No. 5.	12 live ticks.	2 doz. (est.)	Some large ticks.	.....	.....		.....	.....	
No. 6.	11 live ticks.	No ticks.	.....	About a dozen small ticks.	Ticks enlarged	Ticks large.	... .	2 full grown ticks.	
No. 7.	3 live ticks.	10 to 12.	.....	.....	.....	.....	.....	.....	
No. 8.	6 live ticks.	8 to 10	.....	.. ...	.....	Large ticks.	6 to 8 full grown	3 full grown ticks.	

Nearly all are small ticks but "mated."

ticks had some of the oil still adhering to the body, but this did not prevent the laying of eggs, which occurred in eight or ten days, and the eggs at first appeared perfectly healthy. In a few days, however, the greater number of the eggs turned black and failed to hatch. Only a few young ticks appeared. These hatched September 12th. It is quite probable that the oil adhering to the bodies of the fully matured ticks had a very damaging effect on the eggs. In this way we may account for the fact that no infestion of the native cattle occurred when everything seemed so favorable for it. The observations of Dr. Francis that those eggs do not hatch that are laid by ticks that come to maturity sometime after the dipping has been

done, is very valuable; and it possibly may be accounted for in the same way, that is, that the direct contact of the eggs with the oil prevents them from hatching, or more likely that fertilization is prevented; though "mating" is not prevented, as will be seen by the notes contained in the above table.

EXPOSURE OF SUSCEPTIBLE NATIVE CATTLE TO THE ABOVE TEXANS.

The native cattle mentioned above were put in the pasture with the Texan cattle on August 13th, five days after the arrival of the latter. None of these natives were under six years old, and all in fair condition as to flesh, and apparently healthy—one was discovered later to have some tenderness of the udder which was found to be due to an abcess, which unfortunately caused the death of the animal (see case reported as number 6, page 110.) These cattle were of about the same grade as those used in the tick infestion experiments, and were probably as fully susceptible to Texas fever, had the cause been presented in the usual way by means of the ticks. The temperature of these animals was taken daily, and a careful examination made for the appearance of the ticks.

These records are now given:

Temperature record of Cow No. 4.—Small red cow, grade Shorthorn, about seven years old, good condition. Exposed with Texan cattle August 13th.

DATE.	Temperature. 7:30 a. m.	Temperature. 5:30 p. m	Weather Record. Max.	Weather Record. Min.	REMARKS.
	Deg. F.	Deg. F.			
August 21	———	102.3	98	71.1	August 20th.—Mr. Albert Dean, Superintendent of Inspection of the Western Division of the Southern Cattle Transportation for the United States Bureau of Animal Industry, made an inspection of all the cattle and collected a few ticks. Said the grounds are suitable for the experiment.
" 22	100.9	102.5	90	69.5	
" 23	100.4	102	82	59.5	
" 24	100.5	101.4	87.8	50	
" 25	100.3	101.4	85.6	52.2	
" 26	100.4	102	81.9	63.9	August 21st.—Dr. J. Sidney Hunt, Pathologist to the Queensland Cattle Commission, Australia, visited the station.
" 27	100.1	101.9	83	49.	
" 28	102.4	101.5	84.6	52.4	
" 29	100.6	101.8	74.6	55.3	
" 30	101	102.6	92.9	52.9	
" 31	100.6	102	85	60.7	
September 1	100.2	102.3	88.7	59.8	
" 2	101	102.5	96	65.8	
" 3	100.9	102.8	83	62.9	
" 4	100.8	———	81.5	53.9	September 4, 8, 10, 13.—No temperatures were taken in the afternoon on account of the press of other work.
" 5	101.1	102.2	79.6	57	
" 6	101.2	101.3	76.2	43.2	
" 7	101.3	102.2	83	47.7	
" 8	102.4	———	77	65	
" 9	101	101.3	82	72.7	
" 10	101.3	———	94.8	67.8	September 10th.—Dr. Chas. Blemer, of the Bureau of Animal Industry, inspected the cattle. He could find no ticks on the Texans or natives.
" 11	101	101.8	74.1	56.8	

September	12	101	101.9	86.8	60
"	13	101.2	———	96.7	67
"	14	100.8	102.4	91.2	65
"	15	101.1	104	85	68
"	16	100.6	102.2	89.3	63.5
"	17	100.6	101.1	82.2	66
"	18	101	102	79	60
"	19	100.8	101.2	68.3	49
"	20	100.6	100.9	67	37
"	21	100.8	101.1	76	52
"	22	100.9	*	65.8	43
"	23	100.8	.....	70.3	33.1
"	24	100.5	.....	78.3	45
"	25	101.4	.....	77.9	54
"	26	101.6	.....	76	53.4
"	27	———	.....	60.5	48
"	28	100.4	.....	60.1	42
"	29	102.2	.....	54.5	42
"	30	101.1	.....	81.2	42.5
October	1	100.2	.....	82	43.7
"	2	100.7	.....	81.7	56.7
"	3	100.3	.....	73.3	47.1
"	4	100.2	.....	74.6	48.5
"	5	99.9	.....	75.7	52.9
"	6	100.6	.....	65.5	45.8
"	7	99.8	.....	63.6	33.6
"	8	100.9	.....	63.9	35.9
"	9	102	.....	71.2	39.6
"	10	101.9	.....	66	50.5
"	11	99.5	.....	51.3	45
"	12	100	.....	57	48.4
"	13	101	.....	68.8	39
"	14	100	.....	73.9	34.4

September 15th— { The only high temperature noted. Made an examination for ticks but found none. The day is very sultry, although the weather record does not show excessive heat. Cow No. 5 also shows an elevation of temperature.

September 22d.—From this date the temperatures were taken only once daily, and that later in the morning.

October 14th.—The temperatures were not taken after this date; but the native and Texan cattle were kept together until November 1st, when the cattle were sold—except two Texans, kept for further work.

RECORD OF TEMPERATURE OF NATIVE COW NO. 5 EXPOSED TO TEXANS AUGUST 13, 1896.

Native cow, brown color, scrub breed, aged about 6 years, in good flesh.

DATE.	Temperature.		Weather Record.		
	7:30 a. m.	5:30 p. m.	Max.	Min.	
	Deg. F.	Deg. F.			
August 21	——	103	98	71.1	Cow was made hot in getting her into the chute. The animal is somewhat wild.
" 22	102	102.6	90	69.5	
" 23	100.8	101.6	82	59.5	
" 24	100.9	101.8	87.8	50	
" 25	100.8	101.6	85.6	52.2	
" 26	100.9	102.4	81.9	63.9	
" 27	100.6	102	83	49	
" 28	101.1	101.5	84.6	52.4	
" 29	100.6	101.1	74.6	55.3	
" 30	101	102.3	92.9	52.9	
" 31	100.9	102	85	60.7	
September 1	101.2	102	88.7	57.8	
" 2	101.2	101.9	96	65.8	
" 3	101.2	101.5	83	62.9	
" 4	100.9	——	81.5	53.9	Temperature not taken in the afternoon.
" 5	101.7	102.1	79.6	57	
" 6	101	101.4	76.2	43.2	
" 7	101.1	101.8	83	47.7	
" 8	101.3	——	77	65	
" 9	101.2	101.9	82	72.7	
" 10	101	——	94.8	67.8	Out of town in the afternoon—did not take temperature.
" 11	101.3	101.6	74.1	56.8	

September	12	101	102	86.8	60	
"	13	101	——	96.7	67	
"	14	101.2	101.1	91.2	65	
"	15	101.2	103	85	68	Day very sultry. See record of cow No. 4.
"	16	101.3	101.6	39.3	63.5	
"	17	101.2	101.6	82.2	66	
"	18	101	101.9	79	60	
"	19	100.8	101	68.3	49	
"	20	100.5	100.8	67	37	
"	21	100.5	101.2	76	52	
"	22	100.9	....	65.8	43	
"	23	100.3	.....	70.3	33.1	
"	24	100.6	.....	78	45	
"	25	101.6	.....	77.9	54	
"	26	104.1	101.2	76	53.4	Cow seems sick; can not find any ticks.
"	27	100	.....	60.5	48	
"	28	100.2	.....	60.1	42	
"	29	100.6	.....	54.5	42	
"	30	100.9	.....	81.2	42.5	
October	1	100.2	....	82	43.7	
"	2	100.7	.....	81.7	56.7	
"	3	100.3	.....	73.3	47.1	
"	4	101.2	.....	74.6	48.5	
"	5	100.9	.....	75.7	52.9	
"	6	101	.....	65.5	45.8	
"	7	100.6	... .	63.6	33.6	
"	8	100.5	.....	63.9	35.9	
"	9	101.3	.....	71.2	39.6	
"	10	101.3	.....	66	50.5	
"	11	101.1	.....	51.3	45	
"	12	100	.....	57	48.4	
"	13	100.9	.....	68.8	39	Kept with the Texans until November 1st. No ticks could be found on the cows.
"	14	100.4	.....	73.9	34.4	

RECORD OF COW NO. 6, EXPOSED TO TEXAN CATTLE AUGUST 13, 1896.

This animal was also used in the Serum Experiment to test the effect of serum as a preventive in the event that the ticks that were dropped on the pastures should prove capable of causing Texas fever. This animal died October 11 from the effects of an abscess in the base of the udder. The record of this case is given in detail in order to show that the death was not due to Texas fever.

It is not thought that the serum injections had any connection with the formation of the abscess. These injections were made in a part remote from the udder—on neck and shoulder—and the material used had been well preserved. No swelling occurred at any time at the point of injection. Nor do we believe that Dr. Lipscomb, the assistant, who made all the injections except the first one, was neglectful of antiseptic precautions in carrying out the work.

This risk of vitiating the results of an experiment will lead to a more careful selection of animals in the future. At the time of purchase it was known that two of the seven cows had suffered from "spoiled" udders—but the consideration of cheapness, an important matter where no small substitute animal is available, led to their purchase, and fortunately no harm came of it. In this case of cow No. 6, however, a superficial examination did not reveal any diseased condition. It was only on the twenty-sixth day of the experiment that the first signs of tenderness in the udder were observed. On this day the first rise of temperature occurred, and in making an examination for ticks, Dr. Lipscomb found the animal very tender about the udder. The handling of the udder on previous occasions had shown no such tenderness. This was on the fifteenth day after the first injection of serum and the second day after the last injection. The careful attention of those who believe there is another natural means of transmitting Texas fever than through the ticks is called to the record of this case.

October 12, 1896. Made post-mortem of native cow No. 6.

Assisted by Dr. Lipscomb, Mr. W. D. Clayton, of the Texas Station, and Dr. Barnett.

Cow lying on left side—no marks of violence to be seen. *The skin was removed and inspected inch by inch for ticks but not a tick could be found.* Bruises seen on right hip after removal of the skin. Blood clots found in jugulars; bloody serum separated from clot and a considerable amount flowed from jugulars when cut. The udder contained a quart or more pus and *clotted milk.* Mounts from the pus showed cocci. No cultures nor inoculations were made. An examination of the blood was made but neither bacteria nor the micro-organism of Texas fever could be found.

Abdominal cavity and viscera: *Peritoneum* healthy; *omentum* healthy; *Rumen* contained about the usual quantity of soft food (hay) and some gas; *third stomach* (maniplies) somewhat enlarged but soft—showed no inflammation on cutting into it. *Fourth stomach* healthy. *Small intestines* no inflammation, no petechiae under serous coat. *Large intestines* contained some hard lumps of feces. *Rectum* contained hard lumps of feces covered with mucus.

Liver showed a slight engorgement with blood; the cut surface of the liver looked healthy. No yellow coloring of the liver substance, no injection of bile capillaries. *Gall bladder* full of green fluid bile—not the thick pasty bile usually seen in Texas fever. *Spleen* appeared normal—no softening of the structure. *Kidneys* healthy. *Bladder* full of light colored urine, no tinge of blood present.

Lungs and pleurae healthy color—no congestion except a slight hypostatic congestion of under part of left lung (cow lying on that side). Anterior lobe of right lung slightly emphysematous.

Heart very much distended with blood (both the auricles and ventricles). The *muscular tissue* of the ventricles appeared healthy; the auricles showed some extravasation of blood into the muscular walls. Cavity of heart filled with blood clot of very

RECORD OF TEMPERATURE AND OF THE INJECTION OF SERUM OF COW NO. 6.

DATE.	Temperature.		Weather Record Temperatu'e		REMARKS.
	7:30 a. m.	5:30 p. m.	Max.	Min.	
	Deg. F.	Deg. F.			
August 21	——	102.7	98	71.1	
" 22	101	102.1	90	69.5	
" 23	100.9	102.1	82	59.5	
" 24	100.2	101.2	87.8	50	
" 25	100.7	101.3	85.6	52.2	
" 26	100.8	102	81.9	63.9	
" 27	101.2	101.9	83	49	
" 28	100.9	102.2	84.6	52.4	
" 29	101.2	102	74.6	55.3	
" 30	101.2	102.1	92.9	52.9	
" 31	101	102.1	85	60.7	
September 1	101	102.2	88.7	57.8	
" 2	101.3	102.2	96	65.8	5 p. m., injected subcutaneously 20 c. c. Serum.
" 3	101.2	102	83	62.9	8 a. m., " " 20 c. c. Serum.
" 4	101.2	——	81.5	53.9	8 a. m., " " 20 c. c. Serum.
" 5	101.4	102	79.6	57	8 a. m., " " 20 c. c. Serum.
" 6	100.9	101.6	76.2	43.2	8 a. m., " " 20 c. c. Serum.
" 7	101.2	101.6	83	47.7	8 a. m., " " 40 c. c. Serum.
" 8	102.2	——	77	65	
" 9	101.6	102.2	82	72.7	8 a. m., September 9th, injected subcutaneously 20 c. c. Serum.
" 10	101.4	——	94.8	67.8	

September	11	101.2	102	74.1	56.8	
"	12	102.1	102	86.8	60	
"	13	101.9	——	96.7	67	
"	14	101.2	101.8	91.2	65	At 8 a. m., September 14th, injected subcutaneously 20 c. c. Serum.
"	15	101.2	102.3	85	68	At 8 a. m., September 15th, injected subcutaneously 20 c. c. Serum.
"	16	101	101.8	89.3	63.5	
"	17	103	102.4	82.2	66	Cow very tender about the udder.
"	18	100.5	102.6	79	60	
"	19	100.6	101.3	68.3	49	
"	20	100.8	101.5	67	37	
"	21	100.6	101.5	76	52	
"	22	101	——	65.8	43	
"	23	101.1	——	70.3	33.1	
"	24	101	——	78.3	45	
"	25	100.8	——	77.9	54	
"	26	101.7	101	76	53.4	
"	27	——	. . . .	60.5	48	
"	28	100.2	....	60.1	42	
"	29	102.6	.. ..	54.5	42	
"	30	100.7	....	81.2	42.5	
October	1	101	....	82	43.7	
"	2	101.1	....	81.7	56.7	
"	3	101.4	.....	73.3	47.1	
"	4	101.4	.....	74.6	48.5	
"	5	104.8	.....	75.7	52.9	Could find no ticks; looks sick, but eats.
"	6	100.8	.....	65.5	45.8	Cow seems better.
"	7	103.4	....	63.6	33	
"	8	102.3	....	63.9	35.9	No ticks; cow eats.
"	9	102	104	71.2	39.6	Cow looks sick, but eats.
"	10	101	.....	66	50.5	Cow not looking well.
"	11	——	101	51.3	45	Cow lying down and very sick.
"	12	COW DEAD				Cow died during the night.

Post mortem notes—see page 111.

Fig. 7.—View of pen in which native and dipped Texan cattle were confined on the Missouri Station grounds.

dark color. The pericardium, endocardium, valves of heart, and the lining of aorta all appeared perfectly normal.

Portions of the liver, spleen, heart muscle, kidney, lymph glands, mammary glands, pus from the mammary abscess, blood from the jugular in sterile pipettes were preserved.

The above description would never be taken as a picture of the morbid changes occurring in Texas fever.

Lest it should be thought that the weather conditions prevailing here during the progress of this trial were unfavorable to the development of the ticks the following account of an outbreak that occurred some fifty miles north of the station after the middle of November is taken from the St Louis *Post Dispatch* of November 20th:

"HANNIBAL, MO., November 20.—Texas fever has broken out among the cattle at Oakwood and a number have already died, while a greater number are now afflicted with the disease. About September 10th a lot of Texan cattle were unloaded at the stock yards and soon afterward the yards were sold and abandoned. Since then the native cattle have been permitted to graze in the yards and thus traveling over the trail of the Texas cattle contracted the disease."

It will be seen that the infestion of the stock yards mentioned above occurred almost a month after the dipped Texas cattle arrived at this station.

The disease occurred about forty days after the Texas cattle were in the yards, while the dipped cattle in the experiment were on the grounds continually for eighty-four days and the natives were exposed to these grounds for seventy-nine days. The close of our experiment was twenty days before the outbreak mentioned.

Another case in point is one reported in a letter from Dr. F. W. O'Brien, State Veterinary Inspector at Hannibal:

"A stock train on the M. K. & T. railroad was derailed at Hassard, Missouri, about the twenty-eighth of July, allowing Southern cattle their liberty.

"They wandered over the farms of John Kendrick and M. Redfoot. About the middle of September a steer which was

in the pasture with the Southern cattle, took sick and from the description of the symptoms given by Mr. Kendrick I concluded that he had been affected with Texas fever. But he recovered and was running with the cows that died a month later." One of these died October 20th, another October 21st, and a third as late as November 25th. This case covers almost the same season and period of time that is covered by the experiment.

Dr. O'Brien was of the opinion that the native steer that recovered was the carrier of the ticks that infested the two cows that died. But the time between the dates given is too short to admit of this secondary infestion. It is possible, however, that the first dates given were in fact much earlier than stated, and that the recovered native was the real conveyor of the infection. But it is more probable that the affected animal came in contact somewhere upon the pasture with a nest of young ticks from the original infestion.

The conclusion that we feel justified in drawing in regard to this particular dipping experiment after a consideration of all the facts is: *That it prevented the contraction of Texas fever by the exposed natives.* But we do not feel justified in recommending the method at present for commercial use. The objectionable features we hope may be removed by another season's work.

The desirability of continuing efforts to make this method a success in every particular is apparent from the following extracts taken from letters received in reply to inquiries made of the General Managers of the stock yards at St. Louis, Kansas City, and St. Joseph which give the opinions of men whose long experience make them competent judges of these matters:

Mr. Palmer of the Union Yards writes: "In reply to your inquiry as to the value of the process if successful, I have to say that it would benefit the entire country without any question, as it would open the market for a cheaper class of feeders for the corn growers of the Middle West."

Mr. Child, of the Kansas City yards, says: "When confidence is fully established in the success of the dipping, and it

is generally stamped as all right and safe, it will be of material benefit to the stockmen in using these cattle for feeders, but mainly in protecting the northern cattle from disease."

The superintendent of the St. Joe yards expresses the same opinion and adds: "I have talked to a number of our stock men about this matter and all are of the same opinion and join me in wishing you a complete success in your undertaking."

(2) The Prevention of Texas Fever by Serum Inoculation.

The need of some efficient and easily applied method of immunizing Northern cattle against Texas fever is apparent when it is known that a large per cent. of the breeding cattle shipped into the South, soon sicken and die from "acclimation fever." This disease, none other than Texas fever, and due to tick infestion, has proved to be the greatest drawback to the improvement of the Southern herds. The following letter from Mr. Matt. Zollner, of Blackland, Rockwall county, Texas, gives some idea of the importance of the efforts that this station is making to give relief to the Southern stockmen, and at the same time open a rich market to our breeders of fine cattle:

December 14, 1896.

H. J. Waters, Dean, College of A. & M. A.

Columbia, Mo.

DEAR SIR:—I beg to thank you for your kind and prompt reply to my letter addressed to your State Veterinarian.

I would be pleased to have you make a memorandum of my address and as soon as you have a supply of the antitoxin on hand to send me some. I will cheerfully make remittance if you will notify me of the amount. I now have thirty-three head of registered Durhams imported from your state; three of these are the offspring of a herd of fifteen shipped last spring. Eight are the remnant of these fifteen, and may be said to be partly acclimated; twenty-two head are a recent shipment, and these I am more anxious about, apprehending trouble next July and August.

"I would thank you for any information or assistance in acclimating these cattle.

[Signed.] MATT. ZOLLNER.

Mr. Zollner's experience is not an isolated one, but an average example of the experience of Southern stockmen who have

endeavored to improve their herds by importations from the North. The stimulus, therefore, to work for a means that will afford relief against "acclimation fever" is not wanting. The attempt to vaccinate against this disease was made at this station several years ago by Dr. Paquin. The plan pursued was that employed in vaccinating against Anthrax, but subsequent investigations have proven that the disease is not of bacterial origin; that the micro-parasite is a protozoon and not susceptible to cultivation outside of the animal body. The vaccines, therefore, that he made from the bacteria with which he worked could not be other than useless. Another method has been suggested and worked upon by the Bureau of Animal Industry, that of giving the animal a mild form of the disease by applying a few ticks at a time. This method would no doubt be very useful if its application could be made with safety by the average stockman. But disaster would surely follow, on account of the difficulty in "dosing out" a small number of ticks. Moreover, the possibility remains that a very few living micro-parasites introduced into the body by the small number of ticks may, under favorable conditions, multiply rapidly in the blood of the animal, and cause death.

Mr. J. H. Wright, of Meridian, Mississippi, the president of the Mississippi Stock Breeders Association, has had very gratifying results in the prevention of "acclimation fever" in the last few years by reversing the method mentioned above: Since the discovery was made that the tick is the tangible cause of the disease, he has used every effort to keep all recently imported animals free from these parasites by careful grooming daily. This method which has proven effective in the hands of so careful a man as Mr. Wright, would fail in the hands of most stockmen, since but few are so situated that they can carry out these measures.

Director Stubbs, of the Louisiana Experiment Station, informed the writer that they had applied insecticides by means of sprays to imported animals with the view of killing the ticks and that these experimental animals passed through the acclimation

period safely. He thinks, however, that there is some doubt as to whether these animals were from noninfected territory.

The dipping methods in use in Texas for ridding their native cattle of ticks, may turn out to be a valuable adjunct in the prevention of acclimation fever in imported cattle.

However a more practical and efficient method than any of those mentioned is very desirable; and the experiments made at this station during the past summer by what may be called the "anti-toxin" or "serum" method is an attempt to supply this need.

This work is a departure from all the methods that have previously been employed in this disease. It is an attempt to test the applicability to Texas fever of Behring's law in regard to the serum of an immunized animal; namely, *that, if an animal has acquired immunity against a disease producing micro-organism or its toxins, the serum from the blood of the immunized animal will prevent the disease in another susceptible animal.*

The discovery of this fact in regard to diptheria and tetanus (lock jaw), is one of the most valuable acquisitions that has been made to human medicine, and has given a stimulus to work in this field of therapeutics that will doubtless result in more successful treatment of many other diseases. A brief consideration of immunity and the methods employed in producing the antitoxines in diptheria and tetanus will be necessary in order to show nonscientific readers the reasonableness of attempting to apply the serum treatment to Texas fever.

The artificial method of immunizing the horse is in brief as follows: The horse is injected with a minute quantity of the poisonous products, called toxins, that result in the artificial culture of the virulent germs of the disease; this inoculation causes a rise in temperature, which subsides in a day or two, the animal is then injected with a larger quantity of the toxins and the temperature rises again. This process is repeated with gradually increasing doses until the horse is able to receive an enormous quantity of the toxic substances; a quantity sufficient to kill a large number of horses if it were given without this grad-

ual preparation. It has been found that the serum from the blood of an animal so treated has the property of preventing in some way the evil effects of comparatively large quantities of the toxins when both are injected into susceptible animals. The protective substances were named anti-toxines by Behring on account of the view that they acted as chemical antidotes to to the toxins, neutralizing them. Other investigations tend to show that the protective power of the anti-toxins is not exerted in this manner.

All investigators now agree that these substances, when present, are produced by the cells of the body in their reaction against micro-organisms or their poisonous products; all are not in accord, however, as to the *purpose* of this product in the animal that produces it, or its *action* when used in the treatment or immunization of another animal.

A study of the experimental facts leads to the conclusion that these antitoxic substances may not have, in the animal that produces them, any specific purpose, but are simply the excrete products of certain cells of the body, but differ from the ordinary products of those cells in some specific way on account of the specific reaction of those cells against a specific micro-organism or toxin. And, further, that these substances have the property of stimulating an activity in the same kind of cells of an animal not immune like that of the cells of the immune animal that produced these substances, and it is probably to this specific action or condition of the cells that the immunity of the animal against disease is due. The destruction of the micro-parasites is probably in the main due to direct cell action, by taking into their bodies the micro-parasite and their chemical products and destroying them.

Kanthack and Hardy made the observation that two different kinds of cells may supplement each other in this protective work, one set of cells secreting a substance that stuns or kills the parasite and the other set taking up these parasites and digesting them.

As an example of the specific stimulating action of cell product, may be mentioned the increased action of the liver

cells when bile salts are brought to them through the circulation; as this is true in physiology, it also may be true in pathology.

Turning now to Texas fever. In this disease, the *cause* is of an entirely different nature; here we have a protozoon micro-parasite (animal in nature); while in diptheria the cause belongs to the *bacteria* (vegetable in nature). This difference in the nature of the cause of these two diseases has led some investigators to the belief that there is a profound difference in the processes by which immunity is gained. But if we take the simple physiological view of immunity there can be no theoretical reason for supposing that any essential difference exists in the processes by which immunity is acquired against micro-organisms and poisons of all kinds.

Immunity against Texas fever is acquired in some way and is fully as effective as that acquired against any of the bacterial diseases. The cells of the body have in some way brought about this condition of security. The point in question then is, do these cells that have established this condition of immunity against Texas fever, secrete some new *specific* substance (or *modified* product of normal activity) that will stimulate in the cells of the body of a susceptible animal a like activity or condition. This is the matter to which we are applying the test of actual experiment.

It may be interesting to note in this connection that Dr. Koch, in his recent investigations of Rinderpest in South Africa (since November, 1896), has so far been unable to discover a bacterial cause for this disease; he has shown that a few bacteria that were supposed to be the cause have nothing to do with the disease. The indications from the reports are that Rinderpest is due to a protozoon micro-organism. It is of greater interest to know that so eminent an investigator has such faith in "serum treatment" in infectious diseases as to begin in this case at once in the empireal way at the therapeutic end, without waiting to discover the cause of the disease. Reports in the British Medical Journal of recent date are to the effect that

the *serum from animals that have recovered from the disease gives protection to other susceptible animals.*

In a case of naturally acquired immunity against Texas fever the ticks have taken the place of the hypodermic syringe in the inoculation process. The animal, while young, is naturally more resistant and may, if the dam is immune, gain some immunity through the milk (as has been shown to be possible in another disease); as the calf grows older the tendency is to lose its natural immunity, but on Southern soil the ticks keep up the natural inoculations from year to year and thus immunity against the disease is maintained and the animal is kept by these natural injections in that condition that the "antitoxin horse" is put into by artificial injections.

In this work, unfortunately, it is impossible to test the serum on cheap animals like guinea pigs or rabbits since these animals are not susceptible to the disease.

If further investigations confirm the opinion that the serum has immunizing properties, failure in the application of the method may frequently arise on account of the selection of an improper animal for furnishing the serum. We would suggest that the best Texas fever serum would probably be supplied by an adult native Northern animal, highly susceptible to Texas fever, that had passed through an attack, and that was kept in a high state of immunity by an occasional infestion with ticks.

The native Southern cattle that have a Southern ancestry of many generations may be in a conditon of natural immunity comparable to that of a species that is not susceptible to the disease, and may not furnish a serum of sufficient protective power. Many points of this kind that are at present only theoretical and based on analogy will be cleared up by further work. The fact should not be overlooked, that the protective serums have only a temporary action and are soon eliminated from the body, after which the animal sooner or later loses its immunity. In the application of the Texas fever serum the subsequent application of the ticks should not be neglected as this insures a more profound reaction, resulting in the

establishment of a permanent immunity. The serum is meant to tide the animal over the acclimation period.

In the use of the protective serums of tetanus and diphtheria the fact has been established that a much larger quantity of serum is required in curing the disease than in preventing it. Indeed, in tetanus the curative value is very small, while its protective value is very great. In diphtheria the preventive value is several hundred times as great as the curative value.

These facts should be remembered by those who take up this work.

The report of the inoculation experiment at this station is now given.

PREPARATION AND INJECTION OF SERUM.

August 29. The serum for the inoculations was secured from a Texas steer well infested with ticks (Boophilus Bovis). The animal used was from the Southern division of the Kansas City stock yards, and was selected for us by Drs. Sihler, Turner, and Kaupp, inspectors connected with the U. S. Bureau of Animal Industry, who also assisted in the collection of the blood.

The blood was drawn into sterilized jars, then let stand until a firm clot had formed. The clot was broken loose from the sides of the jar by means of a glass rod. The covers were replaced and the jars put in a refrigerator. On the following day the serum which had separated was drawn off into bottles and preserved by the addition of trikresol 0.5 per cent.

The serum was taken to the Experiment Station at Columbia and injected into a native Missouri cow, a grade short horn, eight years old, weighing about 850 pounds, and in good health.

September 2. The injections in doses of 20 c. c. to 40 c. c. (5½ to 11 drachms) were begun September 2, 1896, and continued to September 15, a total of 200 c. c. (7 ounces) before infesting with ticks. An additional quantity of 80 c. c. (2.8 ounces) was injected during the three weeks following

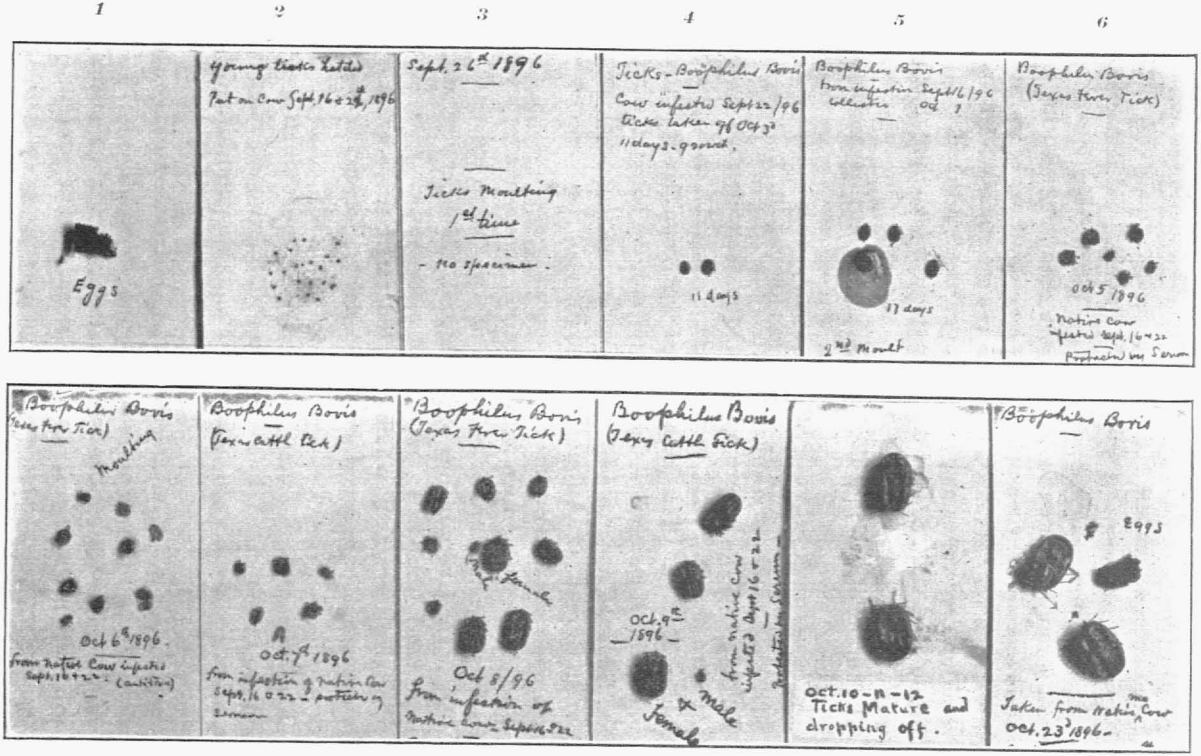

Fig. 9. Ticks grown on cow injected with serum.—See Fig. 10. On the animals that died the ticks were of the size shown in No. 5.

the application of the ticks. The total quantity injected during the experiment was 280 c. c. (almost 10 ounces). The ratio of serum to body weight was about 1 to 1400.

September 16. The animal was put in the pasture where three cows had died of Texas fever, two by artificial infestion with ticks, and the third by taking up the ticks from the pasture. In addition to this exposure to the infested grounds, several hundred young ticks hatched in the laboratory were applied We believe that a much larger number of

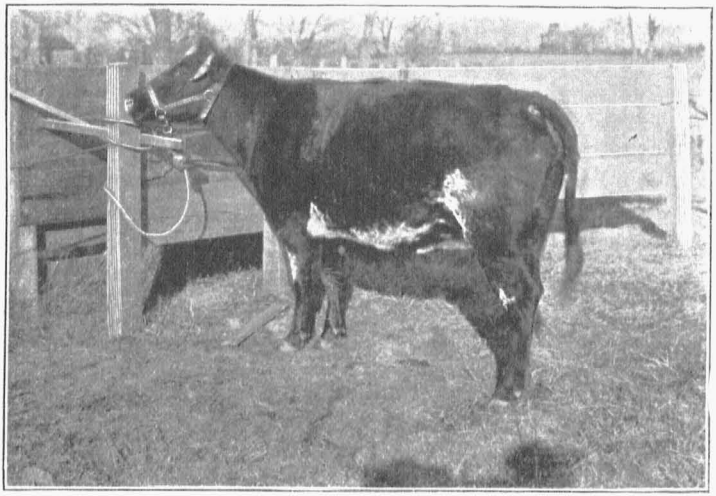

Fig. 10. Cow inoculated with serum, and subsequently infested with ticks.—Photograph taken at close of experiment.

ticks became attached to this cow than to any one of the three cows that died in the other experiments. The ticks used in this experiment were from the same source as those used in producing Texas fever in the three native cows mentioned. The old ticks from which all the young ticks were hatched were sent to us by Dr. Francis, of the Texas Station.

The temperature of the inoculated cow was taken twice daily, with but few interruptions, from the date of first injection until the ticks had begun to decrease in numbers. The

temperature remained within normal limits, except on the afternoon of the seventeenth and eighteenth days after infesting with ticks. On the first date the temperature rose to 104 F. and on the latter date to 106 F. The animal showed no outward signs of fever. The appetite was good, and all the actions indicated perfect health. An injection of serum, 20 c. c., was made at this time. On the following day the temperature was normal and continued so during the remainder of the experiment. The ticks grew well, became fully mature, and began to lay eggs in eight to ten days after being picked from the cow. Figure 9 slightly reduced from a photograh of specimens of ticks taken from the animal, gives a fairly correct idea of the growth of the tick. Specimens No. 2 were taken from the incubating jar. Card No. 3 gives the date of first moulting as taken from the notes. This was ten days after the first infestion. Unfortunately no specimens were preserved. Card No. 4 shows ticks of eleven days growth. These were taken from that part of the body upon which the second infestion was made. Card No. 5, ticks of seventeen days growth, taken from the part of the body first infested. The intermediate stages were not collected. It will be seen that the increase in size after the second moult is very slow up to and including the twenty-first day (specimen No. 8). The increase in size is then very rapid (specimens 9, 10, 11). The first fully matured ticks appeared on the twenty-fourth day after the first infestion. Thirty-seven days after the second infestion only four ticks were seen, and two days later, November 2, no ticks could be found. The photograph of the cow was then taken (see Figure 10), and further observations were discontinued.

The size of the ticks on the experimental animals that died corresponds to those in card five of figure nine. These animals, it will be noted, were infested in midsummer, and with a very large number of ticks. The writer has had opportunity to observe in an outbreak of Texas fever in Enterprise, Mississippi, that when the infestion occurs in cool weather many of the ticks may come to full size before the death of the animal,

and some animals may recover if the infestion has not been extensive.

Whether we must give to the cooler season in which the serum inoculations were carried on some credit for the result, is a matter that must be determined by further experiment. But the fact that a much larger number of ticks were put on this animal than on those that died, and the further fact that two outbreaks of Texas fever occurred in this State farther north than this Station (see page 115), one about September twenty-third, and the other as late as November twenty-fifth, leads us to think that the serum has preventive properties. Moreover, a recent application of the serum treatment in a herd at Enterprise, Mississippi, mentioned above, strengthens this belief. The full details of this outbreak and the inoculation experiments will be published later by the Mississippi Station. We will here give only a brief history of the case.

January 23, 1897, Kaemper, Miller & Co., of Enterprise, Mississippi, received from Topeka, Kansas, twenty-seven head of Jersey and Dutch Belted cattle, previously owned by the La Vita Cattle Co. Some of the Dutch Belted cattle were raised by E. O. Thornton, in Saline county, this State. All were highly bred, and some of them prize winners.

Three days after their arrival pine straw was put into the barn for bedding, and by this means the Texas fever (acclimation fever) ticks were introduced. On February eighth, thirteen days after the pine straw bedding was put in the barn, one of the cows was found to be sick; on the next day she passed bloody urine, and on the afternoon of the third day she died. A post-mortem examination was made by Mr. Seeger, one of the parties interested in the dairy. His report of the morbid condition of the organs was so accurate that a diagnosis of Texas fever was easily made without any reference to the history of the case.

On February eighteenth a second animal sickened, and three days later died. Other deaths occurred on the following dates: February twenty-fourth, twenty-fifth, twenty-seventh, twenty-eighth, March third, fourth, seventh, eighth, thirteenth.

A total of twelve animals died, three Dutch Belted cows, one Dutch Belted bull, five Jersey cows, one Jersey bull (adult), one young Dutch Belted bull, and one Jersey heifer.

Soon after these animals began to die Director Tracy, of the Mississippi Experiment Station, wrote us in regard to the serum treatment. We advised him to try the experiment and gave directions for the preparation of the serum. Dr. Robert, veterinarian to the Mississippi Experiment Station, carried out this part of the work, and succeeded in obtaining as clear a serum from a naturally immunized cow as that which is put upon the market by the diphtheria antitoxin producers from the horse.

Before the serum was prepared ten of the animals had died, and others were sick. Director Tracy and Dr. Robert went to Enterprise, and began the inoculation on March eighth. The writer was telegraphed to come and aid in the work, which he did, arriving at Enterprise on March twelfth. Dr. Robert found two of the animals so ill that he concluded not to use the serum on them. One of them died on the day of their arrival, March eighth, and the other on the thirteenth. The latter one the writer made an examination of, and found the death to be due to Texas fever. There remained of the herd fifteen animals—three young bulls, one Dutch Belted cow, and twelve young heifers. All of these except three were treated with serum. These three were, however, cleaned of ticks, two of them by the use of cotton seed oil, and the third by picking them off by hand. All of them received tonic treatment. On account of the value of these animals we did not feel justified in making of this a pure experiment. No further losses occurred after the inoculations, and other treatment were begun. Two of the young heifers passed bloody urine, but have gone safely through the attack, and others had high fever. As we go to press Dr. Robert has written that all the cattle are doing well except one that was not inoculated, and the temperature of this animal had risen to 104.6° F. The owner requested him to inject the animal with serum.

While the evidence thus far obtained from these experiments gives us grounds for believing that serum prevention may be made a success in "acclimation fever," we do not feel justified in so asserting since the evidence is not yet sufficient to remove all doubt. It is hoped, however, that this matter may be definitely settled during the present season. If all the Experiment Stations of the South take hold of this matter with us, the solution of the question will be much sooner reached. Dr. Francis has had flattering reports from some of the stockmen of his State who have used serum sent by him. The Experiment Station of Mississippi will do some systematic work along this line during the coming summer, and the Louisiana Station has expressed a willingness to test the serum method. Other Stations in the quarantine district should also give the matter a trial.

TEMPERATURE RECORD OF INJECTED COW.

In order that the reader may be able to form his own judgment as to the value of the inoculation experiment made at this station, the following data in relation to the temperature of the animal, temperature of the weather, date of injection of serum and quality used, daily notes of the general condition of the animal, and the growth of the ticks are given in the table below:

Material used and method of preparation of same already given.

Animal:—Grade Short Horn cow, 8 years old, in good health, weight 850 pounds.

DATE.	Temperature.		Weather Record.		
	8 a. m	5 p. m.	Max.	Min.	
	Deg. F.	Deg. F.			
September 2	———	103.1	96	65.8	20 c. c. serum injected subcutaneously.
" 3	101	101.5	83	62.9	20 c. c. " " "
" 4	101	———	81.5	53.9	20 c. c. " " "
" 5	101.3	102	79	57	20 c. c. " " "
" 6	101.8	101.8	76	42	———
" 7	101.7	102.1	83	48	40 c. c. " " "
" 8	101.8	101.8	77	65	——— The temperatures from September 2 to 15
" 9	101.7	101.5	82	73	——— were taken at the college barn.
" 10	102.2	100	95	68	20 c. c. serum injected subcutaneously.
" 11	101.8	101.5	74	57	20 c. c. " " "
" 12	102	102.1	88	60	———
" 13	102.4	———	96.7	67	———
" 14	101.4	102.2	91	65	20 c. c. " " "
" 15	101.4	102.1	85	68	20 c. c. " " "
" 16	101.8	———	89	63	Put in pasture lot where three cows died of Texas fever. Also infested with several hundred young ticks.
" 17	———	———	82	66	The cow on transfer to the pasture could not be caught on the days where the temperature record is blank.
" 18	———	———	79	60	
" 19	———	———	68	49	

September	20	102.4	102.2	67	38	Put rope on cow after considerable chasing.
"	21	102	102.8	76	52	Cow heated up by chasing.
"	22	102.1	102.6	66	44	*Infested with more ticks.*
"	23	101.6	102	70	33	
"	24	101.9	102.8	78	45	Cow very wild, fell down several times.
"	25	102	102.6	78	54	*Found great number of ticks attached.*
"	26	101.6	102.3	76	53	*Ticks moulting.*
"	27	101.5	101.6	61	48	Cow looks well, appetite good. 11th day after infesting with ticks.
"	28	101.8	101.8	60	42	20 c. c. serum injected. 12th day.
"	29	101.9	102.9	55	42	Cow looks well, appetite good. 13th day.
"	30	101.7	102.8	81	43	20 c. c. serum injected. 14th day. Ticks increasing in size.
October	1	101.9	103	82	44	Made hot by running. 15th day.
"	2	101.6	102.7	82	57	20 c. c. serum injected. 16th day. Made mount of blood
"	3	102.2	103.8	73	47	Noon 104. Ticks mating. 2d moult, 17th day.
"	4	102	106	75	41	Cow very well, appetite very good. 18th day. 20 c. c. serum injected.
"	5	100	101.4	76	53	19th day. Urine clear.
"	6	102.8	103	66	46	Ticks increasing in size.
"	7	100.4	101.2	64	33	Cow well, appetite good.
"	8	100.8	101.3	64	36	Made mounts from blood.
"	9	100.9	101.4	71	40	Some ticks full grown.
"	10	101	101.6	66	51	Ticks falling off.
"	11	100.8	101	51	45	Picked off some ticks for laboratory.
"	12	101.2	101.9	57	48	Large number of ticks mature from first infestion on belly and udder.
"	13	101	101.2	69	39	Ticks on neck maturing, 2d infestion of September 22.
"	14	100.6	101.1	74	34	
"	15	100.9	101.1	76	37	Large number of ticks mature.
"	16	100.6	101	66	37	Large number of ticks mature.
"	17	100.1	101.2	59	39	
"	18	100.7	100.9	57	31	Had more matured ticks to-day than on any previous day. A large number, 33d day. A large number of immature ticks are also to be seen.
"	19	100.3	101.2	77	38	
"	20	——	——	63	37	
"	21	——	——	69	27	Ticks begin to decrease in number.

TEMPERATURE RECORD OF INJECTED COW—Continued.

DATE.	Temperature.		Weather Record.		
	8 a. m.	5 p. m.	Max.	Min.	
October 22	——	——	68	42	
" 23	——	——	56	38	
" 26	——	——	71	44	
" 28	——	——	82	62	
" 31	——	——	64	37	Only four ticks October 31.
November 2	——	——	67	53	Picture of the cow was taken. Cow in good condition, would make good beef. 60th day of the experiment. 47th day after first infestion. 41st day after second infestion.

REMARK:—Dr. O'Brien, state veterinary inspector, reported four cases of Texas fever at Hassard, Ralls county, Missouri, fifty miles further to the north than this station. One case on September 26, one October 20, one October 21, and one November 25. The grounds on which these animals caught the disease were infested July 28 by Texan cattle from a wrecked train on the M., K. & T. R'y.

In the *Post-Dispatch* of November 28, an outbreak of Texas fever was reported at Oakwood, near Hannibal. Several animals died.

The mean of the maximum weather temperature for the two weeks preceding the deaths that occurred in November was about 56 degrees Farenheit, and the mean of the minimum temperature 35 degrees Farenheit. The maximum of any one day was 77.3 degrees Farenheit, and the lowest minimum temperature 18.4 degrees Farenheit.

DISINFECTION OF PASTURES.

OBSERVATIONS AND EXPERIMENTS ON THE MOVEMENTS AND OTHER HABITS OF THE SOUTHERN CATTLE TICK, AND CONCLUSIONS IN REGARD TO THE FEASIBILITY OF DISINFECTING PASTURES.

The fact that certain small areas of our state have, in the past, been infested with the Southern cattle tick to an extent that caused the United States government to quarantine against two of our counties, and further that the danger of a reinfestion may at any time arise, led to the study of the movement and other habits of both the adult and young Southern cattle tick, in order to determine the probable area of pasture that may become infested through the movements of the ticks themselves, when dropped from cattle cars or from cattle that escape from wrecked trains.

These studies show that it is not difficult to confine an infestion within very narrow linits, nor to disinfect quite large areas if systematic efforts be made to that end.

In the experiments with the adult ticks, they were placed in the most favorable conditions for rapid movement, viz.: upon a flat surface with but few obstructions. This surface was a piece of heavy paper three by four feet in size, blackened by soot from kerosene lamp. The tick in crawling over the paper made a tracing by removal of a part of the soot. From time to time the position of the tick and the hour were marked on the tracing, and at the end of the experiment the paper was passed through a solution of shellac. In figure eleven, on the following page is shown a reduced reproduction of one of the tracings. A glance at the tracing will show the character of the movements. The ticks wander about, crossing and recrossing their track many times, and in the course of an hour may be close again to the starting point.

By means of a registering tracing wheel or map measure, the actual distance traveled by the tick was determined; also the radial distance from the starting point. It was found in

the case given that the average rate of travel was about eleven feet per hour; but the actual distance from starting point was hardly as many inches. It will be seen that where obstructions were placed on the tracing a great deal of traveling was

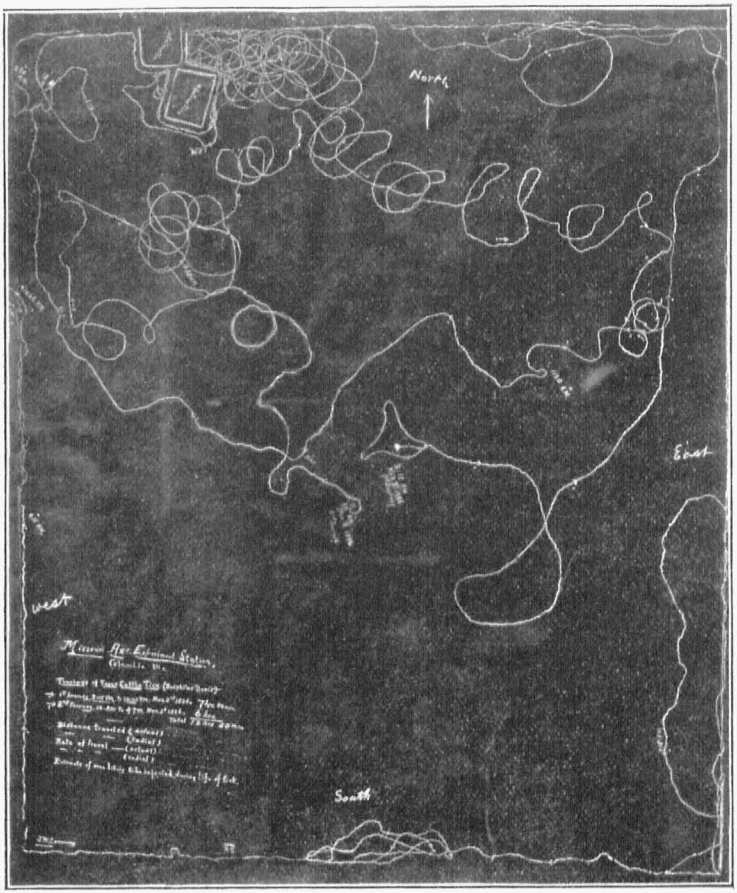

Fig. 11. Showing movements of an adult tick—reduced from 3x4 feet.

done, but only a small area covered. On some of the tracings when more obstructions were placed than in the one here shown, the ticks would frequently circle around the obstacle

many times, apparently seeking a hiding place beneath it. In one experiment a tick found such a hiding place and remained in it until removed several hours later. The object seems to be to find a protected place in which to lay their eggs.

When we consider that the pastures afford obstructions and hiding places in countless numbers, we can understand after this study of the habits of the tick, how a veterinary surgeon of a few years ago could honestly and "to the best of his knowledge and belief" testify before a jury that a barb wire fence was sufficient to turn Texas fever. In the light of our present knowledge of the cause of the disease such testimony would seem absurd, yet such testimony is not without a basis of truth. The ticks, as shown by the laboratory experiments, have the ability to travel several hundred feet during their life, but these experiments also show that their movement and other habits are such that, under ordinary conditions, they probably do not get more than a few inches from the point where they were dropped. Some outdoor experiments under natural conditions will be made with adult ticks during the coming summer. The young ticks have the power of quite rapid movement, but the observation was made that the young ticks do not spread to any extent over the pastures from the point at which they were deposited. A jar containing quite a number of young and adult ticks was emptied upon the grass beneath a temporary open shed in the pasture. The attendants in walking over the pasture near the shed never picked up any ticks within two or three weeks after they were placed there, but on going under the shed at any time during this interval large numbers of the ticks crawled upon their feet and legs. The habit of the young tick is to crawl to the top of a blade of grass or other convenient object and remain there until brushed off by some passing animal.

The above experiments and observations have a practical bearing upon the question of quarantining and disinfecting pastures and other infested grounds. Practical measures suggest themselves, such as the fencing in of grounds that have become infested, plowing a few furrows around the outside of the fence,

the burning off of the pasture, preferably after the young ticks have hatched, as the danger lies in these and not in the old ticks. The latter do not attach again to the cattle, but die after the eggs have been laid. If the pasture is burned before the young ticks have hatched, many of the eggs may escape destruction on account of having been deposited beneath clods, dung, etc, under which the adult tick has burrowed. Young ticks begin to hatch in about four weeks in warm weather after the adult tick is dropped on the pasture. Unfavorable weather will considerably prolong this hatching period.

Col. J. R. Rippey, secretary of the Missouri State Board of Agriculture, makes the following recommendation in regard to the disinfection of pastures affected with the Texas tick.*

"Place no other cattle on the infested pasture. Let the grass grow until of sufficient height, when it may be mowed and when dead and dry enough may be burned. Let the burning take place when the ground is thoroughly dry, so that everything, including the old manure and decayed vegetable matter may be consumed. This, if properly done, should destroy all the ticks, but if not, the ground being rendered bare and every portion exposed, the freeze during the succeeding winter should complete the work. However, as an additional security against further loss, we would advise the cultivation of the field for a year or two. It might be sowed to oats or in some small grain that would leave a stubble that could be burned in the fall, thus leaving the ground bare each winter after cultivation.

"When the pasture is an enclosure of woodland, or ground unsuitable for cultivation, or can not be clipped with the mower, all that can be done to encourage a vigorous growth and burn the first opportunity after it is killed by the frosts. The leaves from the timber and the grass that will grow on spots where timber is thin will generally be sufficient to give the desired heat if a suitable time is selected for the work. On spots so bare that they will not afford rubbish sufficient for

*Crop Report of Missouri, State Board of Agriculture of August, 1896, page 13.

burning, the hard freeze that may be expected through the winter will in all probability accomplish the desired end.

"Lots and paddocks that do not produce sufficient growth for burning may be sprayed with a mixture of crude kerosene and five per cent naphtha, or ten per cent of gasoline. The spraying should be sufficient to moisten all rubbish and care should be taken to get it well distributed over all the ground. Immediately after spraying apply the match, taking care to be so situated that you can readily step out of the way of the flames, as this solution will burn very rapidly. Buildings and fences should be looked after and such action taken before applying the solution as will protect them from the conflagration, as you will have but little opportunity to make such arrangements after your fire is once started.

"Open or unenclosed grazing lands may be disinfected by the free use of fire. If the farmers in an infected vicinity would unite in the work and prepare for the protection of their fences and buildings, large areas could be burned over with a fair prospect for relief from ticks by the heat occasioned by burning, or by the action of the frost on the exposed surface.

The importance of disinfecting these areas can not be overestimated. If no steps are taken to eradicate these parasites when they are found, some of our territory may become permanently infected, carrying with it not only a severe loss by death of animals, but a material reduction in prices when placed on the market.

Citizens should, in the interest of the cattle industry of South Missouri, promptly report all cases of supposed Texas fever, and then unite with the state veterinarian in prompt and energetic measures for its control and eradication.

As mentioned elsewhere, a host is necessary for the propagation of the tick, and as the ticks do not travel far, the quarantining of infested grounds would probably disinfect the ground after a winter, but the burning measure recommended should not be neglected when it is practicable.

If horses and cows are kept off an infested pasture the tick will finally die, as one of these hosts is necessary to the propa-

gation of these parasites. The mating of the male and female occurs on the host.

Experiments made at this Station with the view of finding a cheap substitute for cattle in this experimental work, show that these ticks do not attach readily to the rabbit, guinea pig, or dog. On the guinea pig not a tick would take hold; on the rabbit a few attached to the ears, but none to the body, even when the hair of the belly was closely clipped. Ticks attached in considerable numbers to the dog, but none of them matured—they dried up and fell off when about half grown.

It is, therefore, probable that cattle and horses are the only animals that are liable to carry the infection, and of these the tick has a preference for cattle. They grow quite well, however, on the horse, without any apparent bad effect to that animal. In our work of the past summer one of the farm horses was used in drawing a dead cow under a shed where some ticks had been put some time previously. The horse became infested and the ticks grew to considerable size before they were removed.

III. EXPERIMENTS ON THE AUSTRALIAN CATTLE DISEASE.

The results of our work on this disease were entirely negative. The number of ticks sent from Australia and their condition on arrival were not favorable to results that would yield any evidence either for or against the conclusion that the Australian cattle disease and Texas fever are identical. These ticks were sent to Dr. Francis, of the Texas Experiment Station, who forwarded them to this station on account of its more favorable location for carrying out the work.

Evidence from another source leads us to think that the two diseases are identical. The description of the Australian cattle disease as given to us by Dr. Hunt, the bacteriologist of the Queensland Cattle Commission, Australia, who visited the Station during the past summer, shows at least a remarkable similarity, in the grosser features. Moreover, the bacteriological studies made by Dr. Hunt afford additional evidence.

The settlement of this question is a matter of considerable importance from the point of view of international traffic in cattle; but on account of the possibility of the introduction of a new and dangerous disease into our country, the investigation of foreign diseases upon our own soil should be discouraged. The investigation of matters of this kind, having an international bearing, does not properly belong to the state, but to the national Bureau of Animal Industry.

The details of the experiment are as follows:

April 24, 1896. Ticks collected from cattle in Queensland, Australia, and posted this day to Dr. M. Francis, at College Station, Texas.

June 2, 1896. The above ticks were sent by Dr. Francis to this station. The package contained only a few adult ticks. Some eggs had been laid en route.

June 16 and 17. Ticks hatching.

June 18. Ticks, probably not more than fifty, placed on Jersey cow ten years old; temperature, 102.

June 24. Temperature of cow, 103.2° F.

June 29. Temperature of cow, 101.8° F. Cow looking well, improving in flesh.

July 3. Temperature of cow, 101° F.

July 7 (nineteenth day). Temperature of cow, 102° F. Can find no ticks attached. Result negative.

ACKNOWLEDGMENTS.

The Texas cattle necessary for the experiment and an attendant, W. D. Clayton, B. S., who remained and made notes on the work, were furnished free of charge by the Texas station and the Missouri, Kansas & Texas, and Wabash railroads transported them from College Station, Texas, to Columbia without cost. The State Board of Agriculture paid incidental costs in transportation, the return fare of the attendant, and furnished the native cattle necessary for the entire series of experiments, while the Missouri Experiment Station furnished properly equipped pastures and necessary feed, and made all observations, conducted the post mortems, did all the laboratory work, and kept the records of the trials. H. A. Lipscomb, M. D., assisted in the observations and laboratory work in these experiments.