U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY.—Bulletin No. 78.
D. E. SALMON, D. V. M., Chief of Bureau.

TEXAS FEVER

(OTHERWISE KNOWN AS TICK FEVER, SPLENETIC FEVER, OR SOUTHERN CATTLE FEVER),

WITH

METHODS FOR ITS PREVENTION.

BY

JOHN R. MOHLER, V. M. D.,
Chief of Pathological Division, Bureau of Animal Industry.

WASHINGTON:
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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., August 4, 1905.

Sir: I have the honor to transmit herewith a manuscript entitled "Texas fever (otherwise known as tick fever, splenetic fever, or Southern cattle fever), with methods for its prevention," by John R. Mohler, V. M. D., chief of the Pathological Division of this Bureau. This article deals in a practical way with a disease which causes great annual loss to the stockmen of this country.

I recommend that this manuscript be published as Bulletin No. 78 of the Bureau of Animal Industry series.

Respectfully,

D. E. Salmon,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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TEXAS FEVER

(Otherwise known as Tick Fever, Splenetic Fever, or Southern Cattle Fever),

WITH METHODS FOR ITS PREVENTION.

By JOHN R. MOHLER, V. M. D.,
Chief of Pathological Division, Bureau of Animal Industry.

INTRODUCTION.

Texas fever, a very serious obstacle to the development and prosperity of the cattle industry of the South, has been pretty thoroughly understood since the investigations and discoveries made by Smith and Kilborne and published in 1893 as Bulletin No. 1 of the Bureau of Animal Industry. Their work showed conclusively that the cause of the disease was an intracorpuscular parasite (one living within the blood cells), the intermediate stage of the development of which occurred in the cattle tick, thus making this tick the indirect but absolutely essential factor in the natural production of the disease. Above the latitude where the cattle tick is destroyed by the cold of winter the disease can be thoroughly controlled by keeping Southern tick-infested cattle from passing through the country during certain seasons. It is also well known that by completely severing the relations of the fever tick and native cattle the former may be exterminated, thus making it possible by intelligent and energetic measures to eradicate the disease, and thereby to remove a constant menace to the Southern cattle breeder, feeder, and dairyman. In spite of these facts, however, comparatively little work has been done along the line of controlling this disease in the infected districts either by State legislation, by county or parish regulations, or by the combined action of cattle breeders over a large extent of country. This probably has been due in a great measure to a lack of knowledge or indifference on the part of legislators and farmers to the advantage which may accrue from their combined efforts. It is with the object of stimulating them and suggesting plans to eradicate the cattle tick, and thereby to enable stock owners of the South to escape the loss of millions of dollars annually sustained by them as a result of its devastations, that this bulletin is issued. Especial pains will be taken to make as clear as possible the absolutely proved facts re-

garding the disease, so that every cattle owner will be able to recognize the malady and the tick which causes it, and to carry out successfully measures for eliminating this tick as well as for immunizing cattle brought into the infected area.

NAME AND SYNONYMS.

Of the long list of terms applied to this disease, none seems to fill completely all the requirements of an ideal name. "Texas fever," although the term most commonly in use in this country, is a very misleading one, as it gives to the uninformed the impression that the disease is confined to the State of Texas. Southern cattle fever is especially inapplicable, as the disease is usually more virulent in Northern cattle when once infection becomes manifest than in Southern cattle. Probably the best name to apply to the disease, since it can only be transmitted in nature by the tick *Boophilus annulatus*, is that of tick fever. This designation, however, is comparatively little used, and, as the disease is generally recognized in this country under the name of Texas fever, this term will be used in the present work. Other synonyms besides those already mentioned are red water, black water, distemper, acclimation fever, murrain, dry murrain, yellow murrain, bloody murrain, Mexican fever, Spanish fever, splenic (or splenetic) fever, protozoan cattle fever, hemaglobinuria, tristeza, paludism of cattle, bovine periodic fever, bovine piroplasmosis, and bovine malaria.

DEFINITION.

Texas fever is a specific infectious disease of the blood of cattle, caused by the development and activity of minute animal parasites (protozoa) which are conveyed to the affected animals by means of the cattle tick *Boophilus annulatus*. After the microscopic protozoan is injected into the blood of a susceptible animal it attacks the red blood cells, causing their disintegration. The disease is characterized by high fever, by destruction of red corpuscles, and the consequent excretion of the coloring matter of the blood by the kidneys, causing a reddish discoloration of the urine, by enlarged spleen, engorged liver, thick, flaky bile, more or less jaundice, emaciation, and death in from 10 per cent of the chronic to 90 per cent of the acute cases. The peculiarity about this disease is that the animals responsible for the spread of the malady are apparently healthy, although containing the protozoa in their blood, while those that become diseased do not, as a rule, convey the affection to others. In the few instances where they do, it is not by contact, but indirectly by means of the progeny of the ticks from these diseased animals. Infection is not transmitted by the air, urine, saliva, manure, or by any other natural manner than by cattle ticks.

HISTORY AND DISTRIBUTION.

The place of origin of this disease is unknown, but it has certainly existed for centuries in some countries of Europe, among which may be mentioned southern France, Italy, Turkey, and along the Danube River in Roumania. It is also prevalent in West Indies, Mexico, Central America, South America, Australia, North Africa, East Africa, South Africa, Ireland, Finland, southern Russia, China, Japan, Java, Borneo, and the Philippine Islands.

It was probably introduced into the United States with the importations of cattle by the Spaniards during the early colonization of Mexico and southern United States.

The disease caused continual losses year after year during the early history of our country. In spite of this fact, it seems to have been described first by Dr. J. Pease toward the close of the eighteenth cen-

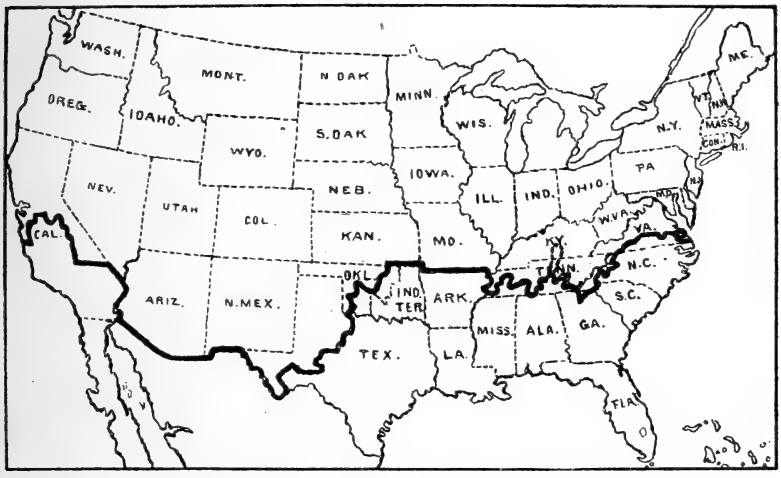


FIG. 1.—Boundary line of the district infected with Texas fever.

tury. At that time a very severe outbreak of the disease occurred in Lancaster County, Pa., and Pease, after investigating the conditions, claimed it to have been due directly to the shipment of some North Carolina cattle into the State.

Experience soon showed that the invariable result following the transportation of Southern cattle into the Northern States was the death of all Northern cattle along the roads and on the pastures over which the Southern cattle had traveled, although the latter animals remained perfectly healthy. In the same way Northern cattle taken South were almost invariably attacked with the malady.

In 1868 Texas cattle shipped north into the States of Illinois and Indiana early in the summer caused enormous losses, and cattle

shipped from these States to the Eastern markets died during transportation. These great losses prompted the study of the disease by many scientific men, whose investigations soon established the great danger of allowing Southern cattle to pass into the Northern States during hot weather, and finally resulted in 1885 in the location of the infected district and the establishment of the Texas fever quarantine line in 1891 by Dr. D. E. Salmon, which have been the most important steps yet taken toward controlling the great losses from the disease.

Smith was the first (1889) to recognize and describe as protozoa the intracorpuscular parasites which are the direct causative agents of the disease, although Babes had previously diagnosed them as bacteria (Hematococcus) for Starcovici, who found them in the blood of Roumanian cattle in 1888. In 1889 and 1890 Kilborne, by conclusive field experiments suggested by Salmon, proved the presence of the cattle tick to be essential in the transmission of the disease. It is of interest to note that this was the first experimental proof furnished on the subject of diseases borne by insects, or diseases that can be carried from one animal to another only by an intermediary host. This mode of transmitting infections has since become quite familiar to the public by the discovery that certain species of mosquitoes spread malaria and yellow fever to man.

It was suggested by the experiments of the Bureau of Animal Industry in 1892 and 1893 that, through the production of a mild, nonfatal attack of Texas fever in Northern cattle, a very considerable amount of protection is afforded against the disease when these cattle are subsequently exposed to the infection on tick-infested pastures. The methods advanced for producing such a mild, nonfatal attack were (1) the artificial inoculation, either into a vein or under the skin of susceptible animals during the fall or winter, of defibrinated blood from an immune cow; or (2) the less certain way, consisting of the exposure of the nonimmune animal to ticks by confining the animal to an inclosed pasture after scattering ripe egg-laying ticks over the grass.

From 1895 to 1897 additional experiments were conducted by the Bureau with the object of further demonstrating the possibility of immunizing cattle against Texas fever by the use of blood obtained from Southern cattle; and experiments with a similar object in view were likewise instigated and perfected about this time at the experiment stations of Missouri, Texas, Mississippi, and Louisiana, and by the Australian Government, with most excellent results. Later experiments with the disease have been performed principally with the view of obtaining a satisfactory chemical solution in which to dip tick-infested cattle for the purpose of destroying these para-

sites, and of developing some methods that may be easily carried out for freeing fields, farms, and counties of the cattle tick.

CAUSE OF THE DISEASE.

The primary or direct cause of Texas fever is the microparasite *Piroplasma bigeminum*, belonging to the lowest form of animal life, the protozoa. This minute parasite is found in the blood (Pl. 3, fig. 5) in every case of Texas fever; and by inoculating blood containing it into susceptible cattle, the disease can be invariably transmitted, thus proving its direct causative effect in the production of the malady. After gaining the circulation the piroplasma undergoes several stages of development which can be studied by examining carefully prepared fresh preparations of the infected blood under the microscope for several successive days. In the first stage the parasite is inside the red blood cell near its margin and is nonmotile and pale, making it difficult to distinguish in the unstained preparations. This stage is principally seen in the chronic type of the disease in which from 5 to 50 per cent of the red blood cells are invaded. This single body later divides incompletely into two small roundish bodies which are partially connected by a narrow intervening strand, and this form may remain in the blood for several days at least. Sometimes four, five, or even six parasites may be observed in one blood cell. In the next stage the minute double rounded bodies become enlarged and spindle-shaped. They probably remain attached, however, as in stained preparations a minute delicate filament may frequently be made out connecting them. The two bodies enlarge uniformly and assume a pear-shaped appearance. It is this stage of the life cycle which is seen in the acute form of the disease, and from one-half of 1 to 2 per cent of the red cells are usually invaded—rarely as many as 10 per cent. The parasites at this time occupy nearly one-fourth of the body of the red blood cells and, as can be readily understood, exert a detrimental influence upon them. Their periphery becomes shriveled or crumpled, and the blood cells finally break up, liberating the piroplasma, which may be observed as free bodies in the circulation—most frequently in the kidneys. The stage of reproduction or multiplication of this protozoa has never been observed in this laboratory, but that it does occur is proved by the fact that inoculation of a small quantity of virulent blood into susceptible animals will give rise to the disease with myriads of parasites in the blood. Hunt, of Queensland, states that reproduction occurs by the development of the protozoa into crescentic or spheroidal bodies which burst and liberate the young forms which they contain. The natural path of entrance of these protozoa, however, is by one channel only, namely, through the bite of the cattle tick. A knowledge of the habits and life

history of the latter is extremely important in controlling the disease, because without this tick Texas fever would be unknown.

LIFE HISTORY OF THE CATTLE TICK AND THE PART PLAYED BY IT IN PRODUCING TEXAS FEVER.

In stating the interesting and important life history of this tick, we will start at the point where the fully developed and fertilized female, being engorged with blood and ready to lay her eggs, loosens her hold on the bovine animal and drops to the ground. Upon reaching the ground she may lie quietly for several days before depositing her eggs, which may consume from four to eight days in summer and two weeks or even longer in the fall. The number of eggs laid by a fully developed female varies from 1,500 to 3,000, while the immature females also lay eggs, but in much smaller numbers. After laying is finished the female is small and shriveled up and, having fulfilled her mission, soon dies (Pl. 3, fig. 3). The eggs, which are light brown and waxy in appearance, proceed to develop the larvæ, or seed ticks, the time required for which varies from thirteen days to six weeks, depending on the conditions of temperature, moisture, soil, etc. These eggs, however, are very tenacious of life, and under unfavorable conditions may remain dormant for several months—from late fall to early spring.

The larvæ, or seed ticks, are minute six-legged parasites of a brownish waxy color, and about $\frac{1}{32}$ of an inch in size (Pl. 3, fig. 2). They crawl quite actively about on the ground and among leaves, bunching in large numbers upon grass blades, shrubs, weeds, and fence posts, to await an opportunity for attachment to their passing host. In case no cattle or horses are present, the parasitism is so perfect that no further development occurs, and death finally results. It is known, however, that these larval forms can live for three or four months on the ground in warm weather independent of their host, and from late September until April during an open winter. When they find cattle, however, they crawl up the legs and attach themselves to the soft skin inside the thighs and flanks, on the escutcheon, along the belly and brisket, around the root of the tail, and inside the forelegs (Pl. 3, fig. 4). They obtain their nourishment by drawing blood from the host, and can cause the fever at this stage, although so small as scarcely to be detected by the naked eye. After being on the animal about one week the seed tick casts its covering (molts) and appears as the eight-legged nymph stage of the parasite, having added one pair of legs posteriorly. During the nymphal stage the sexual organs develop, and at the second molting from the nymphal to the adult stage the sexual organs are complete. The male and female at this stage are about the same size, as the female

does not become very large until after she becomes fertilized, which occurs about two weeks after the six-legged seed tick reaches its host, or shortly after the second molting (Pl. 3, figs. 7 and 9). After intercourse with the male the female slowly enlarges for six to twenty days in summer, and then rapidly increases in size in the course of a day or two before dropping off the animal. In fall and winter development occurs more slowly, the tick not falling off for six weeks or more. After reaching the ground the female soon commences to deposit eggs, thus completing the life cycle, which requires from six to ten weeks in warm weather, or a much longer period during the cold season.

Although young ticks are very active, neither they nor the adult ticks are capable of crawling very far, but they may be transported long distances by animals, by rains, by winds, cattle cars, hides, and on the clothing of man. Hence the constant danger that tick-free pastures below the line may become infested with ticks at any time.

The tick causes more or less irritation of the skin at the point where it attaches, and it has been suggested that it injects some poisonous substance into its bites along with the *Piroplasma bigeminum*, which reduces the vitality of the tissues and enables the protozoan to multiply, and to get a start, so to speak. This is considered to be the case, because it has frequently been experimentally attempted to reproduce Texas fever by inoculating susceptible animals both into the vein and under the skin with salt solution emulsions of ticks ground up in a mortar, and also by feeding ticks, but uniformly without success. However, it is probable that the protozoan passes a resting stage of its life cycle in the body of the ticks, which would explain these failures.

The great length of time required for the appearance of the disease in Northern cattle after the passage of tick-bearing cattle through the country (thirteeen to ninety days) can easily be accounted for by the life history of the tick. It is necessary before the disease appears for the fully developed fertilized female to drop off the Southern cattle and deposit the eggs, and for them to hatch into the six-legged larvæ. These must then crawl up on the Northern cattle and insert the microparasites they carry through the bites made in the skin in procuring their nourishment. Texas fever follows. It will thus be seen that these females transmit the infection through their eggs to their progeny, and the latter have the power to infect any susceptible animal to which they attach. The disease therefore is not conveyed by the same ticks which take up the infected blood, but only through the generation descending from them.

The first experiment performed by Kilborne in proving the "tick theory" consisted in placing four North Carolina tick-infested cattle in a special inclosure, and at various times thereafter placing 13 sus-

ceptible animals in the same field; of these 10 died of the disease, 2 recovered, and 1 was unaffected. In the second experiment all ticks were carefully picked by hand from 3 North Carolina cattle which were placed in a second noninfected field. Five susceptible cattle were then placed in the field with these tick-free North Carolina cattle and all remained perfectly healthy. Finally, in 1890, young ticks, hatched and raised in the laboratory, were placed on 4 susceptible animals and produced Texas fever in every case, thereby proving that the tick was responsible for the disease. Other experiments have been performed by feeding virulent materials, by exposing cattle to the urine, manure, and nasal secretion of sick animals, and to the blood and viscera of cattle dead of Texas fever, but always with negative results, thus eliminating these as the causative factors, and furnishing indirect evidence substantiating the "tick theory."

HOW TO DISTINGUISH HARMLESS TICKS FOUND ON CATTLE FROM TEXAS-FEVER TICKS.

The Texas-fever tick, also called the cattle or cow tick, is continually confused with a number of other ticks occasionally found on cattle, but, so far as concerns the transmission of Texas fever, entirely harmless to them. It is this lack of identification and the inability of many cattle owners to distinguish between these various ticks that have caused so many diverse opinions regarding the important part played by the Texas-fever tick in transmitting Texas fever. In order to differentiate between the ticks that may be found on cattle, a brief description of the upper surface of the maturing or adult female of each is here given, together with illustrations of this view of the ticks, natural size, and also magnified four diameters. It was not thought necessary to furnish the stockman with a description of the male and immature female ticks at this time, inasmuch as these ticks are much smaller in size, and therefore it is more difficult to recognize the various differences between these forms of the different species by means of the naked eye. Moreover, it is usually possible to secure a maturing female in those instances where a diagnosis is desired, and at this stage of development ticks possess certain characteristic features or markings which should cause them to be classified readily as harmful or harmless even by superficial examination. Ticks said to be Texas-fever ticks have been reported by some stockmen as infesting susceptible cattle without producing Texas fever, and by others mature ticks, presumed to be Texas-fever ticks, have been found on uncultivated land and in woods where cattle have never grazed. These statements have been frequently advanced in order to refute the experiments already mentioned as to the essential part played by the Texas-fever tick in caus-

ing Texas fever. If fever ticks have been found on nonimmune cattle without producing Texas fever, the explanation is that these particular ticks were probably noninfectious, which in rare cases is seen, as described in section on "Some objections to the rôle of ticks as carriers of Texas fever, with explanations." On the other hand, it has very frequently happened that an examination by one familiar with the characteristics of ticks has shown that those found on such cattle and supposed to have been fever ticks belong to another species that is entirely harmless as regards transmitting Texas fever.

All the investigations regarding the life history of the Texas-fever tick show that although the young, or larvæ, may live for a long time on the ground without a host, they can not mature except as parasites on the bodies of cattle, or, less frequently, of horses, mules, and asses. And statements claiming that the adult ticks of this species have been observed to develop in localities where their absolutely necessary hosts have never been are erroneous, resulting from the confusion caused by the similarity in appearance of the cattle tick to the harmless ticks. It therefore becomes merely a question of recognition, and the following short descriptions, taken principally from Salmon & Stiles's paper on "Cattle ticks," are furnished to assist in recognizing the fever tick and in distinguishing it from others that may be observed on cattle.

There are eight species of ticks which have been found on cattle in this country, but the first six mentioned are by far the most common. They all show the same successive stages of development, namely, eggs, larvæ or seed ticks, nymphs, and adult male and female ticks. Those parts of the adult female tick which will be described below are the head and adjacent shield—which together have erroneously been termed the head parts—and the back of the body, since these portions of the parasite furnish features which to the naked eye are the most readily distinguished by cattle owners. Much stress can not be laid upon the color of these various ticks, as it changes considerably with age. In the adult stage they all have four pairs of legs, varying in length and slenderness according to the species, but these differences are not sufficient to separate one species from another.

Boophilus annulatus (*Texas fever, or cattle, tick*).—Plate 1, figure 1a, shows the natural size of an adult female Texas-fever tick, whose characteristic markings are better brought out in figure 1, magnified four times.[a] This tick may be readily distinguished from the other seven ticks by the small size and the color of the head and shield, the so-called head parts, whose lateral borders are straighter and more parallel, as shown in figure 1b. These head parts are short and relatively broad and dark reddish brown or chestnut brown in

[a] In each of Plates 1 and 2 there are shown (1) the natural-sized mature female tick, (2) this tick magnified four times, and (3) the head and shield of the same enlarged ten to fifteen times.

color, appearing as a convex plate on the median line at the fore end of the tick. The body is oblong oval in shape and may reach ½ inch in length. The color varies from a dull yellow to an olive brown; often it is mottled with irregular areas of yellow and brown or streaked with wavy lines of these colors. Two grooves or indentations are seen running from the front to the rear on the skin of the back, which become almost, if not entirely, effaced at about the middle of the body. Another groove is seen between these two grooves in the posterior half of the body. These grooves are caused by the contraction of the muscles of the body and therefore vary considerably, entirely disappearing when the tick is full of blood. They are very distinct when the ticks have been removed from cattle several days. The four pairs of legs are brown, moderately long, and very slender. This tick is found principally on cattle, less frequently on horses, mules, and asses, and in one case it was found on a deer. The Federal quarantine line indicates the northern boundary of the section of the United States infested with fever ticks.

Ixodes ricinus (*castor-bean tick*).—The body of this tick (Pl. 1, figs. 2 and 2a) resembles in shape that of an eggplant, and it takes its name from its similarity to the bean of the castor-oil plant. It is lead-colored, with a variegated mixture of yellowish red, brown, or gray. The body contains two anterior grooves that slightly diverge from each other, and three posterior grooves, the middle one of which is straight, while the other two are curved outward. The mature female is from ⅜ to 7/16 inch long and has four pairs of dark-brown thin legs. The head and adjacent shield are a shiny dark brown or a chestnut brown, the latter portion being five-sided, like a pentagon (fig. 2b), with lateral borders prominent and rear angle rounded. Two stout and well-developed feelers (palpi) may be seen extending outward on each side of the head. This tick has been collected from sheep, cattle, goats, horses, deer, dogs, cats, foxes, rabbits, birds, man, and a few other animals. It was one of the first ticks studied, and has a very wide distribution in the United States.

Dermacentor reticulatus (*net tick*).—The body of the adult female tick is oblong oval, ⅝ inch long, and of a deep brown or slate color (Pl. 1, figs. 3 and 3a). It has four pairs of brown legs of moderate length. The skin of the back and head is covered with fine points, or punctations, which almost disappear at this stage. Besides the grooves that are located like those in the cattle tick, there is a marginal groove extending around the body just inside the border. There are also eleven small indentations (festoons) arranged about the posterior margin of the body. These festoons and grooves become shallow or effaced in the adult stage. The shield portion of the head parts has a silvery white metallic rust extending along the two sides and posterior portion (fig. 3b). It may have a rose or greenish tinge. The head is larger than that of the cattle tick. The net tick has been found on man, cattle, horses, sheep, and deer; and in this country it seems to be most common in the West, especially in California, Texas, and New Mexico.

Dermacentor electus (*American dog tick; also called wood tick*).—This tick (Pl. 1, figs. 4 and 4a) resembles the net tick (*Dermacentor reticulatus*) so closely that a hand lens must be used to distinguish between them. However, it can be readily known from the Texas-fever tick by the fact that the so-called head parts are longer and broader (fig. 4b). Here there is also a yellowish white rust in the posterior portion which extends anteriorly along each side as two bright, iridescent lines separated by a central brownish area. The body is oblong oval in shape and measures as much as ⅝ inch in length. The skin of the back contains grooves like those found in cattle ticks, and, in addition, another groove extending around just inside the margin, together with eleven smaller grooves (festoons) on the posterior border. These lines,

so distinct in the young female, become shallow at maturity. This tick has been found on man, cattle, dogs, horses, rabbits, and panthers, and has been collected in woods and on uncultivated lands in many sections of this country, especially in eastern United States.

Amblyomma americanum (*Lone Star tick*).—As is indicated by figures 1 and 1a of Plate 2, the body of this tick is oblong oval and of a yellowish gray or brown color. The skin is rough and puckered unless the body is full of blood. The reddish brown area at the front of the tick is composed of the head and head shield. The latter extends backward a short distance to form a triangle, in the apex of which is a white or metallic yellow spot from which it derives its name "Lone Star" (fig. 1b). The mature female may reach ½ inch in length and has four pairs of long thin legs. This tick has been found on cattle, dogs, horses, sheep, and man, and is very widely distributed in the United States.

Ornithodoros megnini (*ear tick*).—As will be observed from figures 2 and 2a, Plate 2, the shape of this tick is similar to that of the body of a violin. It is nearly twice as long as broad, rounded at both ends, narrower behind than in front, and slightly constricted in the middle. In color it varies from gray or brown to violet, and has two grooves behind the head, with a middle one in the posterior portion. On the skin of the back are numerous minute spines, or stiff hairs. The adult females are from ¼ to ⅜ inch in length, and have four pairs of long stout legs. The anterior portion of the tick is curved downward to form a cover for the very small and short head, which can only be seen from the under side of the tick. The feelers (palpi) and beak, however, stick out from under the front part of the body and can be seen from above (fig. 2b). This tick is found in the ears of cattle, horses, mules, asses, and other animals in the South and West.

Argas miniatus (*chicken tick*).—In shape and appearance this tick is like an enlarged bedbug, and is of a uniform reddish brown color, with four pairs of lighter colored legs. The skin is wrinkled and contains very short and minute hairs. On the top as well as the bottom of the tick are numerous bright pits or cavities with raised borders (Pl. 2, figs. 3 and 3a). These vary in size, are arranged in rows radiating from the center more or less uniformly, and are usually symmetrical on each side. It is about ⅜ inch in size when mature. The head is so completely covered by the body that it can not be seen from the back (fig. 3b). This tick has been observed on cattle once only, but is frequently found on chickens, turkeys, and other birds in the South.

Ixodes hexagonus (*European dog tick*).—The body of this tick is oval in shape and of an ashy color (Pl. 2, figs. 4 and 4a). The grooves on the back are united in an arch in front and diverge in the posterior portion of the body. The four pairs of legs are longer, thicker, and stronger than those of the cattle tick. The head and shield are brown-red in color and similar in shape to those of the castor-bean tick, but less oval and rather more lozenge-shaped, with more acute lateral angles and narrower posterior angle (fig. 4b). The palpi, or feelers, are longer and more prominent than in the cattle tick, but not so long as in the castor-bean tick. This dog tick has been collected from dogs, cattle, sheep, foxes, rabbits, squirrels, gophers, cats, birds, man, and other hosts in eastern United States.

SOME OBJECTIONS TO THE RÔLE OF TICKS AS CARRIERS OF TEXAS FEVER, WITH EXPLANATIONS.

Texas fever in animals apparently not infested with ticks.—One objection that has been advanced against the fact that the cattle tick is a carrier of Texas fever is that cattle are sometimes found to

be suffering with the disease without showing the presence of the ticks on their bodies. This condition, in case of Southern cattle, may be explained on the hypothesis that the animal already had its blood infected with the microparasites and under normal conditions was immune from Texas fever; however, as a result of lowered vitality caused by some other disease, or by exposure, privation, injury, rough handling, etc., this immunity has become reduced and finally overcome, and the parasite of Texas fever, dealing now with an impoverished condition of the animal, succeeds in producing Texas fever. Since the experiments of this Bureau show that the blood of an immune animal may contain this microparasite for at least thirteen years after removal from all sources of infection, it would appear that this recurrence of disease in immune animals placed under adverse conditions could occur at almost any period of their lives, and may be termed a relapse. Thus it has been frequently noted that Southern cattle, born and raised in infected pastures but later freed of ticks and placed on noninfected soil, have died of Texas fever when their health was so weakened as to permit the parasites already infecting the blood to overcome the natural resistance of the body, and produce the disease.

Again, in certain dipping experiments where the animals had been roughly handled and unduly exposed after having been dipped in a severely irritating solution, a few deaths occurred from Texas fever among cattle which were known previously to have been immune—tick-infested Southern animals—but whose vitality had been reduced through these extraordinary conditions.

On the other hand, when this disease is observed in Northern animals, the young seed ticks may be so small and so few in number as to be passed readily by even a careful examination, yet numerous enough to cause the affection. In such cases the proof will be found either by prolonged search or in the fact that other animals subsequently take the disease with larger ticks apparent on the skin.

Southern cattle infested with fever ticks may die of Texas fever.—When cows born and raised in the South die of Texas fever, it is proof that such cattle never came in contact with infected cattle ticks before, or that they were raised on tick-free pastures, or that they belong to those cases of immune Southern cattle which lose their immunity when subjected to adverse or extraordinary conditions, such as those mentioned above. Otherwise they would have been unsusceptible and would not have developed Texas fever. Southern cattle, when raised and kept in districts free from cattle ticks, fail to secure the natural immunity induced by gradual and constant tick infestation from birth, and they are just as susceptible to the disease as are Northern animals. Under certain conditions, as when living on horses, mules, etc., fever ticks lose their infectious-

DESCRIPTION OF PLATES.

PLATE 1.

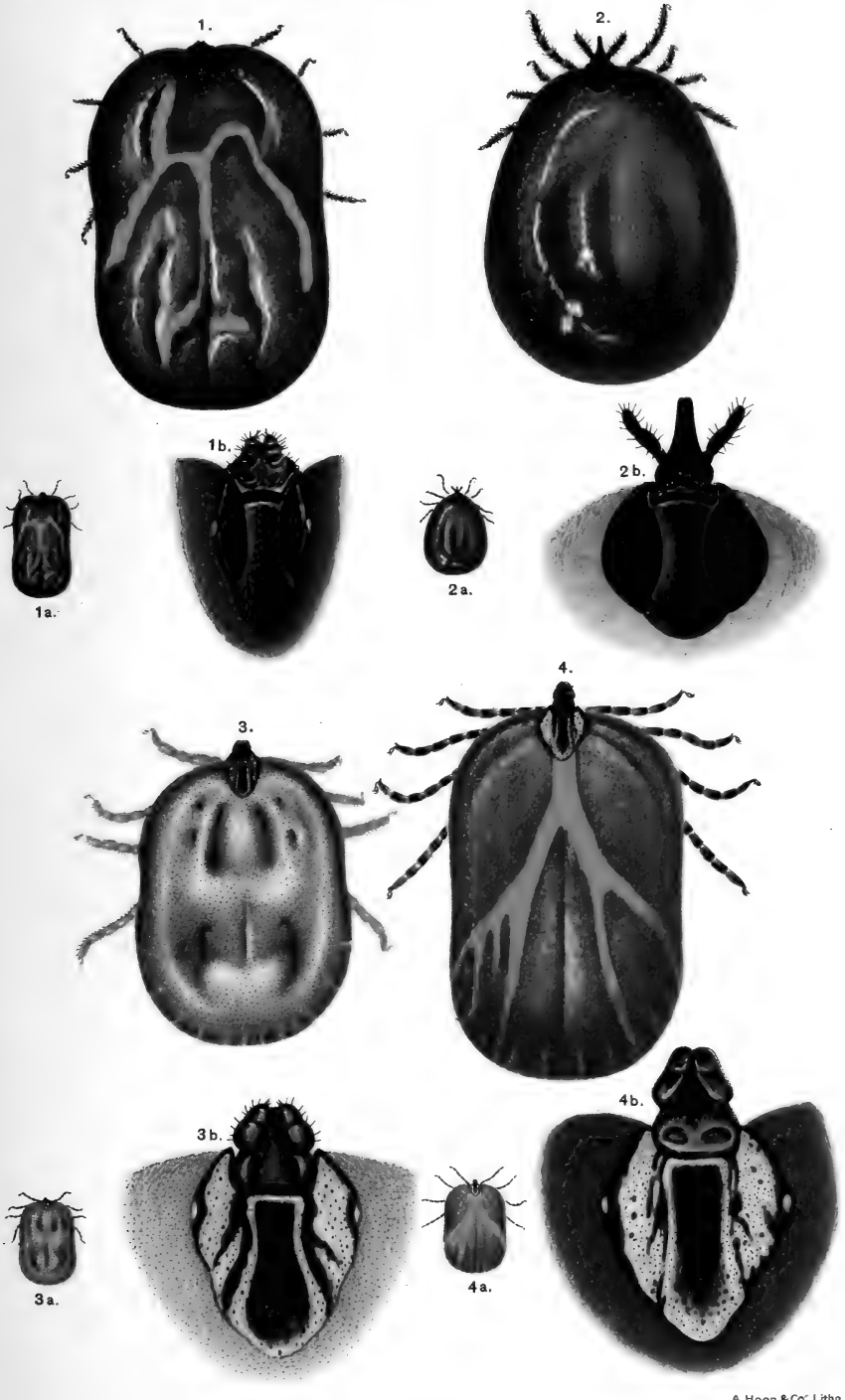
FIG. 1. Mature female cattle tick (× 4).
1a. Mature female cattle tick (natural size).
1b. Head and shield of same (× 15).
2. Mature female castor-bean tick (× 4).
2a. Mature female castor-bean tick (natural size).
2b. Head and shield of same (× 15).
3. Mature female net tick (× 4).
3a. Mature female net tick (natural size).
3b. Head and shield of same (× 15).
4. Mature female dog, or wood, tick (× 4).
4a. Mature female dog, or wood, tick (natural size).
4b. Head and shield of same (× 15).

PLATE 2.

FIG. 1. Mature female Lone Star tick (× 4).
1a. Mature female Lone Star tick (natural size).
1b. Head and shield of same (× 15).
2. Mature female ear tick (× 4).
2a. Mature female ear tick (natural size).
2b. Head of same protruding from beneath (× 15).
3. Mature female chicken tick (× 4).
3a. Mature female chicken tick (natural size).
3b. Upper portion of same, head invisible (× 10).
4. Mature female European dog tick (× 4).
4a. Mature female European dog tick (natural size).
4b. Head and shield of same (× 15).

PLATE 3.

FIG. 1. Larva of cattle tick (× 25).
2. Larva of cattle tick (natural size).
3. Mature female and eggs (natural size).
4. Hide showing cattle ticks (natural size).
5. Blood cells containing Texas fever protozoa (× 1,000).
6. Male cattle tick (× 15).
7. Male cattle tick (natural size).
8. Young female cattle tick (× 15).
9. Young female cattle tick (natural size).
10. Various stages and colorations of cattle ticks.



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VARIOUS TICKS THAT INFEST CATTLE.

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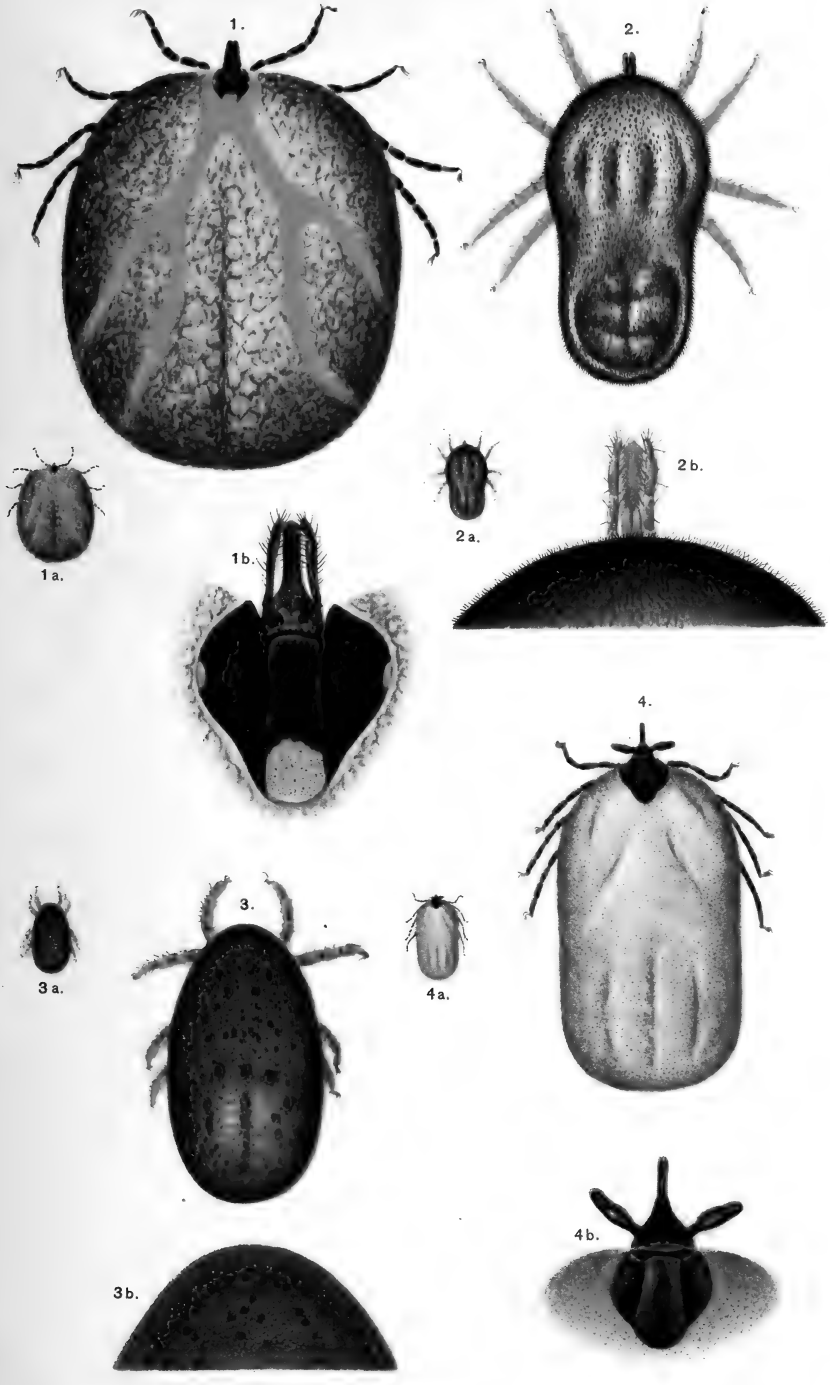

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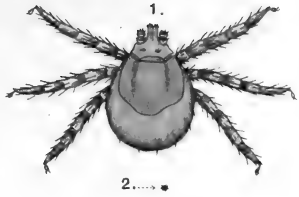
Various Ticks that Infest Cattle.



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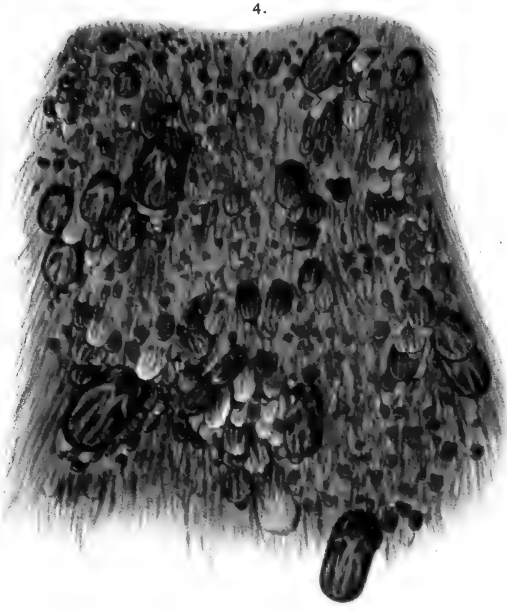

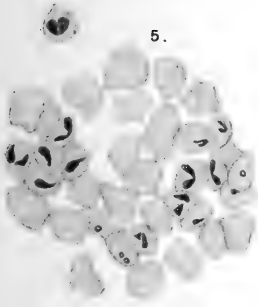

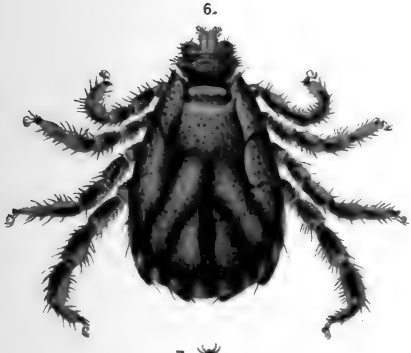

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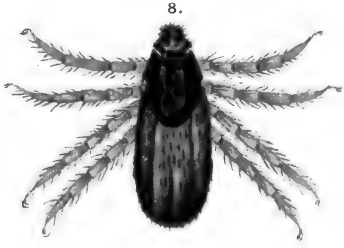

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TEXAS FEVER PROTOZOA AND THE TICKS WHICH TRANSMIT THEM.

ness, and when Southern cattle not previously infested with any but these noninfected ticks come in contact with infected ticks they are just as susceptible as cattle raised on tick-free pastures, as indicated below.

Harmless ticks mistaken for Texas-fever ticks.—A very prolific cause for argument against the relation of ticks to Texas fever has been the confusion which exists with reference to the various species of ticks observed on cattle. Some stockmen have claimed that ticks will not cause Texas fever, because their experience has not been with the Texas-fever ticks, but with the species of ticks described in the preceding pages, which are harmless so far as their ability to transmit Texas fever is concerned, or with the noninfected cattle ticks mentioned below. A similar experience with these harmless ticks upon woodland far removed from cattle and confusing them with cattle ticks have led others to claim that it would be impossible to eradicate the latter from infested pastures. However, their life histories are not parallel, since the cattle ticks demand the blood of cattle or equines in order to mature, while the ear, dog, Lone Star ticks, and others do not. Thus, if the fever ticks can be separated from these animals for a definite period they will die from lack of a host.

Susceptible animals having fever ticks without Texas fever.—In rare cases it has been observed that certain Texas-fever ticks do not contain the protozoan of Texas fever, and when such ticks fail to produce disease in susceptible animals some persons have been led to argue that none of this species will transmit the infection. Texas-fever ticks without the virus of Texas fever in their bodies are termed noninfected ticks. They may have lost their infectious property by living on a nonsusceptible animal, such as a horse, mule, ass, or sucking calf, as experiments have shown that a generation of infected ticks on these animals will eliminate the infection from their bodies and, when the next generation of seed ticks is placed on susceptible cattle, no disease is produced. These ticks will become reinfected, however, if allowed to infest Southern cattle containing the Texas-fever protozoa in their blood. Noninfected cattle ticks are so very uncommon that they are the exception, and since the vast majority are dangerous it would be advisable to treat all cattle ticks as infected and capable of transmitting Texas fever .

Fever ticks on other animals without producing disease.—The reason that Texas-fever ticks can remain on animals other than cattle without producing the disease is because these animals are not susceptible to Texas fever. Numerous experiments have shown that only bovines contract Texas fever, so it is not difficult to understand why other hosts can be infected with impunity.

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OTHER INJURIOUS EFFECTS OF CATTLE TICKS.

Many cattle owners who have always been accustomed to see both ticks and ticky cattle on their farms are unfortunately not inclined to attach much importance to cattle ticks, and, as a rule, through lack of appreciation of their damaging effects, placidly consider them as of little consequence. That ticks may be detrimental to their hosts in several ways has probably not suggested itself to these stockmen, who are most vitally affected, and it therefore seems necessary to emphasize the fact that, in addition to their relation to Texas fever, they may also be injurious to cattle as external parasites. While the power of transmitting Texas fever is undoubtedly the most dangerous property possessed by the cattle tick and is the principal cause for adopting stringent measures in securing its complete eradication, nevertheless there still remain other good reasons for the accomplishment of this achievement. These secondary objections to the presence of ticks on cattle consist in the physical harm they do to the host aside from the production of the specific disease of Texas fever. True, a few parasites may remain on cattle indefinitely without causing any noticeable effect, but it is not uncommon to notice bovine animals on pastures with their hides heavily infested with these pests. In such cases it can readily be seen that the continuous sucking of blood causes more or less impoverishment of the circulation. The animal must therefore be fed heavier in order to meet the demands of the parasites in addition to the ordinary needs of the host. If the ticks be removed from the body, the bites inflicted are often distinguished by small inflamed or reddened areas somewhat swollen, with perforations of the skin which may allow the entrance of various kinds of disease germs, and showing that more or less irritation of the hide is produced by these parasites. This condition, together with the loss of blood, frequently induces an irritable state and evidences of uneasiness commonly known as "tick worry," which results in the loss of energy and other derangements of the animal's health. It may in some cases become so pronounced, especially in hot weather, that the animal will lose flesh in spite of good pasturing, thereby reducing the vitality and rendering it more susceptible to the inroads of disease. Moreover, if the infestation of ticks is not controlled, the cattle may be so reduced in condition that growth is retarded, and, in the case of young animals, they may never become fully developed, but remain thin, weak, and stunted—a condition that has been termed "tick poverty"—and easily succumb to other diseases as a result of lowered vitality. In milch cows this debilitating influence of the numerous ticks is shown in a greatly reduced milk supply. This should not appear strange when it is considered that some animals harbor several thousand of these blood-

sucking parasites. If these parasites are crushed, it will be found that their intestines are completely filled with a dark, thick mass of blood abstracted from the animal host and containing nutriment that should go to the formation of milk, flesh, and the laying on of fat. In some rare cases the large number of bites over a limited area of skin may be followed by infection with pus-producing organisms, giving rise to small abscesses which may terminate in ulcers. The discharge from such sores, or in some cases the mere oozing of blood serum through the incision made by the mouth parts of the ticks, keeps the hair moist and matted together, and the laying and hatching of fly eggs in these areas give rise to infestation with destructive maggots, causing ulcers and other complications that require medical treatment. These statements regarding the secondary injurious effects of cattle ticks also apply to those ticks which have been previously spoken of as harmless in so far as Texas fever is concerned, and, in fact, to all external parasites. Therefore, it is just as important to eradicate the cattle ticks for reasons other than those associated with Texas fever as it is to exterminate lice, fleas, and other vermin. Furthermore, cattle ticks, aside from the losses sustained by their purely parasitic effects, are the greatest menace to the profitable raising and feeding of cattle in the South, because they are an obstacle to cattle traffic between the infected and noninfected districts.

LOSS OCCASIONED BY CATTLE TICKS.

The economic aspect of the tick problem is unquestionably of the greatest practical interest, since the fundamental importance of all the other questions which surround it depends upon the actual money value involved. It would therefore seem advisable to furnish a few statistics showing the financial loss sustained by the country as a result of the presence of this parasite. It is well known that those animals, coming from an infected district and sold in the "southern pens" of northern stockyards, bring an average of one-fourth to one-half a cent less per pound than the quoted market price. The handicap that is placed on the southern cattle raiser as a result of this decrease in value of his stock will average at the former figure at least $1.50 per head, allowing an individual weight of 600 pounds for all classes of animals, so that the loss on the estimated 705,000 southern cattle, including stock, beef, and dairy animals, marketed yearly under these conditions will sum up a loss of $1,057,500 per annum. Carrying this estimate still further it will be found that this decreased value reacts and fixes the valuation of all cattle which remain in the infected territory, thereby reducing the assets of the cattle industry of that section by this ratio per head for the four and a half millions of cattle east of the Mississippi River and the eleven

millions of cattle west of the Mississippi River; or, altogether, the enormous shrinkage in value of $23,250,000 directly chargeable to the cattle tick. This sum, however, should not be considered in determining the yearly devastation caused by the cattle tick, but rather as an unnecessary reduction in the assets of the infected country. This last loss does not include the decrease in flesh and lack of development of southern cattle occasioned by the parasitic life of the ticks from without and by the blood-destroying and enervating properties of the protozoan parasites from within, an additional loss which is so very great that a conservative estimate would place it equal to the loss above mentioned, or $23,250,000.

The shrinkage in the milk production of cattle harboring many ticks will average 1 quart per day, and the loss occasioned thereby at 3 cents per quart for the 875,000 ticky dairy cattle out of more than 4,000,000 dairy cattle below the quarantine line would amount to $26,250 per day, or, counting three hundred milking days for each cow to the year, $7,875,000 per annum. The damage resulting to the southern purchaser of northern purebred or high-grade cattle is another item of no small moment. About 10 per cent of all such cattle taken South die of Texas fever even after they are immunized by blood inoculations, and about 60 per cent of these cattle succumb to Texas fever when not so treated. Since they are usually very expensive animals and of a highly valued strain of blood, the loss in certain cases is excessive and in others almost irreparable owing to the possible extinction of some particular type especially selected for the improvement of the herd. Thus of the approximate 4,600 of such cattle brought South each year, at least 460 die of Texas fever. The loss entailed would naturally depend on the value of each animal, and since the prices paid for such well-bred cattle range from $100 to $1,000 or even more, it can readily be conceived that the yearly loss from this item alone varies from $46,000 upward.

Another instance where it is difficult to figure the injury done by the ticks is in the case of death of nonimmune cattle in the tick-free pastures of the South. Such animals are as susceptible to Texas fever as nonimmune northern cattle, and, inasmuch as there are in many States only one out of every four farms infested with ticks, the cattle on the remaining farms will in many cases contract Texas fever when exposed to the fever tick. These losses can scarcely be computed, as the death rate depends so much on the season of the year when exposure occurs and on the age of the animal affected. However, the deaths among such cattle are considerable, although this fact is little appreciated or understood by many outside of the infected area. Thus, if we consider one-tenth of the cattle below the line as nonimmunes which contract the disease on exposure to ticks, and if we figure on the death rate of 25 per cent of these

animals—a conservative estimate—the loss would amount to 387,500 animals, which, at an estimated value of $15 per head, would amount to a loss of $5,812,500 per annum. And this sum, excessive as it may seem, represents a smaller percentage of loss on the total valuation of neat cattle than has been determined by several of the infected States.

On rare occasions a small outbreak of Texas fever occurs north of the quarantine line as a result of improperly disinfected cars, of unscrupulous dealers breaking the quarantine regulations, or of some accidental condition. Such damage, however, is slight, but should be given consideration in summing up the loss occasioned by the fever tick.

The advertisement which a breeder obtains and the sales which are made by having his stock in the show ring are usually lost to the southern cattle raiser who aspires to display his animals in the North, as they are barred from most of these exhibitions. On the other hand, the southern farmer is not given an opportunity to see and be stimulated by the fine specimens of northern cattle which might be shown at southern stock exhibits, for the reason that the danger of contracting Texas fever is too patent to warrant such exposure. The expense incurred by the Government in enforcing the regulations that apply to the quarantine line reaches about $42,000 per annum, while the cost to the various States for similar work along their individual quarantine lines amounts to a very modest sum in some States, but to large figures in others, aggregating about $23,000 yearly.

Another loss which is indirectly sustained by the southern cattle industry through increased freight rates is the cost to the railroad companies of cleaning and disinfecting the cars that carry southern cattle and in providing separate pens for these animals at various locations. This sum may be calculated at not less than $29,000 per annum.

If all the above-mentioned losses are added it will be found that the Texas-fever tick is responsible for about $40,000,000 of loss annually to the people of the infected country, and that it also lowers the assets of the South by an additional $23,250,000. These figures are not given as accurate in any particular, but they are sufficiently close to indicate that the loss to the quarantined section from the cattle tick is something enormous and represents about 16 per cent of the total valuation of the cattle in that region. It must be admitted that this is by far too great a barrier to the successful operation of any business. Such a series of encumbrances as those recorded could be carried by the cattle industry of no other section of the country but the South, whose excellent pastures, rich soil, and salubrious climate are the only reasons for its ability to overcome such obstacles in meet-

ing the competition of the West. And it is the inherent capacity of the South for greatly increasing its herds and enlarging its pasture lands that makes the actual loss even secondary to the potential loss due to restrictions necessitated by the presence of the cattle tick. This potential loss may be described as the difference between the value of the cattle industry of the South to-day and the extent to which this industry would be increased if farmers and ranchmen were assured that their lands and cattle would not become infested with fever ticks. Could this assurance be given the beneficial effects would extend over the entire country, because the market of the northern breeder would thereby become greatly extended.

These appalling losses and annual sacrifices of the cattle raisers of the infected district can be entirely effaced, and this at a small proportionate cost; for, with enthusiastic stockmen, satisfactory State legislation, sufficient money, and a trained corps of inspectors, the cattle tick may be exterminated, and every dollar expended in this work will be returned many fold during each succeeding year.

PERIOD OF DEVELOPMENT OF DISEASE AFTER EXPOSURE TO TICKS.

The length of time elapsing between the exposure of susceptible cattle to the cattle tick and the appearance of Texas fever among them is dependent upon the climate and the development of the ticks to which they are exposed. Thus, if any Northern animals are placed upon pastures, highways, or in pens, cars, etc., in summer immediately after the premises have been infested with ticks from Southern cattle, Texas fever may occur in from thirty to sixty days, as the females that drop from the Southern cattle must lay eggs and these must hatch before the Northern animal becomes infested with ticks, and thereby inoculated with the disease. In cool weather this period may extend to ninety days, as it takes much longer for the eggs to hatch. Where Northern animals are not exposed in an infested pasture until the ticks which fell from the Southern cattle have laid eggs and the larvæ, or seed ticks, are already present, the former cattle will develop symptoms in thirteen to fifteen days in hot weather. Thus under natural conditions the disease appears in thirteen to ninety days after exposure. After the seed ticks become attached to the animal the disease will appear in about ten days in summer, and after a somewhat longer period in cooler weather. In fact, the disease may occur before the ticks are large enough to be seen without a very careful search. By artificially inoculating a cow under the skin or into a vein with virulent blood the disease may be produced in three to ten days.

SYMPTOMS.

The symptoms of Texas fever present two distinct types, depending upon the time of year the disease makes its appearance and the sus-

ceptibility of the animals attacked. These types are spoken of as the acute and chronic forms of the disease. The acute, fatal form is seen when nonimmune Northern cattle and the susceptible Southern animals raised on tick-free pastures are attacked in the hot summer months. The milder, chronic form, usually nonfatal, occurs when nonimmune cattle are affected in the late autumn and in the partially immune cattle below the Texas-fever quarantine line at all seasons of the year, the latter animals usually not being attacked by the acute form of the disease.

Acute type.—In this form of the disease the temperature rises within twenty-four to forty-eight hours to 107° or 108° F., and the animal rapidly shows signs of being affected with a severe malady. It is depressed, leaves the herd, and lies down or stands off by itself with head lowered, ears dropped, feet drawn together, and back arched from the pain in the liver and kidneys. If the nature of the disease is suspected, the rise of temperature may be ascertained by the use of the thermometer or by merely placing the hand about the root of the tail or between the thighs. The muzzle is dry, the appetite lost, and rumination ceases. Constipation is always present during the first stages of the disease, but it frequently gives place later to diarrhea, and the manure is usually heavily stained with bile and in rare cases may be mixed with blood. Accompanying the rise of temperature, as in all other acute febrile diseases, there is an increase in the rate of respiration and pulse beat. The former may rise to from 50 to 90, while the latter varies from 90 to 120 per minute.

The changes which occur in both the urine and blood are extremely important, but the urine will receive first consideration here, as it is more readly examined by the layman than the blood. The peculiarity of the urinary secretion is that it is blood-stained—the so-called hemaglobinurea—from which symptom the disease has derived its name of "red water." The protozoa in the circulation break up the red corpuscles, liberating the substance hemaglobin, which is the coloring matter of the blood. This substance being free in the blood plasma is excreted by the kidneys, giving the urine its red color, which is so characteristic of Texas fever. This discoloration of the urine is present in the majority of the acute cases, but it is frequently wanting in the chronic form of the disease. The color varies greatly from a mere pinkish tint to an almost black color, depending on the rapidity of destruction of the red cells and the excretion of the coloring matter through the kidneys into the urine. There is also a small quantity of albumen in the urine of the majority of cases. The comparative weight (specific gravity) of the urine, which in the beginning stages is increased (1,028 to 1,040), is later reduced to normal (1,010 to 1,020).

The blood also furnishes great assistance in making a diagnosis

of suspected Texas fever, and the finding of the intracorpuscular parasite microscopically is conclusive evidence. This fluid, as it oozes from a small incision in the skin, is pale and watery, indicative of great reduction in the cellular element, and is readily seen to differ markedly from the normal red blood of healthy animals. Sometimes there is such a lack of blood in the vessels of the skin that a very deep incision has to be made in order to obtain sufficient blood for inspection. It is also at times noted that the power of coagulability of the blood is so reduced that when it once starts to flow it is only after a considerable time—or by applying pressure—that the hemorrhage is stopped. In the majority of cases, however, the tendency of the blood to clot is unaffected.

Cerebral symptoms are noticed in a certain percentage of cases manifesting themselves in the form of staggering gait, disturbances of vision, or delirium. There is in milch cows a reduction or a complete stopping of the milk secretion. Abortion is also very common in pregnant animals. Death usually occurs within three or four days, and is generally preceded by a marked fall of body temperature to normal or even subnormal a few hours before the fatal termination. In nonfatal cases the temperature falls gradually after the crisis and soon reaches the normal, but recovery is prolonged over weeks and even months, as a great deal of time is required to regenerate the greatly impoverished blood.

Chronic type.—This form of the disease appears under natural conditions usually in the late autumn and early winter. It can be produced experimentally, however, by placing a few ticks on the skin of a susceptible animal—a fact of very great importance in the production of immunity against the acute type among Northern cattle.

This form shows all the symptoms of the acute type, but in a milder degree. The temperature usually remains about 103° and never exceeds 105° F. There is loss of appetite, stoppage of rumination, constipation, and albumen in the urine. An anemic condition of the blood, as indicated by the pale and bloodless mucous membranes, is also present, but hemaglobin is not usually excreted by the urine, hence the red-water symptom is absent. There is also excessive loss of flesh and, before the end of the attack, the affected animal is greatly emaciated; although death rarely occurs the valuation of the animal is much reduced.

Relapses.—Following recovery from an acute attack, when the red blood corpuscles have apparently reached their normal number, there has frequently been observed a relapse or recurrence of the disease in the mild, chronic form, accompanying which there is a second period of destruction of the red cells. This follows within three to six weeks after the symptoms of the acute attack have subsided. For a considerable time it was unknown whether this was a relapse of the

acute attack or due to reinfection from a second generation of ticks. Smith and Kilborne, however, proved that it could occur as a relapse without the presence of ticks, but it may also in some cases be caused by a second extraneous infection.

APPEARANCE AFTER DEATH.

The postmortem examination should be made as soon as possible after death, as the carcass of an animal dead of Texas fever undergoes decomposition very rapidly. The skin should always be first examined for the presence of the cattle tick, as the discovery of any of the forms of this parasite on the skin of the escutcheon, thigh, or belly leads at once to a suspicion of the presence of the disease. The skin is usually normal in appearance, no visible alterations being present except possibly the small swellings, minute hemorrhages, and perforations from the bites of the ticks. Upon cutting into the hide and skinning the carcass, a marked lack of blood in the blood vessels of the skin and underlying tissues is observed. Occasionally there may be noted a yellowish, jaundiced discoloration of these tissues. The fatty tissues are also yellowish, and, instead of possessing the normal firm consistency, they are soft and oily. In very severe cases, even the muscular system may have a jaundiced appearance. This discoloration is due to the alteration of the bile-secreting function of the liver, but is by no means present in all cases, being most constant in the acute, rapidly fatal form of the disease.

Probably the most marked pathologic alterations in the disease are found in the liver. This organ is very much enlarged and has a yellowish, mahogany-brown color, due to the bile it contains. This secretion becomes excessive, and minute plugs of congealed bile form in the small bile ducts, thus stopping them and damming the bile in the organ, which produces the yellowish color. This does not occur evenly throughout the organ, and consequently it has a mottled appearance. The gall bladder is usually distended with bile, and its mucous membrane often contains numerous minute hemorrhages or petechial spots. The bile is very thick, has the appearance of "chewed grass," and contains numerous firm, irregular flakes. The spleen also shows marked pathologic alterations. Normally this organ weighs from $1\frac{1}{2}$ to $2\frac{1}{2}$ pounds, but in cases of Texas fever it is enormously enlarged, sometimes reaching four times its normal dimensions. It is very dark at times, almost black in color, due to the enormous accumulation of red corpuscles and hemaglobin within its substance. Upon cutting into the spleen, or merely attempting to pinch it up, the pulpy tissue will sometimes run out as a semifluid, blackish mass, due to the breaking down of its structures and to the excessive engorgement of the organ.

In death from the acute type of the disease the kidneys are usually found to be very dark in color and congested, and, on cross section, the normal markings are indistinguishable. The blood vessels are engorged with blood, and there is edematous infiltration of the surrounding fatty tissue. In the older, more chronic cases, the kidneys are paler and somewhat flabby.

The bladder usually contains a varying quantity of urine, which may or may not be blood-stained. The mucous membrane frequently contains a few minute hemorrhages.

No characteristic lesions are found in the stomach and intestines. There may be slight congestion of the third and fourth stomach, with slight peeling off of the epithelial lining. The intestines usually contain considerable bile and there is more or less edema of their walls. Blood effusions may have occurred from the walls of the gut, especially in the rectum, producing a bloody discoloration of the feces. The large intestine also frequently shows severe congestion. None of these lesions, however, are constant, and the intestines furnish very little positive information in establishing a diagnosis. The lungs are rarely affected by the disease and, barring a slight edema, are found to be in a healthy condition.

The membrane surrounding the heart (pericardium) frequently shows pin-point hemorrhages, as does also the membrane on the inner surface (endocardium) lining the walls of the heart cavities. The blood is observed to be paler and the clots softer than normal.

COURSE AND TERMINATION.

The course of the disease depends not only upon the time of the year the infection occurs, but also on the age, strength, and susceptibility of the animals attacked. When mature susceptible cattle contract the disease in the hot summer months, death usually occurs within a week—generally three or four days—after the first appearance of symptoms, but it may follow inside of twenty-four hours.

In the late fall infections of nonimmune cattle and in the partially immune Southern cattle, however, the course of the disease is much more prolonged and covers a period of many weeks or even several months. In this type the continuous fever causes exhaustion, while at the same time the enormous destruction of red blood cells interferes very materially with the nutrition of the patient. As a natural consequence, emaciation becomes marked, and this, together with the poor appetite, leads to a fatal result in some cases. In the majority of cases, however, in spite of the severe alterations of the blood and internal organs, they begin after several weeks to show improvement. The temperature becomes normal and there is a tendency toward regeneration. This, however, requires weeks and months, the

animals in the meantime appearing weak and thin, having pale mucous membranes. During the recuperative period the animal should by no means be fed excessively, as numerous cases of fatal gastro-intestinal disturbances have been reported from overfeeding. The few animals which recover from the acute type of summer are quite likely to have a relapse in the form of the chronic type in the fall.

The mortality in adult susceptible cattle, as the above statements readily show, may vary considerably, and ranges from 90 per cent in the months of July and August to less than 50 per cent in the late autumn and early winter. The prognosis must therefore depend on the time of year the outbreak occurs. In animals under 9 months of age, the course of the disease is usually short and the affection seldom fatal, while the death rate among 1-year-old cattle during the hot season is about 25 per cent, and less than 10 per cent in the fall and winter. Between $1\frac{1}{2}$ and 2 years of age, the mortality is about double that at 1 year.

INFECTIVE CHARACTER.

Texas fever belongs to the group of infectious diseases, and it is a typical example of the few diseases of this class which do not combine the property of being contagious. It is infectious because it is due to the entrance and multiplication of a pathogenic microorganism within the body, but sick animals, in the absence of ticks, can remain in intimate association with healthy susceptible animals indefinitely without transmitting to them the disease, and hence it is not contagious. Furthermore, a cow perfectly healthy in appearance may contain in its blood the Texas fever protozoan, which, when transmitted to susceptible cattle by the fever tick, will produce the disease. It is certain that the piroplasma are present in varying numbers in the manure and urine of infected animals, and yet susceptible animals have never been known to become affected from grazing over tick-free pastures soiled with excrement from the sick animals.

In 1890 the experiment was made by the Bureau of polluting a pasture with the blood and spleen of an animal dead of Texas fever and then allowing susceptible cattle to graze in the field for two months, but the animals remained perfectly healthy. Moreover, as has previously been stated, the feeding of ground-up ticks and virulent blood failed to produce the disease, showing that the digestive tract is proof against the infection.

The disease therefore can be transmitted by three known methods only: (1) By the bite of the cattle tick; (2) by inoculating the blood of sick animals into healthy animals; (3) by inoculating the infected blood of apparently healthy Southern cattle into nonimmune cattle.

ANIMALS AFFECTED.

Numerous experiments have been made on various species of animals with highly virulent blood from cattle suffering with Texas fever, but the disease has been produced in bovines only. Among those animals that have failed to develop the disease after inoculation may be mentioned horses, asses, sheep, pigs, dogs, cats, mice, rats, guinea pigs, rabbits, chickens, and pigeons. All bovine animals that have never been exposed to the disease are susceptible to Texas fever, although sucking calves are so resistant as to be practically immune. Adult cattle are the most susceptible, and, if attacked in the summer months, usually die, while in the fall and winter they more frequently recover. Calves under 8 months of age contract the affection in a very mild form, as a result of which they become immune from the disease.

DISEASES MISTAKEN FOR TEXAS FEVER.

There are two diseases of cattle which may be confounded with Texas fever. The differential diagnosis of the latter and anthrax is by far the more important, and it will therefore receive first consideration. Although these two diseases are frequently mistaken one for the other, there are numerous differences between them which, if carefully considered and taken together, are usually sufficient to establish a diagnosis. The following are the main features of Texas fever not found in anthrax: Young ticks are usually found on the hide of the affected animal; if occurring in the uninfected territory, the disease can invariably be traced to the shipment of Southern cattle into the country thirteen to ninety days previously; young sucking calves are not affected; the mucous membranes become extremely pale and jaundiced, while in anthrax they are very red and congested; cattle only are attacked, while anthrax attacks all animals. Upon postmortem examination in Texas fever the tissues under the skin are very pale, while in anthrax they are congested, with the blood vessels standing out prominently. The blood is thin, pale, and watery, whereas in anthrax it is tarry, black, and incoagulable. The bile is semisolid and contains numerous hard flakes, while in anthrax it is fluid. The spleen is affected quite similarly in both diseases, but the liver in Texas fever is enlarged, yellowish, and mottled from the plugging of the bile ducts, whereas in anthrax the liver, although enlarged, is very dark in color and is congested.

It can usually be differentiated from blackleg by the fact that the great majority of victims of blackleg are between 6 months and 2 years of age. There is usually a total absence of ticks on the hide in the latter disease, while there are present superficial crackling swell-

ings which on being opened are found to contain gas bubbles with the peculiar odor characteristic of the disease. There is also an absence of blood-stained urine. On postmortem examination in blackleg the muscular tissues beneath the swollen areas are very dark and soft, with bloody fluid, while the liver, spleen, and kidneys are apparently unaffected.

TREATMENT.

Medical treatment of the sick has generally been unsatisfactory, although in chronic cases and those occurring late in the fall beneficial results have followed. If the animal is constipated, a drench containing 1 pound of Epsom salts dissolved in 1 quart of water should be administered, followed by the sulphate of quinine in doses of 30 to 90 grains, according to the size of the animal, four times a day until the system is well saturated with it. Tincture of digitalis $\frac{1}{2}$ ounce, and whisky or alcohol 2 ounces, may be combined with the quinine, according to indications of individual cases. An iron tonic containing reduced iron 2 ounces, powdered gentian 4 ounces, powdered nux vomica 2 ounces, powdered rhubarb 2 ounces, and potassium nitrate 6 ounces will be found beneficial in the convalescent stage when the fever has run its course. This tonic should be given in heaping tablespoonful doses three times a day in the food. Good nursing is essential in treating these cases. The animal should be given a nutritious laxative diet, with plenty of clean and cool drinking water and allowed to rest in a quiet place.

If the stable or pasture is infested with ticks, the animal should be placed in a tick-free inclosure, to prevent additional infestation with these parasites and the introduction of fresh infection into the blood. It is advisable, not only before but also during treatment, to remove from the sick cattle all ticks that can be seen, as they keep weakening the animal by withdrawing a considerable quantity of blood, and thereby retard recovery.

PREVENTION.

It is generally accepted that if Southern cattle are entirely free from that species of tick known as *Boophilus annulatus*, they can be allowed to mingle with the most susceptible animals without danger. Furthermore, it has been learned from the study of the life history of the cattle tick and from the fact that this tick infests pastures only transiently, never permanently, and will not mature except upon cattle or equines, that its extermination is possible, and that the disease it causes may be prevented. The various methods with these results in view should be directed toward the destruction of ticks on cattle as well as their eradication from the pastures.

HOW TO FREE CATTLE OF TICKS.

Among the most important measures to be adopted in eradicating these parasites from cattle in the infested districts may be mentioned: (1) Picking or brushing them off; (2) smearing or spraying the animals with a disinfecting solution, and (3) dipping the "ticky" animals in a vat containing a solution capable of killing the ticks without injury to the cattle.

The systematic application of one or more of these methods, together with appropriate measures for eradicating or destroying the cattle ticks upon pastures, has been successfully adopted in certain sections, and has thus diminished the area of the infested district.

Picking or brushing ticks off cattle.—Where the herd is small a very effective but laborious method is to pick off these parasites by hand or to scrape them off with a dull knife or a currycomb. This should be done at least three times a week in order to find all the adults before they mature and fall off, as by this system the smaller ticks which at first escaped detection will be found before they are fully developed. After removing the ticks they should be destroyed, preferably by burning. Care should be taken to go over all parts of the animal frequented by the ticks, especially under the belly, around the tail and udder, and inside the legs. After the ticks are picked or brushed off, the cattle should not be neglected, but should be carefully examined later for the presence of ticks which have been picked up in the meantime. If this work is thoroughly performed and no ticks are allowed to fall off and lay eggs from June 1 to the end of November, the cattle will be free of ticks, and the pastures will have had an opportunity of becoming cleaned.

Smearing or spraying cattle with a disinfecting solution.—Greasing the legs and sides of cattle with cotton-seed oil, fish oil, or Beaumont crude petroleum will assist in preventing the ticks from crawling up on the body. In small herds, smearing the cattle with a mixture of 1 gallon of kerosene, 1 gallon of cotton-seed oil, and 1 pound of sulphur, or with a mixture composed of equal parts of cotton-seed oil and crude petroleum, or with Beaumont crude oil alone, has proved efficacious when applied to the skin two or three times weekly during the tick season. For this purpose sponges, syringes, brushes, mops, or brooms may be used. This method not only kills the older ticks on the cattle by mechanically plugging up their breathing pores, but also makes the legs so slippery that the seed ticks are unable to get a foothold in order to crawl up on the cattle. Where a large number of animals are to be treated, but not sufficient to make it advisable to construct a dipping vat, spraying the infested animals has given very favorable results. The animals should be placed in a chute or a stall, or tied to a tree, and then sprayed with Beaumont oil or a 5 per cent solution of any of the standard coal-tar dips. The solution may be

applied by means of a force pump, such as is used by orchardists to spray fruit trees, or by placing the solution in a barrel upon a wagon or on a platform above the animals and allowing the fluid to gravitate through a hose, to the end of which is attached an ordinary sprinkling nozzle. The solution is then allowed to flow over the skin of the animal, especially upon the legs and under portions of the body. If the cattle are on tick-infested pastures, this treatment—either smearing or spraying—must be continued through the whole season, and if thoroughly done it will leave the fields free from ticks the following year.

Dipping in a vat.—Many efforts have been made to discover a practical method for dipping cattle to destroy ticks without injury to the cattle, and the Bureau has experimented for years with this object in view. Numerous kinds of dips have been used and many failures have been recorded, but apparently a successful one has been found in the crude oil—so-called Beaumont oil—obtained from certain Texas wells. This oil has now been used on a rather large scale, and it has been very successful in killing ticks without at the same time materially affecting the health of the cattle when the proper precautions have been observed. In fact, it is distinctly superior to any of the other dips that have been tested. In these experiments it was found that a light oil heavily charged with sulphur is the most desirable for dipping cattle, as the heavy oils injure the animals dipped in them. An oil with 40 per cent of its bulk capable of boiling between 200° and 300° C., having a specific gravity between 22½° and 24½° Beaumé, and containing 1¼ to 1½ per cent of sulphur is most desirable, and these requirements should be stipulated before purchase. In a recent dipping of 57,000 head of cattle on the Kansas and Osage Indian reservations the results were very highly satisfactory, both as regards the eradication of the cattle tick and the after results of the dipping, since the loss from all causes was less than 0.75 per cent. This loss represented in dollars and cents would amount to a very small portion (about one-twelfth) of the loss incurred by the sale of these animals as "ticky" cattle in the stock yards of the North. Other cattle dipped in the same oil, but under conditions that can not be considered parallel, suffered more severely. In order to obtain the best results, the animals, after dipping, should not be unduly exposed to the hot sun nor driven any considerable distance, but should receive plenty of food and good water. They should be allowed to stand for four or more days after dipping and prior to shipment. Dipping should not be attempted until after they shall have shed their winter coats, as a large percentage of all cattle dipped before the heavy coat is lost suffer from a severe irritation of the skin. The method usually adopted in dipping cattle is to construct a narrow swimming tank with a chute at one end for the entrance of the

cattle and a sloping exit at the other end where the cattle emerge after getting a uniform coating of oil in passing through the vat. A drip chute, or floor, is connected with the exit where the excess of oil is allowed to drip off the animals and to drain into the vat. Plans and specifications for installing a dipping plant suitable for either small farms or large ranges are published in Farmers' Bulletin No. 152, which may be obtained from this Department. It is relatively more expensive to dip cattle in the South, where the farms and plantations contain a small number of cattle, than in the range country of the Southwest, where this method of eradicating ticks becomes not only plausible and practicable, but also economical. When cattle have been properly dipped in Beaumont crude petroleum or any other approved petroleum under the supervision of a veterinary inspector and by him found free of infection, they may be shipped to any point above the quarantine line, subject only to such restrictions as may be imposed at the point of destination. Such cattle must be shipped in clean, disinfected cars, and must not be driven through the quarantined area or be unloaded therein, except at those points designated by the Secretary of Agriculture. It is earnestly recommended that such shipments shall not occur earlier than four to eight days after the dipping is performed.

By the "soiling" method.—This method of freeing cattle of ticks was suggested by Curtice. It is based upon a knowledge of the life history of these parasites. The time required for the female tick to lay eggs and the latter to hatch—in other words, the time spent on the ground—is rarely less than three weeks, and the period required by the seed ticks to molt and mature—or the time spent on the cattle—is usually from twenty to forty-five days. When cattle infested with ticks are to be cleaned for any reason—as, for instance, before being placed on noninfested pastures—it is recommended that the cattle be kept in a small tick-free inclosure for three weeks, when many of the ticks will have fallen off. They should then be removed and placed in a similar paddock for another three weeks. At this time the cattle should be examined, and if found free from ticks they may be placed in the noninfested pasture at once. On the other hand if any ticks are observed the cattle should be placed in a third pen for two weeks more. By this time even the youngest ticks that were on the cattle at the start will have matured and dropped off; and as the animals are removed from each pen before they could possibly become reinfested with the seed ticks that hatch from the eggs of the females that fell off, they are now tick free. The same pens can not be used repeatedly for this purpose without thorough disinfection, as they become infested with young ticks, which will at once attack cattle if given an opportunity to do so. Care should be taken that hay fed the animals in these pens is from noninfested fields.

HOW TO FREE PASTURES OF TICKS.

How to rid pastures of ticks without destroying the vegetation on them was for a long time a problem. While this may be impossible on large ranches, it has been successfully accomplished on small farms by systematic efforts based upon a knowledge of the life history and the habits of the cattle ticks. The most satisfactory as well as the most practicable methods have been found to be as follows:

By excluding cattle for a definite period.—The removal of animals from an infested pasture for a stated period will cause all ticks present therein to starve and the pasture will thus become tick-free. One method of accomplishing this result is to divide the pasture into two parts by a double line of fence. This fence should be board-tight at the bottom to prevent ticks from crawling out, and there should be a 10-foot space between the two lines so that the ticks would be unable to crawl across to the opposite pasture if they should perchance get out. One of these pastures is then kept free from cattle, horses, mules, and asses from spring to late fall, or, better, until January. By this time it will be free of ticks and ready for tick-free cattle that have been cleaned by any of the methods above described; then the other pasture is abandoned for the same period of time.

Butler states that the pasture may be kept free of ticky animals for a shorter period with equally beneficial results, and recommends the following method:

The tick-infested cattle should be removed from their pasture on September 1, cleaned of ticks by any of the methods previously mentioned, and placed in a cultivated field or pasture where no ticky animals have been for at least six months and where they can not come in contact with ticky animals or ticky soil. The original pasture should not be restocked until the following spring (April), at which time all the eggs laid there before September 1 will have hatched, the seed ticks will have starved, and the pasture will be free of ticks. It may then be used for cattle that have no ticks upon them. In case the cattle are not free of ticks when placed in the cultivated field or noninfested pasture on September 1, they will infect this field and will carry ticks to the original pasture if placed there in the spring.

By cultivation.—Another method of destroying ticks on pastures is to cultivate the soil for a year without permitting any ticky cattle, horses, or mules on the ground during this period. After this treatment the field will be without any Texas-fever ticks and may be restocked with cattle not infested with these parasites.

By burning off the grass.—Pastures that are too large to be disinfected by the above measures or those grazing lands that are open

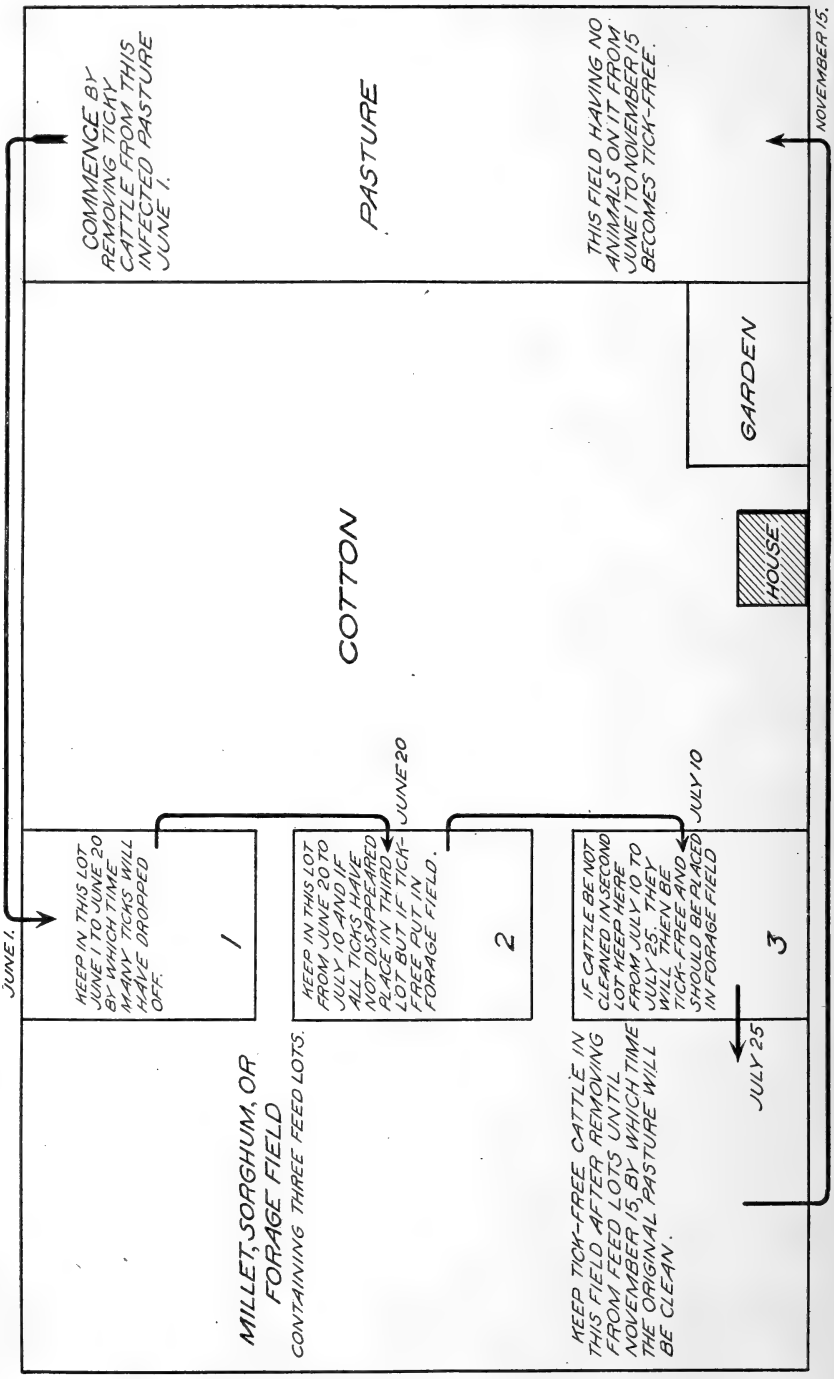

FIG. 2.—Cleaning cattle and soil by "feed-lot" method.

and can not be inclosed, or ranches where a division of the pasture is impracticable, may be freed from ticks by burning them off in the spring or fall and then keeping tick-infested animals from the land. It is advisable to burn off the grass in the spring when practicable, as this permits the pasture to recover quickly and to supply feed in several weeks.

HOW TO FREE CATTLE AND PASTURES OF TICKS AT THE SAME TIME.

By the "feed-lot" method.—The "feed-lot" method has been recently recommended by Morgan after conducting field experiments in Louisiana, and has for its object the ridding at the same time of pastures and cattle of the fever tick. This plan, like the "soiling" method, suggested by Curtice, is based upon the length of time the tick lives upon cattle and the period required for the eggs to be laid and hatched and the seed ticks to attach themselves to their host. For carrying out this idea take a field which has been sown to corn, millet, sorghum, or other forage and fence off three lots within such a field, in one of which the ticky cattle are placed on June 1 by removal from their customary pasture.[a] (See fig. 2.) In the first feed lot the greater number of ticks drop off and lay eggs. After an interval of twenty days and before these eggs have had time to hatch, the cattle are moved to the second inclosure, where they are kept another twenty days, when they will in many instances be free of ticks and can be turned into the forage field. However, in case ticks are still present, the cattle should be placed in a third paddock for fifteen days longer. All the ticks that were on the animals when placed in the feed lots will have dropped off now, and, as the cattle leave each feed lot before they can become reinfested by the seed ticks which hatch from the eggs of the ticks that fall off, they will be clean and safe. These tick-free cattle are then pastured in the sorghum, corn, or millet field containing the feed lots and the latter are plowed immediately after the cattle are taken out, their edges are sprayed with Beaumont oil, petroleum, or other disinfectant substances, and the soil is cultivated. The cattle are kept in the forage field until November 15, or even later, when all the ticks on the regular pasture will have died of starvation from the exclusion of cattle since June 1, and the tick-free animals can then be replaced on this tick-free pasture. In adopting this method it is essential that the feed lots be inclosed by a fence which is board-tight along the ground, and that this fence be watched carefully and disinfected occasionally to prevent the ticks from getting into the forage field; a single furrow could be thrown up on both sides of the fence for the same purpose.

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[a] From our experience the two lots recommended by Morgan would not be sufficient under all conditions.

These feed lots should be situated along the edge of the field in order that the cattle in changing from one lot to the other may pass, as directly as possible, through a portion of an adjoining cultivated or tick-free field, so that if the ticks fall off during this drive they will not infest the forage field, and later the cattle when pastured therein. The cattle should be fed on the annual crops while in these lots, but never upon crops obtained from infested pastures, as such food may contain seed ticks. Water may be supplied by piping from a well, spring, or creek, by carting it to the feed lots in barrels, or by placing the fence so as to include a spring or portion of a creek, provided the latter does not flow through an infected pasture a short distance above.

By pasture rotation.—A very satisfactory method for freeing cattle as well as pastures of the cattle tick is by pasture rotation, which combines the suggestions of Curtice, Butler, and Morgan. It is based upon the knowledge that by severing the relation of the fever ticks and the animals upon which they develop these ticks will perish. To adopt this plan first divide the infected pasture into two parts, which is best accomplished by a double line of fence with a 10-foot space between the lines to prevent ticks crossing from one pasture to another (fig. 3). In order to observe all possible precautions, this fence should have either a furrow thrown up against it or a board or rail placed tightly along the bottom to help keep the ticks within. All animals that carry the cattle tick are excluded from the first half of the pasture, which may be termed pasture No. 1, from June 1 until November 10, at which time all the ticks that were there will have perished from want of a host and the field will be ready for receiving tick-free cattle. The ticky cattle, on being removed from pasture No. 1 on June 1, are placed in the other half of the original pasture, which may be called pasture No. 2, where they are kept from June 1 to September 10. They may now be partly cleaned of ticks by placing them at the latter date (September 10) in a cultivated field—for instance, a rye or vetch or wheat and vetch field—and by keeping them therein for twenty days, when a large number of ticks will have fallen off. The partly cleaned cattle may then be removed on September 30 to a field sown to corn and sorghum, corn and cowpeas, or a combination of corn, sorghum, and cowpeas, or other forage crops.

In this field most of the remaining ticks, if not all of them, will have dropped from the animals within twenty days, but in a few instances the cattle may still be infested, so the animals should be moved on October 20 to a cotton field in which rape or crimson clover had been sown at the last cultivation for the purpose of furnishing food for the cattle while there. The crops should have been gathered from

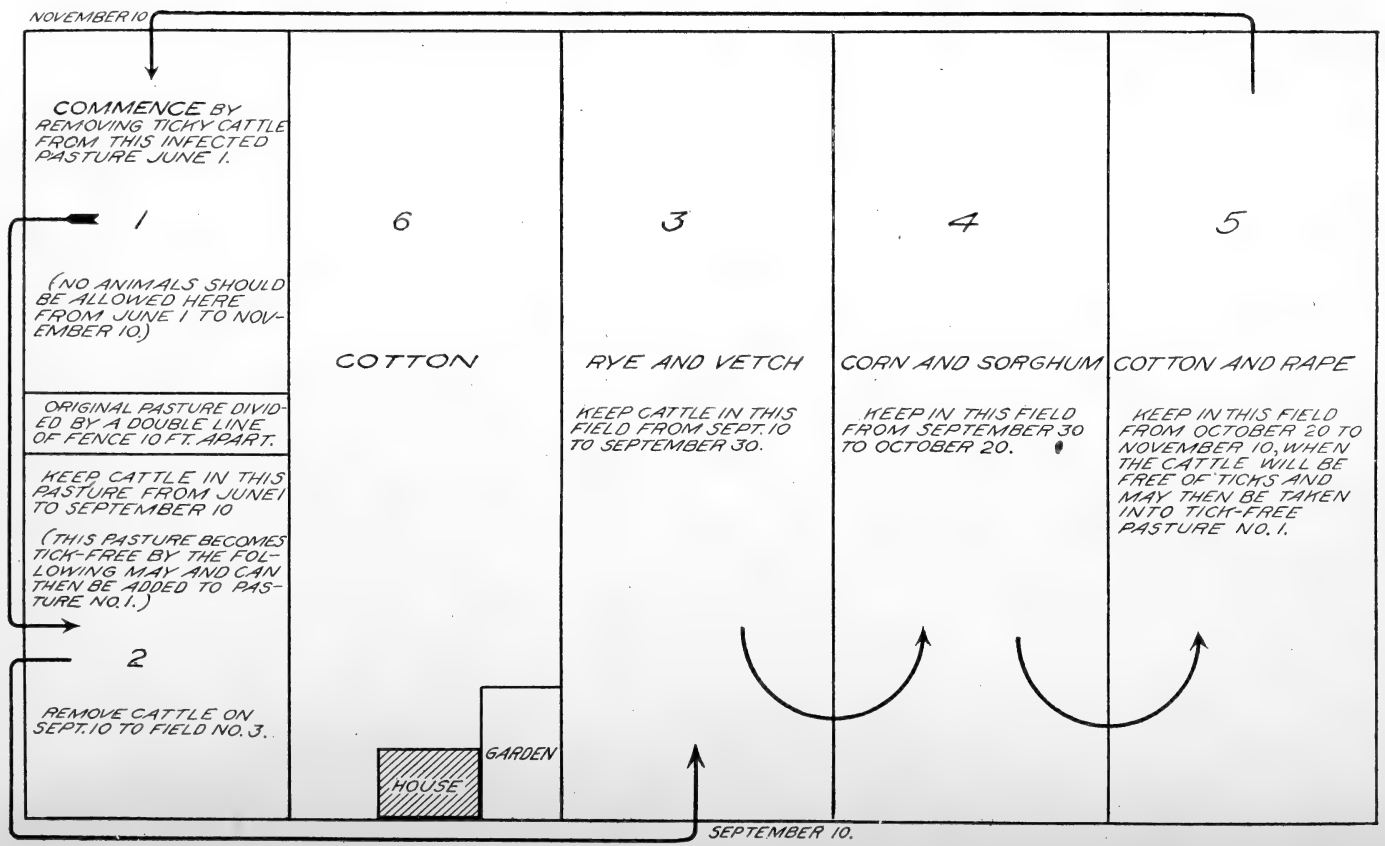

FIG. 3.—Cleaning cattle and soil by pasture rotation.

all these fields before turning in the cattle. Here they are kept for another twenty days (to November 10), not because they would not be free of ticks at an earlier date, but on account of the desire to keep cattle away from pasture No. 1 until November 10. On this date these clean cattle are returned to pasture No. 1, which will now be tick-free as a result of the exclusion of animals since June 1. These cattle should be kept in this pasture until May, by which time the ticks in pasture No. 2 will have starved, owing to the absence of animals therefrom since September 10. Both the cattle and pastures will now be tick-free and the double line of fence between the two fields can be removed and the original pasture restored. This plan, as represented by the diagram, is merely a suggestion of arrangement and may easily be varied with regard to the selection of crops and the location of pastures to suit the demands of individual farms. To prevent ticks from crawling under either of the fences between fields III and IV and fields IV and V, it is necessary to have a board or rail placed tightly on the ground along these lines of fence, or to throw up a single furrow along both sides of the fences. To avoid the danger of infestation from the outside, care should be taken to feed the animals, in those cases where the pastures or fields are overstocked, on hay cut from tick-free fields, and to keep out work oxen, mules, and horses that may harbor fever ticks, thus preventing reinfestation of the pasture. When the cultivated fields are on a slope it is advisable to use the lowest field first, in order that the ticks dropped within may not be washed by drainage upon the adjoining fields which are later to hold the cattle. For the same reason, where a stream runs through the fields upon which the cattle are to be placed, the field farthest removed from the head water should be used first. Where an endeavor is made to rid a farm of ticks, it is essential that the work animals (oxen, mules, and horses) used in cultivating the fields be curried to keep off the ticks and prevent the latter from being carried into these fields. Cats should also be kept from the pastures and fields; for, although they do not harbor the mature ticks, seed ticks have been found on them, and, while these seed ticks remain only for a short period, this time may be sufficient to allow them to be carried into the disinfected pastures, where they may fall off and reinfest the soil. If a farm or plantation consists of a pasture and but one field under cultivation, the above plan can be made applicable by fencing off three inclosures in the latter and by rotating the cattle in them every twenty days in the manner just described. The same precautions should be observed in changing the cattle from one lot to another and in preventing ticks from getting into the cultivated field, as are mentioned above.

IMMUNIZATION OF SUSCEPTIBLE CATTLE.

By blood inoculation.—It is often desirable to ship well-bred cattle into infested districts, that they may be used to improve the quality of the native cattle already there. Previous to the discovery of the cause of Texas fever, it was found to be wellnigh impossible to introduce purebred cattle from the North into any of the infected regions without suffering great loss—sometimes as high as 90 per cent—within a few months of their arrival at their Southern destination. At first it was thought that the fatalities were due to climatic changes, but later the discovery was made that Texas fever was causing these numerous deaths.

It has now been found practicable to immunize this class of cattle so perfectly that the losses which follow their transportation to a tick-infested region are reduced to a minimum. Young animals six to fifteen months old should, so far as possible, be selected for this purpose, as they are more readily immunized than adults, are more easily handled, and the dangers which may arise from pregnancy while undergoing the immunizing treatment are thus avoided.

Immunity in these cattle is obtained by introducing the microparasite of the blood into their systems. It may be done by direct artificial inoculation or by placing virulent young ticks upon the animals and allowing them to perform the inoculation in the natural manner. The subcutaneous injection of a small amount of defibrinated virulent blood has been found, by means of prolonged experiment, the preferable method, as the number of microorganisms introduced can be more accurately gauged from the syringe than by allowing the infection to be produced by bites of ticks. Two or three inoculations, if repeated at proper intervals, are accomplished with greater safety to the animal than would be possible by means of a single inoculation. The amount first injected should be small and then gradually increased in the succeeding treatments.

The inoculation always results in a more or less serious attack of Texas fever. Besides having a fever, there is great diminution of red blood corpuscles, and in about 3 per cent of the cases a fatal termination; but the proportion of deaths resulting from the inoculation is small when compared with the fatalities among untreated animals taken into infested districts. To this number should be added those animals (less than 7 per cent) that do not receive sufficient immunity by this method and which succumb when exposed to infested pastures. Combining these failures it will be seen that by this method of immunization, instead of a loss of 90 per cent among breeding stock taken South more than 90 per cent can be saved. The animals should be carefully nursed through the attack and their symptoms treated as indicated on page 29.

Immunizing inoculations are now being made by the veterinarians of most of the agricultural experiment stations of the Southern States without cost for the services rendered, a charge being made merely for the actual value of food consumed and attendants' wages. These veterinarians have also issued station bulletins which describe fully the necessary steps to be taken in securing the blood and injecting it into the animals to be immunized, so that the stock owner can follow the instructions with prospects of getting good results.

This operation is not a difficult one, and excellent results will follow where absolute cleanliness and ordinary care have been used, but undoubtedly the best results will be obtained by those who have thoroughly familiarized themselves with the nature of the disease and are experienced in extracting blood from animals. Two methods are in use and will be described separately. One consists in drawing the blood from the jugular vein of an immune animal and immediately injecting it into the cattle to be immunized. It is comparatively simple, requires few instruments, and can be satisfactorily carried out where a small number of animals are to be immunized and if a suitable immune animal is close at hand. First, select an immune animal which is in good health and which is infested with fever ticks or had them the preceding year. Fasten the animal securely, either by tying, throwing, or by placing in a chute. Clip the hair from a space about 4 inches in diameter over the jugular vein on the upper third of the neck, wash the skin thoroughly with a 5 per cent solution of carbolic acid, and then fasten a strap or rope around the neck below the hairless area and draw it tight in order that the blood in the vein will be stopped, causing distention. With a large hypodermic syringe needle previously sterilized in a 5 per cent carbolic-acid solution, puncture the vein at a slight angle, directing the point forward. When the needle enters the vein the point can be rotated freely in contrast to the restricted movements if still in the tissues, and the blood will either drop or flow from the opening in the needle. Attach the disinfected syringe to the needle with piston in and gradually draw out the piston until the chamber of the syringe is full of blood when the needle is withdrawn. The blood, before it has had time to clot, is immediately injected into the animals to be immunized and which have been previously tied or restrained, the hair clipped, and the skin disinfected at the seat of injection in the region of the shoulder. Inject then from 1 to 3 cubic centimeters, according to the age of the animal, under the skin of each animal until the blood is exhausted. When more animals are to be inoculated than one syringeful will inject, the operation may be repeated in the same manner. The only objection to this method is the possibility of the blood clotting in the syringe, but with practice and promptness this can be easily overcome.

The second method is better suited for the inoculation of a large number of cattle or where the immune animal is at a distance from the cattle to be immunized.

The preliminary steps—the clipping of the hair, disinfection of the skin, placing the rope around the neck to distend the jugular vein, and restraining the animal—are the same as for the first method. In puncturing the vein it is advisable to use a small trocar and canula after sterilization in a 5 per cent carbolic-acid solution, and, when the vein has been entered, to draw out the trocar, allowing the blood to flow through the canula into a perfectly clean and sterile vessel. After sufficient blood has been drawn for the animals to be injected, a clean stick, previously sterilized by boiling in water, is placed in the vessel containing the blood and the latter is stirred for ten minutes or so or until the fibrin in the blood is whipped out. The remaining blood, known as defibrinated blood, is then inoculated under the disinfected skin of the animals to be immunized, as in the first method. This blood should be used as early as possible after drawing, to prevent it from becoming contaminated and decomposed. The place where this injection is made is immaterial, but for convenience a point just behind the shoulder is usually chosen. The dose and number of injections vary with the individual animals. As a rule, it may be stated that 1 cubic centimeter should be injected into an old animal coming into the infested district, 2 cubic centimeters for a 2-year-old, and 3 centimeters for an animal 9 to 15 months old. It will be observed that, unlike the usual custom of applying treatment, the older animals take less than the young ones, owing to their greater susceptibility to the disease. Where an animal has reacted well to a first injection and shows a very high temperature, great reduction of red blood cells, or other symptoms indicative of reaction, it will not be necessary to repeat the injection, but in those cases where the reaction is slight, a second injection should follow after an interval of forty days, and, if need be, a third injection after a similar lapse of time, always increasing the size of dose 50 per cent. A thermometer, to indicate the course and severity of the disease, is indispensable in this work. Usually, after three to ten days, sometimes longer, the inoculated animals show a mild type of Texas fever, which runs a course of from six to eight days and is followed in about thirty days after the injection with a second attack of a milder character than the first. After forty days, when the animal has entirely recovered from the inoculation, a second injection may be given to increase its immunity. In some cases a very severe type of fever follows the first inoculation, requiring careful nursing and treatment, as suggested above. A second, milder attack follows usually in about thirty to forty days, after which the animal need have no further inoculations. It is advisable to prevent any ticks

from getting on the cattle until sixty days after their inoculation or until they have fully recovered, at which time a few ticks may be placed upon them in order to reenforce their immunity. Naturally this time varies according to the type of the attack. As the best results with these immunizing experiments have been obtained in cool weather and with young cattle, it is recommended that animals from 6 to 15 months old be selected for inoculation, and that they be immunized during the late fall or winter months, in order that they may enter tick-infested pastures in the spring without danger.

By infesting with ticks.—Immunity may also be induced in susceptible animals by placing a limited number of fever ticks upon their bodies in order to produce the disease naturally. For this purpose only animals less than 1 year of age should be used, as the method is not applicable for older and more susceptible animals. Upon the bodies of these young cattle from twenty-five to fifty seed ticks should be placed, which in the course of about ten days will occasion a rise of temperature and a mild form of Texas fever. When the animal has entirely recovered from this attack, a second crop—double the number first used—should be applied to the animal in order to increase its power of resistance when pastured on infested soil. In order to carry out this method successfully, a constant supply of seed ticks must be at hand. This can be accomplished by placing the mature females in a Mason fruit jar among some dirt and leaves and keeping them in a warm place. In a few weeks the eggs will have been laid and hatched, and a number of seed ticks will be present for use in infesting the cattle to be immunized. By placing a few adult females in the jar every two months there will always be a supply of these young ticks. This method of producing immunity by controlled tick infestation is not so safe as blood inoculation, since the quantity of germs injected can be more accurately regulated by means of a syringe.

FEDERAL SANITARY REGULATIONS.

The sanitary regulations which have been enacted by the Department of Agriculture for the control of cattle shipments from the infected districts have for their initial purpose the prevention of the transportation of cattle ticks from infected regions to those that are not infected, either upon cattle or in stock cars or other conveyer, during the season of the year when infection is possible. They are based upon the fact that Texas fever is carried north only by the cattle tick; and the exclusion of this parasite from the noninfected territory has in every instance been found a certain method of excluding Texas fever. The regulations governing the movement of cattle from below the quarantine line are made yearly by the Secretary of Agriculture and they define the boundary of infected dis-

tricts. The line as now determined starts in Virginia on the Atlantic coast and passes in a westerly direction through Virginia, North Carolina, Georgia, Tennessee, and a small portion of Kentucky, along the northern border of Arkansas and Indian Territory, thence through Oklahoma and Texas to the Rio Grande and the Mexican border, whence it passes along the southern boundary of New Mexico and Arizona and across the central portion of California to the Pacific slope (fig. 1). This year (1905) cattle may be moved from the quarantined district for purposes other than immediate slaughter during November, December, and January into the noninfected area within the States of Virginia, North Carolina, Georgia, Tennessee, Texas, Oklahoma, and California, and to the States of Missouri and Kansas and the Territories of Arizona and New Mexico, as may be provided for in the regulations of these States and Territories, and after inspection by and upon written permission of an inspector of the Bureau of Animal Industry or a duly authorized inspector of the State or Territory to which the cattle are destined, and after permission shall have been obtained from the proper officer of the said State or Territory. All cattle from the quarantined district destined to points outside of the States and Territories above named may be shipped without inspection between November 1 and January 31, inclusive (the open season), without restrictions other than may be enforced by local regulations at the point of destination. At the present time no cattle shall go out of quarantine, except for immediate slaughter, during that portion of the year included between the dates of February 1 and October 31, and known as the closed season. These cattle must be slaughtered within two weeks after arrival at their destination, and the regulations of the Secretary of Agriculture concerning their handling and movement shall be enforced. The following is an abstract of the regulations in force May 1, 1905:

Cattle coming from the infected districts during the closed season can not be driven, but must be conveyed in cars or boats placarded as containing "Southern cattle," and bills of lading, waybills, and conductors' manifests shall have this information written upon them. When the cattle are unloaded for feeding, watering, or other purpose they must be placed in pens reserved for such animals only, in which native stock is not allowed, and a large sign with the words "Quarantine pens" or "Quarantine yards" must be conspicuously placed on all such inclosures. On unloading at their destination, only the chutes, alleyways, and pens reserved for Southern cattle shall be used. Before the cars or boats which carried these animals are again used their entire interior must be thoroughly washed with water, after the removal of all litter and manure, and then disinfected with a mixture made of $1\frac{1}{2}$ pounds of lime and $\frac{1}{4}$ pound of 100 per cent carbolic acid to each gallon of water, or with a solution made

by dissolving 4 ounces of chloride of lime to each gallon of water. The litter and manure may be disinfected as above, or, if not disinfected, it shall be stored away where cattle can not reach it during the period from February 1 to October 31 of each year. All chutes, alleyways, and pens used en route and at destination but not reserved for the exclusive use of Southern cattle shall be similarly disinfected. Where these animals are yarded adjacent to cattle from above the line, at least a 10-foot space not occupied by cattle must be left between, on each side of which shall be a tight board fence not less than 5 feet high.

In consequence of the enforcement of these quarantine regulations Texas fever has been practically prevented in the noninfected districts during the last several years, and little or no hardship has been caused to those stockmen handling cattle from the infected areas. Previous to their adoption the tick-infested district was rapidly extending northward, but since the quarantine line was established and rational regulations enforced it has gradually been moved farther south. This problem of still further reducing the infected area is of the greatest importance to the cattlemen of the South—in fact, to those on both sides of the line—and one which is receiving special consideration by this Department as well as by many of the interested States.

OTHER IMPORTANT MEASURES FOR REDUCING THE INFECTED AREA.

The first and probably the most important step in eradicating the cattle tick is to start and continue a plan of educating the cattle owner as to the nature of Texas fever and the method of its transmission. This may be best accomplished through farmers' institutes, the issuance of press bulletins and circluars, the publication of short articles in agricultural journals, and, best of all, by personal intercourse between the agricultural population and educated stock inspectors who are capable of imparting the necessary information. There can be no doubt that the crying need of the infected country is not so much the development of new ideas for exterminating the cattle tick as it is to remove all doubts of stockmen regarding what they term the "tick theory," and to impress upon them the fundamental truths concerning the cattle tick, its relation to Texas fever, and simple methods for its extermination. In other words, the stockman himself must be made to realize the proved facts regarding this disease, and then to appreciate the feasibility of eradicating the ticks which cause it. There is still a large number of cattlemen who are incredulous regarding the nature of Texas fever and until the absolutely established facts of the disease are known and accepted it will be impossible to have intelligent cooperation and earnest endeavor

among those most vitally interested to eradicate the Texas-fever tick and prevent the disease. In some counties within the infected district bordering on the quarantine line the local authorities have organized cattle clubs composed of stockmen with the view of interesting them in exterminating the ticks from their premises, and in preventing cattle in adjoining tick-infested sections from coming upon their property. These organizations are the means of disseminating general information respecting Texas-fever infection and the cause of the restrictions placed on the cattle in the infected district, and through them a concerted action of the cattle owners is obtained, resulting in the control and final eradication of the infection within a portion or the whole of a county. When a county has been handled in this manner a thorough inspection is made at the proper time by a representative of the Bureau of Animal Industry, and if the conditions warrant such action it is released from quarantine. The success of such clubs in accomplishing both these purposes is a constant reminder of what other organized stockmen could do. The desirability of rational legislation based on an accurate knowledge and a complete understanding of the disease is self-evident. Every county in all the infected States should have stock or "no fence" laws to prevent stock owners from allowing ticky cattle on commons, uninclosed lands, or highways. Especially should these be enforced in the States on the quarantine line and in those having many noninfected areas in the quarantined region. In the former case this would assist in securing a position above the line, and in the latter it would tend to enlarge the tick-free sections. In a number of counties in Virginia, North Carolina, and Georgia, where the laws prohibit cattle from running at large and compel fencing of pastures, the cattle tick soon disappeared, and such tick-free counties were placed above the quarantine line without any loss having followed from the cattle in these districts. Butler suggests that each county should have laws providing for a farm-to-farm inspection, with employment of a stock inspector, in order to locate the tick-infested farms. Stockmen themselves should organize in order to aid the county in its endeavor to exterminate the ticks; and information concerning their habits, the importance of their extermination, and methods for accomplishing it should be furnished to owners of infected lands. With the active cooperation of the people and the enforcement of the stock laws, much territory may be freed of ticks at a very moderate annual expense. If ticks on one farm, one section, one county, can be exterminated, it certainly should be possible for the entire State or entire infested district to be cleaned.

In all the infected States a uniform legislation should be secured on the subject of communicable diseases, particularly Texas fever, by

which these States would be enabled not only to cooperate with the Federal Government, but also with each other. Such laws should prevent the entrance of ticky cattle into the State, unless for slaughter, compel the holding of cattle on inclosed premises, enforce an effectual quarantine on all badly infected areas, make it compulsory to clean up the infection where the ticks are few in number, and stipulate that the stock inspectors appointed for this work must be educated and experienced in the subject of Texas fever. Then, after securing these laws in the various States, they should be enforced, all violaters should be punished, and such punishments should be given widespread publicity. Such action is absolutely necessary before any decided progress can be made in the general extermination of the fever ticks and in the reduction of the infected areas.

For some years past the Bureau of Animal Industry has had a number of inspectors stationed along the quarantine line who have been required to disseminate information relative to the nature of Texas fever, to investigate reported violations of the quarantine regulations, to inspect cattle in those counties wishing to be placed above the line, to keep a careful watch over the uninfected pens at the railroad feeding stations in the infected district where tick-free cattle are rested, fed, and watered in passing through, and to examine for the presence of ticks all cattle that come out of the modified quarantined counties. These modified districts are those wherein the infection is confined to small areas and which are placed provisionally above the line subject to inspection of all cattle leaving that area for noninfected territory. No cattle are permitted to come into the district unless they come from above the quarantine line. In certain cases where a county has only a few infected farms, the Department has at times accepted the declaration made by the State officials to enforce an adequate quarantine on these premises and has allowed the entire county to be placed above the line. Such concessions as these indicate the interest taken in relieving the burden of quarantine, and while some unfortunate results have followed, the beneficial effects have far exceeded them.

The authority of the Federal veterinary inspectors is limited within the boundary of the States, and the progress they are able to make under these conditions is slow. In order to give these men greater influence within the State, it might be advisable to have the State law permit of their appointment as officers of the commonwealth to serve without compensation. Thus, in the eradication of foot-and-mouth disease from New England and of scabies from the West, some States, such as Massachusetts, Wyoming, and others, made State officers of the Government men, which resulted in a larger amount of work being performed and with greater expedition. The restrictions which are necessarily thrown around a Federal inspector when deal-

ing with a local question of interstate importance would by these means be relieved.

It would be advisable for the State or Federal Government, or both, to make sufficient yearly appropriations for the purpose of giving object lessons by means of demonstration farms, where approved methods for eradicating Texas-fever ticks could be carried out. Results of such practicable demonstrations would have a very wholesome effect upon other owners of stock in that section and would encourage the application of similar methods for a like purpose. It is generally admitted that extermination of ticks along the quarantine line is desirable, but the disinfection of pastures within the line is thought by some to be inadvisable. In fact, these writers recommend placing a few ticks on the cattle while young to render them immune when in these tick-free pastures. This plan of infecting clean pastures is a questionable proceeding, and if carried out by all below the line would result in producing thousands of ticks where now there are hundreds only. It must be remembered in this connection that the cow tick is not only the carrier of Texas fever, but is a parasite which deprives its host of much blood, retards growth, reduces the milking capacity, and induces an irritable state known as "tick worry." Even if we exclude its fever-carrying property, it should still be exterminated in all districts, whether on the quarantine line or below it, for the same reasons as lice and other vermin are destroyed. Furthermore, cattle may now be rendered immune by blood inoculations, and the necessity for having ticks on the animals for this purpose does not exist. It would therefore seem preferable to keep noninfected farms free from ticks, and, if they are in danger of exposure to these parasites, make the animals immune by blood injections. If these injections are made merely with the view of preventing fatalities among the uninfested cattle when exposed to newly purchased ticky animals, it would be far better to remove the ticks from the latter before allowing them to commingle. Others buying these susceptible cattle for their own infected pastures would also run the risk of their death from Texas fever unless previously immunized with blood or gradually infested with ticks. Notwithstanding the precautions which must be taken to avoid losses as a result of noninfected areas in the quarantined zone, it is held that, unless these pastures continue free of ticks and other pastures are added to them, there can be no solution of the Texas-fever problem.

It might be asked, What advantage is it to the stockman below the line to clean his cattle and pastures of ticks unless his animals are recognized as tick-free and permitted to come North without restriction? The greatly improved condition and better development in all respects of such cattle are sufficient answers to this query, and their

appearance furnishes a marked contrast to that of those which harbor these parasites. Furthermore, provision has been made for noninfected animals to come above the line at any season of the year, but, like the ticky cattle, they are subject to the restriction that they be dipped in Beaumont crude petroleum or other crude oil to prevent them from becoming infested in passing through the quarantined district. And they must also be shipped in clean, disinfected cars, and must not be driven through the infected area or unloaded therein except at points designated by this Department.

By the general application of the previously described measures for reducing the infected area, supported by well-directed legislation in all the infected districts, it would become merely a matter of a short period of time before the fever tick would be exterminated and Southern cattle permitted to reach the more favorable markets of the North at any time of the year without restraint. Prices would then be higher, the demand greater, and the odium attached to ticky cattle at the stock yards removed. Purebred Northern cattle could then be brought into the South to improve the native breed without danger of death from Texas fever, Southern animals could enter the show rings of the North without restriction, and the total cost of tick extermination would be far less than the amount saved in the first year after it had been accomplished. However, much cooperation must be had between the farmer and the State and Federal Governments before such a desirable result is possible. And in the meantime, with such conditions attainable, laxity should not be allowed in enforcing the present regulations, National, State, and local, and equal care should be taken to enlighten the stock raisers of the infected district as to the benefits which will follow their thorough understanding of Texas fever and their intelligent assistance in its eradication.

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