FOOT-ROT OF SHEEP:
ITS NATURE, CAUSE, AND TREATMENT.

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U. S. DEPARTMENT OF AGRICULTURE,
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Washington, D. C., September 27, 1904.

SIR: I have the honor to transmit herewith a paper entitled "Foot-rot of sheep: Its nature, cause, and treatment," by John R. Mohler, V. M. D., chief, and Henry J. Washburn, D. V. S., acting assistant chief, of the Pathological Division of this Bureau.

Owing to the magnitude of the sheep industry in this country and the serious character of the disease in question, it is of prime economic importance that our sheepmen should be in possession of full information concerning the nature, cause, and treatment of this malady. The authors have endeavored to present these matters in a clear and comprehensive manner by means of an analysis of the previous knowledge of the subject, supplemented by original investigations and experiments undertaken for this work.

Foot-rot of sheep, while not usually fatal in its results, is nevertheless a possible source of great danger and loss to sheep owners because of its highly contagious nature and the frequent violence of its outbreaks, whereby the animals become stunted, owing to the slow, protracted course of the disease; to all of which must be added the difficulty of completely eradicating the virus from the soil and premises.

In view of these considerations, I recommend the publication of the article as Bulletin No. 63 of the Bureau series.

Respectfully,

D. E. SALMON, Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.
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INTRODUCTION.

The sheep is the natural host of many species of internal animal parasites, and surrounding it externally are numerous carnivorous animals which merely await a convenient opportunity to fall upon and devour their helpless victim. Contagious and infectious diseases also play an active part in reducing the income from the sheep industry. They not only destroy many valuable members of the flock, but, more serious still, a greater number than the total of those which actually succumb to the disease will become weakened, debilitated, and unthrifty, and may remain during an entire season a source of worry, discouragement, and expense to those who had planned to derive benefit from them. In this way the loss sustained by the owner and feeder, while not tangible enough to be estimated accurately, is nevertheless very considerable. Among the destructive communicable diseases that always run a slow protracted course, and which at times kill off the sheep, may be mentioned helminthiasis (the affection due to parasitic worms), scabies, and foot-rot. These scourges are probably formidable to the American shepherd in the order named, and in that order destroy or lessen his receipts from an otherwise profitable industry.

Although foot-rot is not so widely scattered among the flocks of this country as are some other diseases, it is nevertheless well-known and greatly feared in many sheep-raising and sheep-feeding localities, and therefore it seems desirable to furnish those interested with information regarding the nature, cause, and treatment of this disease.

NAME AND SYNONYMS.

For many years writers on topics of economic importance to livestock owners have made mention of troublesome affections to which
the feet of sheep are liable, designating them collectively as foot-rot. Under this term all varieties of lameness, whatever the cause, were described. As a result much confusion followed and many controversies arose regarding the nature of the disease to which the name foot-rot was applied. Some writers argued that the disease was contagious, others claimed that it was not, while still others stated that foot-rot was merely a form of foot-and-mouth disease. Thus the term foot-rot became very ambiguous and it was necessary to be familiar with the views of the individual writer in order to know whether it was applied to the so-called benign form of foot-rot, to the contagious form of the disease, to wounds of the foot, to cutaneous abscesses, or to foot-and-mouth disease. It naturally followed that a writer describing the first-mentioned malady claimed that it was noncontagious, while another working with the second disease would assert its contagiousness. It is probable that the nomenclature is responsible for this unfortunate confusion, and therefore it is proposed to differentiate these diseases and to give an appropriate name to each affection, believing that there is as much difference between the so-called benign and the contagious forms of foot-rot as there is between mycotic stomatitis and foot-and-mouth disease. For this reason the so-called benign foot-rot, which results from simple mechanical irritation, will be called purulent inflammation of the foot, or "fouls," while the nomenclature of Moore, "suppurative cellulitis," is retained for the cutaneous abscesses involving the feet. For the contagious foot-rot is preserved the term "foot-rot," and by this name we refer to the chronic inflammation of the foot followed by ulceration, softening of the hoof, formation of a fetid, sticky discharge, occasioning lameness and due to the Bacillus necrophorus.

The true foot-rot, as last described, occurs in a contagious and enzootic form among sheep, attacking their feet and spreading from one member of the flock to another either by direct or indirect transmission. We likewise, for the reasons mentioned later on, see no cause for considering foot-rot a complication of foot-and-mouth disease, and these two diseases are recognized by us as individual specific affections, each produced by an infectious principle and in no way related one to the other.

English writers have usually adopted the term "contagious foot-rot" in their descriptions of this affection. Those who employ Latin names in their theses on medical matters refer to foot-rot as "paronychia ungularis ovium maligna," and to one conversant with this language the name proves helpfully descriptive. "Pietin contagieux" is the name by which the disease is designated by French authors. German pathologists seldom refer to the malady except in articles devoted to a discussion of its relation to contagious foot-and-mouth disease as seen in sheep. When they require a specific name for the
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disease, one wholly independent of foot-and-mouth disease, they employ the excellent term "bösartige Klaunenseuche der Schafe."

Under these names the troublesome affection has been universally recognized in veterinary literature, and, although it hardly seems to have attracted the attention which its destructive character deserves, the general descriptions of the lesions of the disease have been remarkably harmonious.

HISTORICAL REVIEW.

Foot-rot was first described by Chabert in the year 1791 as existing north of the Pyrenees on the banks of the Gironde and Lower Medoc. Later it spread to central France, and was described by Pictet in 1805 and by Gohier in 1808, both of whom declared it to be a communicable disease. It was likewise observed about this time in Piedmont, Italy, and spread into Germany about 1815 as a result of the introduction of French Merinos. Not only has it appeared in epizootic form in continental Europe, but it has also spread through Great Britain, Australia, and the United States, where it was not infrequently observed during the past century.

The date of its first appearance on American soil is unknown. The statement has frequently been made that the disease was brought to American shores by the colonists through importations of Spanish Merinos, and this statement seems to have been accepted by many writers without question or discussion. The first importation of Spanish Merinos for breeding purposes is reported to have been made in the year 1808, but the disease had become well established in this country prior to that time. Another reason for considering sheep from Spain very improbable as originators of the disease upon American soil is the fact that the sheep of Spain have been remarkably free from foot-rot. It is even asserted that it has never been seen on the dry table-lands which constitute the pastures of the entire region south of the Pyrenees. Spanish Merinos may have introduced the disease here, but it is very probable that they were first shipped from Spain to some other country, and thence, after a longer or shorter stay in their new home, reshipped, together with an infection of foot-rot, to America. It has been historically stated that the first settlers who attempted to establish flocks of sheep upon the prairie farms of Ohio, Indiana, and Illinois met with most disheartening experiences, which were in some measure due to the spread of foot-rot. In the year 1797 an agricultural settlement was made in Illinois by farmers from the Eastern colonies, who brought with them flocks and herds of the sheep and cattle common to the section of country whence they came. During the decade following many new homes were established in the prairie regions, and a number of the new settlers brought with them foundation stock with the intention of growing large flocks of sheep,
but wolves and panthers proved to be very destructive, and liver disease and foot-root also hindered the establishment of large bands, until finally the pioneers were forced to be content with small flocks that could be constantly housed, guarded, and given careful attention.

The farmers of Maryland and Virginia were taking an increasing interest at this time in improved sheep. They had many discouraging conditions to contend with, and, although it is possible that foot-rot was not known among their flocks at this time, it is certain that much trouble was caused by the appearance of "diseases, dogs, and wolves," and that contagious foot-rot made itself known and feared as early as 1832 in these States.

Owing to the imperfect knowledge at that time of matters pertaining to bacterial diseases, the sheep owners struggled against the spread of foot-rot in their flocks somewhat unsuccessfully, and it often required constant watchfulness and persistent treatment for three or four years to eradicate the disease after it had become thoroughly established upon the premises of the sheep grower.

Later than this, in the late "fifties" and early "sixties," there was a marked revival of interest in sheep raising throughout the Middle West, and at this time many who had previously devoted their energies exclusively to grain or to cattle and hogs concluded to change over to sheep, and the resulting traffic in these animals caused them to be moved about over the country roads and into new sections of the agricultural regions in numbers never before equaled. In several instances these traveling flocks carried foot-rot with them and infected the flocks with which they came in contact along their routes. The States of Ohio, Michigan (southern), Illinois, and Iowa were most seriously infected, and in all of them the disease secured such firm foothold that several years of strenuous combat were necessary before it was even partially subdued. It was during this period that a sheep raiser of long practical experience, in writing from his home State (Ohio) made the statement that farmers in his part of the country had in times past been seriously troubled by the appearance of stubborn outbreaks of foot-rot among their flocks of sheep. In no case, however, had he been able to discover the spontaneous appearance of the disease, but with a little persistent inquiry it had been an easy task to trace the origin of each outbreak to the careless handling of diseased sheep brought from other localities. Since that time the disease has appeared frequently, but its spread has never assumed such alarming proportions, and, owing to a better understanding of the disease, it has been more successfully controlled.

The change from former methods of transportation has much to do with the prevention of such widely spread outbreaks as the one just recorded. Instead of driving large flocks on foot over many miles of highway, they are now conveyed by rail in such a manner that the
possibility of transmitting the contagion to healthy flocks along the route is avoided, except at the railway stock yards, where unloading is necessary. At the more important of these stock yards Federal inspectors are stationed, who are very careful to prevent, so far as possible, the infection of healthy flocks while in transit. The disease is by no means eradicated from the United States, however, and it occurs at irregular intervals in certain localities with as great virulence as it has ever shown, and it is only because of a more complete knowledge of its characteristics that its spread is prevented from becoming more general.

SYMPTOMS AND LESIONS.

The first evidence of an attack of foot-rot to attract the attention of the shepherd is a slight lameness, which rapidly becomes more marked. Previous to this, however, there has appeared a moist area just above the horny part of the cleft of the foot, and this has gradually reddened and assumed a feverish, inflamed appearance. It may first become visible either at the front or back part of the cleft, but usually the erosions make their first appearance at the heel. The inflammation rapidly penetrates beneath the horny tissue, while from the ulcerous opening there exudes a thin, purulent fluid. The lameness has increased and the region of the foot above the hoof is becoming swollen and warm to the touch. The exudate from the erosions contains pus cells, bits of destroyed tissues of the foot, and bacteria. It possesses an odor, pungent and disagreeable, but at the same time very characteristic. The experienced sheep man is frequently able to detect the presence of the disease among a flock of sheep, even though it be while making a casual visit to a strange flock, simply by means of the diagnostic and unmistakable odor which arises from the affected feet. This odor is so pathognomonic of the disease that it would reveal the presence of affected sheep to one familiar with the character of the infection, even before noticing the animals.

The erosion progresses, if no treatment is applied, and there is rapid formation of fistulous passages beneath the horny covering of the foot, while the softer tissues of the interdigital space are gradually becoming degenerated and purulent. The invading microorganisms possess marked burrowing propensities, and the result of their invasion is that large areas of the hoof become loosened from the sensitive tissues lying beneath.

Should the loosened horny tissue be cut away it will be seen that the undermining process has been advanced by the microorganisms until numerous ulcerative channels have been formed which are filled with grayish purulent matter and that the encroachment upon the healthy areas is persistently and constantly being extended. Should but one
of the claws of the foot be primarily affected, the disease may readily spread to the other by means of passages or channels eroded beneath the skin of the interdigital space.

The invasion of the necrotic process may continue until ligaments, tendons, and even the bones are attacked; but before this final stage is reached nature will attempt to repair the damage, and for this purpose the secretion of formative elements in the injured part is greatly increased, until there appears a peculiar growth composed of horny elements, dense epithelial cells, and granulation tissue. These unsuccessful attempts at renewed development of tissue are termed “fungoid growths,” and they have been known to materially hasten the shedding of the horny covering of the foot by their persistent enlargement within the ulcerous channels cut by the advancing infective elements.

The hoof of a sheep suffering from a chronic case of foot-rot grows out rapidly and becomes very hard. It will often be found with the toes so thickened and lengthened that the front part of the foot is raised above its natural incline and the tendons at the heel are subjected to additional strain, all of which tends to increase the lameness and the awkwardness in gait of the victim. These thickened and elongated toes will frequently be seen to have attained an added length of 3 or even 4 inches, and they curl up like sled runners, greatly interfering with the progression of the animal. (See Fig. 1.)
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The sheep finds the act of walking so painful when the disease has become thoroughly established that it remains quietly lying in some secluded corner or, if diseased in the fore feet only, crawls around on its knees in its efforts to keep with the remainder of the flock or to get within reach of its food. Its temperature rises until there is evidence of considerable fever. The appetite is seriously impaired and the patient rapidly loses condition and weight.

During warm weather there is great danger of an attack by maggots as soon as the lesions are discharging freely, and unless these are quickly removed they will appear in such numbers as rapidly to bring the course of the disease to a fatal ending. They not only invade the affected feet, but will also locate at any point of the body at which the wool has become sufficiently contaminated by the purulent discharge from the ulcerous tracts to afford them a suitable moistened feeding place. The wool on the sides of the body is frequently more or less soiled from contact with the diseased feet while the animal is lying down, and it is in such areas that the fly deposits the eggs that hatch into destructive larvae. As soon as the maggots are hatched they begin to burrow into the tissues upon which they are located and they quickly perforate the skin of their host, thus causing complications which bring its suffering to a close.

It having been found that the bacillus of necrosis is the cause of foot-rot in reindeer as well as in sheep, the following description by Horne of the disease in the reindeer of Scandinavia is here given, that the reader may note the great similarity of the course of the disease, as well as the macroscopic lesions produced by this microorganism in the feet of these two species of animals:

One's attention is called to the disease by the fact that the reindeer becomes lame, walks with difficulty, and remains in the rear of the herd. As the disease progresses the affected reindeer becomes unable to follow the rest of the animals in their wanderings and lies down; now the disease advances rapidly and the animal is not able to seek nourishment. It soon becomes emaciated and dies, or falls a prey to wolves or other wild creatures. The disease is located between the claws of the hoof, or at the lowest joint of the limb. The foot swells greatly, so that it resembles a club, and hence the name "club disease." The diseased foot is very tender, preventing the animal from walking upon it. After a while the hide cracks and there appears in the sore a peculiar discharge. The pathological picture of the inflammatory process itself and the transformation of the web into a dry, yellowish green necrotic mass, lead to the opinion that it must have been a process similar to hoof carbuncle and to the other diseases brought about by the necrosis bacillus.

COURSE AND SUSCEPTIBILITY.

The course of this disease is slow and protracted, usually starting with one foot and subsequently involving one or more of the others. During this interval it would probably have likewise spread to the feet of other sheep, and in this way the disease may remain for several months
in each member of the flock and for eight or ten months in the flock itself. When the ulcerous processes have become advanced and aggravated, fever develops, the appetite is lost, and the animal grows so emaciated that death intervenes. In some cases that are left untreated recovery may follow slowly, but there is usually either a dense fungoid growth between the claws, a stiffening of the joints of the ankle, or a long fissured and misshapen hoof. When treatment is properly applied in the early stages of the disease, it is usually cured within ten days. It is very rare for death to occur as a result of foot-rot, although in very virulent outbreaks involving 3 or 4 feet of each sheep the affection may terminate fatally within two or three months.

The course of the disease is also dependent upon the susceptibility of the affected animal. Thus, it is a well-accepted fact that the pure breeds of fine-wooled sheep are especially susceptible to foot-rot, although the pure breeds of coarse-wooled sheep and the grades of both of these breeds of animals are by no means exempt. In the latter animals, however, the disease runs a milder course, and is more amenable to treatment than in the case of the fine-wooled sheep. Sex or age does not appear to have any important influence on the susceptibility of the animals, as the disease manifests itself quite generally in the flock, attacking lambs, yearlings, and aged sheep alike, without regard to their being male or female.

**CONTAGION.**

Some of the early writers seem to have been convinced that this disease was in no degree contagious, but at a later period many investigators opposed this opinion and strongly maintained that it spread from sheep to sheep by means of some contaminating agent which exuded from the erosions upon the affected feet.

In opposition to these statements many veterinary writers were positive in their declarations that the disease was never caused otherwise than by pasturing on low, swampy lands, or as a result of overgrown toes, or by other conditions due to faulty care and surroundings. This view is concisely presented in the following statement by a writer of prominence:

By nature not unlike the goat it (the sheep) frequents the summits of the lofty mountains, where its hoofs, altogether analogous to those of the horse, are exposed to much wear and tear. When from these alpine regions we transfer the sheep into our grassy lawns, our moorish lands, or sandy soils, this wearing away of the crust is put an end to; it grows too long and proves a great incumbrance. In this state it is necessarily exposed to many injuries, among others from the long grass of the pastures, and itself necessarily injures the soft parts beneath; and hence lameness, inflammation, suppuration, to the extent of casting the hoof, are the consequences. The circumstance of the disease occurring epidemically arises from the whole flock being placed in precisely similar circumstances.

The above paragraph has been widely quoted and seems to have formed the basis of a long list of arguments in favor of the noncon-
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Tagiousness of foot-rot. But while the majority of writers seem to have denied that the disease possessed any contagious properties, there remained a very lively minority who entered a most vigorous protest against this view of its character, and who cited instance after instance in support of their claim that it was strictly of a contagious nature. They mentioned cases in which affected sheep had been brought from a distance and placed in flocks that had been sound and healthy for years, with the result that a portion of the flock soon became affected; also a case in which healthy and diseased flocks pastured in adjoining fields without any transmission of the trouble until a time when two or three of the sound animals jumped the dividing fence and grazed for the remainder of the day with the contaminated flock, with the result that they promptly contracted foot-rot. These writers recorded the infection of sound flocks as the result of their having been driven over roads which diseased sheep had traversed but a short time previously. Reports were made of test lots of sheep that were pastured for months on swampy and muddy lands without spontaneous development of foot-rot, which promptly became affected, however, on their removal from these pastures when inoculated on the skin between the claws of their feet with discharge from an affected foot. They mentioned several attempts at experimental inoculation with bits of diseased tissue, or with some of the moist excretions from an affected foot, which usually favored the investigator with successful terminations.

One of the best of these experiments was reported by Favré in 1823. He simply moistened the skin between the claws of 32 healthy sheep with matter obtained from diseased feet, with the result that 21 of them contracted the disease in consequence of this slight exposure.

Another convincing argument in favor of the dependence of foot-rot on a specific cause is found in the fact that young lambs yeaned by affected ewes have been known to show unmistakable symptoms of the disease as early as the sixth day after birth, and, as this has occurred in flocks that have been closely stabled, there remains no possibility that the lameness of these lambs could have originated in swampy or muddy pastures.

Additional evidence of the contagious nature of the disease, as well as an example of one of the ways in which the infection may be placed where it will do great harm to innocent parties, will be found in the following account of an outbreak in one of the small country towns of Vermont several years ago. A carload of thin sheep were shipped out from Boston to be fattened on one of the stock farms of that vicinity, with the intention of reshipping to the Boston market when finished. They arrived at their new home in the fall of the year, a season in which there is always great activity among stock owners in preparation for the winter. Many of them were infected with foot-
rot at the time of their purchase, but, in spite of this fact, they were unloaded with the rest of the flock, and all were driven over several miles of country highway from the station to their owner's farm. The result of this journey was that four other bunches of sheep that soon traversed the same route or portions of it became affected with foot-rot in its most virulent form. The owners tried every form of treatment that they could hear of, but only with unsatisfactory results, and the disease was not wholly eradicated from the affected district until the fourth year after its introduction.

Writers of recent years, both in Great Britain and France, have become more and more willing to declare that the disease owes its origin and perpetuation to a specific cause. Many German writers still have the disease inextricably confused with foot-and-mouth disease, and for this reason their literature does not offer the assistance to a student of the ailments of the sheep that one would naturally expect to gain.

Innumerable instances have been recorded in American agricultural periodicals which indicate very clearly that foot-rot of sheep is an affection which is in no respect related to foot-and-mouth disease, and they also show that the disease possesses some contagious principle whereby it may be readily carried from flock to flock or from a diseased to a healthy animal on the same premises.

Among the first experiments made by this Bureau, preparatory to the publication of this article, were some for the purpose of investigating the contagious nature of the disease. It may be of interest to mention in this connection that the material with which our experiments were made was derived from five individual outbreaks of foot-rot in different States and in no way connected one with another. The first case investigated came from a flock of Merino sheep in Ohio. The material obtained to confirm these first results was secured at the Buffalo stock yards from the feet of three affected Shropshire sheep that were shipped from Michigan. The third outbreak was observed at Deerpark, Md., in Rambouillet Merinos, which had been imported into this country only five weeks before. The fourth outbreak investigated was in a flock of sheep near Martinsburg, W. Va., from which a grade Shropshire was received at this office, while the last material obtained consisted of two badly affected Merino sheep from New York State. By means of careful tests performed with the purulent exudate from the feet lesions of these animals it was proved that foot-rot could be produced at will in healthy sheep, not only by spreading a little purulent matter from a diseased foot upon the shaven interdigital skin of sound feet, but quite as readily when bouillon cultures inoculated with some of the discharge from an affected foot were applied in a like manner, even when the cultures used were of the third generation of the original growth.
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It appeared from these experiments that the disease was dependent upon a specific organism for its existence, and that this organism could be readily perpetuated by the employment of the usual methods of bacteriological culture.

BACTERIOLOGY.\(^a\)

All early attempts to recover an organism from an affected foot that would produce the disease when applied to the foot of a healthy sheep proved failures. It was only by the inoculation of rabbits or mice and the application of anaerobic conditions that the slender, straight or wavy rods, constantly present in the affected feet, could be isolated in purity. A mixed culture obtained by inoculating ordinary nutrient bouillon with pus from a diseased foot was found to retain its virulent principle for at least a month and a half and to the third generation. This culture would produce the disease in the foot of a healthy sheep, the lesion appearing in from three to nine days after its application to the shaven skin in the cleft of the foot. First a moist condition of the surface of the skin was noticed, followed by various inflamed spots.

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**DESCRIPTION OF PLATE 1.**

**Fig. 1.**—*Bacillus necrophorus* from a 10-day-old bouillon culture stained with Loeffler's methylene blue.

**Fig. 2.**—Ten-day-old bouillon-agar growth of this bacillus stained with Loeffler's methylene blue.

**Fig. 3.**—Cover-glass preparation showing the bacillus of necrosis obtained from the purulent exudate from the foot of sheep No. 108 after artificial inoculation with pus from a case of foot rot.

**Fig. 4.**—Forty-eight-hour-old bouillon culture showing short forms of *Bacillus necrophorus* obtained by inoculating this medium with the material represented in figure 3.

**Fig. 5.**—Cover-glass preparation made from the pus of a foot affected with a long-standing spontaneous case of foot-rot and showing the presence of various microorganisms, including *Bacillus necrophorus*.

**Fig. 6.**—Cover-glass preparation made from the purulent discharge from foot of sheep No. 88, seven days after the application of a pure culture of the necrosis bacillus that had been obtained from a case of foot-rot.

These six camera-lucida drawings were made at the base of the stand with Zeiss No. 4 compensating ocular and 2 mm. oil immersion objective.

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**DESCRIPTION OF PLATE 2.**

**Fig. 1.**—Cover-glass preparation made from gelatin-agar colony obtained from the liver of a rabbit, which was the third in a series inoculated from the foot of an infected sheep. Stained with Loeffler's alkaline methylene blue. Camera-lucida drawing made with Zeiss No. 6 compensating ocular and 2 mm. oil immersion objective.

**Fig. 2.**—Liver of rabbit which died twelve days after the subcutaneous inoculation of *Bacillus necrophorus*. Stained with Loeffler's alkaline methylene blue. Camera-

\(^a\) A more detailed description of the *Bacillus necrophorus* will be given in a forthcoming publication on necrotic stomatitis (calf diphtheria).
lucida drawing made with Zeiss 4 mm. objective and No. 6 compensating ocular. Notice the invasion of the normal liver structure by the necrosis bacilli arranged along the border of the necrotic focus.

Description of Plate 3.

Fig. 1.—Bouillon-agar culture (first dilution) of Bacillus necrophorus, showing 24-hour growth, with numerous small gas bubbles, but the colonies have not developed sufficiently to become visible.

Fig. 2.—Seven-day-old bouillon-agar culture of this organism of the fourth dilution. The isolated colonies are characteristic in that their grayish centers are surrounded by fuzzy white areas, not unlike the strands of loose, fleecy cotton.

Fig. 3.—Single colonies of the necrosis bacillus, showing this filamentous character of their growth (enlarged about seven diameters).

which rapidly spread and coalesced. Within twenty-four hours of the appearance of the reddened spots, the characteristic burrowing propensities of the disease were in full evidence, and the hoofs were soon undermined.

Microscopical examination of the purulent material discharged from the open sore of a case of foot-rot revealed the constant presence of various microorganisms (Pl. 1, fig. 5), and similar examination of the mixed bouillon culture that had proved virulent when applied to healthy sheep showed that some of these bacteria were still present in the latter material. Various micrococci, or round forms, were present in both samples. Plump bacilli with rounded or blunt ends were also frequently observed, and either these or the cocci would readily grow under common methods of bacteriological culture, when isolated in pure culture, but neither of them would show lasting harmful effects when placed upon the foot of a healthy sheep. That such a condition of mixed infection should occur must appear perfectly natural when it is considered that the affected foot is exposed to the manure and filth of the stable and to the mud and dirt of the pasture; and it is this constant presence of extraneous, saprophytic microorganisms that is a factor in making the isolation of the causative agent more difficult. However, there appeared in each sample placed under the microscope long, straight or wavy baccilli which were found to compose fully one-half of the number of organisms and which it was impossible to separate from the other forms by any of our methods of plating (Pl. 1). These baccilli were not of sufficient similarity, however, to lead one to suspect that they were related organisms; those found in smears taken directly from the affected foot appearing as long lines or threads, while those discovered in the mixed bouillon culture were shorter, more slender, and never united in long filaments, usually appearing singly or less frequently in pairs (Pl. 1, fig. 4). Later observations, however, showed these to be but differing forms of the same organism, the differences being due to the conditions surrounding their growth. It was found by repeated tests that the shorter separate forms present in the mixed bouillon cultures would produce the long filamentous forms when inoculated upon sheep or rabbits, and, conversely, the results
Bacillus necrophorus from foot-rot of sheep.

Haines, del

BREWER & KESSLER CO., PHILAD.
FIG. 1.—Bacillus of necrosis.

FIG. 2.—Necrotic area in liver of rabbit.
Development of colonies of Bacillus necrophorus.
obtained by growing these long filaments in mixed culture in ordinary bouillon, or in pure culture in rabbit bouillon, gave a reappearance of the shorter single forms so uniformly present in all previous examinations of the baccillus when derived from like environment.

The isolation of this bacillus from the other forms of bacteria present offered many difficulties, and if it were not for the peculiar susceptibility of the rabbit to this organism it would be a task closely bordering on the impossible, as viewed in the light of present laboratory methods.

Having become convinced that foot-rot could be readily transmitted from diseased to healthy sheep by the use of mixed cultures, as well as by pus obtained from the diseased surface and applied to the interdigital space of the sound foot, it became desirable to obtain directly from the sheep a culture of the organism which is immediately responsible for the spread of the inflammation into the tissues of the healthy animal. To accomplish this end recourse was had to the following plan: A healthy foot of a fresh sheep was carefully washed, then sterilized by the application of 5 per cent carbolic acid, later washed with sterilized water, immediately inoculated from the foot of a diseased sheep which was occupying a box stall near by, and then wrapped up in rolls of sterile cotton, over which a close linen wrapper was loosely bound. In this manner much of the contamination from contact with the stable floor was avoided, and the organisms which under these coverings could multiply and cause ulcerous inflammation must closely represent the universal agent to which the spread of foot-rot is due. Plate 1, fig. 3, represents the appearance of smears taken during the initial stages of the inflammatory process from a foot thus treated.

Having under these precautions obtained material for further inoculations, one should now rely upon the rabbit or white mouse for the complete isolation of the causative bacillus.

The subcutaneous inoculation of a rabbit with a small amount of the watery excreted matter from a diseased sheep’s foot will result in the death of the rabbit in four to seven days. A second or perhaps a third rabbit must now be used before one may hope to obtain a pure culture of this bacillus. The first rabbit will, however, in spite of the contaminating microorganisms present in the material used in its inoculation, show very characteristic lesions which can be referred to the action of no organism other than the bacillus of necrosis. The chief of these typical changes will be noted at the point of inoculation, where, on the removal of the skin, will be found an irregular area, about 1½ to 2 inches in diameter, lying immediately beneath the skin and extending down for a greater or lesser depth into the muscular tissues. This area presents to the naked eye much the appearance of a flattened mass of soft, fresh putty, and to the nose a penetrating odor as of gaseous decomposing flesh.
This pulpy, yellowish white, malodorous mass is the detritus of muscular, fatty, membranous, and vascular tissues which have been attacked and destroyed through the presence and by the effective poisons of the bacillus of necrosis. Extending out into the surrounding tissues for about half an inch in all directions will be found a zone of inflammatory tissue, and the subcutaneous tissues of the abdominal region will appear inflamed and edematous through the gravitation of inflammatory agents from the local lesion caused by inoculation. Examination of the soft mass found in the necrosed area at the point of inoculation, shows that it is penetrated in every direction by long, thread-like bacilli, and a small scraping of this material used for the subcutaneous inoculation of a second rabbit serves to eliminate a large proportion of the contaminating microorganisms. Because of the greater purity of the material now used, the inoculation will not result fatally until a period varying from eight to fourteen days, and in many instances it will be found that this length of time has proved sufficient to allow the circulation to take up a few of the bacilli of necrosis and deposit them in the plexuses of lungs, liver, or kidneys, where small yellowish-white spots of necrosis will result, and from these spots the bacillus of necrosis may be obtained in pure culture.

The Bacillus necrophorus advances in its destructive invasion of the healthy tissues which surround focal points with all of the precision of an advancing army. Plate 2, fig. 2, illustrates the invasion of a healthy section of liver from a necrotic focus, and at the same time indicates that the best place to obtain pure cultures of the microorganism is at the line where the area of absolute necrosis is surrounded by a zone of invasive inflammation.

From rabbits that have developed secondary lesions of necrosis in the visceral organs pure cultures of the necrophorus bacillus may now be gained, and their further development may be secured by the utilization of anaerobic methods of culture.

This bacillus, although of nearly uniform thickness, 0.75 to 1μ, may grow to a variety of lengths, and has a tendency under certain conditions toward the formation of long, slender, slightly wavy threads. It is this character of varying from small coccoid rods to long filaments which may reach a length of 100μ that denotes its pleomorphism.

The bacillus being an anaerobe, develops an active growth in the absence of oxygen. A culture medium composed of 1 part of blood serum, 1 part gelatin (10 per cent), and 2 parts agar (1.75 per cent) will support ready growth of the bacillus along the line of the stab below the surface of the mixture. Equally good results in obtaining cultures may be reached by the use of stiffened fluid media as will be derived from relying altogether upon firm, solid material. One of the best, because simplest, preparations will be found to consist of
ordinary bouillon to which sufficient melted agar has been added to afford the mixture, when cooled, the consistency of soft jelly.

Tubes supplied with Martin's bouillon or neutralized rabbit bouillon and inoculated with this organism produce good growths, especially at the bottom of the tubes, when placed in a hydrogen jar.

Gelatin agar is still another satisfactory medium, and develops thrifty colonies.

It has been found necessary to rely upon dilution by transfer from tube to tube through a series of three or four tubes for the obtaining of separate colonies of the bacillus, as our attempts at plating this organism have not been satisfactory. It has been noted that the reduction of the numbers of colonies in tubes of a certain size will always be accompanied by an increase in the dimension of each colony. Plate 3, fig. 1, shows a 24-hour growth of the bacillus in stiffened fluid media (bouillon agar). Numerous small gas bubbles will be noted, but the colonies have not yet developed sufficiently to become visible. These will appear after forty-eight to seventy-two hours' growth as small, yellowish-white specks, around which will later develop a fuzzy, white area, not unlike a covering of loose, fleecy cotton. These characteristic colonies are better shown in the diluted culture (Pl. 3, fig. 2), seven days old.

The organism not only produces gas during the period of its growth in artificial culture media, but the same characteristic is also noticeable in the flesh of rabbits that have succumbed to inoculation. If the carcass of the rabbit is left undisturbed on ice for eight or ten hours after death, there will then be areas present surrounding the seat of inoculation, in which the muscles appear darkened, and the interfibrillar spaces, together with the intermuscular and subcutaneous spaces, will contain small bubbles of gas, and show edematous infiltration.

Development occurs between 30° and 40° C., the temperature most acceptable to the organism being 35° C. It does not stain by Gram's method, but takes the ordinary aniline dyes, often presenting, especially the longer forms, a characteristic beaded appearance (Pl. 1, figs. 1 and 2).

PATHOGENESIS.

INOCULATION OF SHEEP.\(^a\)

The readiness with which the disease will spread from sheep to sheep when the flock is kept under suitable conditions for such spreading has been recognized for many years by sheep owners. In addition to

\(^a\)We are indebted to Dr. E. C. Schroeder, superintendent of Experiment Station, Bureau of Animal Industry, for the inoculation of many of the sheep in this experiment and for the clinical notes concerning them.
the practical demonstration of its contagious character, which has been given in past years in nearly every sheep-growing State in the Union, numerous experiments have been made by interested investigators in different countries for the purpose of determining the cause of the transmission of the disease from one sheep to another. These experiments have been so comprehensive (see the writings of Brown\(^a\) and Law\(^b\)) that the preliminary tests one must make in an investigation of the character here recorded are necessarily repetitions of work that has previously been done by others. In spite of this fact several of the experiments commonly made by students of foot-rot have been repeated during this investigation, and the record of some of the successful inoculations with material from diseased feet will be given here merely as a substantiation of the claim that the disease is strictly contagious.

Direct, by pus from affected foot.—Two sheep, Nos. 40 and 63, were inoculated on the scarified interdigital skin with some of the exuded matter from an infected foot, and developed the disease in typical form in seven days in each case.\(^b\)

Sheep No. 313 was inoculated with discharge from an infected foot on the shaven surface of the cleft of its foot. This was followed by the appearance of a characteristic inflammation on the ninth day, and the inflammation gradually developed into the usual course of ulceration seen in this disease.

Sheep No. 108 was inoculated upon the shaven surface of the skin of the foot with discharge from a diseased foot, following which a protective application of moist sterile cotton and a linen bandage was applied. A characteristic case of foot-rot developed on the fourth day as a result. It seems probable that the early appearance of the disease in this instance was brought about by the partial exclusion of air and by the retention of more or less moisture upon the treated surface, through the agency of the cotton and bandage.

Lamb No. 94 is of special interest, having been born in an infected stall in December, 1901, and having continued until March 10, 1902, in daily contact with diseased sheep without showing the slightest evidence of lameness. During this period of exposure the stall in which the animals were confined was kept dry and clean. Had mud and moisture been present for the animals to walk about in, in common, the result would doubtless have been different. This test was continued for seventy-nine days, at the end of which time it was seen that the healthy lamb had received no degree of infection, although the disease had slowly continued to advance in the feet of its diseased companions until the affected members had become deeply eroded. Follow-

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\(^a\)The figure references are to bibliography at end of bulletin.

\(^b\)In many cases where foot-rot was produced by inoculation antiseptic treatment was applied and a cure effected as soon as the disease had become characteristic.
ing this preliminary test, the lamb was directly inoculated on March 10 by the application of material taken from a diseased foot to both of its feet on the right side. The interdigital spaces of both feet were scraped until the surface became blood tinged, when the watery exudate from the diseased foot of sheep No. 62 was smeared over the scraped surfaces. There appeared on both of these feet in fifteen days characteristic lesions of foot-rot, while the left hind foot also developed this disease from natural infection, although the lamb had previously withstood the danger incident to living in daily contact with diseased sheep. It may be stated in this connection that other negative results were also met with by exposing healthy to diseased sheep, but although seven such experiments did not produce the disease these can in no way offset the positive results obtained, considering that the exposure pens were always clean and dry and unlike the natural conditions under which sheep are usually kept.

Indirect, by cultures.—A review of experiments made with pure cultures of the bacillus of necrosis will serve to show the part which this organism is capable of taking in the development of foot-rot in sheep.

A pure culture of the bacillus was obtained from the liver of a rabbit, which was the third in a series inoculated from the foot of an infected sheep. This pure culture was then applied to the scraped surface of a healthy foot of sheep No. 87. The surface upon which the culture was placed began to show inflammation on the tenth day, appearing reddened and moistened, and exhibiting the presence of considerable heat. For ten days more the irritation appeared to progress, until at the end of that time a painful ulcer, coated with a grayish-white exudate, had formed. Spontaneous healing commenced at this period, but its progress was slow, and microscopic examination of the watery exudation from the ulcerous opening taken nearly two months later showed that many of the long filamentous forms of the necrophorus bacillus were still present in it.

Another healthy sheep, No. 88, was inoculated upon the scraped surface of its foot with the same material as that used in the preceding case. The response was much more prompt (four days) in this case, and the ulceration penetrated the tissues of the foot for about the same depth, while the final healing, which occurred by scab formation, required about the same length of time for its establishment.

A third sheep, No. 89, to which the bacillus was applied in a pure state, showed inflammation of the foot in a few days and by the eighth day was sore and lame as a result. The erosion penetrated beneath the skin of the heels, constantly excreting foul-smelling yellowish pus. Spontaneous healing began to make its appearance in about three weeks after the inoculation, and rapidly progressed to the complete restoration of the foot.
A fourth test of a similar nature gave much the same results, except for a slight loosening of the hoof from a portion of one of the toes.

From the very nature of the conditions surrounding a flock of sheep it must be known that a natural infection by the necrophorus bacillus in a pure state is an utter impossibility. There must of necessity be material contamination by various cocci and other bacteria from the floor of the sheep pens, or from muddy yards and runs. Many of these invading forms in all probability offer great assistance to the necrophorus bacillus in penetrating normal tissue and in perpetuating and extending the disease.

The character and appearance of the material discharged from a foot inoculated artificially with a pure culture of the necrophorus bacillus indicate that there is a slight difference between the disease when produced in this manner and the natural type. The same redness of the surface is noted and the same tendency to send deepening processes of ulceration and degeneration into the depths of the foot may be seen in both, but the discharge will be seen to consist largely of soft yellowish pus in those cases in which the foot has been inoculated with pure culture and the foot afterwards kept dry and clean, while in the natural infection under ordinary barnyard conditions and in cases produced artifically by the application of mixed bouillon cultures the exudate has more of a yellowish gray watery appearance mixed with pus.

There is no noticeable difference in the odor of the affected feet whether the lesions are produced naturally or artificially, and the same disagreeable stench pervades all cultures made from them, especially after these cultures have grown for forty-eight hours or longer in the incubator; and it is a remarkable fact that the same odor may be detected lingering about the carcass of a rabbit which has succumbed to an inoculation with necrosis bacilli in all cases, whether the bacteria were derived from cases of foot-rot in sheep or from some other source.

The following experiments were made with tissue containing an abundance of necrosis bacilli and with mixed bouillon cultures made from the pus of affected feet.

Sheep No. 83 was inoculated under the skin of the heel with material taken from the center of a necrotic lesion in a rabbit that died as a result of the infection of the necrosis bacilli. Here the attack was prompt and serious. The animal was unable to use its foot by the third day, this degree of lameness lasting for fully a week. The organism penetrated beneath the hoof on each toe, causing it to be separated in each instance from the tissues beneath. A profuse discharge was constantly exuding from the point of inoculation, in which
the long threads of the necrophorus bacillus could constantly be
demonstrated.

Sheep No. 102 was inoculated on the foot by the application of a
mixed bouillon culture that had been taken direct from a diseased foot
and grown in an incubator for forty-eight hours, at a temperature of
35° C. Foot-rot was well established in the foot by the sixth day fol-
lowing, and its course was rapid and acute.

Goat No. 71 was successfully inoculated by having the skin of its
interdigital space bared by the clipping off of the hair and the exposed
surface then smeared with mixed bouillon culture of the third genera-
tion. As a result of this procedure the disease made itself manifest
on the ninth day, and followed a typical course through the various
stages of inflammation, spreading ulceration and necrosis.

Subcutaneous inoculations.—In order to test the action of the bacillus
of necrosis when applied to sheep upon some part of the body other
than the foot, a strong, healthy sheep was inoculated subcutaneously
on the inner surface of the thigh with 1 c. c. of a bouillon culture which
contained the necrophorus bacillus in pure state.

A spreading area of inflammation resulted from this inoculation,
making itself apparent upon the third day, and gradually extending
until the animal became feverish, off its feed, and showed considerable
lameness: In the center of this inflamed area an abscess the size of a
hen’s egg developed, which ruptured spontaneously after a few days’
duration, discharging a quantity of foul-smelling, yellowish watery
pus, within which great numbers of necrophorus bacilli were swarm-
ing. Recovery was rapid after the rupture of the abscess, and in
fifteen days after the inoculation all soreness had gone and only a scar
remained.

This experiment was repeated with sheep No. 13 by inoculating it
under the skin of the left shoulder with 2 c. c. of a bouillon culture
obtained from lamb No. 94. Six days later a hard tumor three-fourths
of an inch in diameter by one-half inch high had developed at the seat
of injection. This lesion likewise remained localized without showing
any indication toward involving the deeper structures, and recovery
followed in nineteen days.

Feeding experiments.—Two sheep were selected for the purpose of
feeding cultures of the necrosis bacillus, in order to disprove that the
organism has any predilection for the feet when ingested with the food.
These animals, Nos. 15 and 84, each received 100 c. c. of a bouillon
culture mixed with mill feed on three successive days. These sheep
were slaughtered thirteen months and four months, respectively, after
the beginning of the experiment, but the postmortem examination
failed to reveal any indication of necrosis in any of the tissues,
although the livers especially were subjected to careful examination.
Injection of filtrates.—In the midst of successful inoculations of healthy sheep with artificial cultures of the organism concerned in the production of foot-rot, it was deemed advisable to test the filtrate of some of these virulent cultures to see if there was any ultramicroscopic organism to which the disease could be credited. A 48-hour growth of a mixed bouillon culture that had been inoculated with the pus from an affected foot was divided into two parts, one of which was used without alteration, while from the other a filtrate was obtained by the use of a Roux-Chamberland filter. The two fore feet of a healthy sheep were next prepared for inoculation by scarifying the interdigital spaces, the same treatment being accorded to each of them, and the application was at once made, using on one foot the unaltered mixed bouillon culture, and on the other some of the filtrate derived from it. The inoculation with the culture in which the bacteria remained soon resulted in a serious case of eroding foot-rot, while the foot which received only the sterile filtrate quickly healed. In order to determine if the products of the necrophorus bacillus were in any way concerned in the production of these lesions a similar experiment was tried. For this purpose a rabbit bouillon culture of the necrophorus bacillus of three days' growth was used by retaining a small portion for direct inoculation, while the remainder of the media was passed through the Roux-Chamberland filter. When the unfiltered culture, which was swarming with the above bacilli, was applied to the scraped interdigital space of a foot it soon began to produce the inflammation and lameness which characterize the initial stages of foot-rot, while the foot which received the filtrate after similar treatment remained unaffected.

INOCULATION OF RABBITS.

Rabbits are the most susceptible animals to the inoculation of the Bacillus necrophorus, and, as Loeffler has stated, they also afford a ready method for isolating this organism from contaminations. A number of rabbits were inoculated subcutaneously, both with the purulent discharge from a foot affected with foot-rot, as well as with pure cultures of the Bacillus necrophorus, and the characteristic yellowish white area of muscular necrosis with the peculiar penetrating odor was prominent in both instances. In the former cases the animals frequently died on the fourth or fifth day, probably as a result of the mixed infection present, but even in these animals the coagulation necrosis of the muscles about the point of inoculation and their transformation into a putty-like consistency was always noted. When pure cultures were used a rabbit would live from eight to fourteen days when injected with 0.5 c. c. under the skin of the back. The resulting lesion is fully described on page 19. It frequently happens when life has been prolonged ten or twelve days that metastasis occurs from
the local lesion, in which cases irregular yellowish areas of focal necrosis are observed most frequently in the liver, and occasionally in the lungs and kidneys. Microscopic examination of the tissues taken from the affected area or from those lesions in the liver or lung that had developed as a result of metastasis shows the presence of typical necrosis bacilli in great numbers. In the case of organic lesions these organisms are seen to be arranged along the border of the area of necrosis, while the central portion is amorphous without showing the presence of any bacilli. (See Pl. 2, fig. 2.)

**INOCULATION OF MICE.**

White mice may be used in obtaining the necrosis bacillus in purity by inoculating three or four successively. However, their susceptibility to the organisms frequently found in foot-rot makes them less valuable than rabbits for this purpose. The results obtained by the subcutaneous inoculation of 0.1 c.c. of an emulsion prepared from the foot of a sheep suffering with foot-rot and of 0.1 c.c. of a bouillon culture of necrophorus bacilli are practically the same if the mouse in the former instance does not die of some intercurrent disease within three or four days following the injection. The usual course of the disease in these animals ranges from five to eleven days. The first indication noticed is a rapid emaciation of the mouse, with a rough staring coat and a gradual drying-up appearance of the animal. On postmortem examination the point of inoculation was found surrounded by the usual picture of coagulation necrosis involving the subcutaneous and muscular tissues, and in many cases involving the abdominal muscles. The internal organs, especially the liver and lungs, and in one instance the spleen, showed small foci of caseation in which necrosis bacilli were readily observed on microscopic examination.

**INOCULATION OF GUINEA PIGS.**

Guinea pigs were inoculated with pure cultures of the necrophorus bacilli both by the subcutaneous and intraabdominal methods, but always with negative results. Six animals were used in each experiment and doses ranging from 0.25 to 1 c.c. of a 48-hour bouillon culture injected without producing any untoward effects.

**VIRULENCE FOR OTHER ANIMALS.**

Among the many conditions in which the bacillus of necrosis has been found as a producer of disease, Francke states that it is shown by the writings of Bang that this bacillus is the causative agent of a troublesome foot disease of cattle which, commencing as a phlegmonous inflammation of the soft parts of the foot close to the horn of the hoof, shows a tendency toward necrotic degeneration.

Through the results obtained by Bang after careful research, Francke is enabled to state positively that all of the necrotic and gangrenous
changes found in this affection of cattle are due to the invasion of the bacillus of necrosis following some injury to the foot.

He also quotes Von Imminger as authority for the statement that the bacillus of necrosis is the causative agent in an infectious disease of the feet of cattle which he had studied. Von Imminger reached the conclusion that there could be no doubt of the contagiousness of the disease, and from the nature of the pathological changes always present he concluded that the bacillus of necrosis was probably the active agent in promoting the spread and continuance of the disease. He appears, however, to have made no bacteriological study of these cases.

Through Francke's own investigations he has found that the bacillus of necrosis is very widely distributed by nature, and that it is very actively concerned, either alone or as accessory to some other virulent organism, in the development of a number of spreading diseases among the domestic animals, and that wherever found, its presence is manifested by an erosive local destruction of tissue.

In cattle and horses necrotic areas are sometimes present in lungs or liver, the origin of which is plainly shown by microscopic examination to be the long threadlike bacillus of necrosis.

Ernst, who has made a careful study of the bacillus of necrosis, states that Bang was the first to recognize the multiplicity of ways in which the pathogenicity of the organism is shown. He described it as the active factor in the production of several diseases which are characterized by more or less necrotic destruction of tissue, in cattle, horses, deer, hogs, sheep, and kangaroo.

In writing of malignant foot-rot in cattle, Hess maintains that this disease is identical with contagious foot-rot of sheep. In studying the disease as it appears in cattle he has found that it is caused by a microorganism first described by Loeffler, and by him named "Bacillus necrophorus."

Nocard and Leclainche state that it is permissible to consider that foot-rot of sheep is caused by the bacillus of necrosis, but they, like Hess, fail to present any bacteriological evidence for their assertion.

Horne has reported a very interesting outbreak of sore feet among the reindeer of Norway from which he has recovered the Bacillus necrophorus. This author writes:

It is emphasized that the disease is contagious; it is declared to be highly contagious. The malady appears to be spread by healthy animals walking in the steps of diseased ones, where they catch the infective principle from the ground in small sores or cracks in the skin.

ECONOMIC IMPORTANCE.

Throughout the Middle West, where packing houses are located in many of the largest cities, the sheep-feeding industry has attained
FOOT-ROT OF SHEEP.

large proportions. At points situated within easy reach of the more important slaughtering centers there have been stations established for the purpose of finishing off those sheep and lambs that have been shipped from the ranges farther west before they had reached a sufficient degree of fatness to admit their being dressed to advantage. The stations are located within easy reach of several of the more important stock yards, thus enabling the owner to take advantage of a favorable turn in market quotations, or to supply any shortage that may occur in the receipts of a particular grade of sheep at the yards with which he is associated.

There are several of these places with a capacity of over 50,000 sheep each, and one near Chicago that can accommodate 80,000, as will be seen by the following list of feeding stations, the total of which shows that 683,000 sheep can be finished for market at one time. This list does not include the vast numbers of animals that are fed in the feeding stations of the far West nor those in bunches of 500 to 3,000 by private individuals throughout the central Northern States.

Partial list of sheep-feeding stations in the United States.

<table>
<thead>
<tr>
<th>Location</th>
<th>Capacity</th>
<th>Location</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grand Island, Nebr</td>
<td>25,000</td>
<td>Plano, Ill.</td>
<td>25,000</td>
</tr>
<tr>
<td>Norfolk, Nebr</td>
<td>25,000</td>
<td>Specht, Ill.</td>
<td>25,000</td>
</tr>
<tr>
<td>Nickerson, Kans</td>
<td>25,000</td>
<td>Rockelle, Ill.</td>
<td>20,000</td>
</tr>
<tr>
<td>St. Marys, Kans</td>
<td>25,000</td>
<td>Milldale, Ill.</td>
<td>15,000</td>
</tr>
<tr>
<td>Hanover, Kans</td>
<td>8,000</td>
<td>Oswego, Ill.</td>
<td>15,000</td>
</tr>
<tr>
<td>Columbus, Nebr</td>
<td>25,000</td>
<td>South St. Paul, Minn</td>
<td>40,000</td>
</tr>
<tr>
<td>Valley, Nebr</td>
<td>35,000</td>
<td>St. Anthony Park, Minn</td>
<td>60,000</td>
</tr>
<tr>
<td>Fremont, Nebr</td>
<td>25,000</td>
<td>Brighton, Minn</td>
<td>25,000</td>
</tr>
<tr>
<td>Stockdale, Ill.</td>
<td>60,000</td>
<td>Trevor, Wis.</td>
<td>25,000</td>
</tr>
<tr>
<td>Lafox, Ill</td>
<td>60,000</td>
<td>Total</td>
<td>683,000</td>
</tr>
<tr>
<td>Montgomery, Ill.</td>
<td>80,000</td>
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<td></td>
</tr>
<tr>
<td>Kirkland, Ill.</td>
<td>40,000</td>
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</tbody>
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It is customary to keep the animals closely penned during the period of their fattening at these establishments; in fact, they are sometimes restricted to rather uncomfortably narrow quarters. They are divided into lots of 200 to 600, to suit the convenience of the feeder, and each lot is provided with a separate pen in which they remain from the time of their arrival until sufficiently finished to warrant the continuance of their journey to the packing house. In many cases their grain is supplied to them through "self-feeders," by which means a supply is kept constantly before them. Water is also available at all times, and the incentive to active exercise is very slight, even if the pen were large enough to allow unrestricted movements. Under these conditions an outbreak of foot-rot quickly assumes serious proportions. While the disease will not of necessity spread from one pen to an adjoining one, there are several cases on record where the contagion has been so thoroughly disseminated among individual pens in which a few infected sheep have been placed that only a small number of its inmates escaped the attack. Inspectors of the Bureau of Animal Industry, United
States Department of Agriculture, occasionally find an affected flock among the arrivals of sheep at the various railway terminals in which the feet of as many as 75 to 80 per cent are diseased to a greater or lesser extent. These bunches of sheep have no doubt been run together in the feeding pens, and the percentage of diseased animals gives one a very good idea of the infectiveness of foot-rot under these conditions.

The sheep raiser or feeder who carries on his business upon a modest scale is often just as seriously injured by an outbreak of foot-rot in his flock as is anyone. His sheep run at will over a large portion of his farm, and it soon becomes so thoroughly contaminated by the repeated passage of diseased feet that the owner not only becomes thoroughly discouraged by the repeated failures of his attempts to eradicate the contagion from the premises, but his neighbors begin to look on him with suspicion, and in certain instances have become so aroused as to warn the unfortunate man against entering upon or crossing their holdings until he has succeeded in stamping out the dreaded plague.

The importer or breeder of choice registered sheep is frequently damaged materially by the appearance of this disease among his valuable animals. Foot-rot occasionally develops in sheep soon after importation from European countries in spite of careful examination at the time of purchase. In these cases it is probable that the virus had become lodged in some deep fissure under the horny covering of the foot during some previous exposure, and that it had remained latent in its hiding place until favoring conditions stimulated its growth. Whatever the manner of propagating the infecting agent, the fact remains that foot-rot frequently manifests itself among flocks of blooded sheep while on shipboard en route to this country, and conditions here favoring the spread of the infection from sheep to sheep, it is not uncommon for the animals of certain pens to show serious lameness by the time the port of debarkation is reached. Another place in which the owner of improved sheep becomes exposed to more or less danger of infection of his best specimens is at the live-stock shows of the country, where his animals are exhibited side by side with sheep from widely scattered localities. This danger, however, is reduced to the minimum by the excellent care given to both animals and pens while the exhibition is in progress. The greatest danger is probably met when the animals are loaded and unloaded over a chute at the railway station, which is used by all of the exhibitors in common.

The raising of Angora goats is also becoming an industry of great economic importance. Their value as producers of mohair, of fleece-bearing skins, and of meat, together with their efficiency as eradicators of brush and weeds, is bringing them into increasing favor with practical American people, while their beautiful silky coats and gentle dispositions make them very attractive as pets for those who seek to
derive pleasure rather than profit from them. At the present time large sums of money are invested in these animals, and individual flocks numbering thousands of animals are not uncommon in some localities. An association of breeders has been formed which supports a registry book, and live-stock exhibitions at which the Angora forms a prominent feature are sure to attract general interest.

The experiments which have been made at this laboratory prove that Angora goats may readily be inoculated with foot-rot from sheep, and that where sheep and goats are allowed to pasture together they may be indiscriminately attacked by an invasion of this disease.

To what degree the prevalence of foot-rot among sheep and goats in this country exists can not be accurately stated, for the reason that our statistics are not sufficiently numerous to furnish a basis for a reasonable estimate. Occasional outbreaks, especially the highly virulent ones, are reported, and in these cases about three-fourths of the flock become affected. Owing to the slow, protracted course of the disease and the length of time required for the affection to pass through a bunch of sheep, the losses occurring from the shrinkage of flesh in market sheep and from the diminution of the supply of milk for the sucking lambs of the affected ewes reach material proportions. In addition to these direct losses, the owner of an infected flock of full-blooded animals is subjected to discouraging failures in his attempts at selling off his surplus breeding stock, as prospective buyers are naturally reluctant to introduce lame animals into their sheepfolds. The time and labor spent in the treatment of the feet of an infected flock should also be brought forward in this calculation of monetary loss.

**Differential Diagnosis.**

There are but few pathological conditions of the feet of sheep or goats that may be mistaken for contagious foot-rot. When lameness first makes its appearance in a flock there may be some hesitancy, however, in determining the exact nature of the trouble. Lameness may be primarily caused in these animals by wounds of the feet, by purulent inflammation of the interdigital space (so-called noncontagious foot-rot), by stoppage of the orifice of the biflex canal, by suppurative cellulitis (cutaneous abscesses), or by foot-and-mouth disease, and for a time the lesions produced by any one of these causes may offer a very confusing resemblance to those characteristic of the invading stage of foot-rot.

**Wounds of the Feet.**

It occasionally happens that in running over fields or roads where sharp stones abound that sheep or goats will puncture the skin of the interdigital space by forcing one of the sharp edges of a stone between the claws of the foot. This accident is not of frequent occurrence,
and the fever and lameness thus produced seldom last for more than a few days.

Another source of injury to the feet is seen where bushes or coarse weeds have been cut off close to the ground, leaving stiff, dense, pointed stubs standing erect, offering with their firm, sharp ends an enduring menace to the feet of all unwary passers. Another common cause of accidental lesions to the feet of sheep is met in or around their stables, where loose boards, with the projecting points of nails sticking upward from their surfaces, are carelessly left for the flock to run over while passing to and from their shelter.

The foot should be cleansed with a 5 per cent carbolic-acid solution when it has been subjected to an injury which leaves an open sore, and in cases in which the formation of pus ensues, this should be liberated by the use of a clean knife or needle, after which the application of poultice supported by a light soft bandage will be found very beneficial.

**PURULENT INFLAMMATION OF THE INTERDIGITAL SPACE (FOULS).**

This condition is one that is frequently met in sheep, and it has often been mistakenly called foot-rot. From this faulty naming has arisen much of the controversy over the question of the contagiousness of foot-rot. Parties who have had experience only with purulent inflammation of the foot, and who have looked upon it as foot-rot, have very reasonably asserted that foot-rot is by no means contagious, that it appears sporadically, may attack but few members of the flock, yields promptly to treatment, and nearly always makes its appearance among sheep during their pasturage upon low, swampy land. If the term foot-rot is used at all in connection with purulent inflammation of the feet, it should be qualified by calling the affection benign or noncontagious foot-rot, in order to avoid all confusion with the real or contagious form of the disease. This purulent inflammation may result from pasturing on wet, filthy grounds or on low, marshy lands. An irritation of the cleft of the foot occurs which is followed by fissures in the skin and a softening of the horn resembling foot-rot. In rainy weather sheep that are pasturing upon clay soils often accumulate irritating masses of twigs, stubble, or small, sharp pebbles in the interdigital space of the foot. These substances become thoroughly embedded in moistened clay and this mixture is gradually molded to the form of the space between the claws of the foot. In this position it will remain for days unless removed by force, and it may be the cause of serious inflammation, suppuration, and lameness so long as it retains its position in this sensitive place. Every step of the animal causes the projecting points of the offending material to cut deeper and deeper into the adjoining tissues of the foot. There ensues swelling above the coronet and the whole of this region becomes reddened and feverish. Cases have been noted where marsh grasses with their
saw-like edges have become entangled in the cleft of the foot and have remained in position long enough to set up a painful irritation by their constant friction. Finally, on examining the foot of a lame sheep one may discover the presence of none of these pointed objects, and still the inflammation is intense. This condition has been known to follow the entrance of particles of sand and gravel into the cuts, cracks, or injuries, and one should always bear this in mind while looking for a cause for lameness, and carefully remove the grit or dirt which may be present. Sometimes the horn, having grown rapidly because of the unusual stimulation, may inclose the gravel and retain it within the foot as a constant source of irritation.

Unless these irritating substances have remained in position long enough to cause suppuration, the only treatment required is their removal. If suppuration has become established the antiseptic treatment previously recommended for wounds of the foot will be found to give admirable results.

STOPPAGE OF THE BIFLEX CANAL.

Sheep and goats are provided with a secretory gland called the interungulate or biflex, situated among the tegumentary tissues of the leg just above the separation of the digits. The orifice of the little vessel that leads from this gland may be plainly seen upon spreading the toes apart. The secretion of the interungulate gland is of an oily nature and serves as a lubricant for all tissues in the cleft of the foot that are subjected to friction during the progression of the animal. In the healthy normal foot the functions of this little secretory organ are carried on unnoticed, but it occasionally happens that mud, sand, or some other gritty substance becomes forced up into the biflex canal and lodges there, not only choking up the excretory passage of the gland above, but also causing inflammation of the walls of the canal, which may develop into extensive suppuration and serious lameness.

This affection may be distinguished from contagious foot-rot by the fact that the ulceration does not tend to invade the tissues beneath the horny covering of the foot, nor does it assume an infectious character. The orifice of the canal should be opened by thorough washing, after which it may be dressed with a poultice held in place by the application of a soft bandage. Should the suppuration have become so deeply seated that it will not yield to washing it may be found necessary to lance the part in order that a passage may be provided for the escape of the imprisoned pus. A knife with a small keen blade should be used in this operation, and it should be carefully cleaned both before and after using. Poultices should always be applied to feet that have required surgical relief, and the bandages ought not to be permanently removed until the wound has healed over, superficially at least, as it
will give valuable assistance to the healing process by keeping dirt from entering the injured areas.

SUPPURATIVE CELLULITIS (CUTANEOUS ABSCESSES).

Stockmen whose cattle and sheep are obliged to pass daily through muddy yards or pens, especially if the mud is so deep that passage requires laborious wading, sometimes notice the eruption of sores, varying in size from the diameter of a millet seed to that of a silver dollar, upon the lower extremities of animals subjected to such conditions. These sores may appear just above the coronary, farther up in the region of the ankle, or still higher until the skin near the knee becomes the seat of the lesion.

The first indication of the trouble will be an erection of the hair over the affected area, quickly followed by swelling of the part, and accompanied by a marked rise in the body temperature of the animal, loss of appetite, sluggishness, and rapid wasting of condition.

As the disease advances, each of the inflamed areas develops a typical abscess, containing creamy pus with a very offensive odor. At this stage it is sometimes discovered that one or more of these abscesses have become established beneath the coronary band or even beneath the horny wall of the foot, although in the majority of cases the lesions are all confined to areas above the foot, where the leg has a thick hairy covering. Should these find lodgment in the tissues of the foot they may be mistaken at first for indications of contagious foot rot. But the discovery in this region of a circumscribed abscess filled with pus, with the simultaneous appearance of similar abscesses beneath the skin of the leg will at once prove to the owner of the flock that the trouble is an outbreak of cutaneous abscesses and not an attack of contagious foot-rot.

Although this disease yields readily when proper treatment is applied during the early part of its development, it will often terminate fatally if neglected. The skin of the lower part of the leg is comparatively thick and resistant, and in consequence the abscesses seldom open spontaneously, but, spreading to the adjoining subcutaneous tissues, assume an eroding character which permits the absorption of their products by the blood vessels, and general septicemia and death result. Investigations from a bacteriological standpoint, especially those of Moore and Voges, prove the constant presence of pyogenic streptococci in the abscesses of the skin, and they are undoubtedly the cause of the affection.

In many instances it has been found that the removal of the flock from their muddy surroundings to dry, clean quarters has the desired effect of checking the spread of the disease. More advanced cases demand that the abscesses be opened surgically and thoroughly cleaned with an antiseptic solution, after which rapid healing usually follows.
FOOT-ROT OF SHEEP.

FOOT-AND-MOUTH DISEASE.

This country, most fortunately, has never experienced a serious outbreak of foot-and-mouth disease in sections in which the sheep industry forms an important factor in agricultural activities. It is one of the scourges of European countries, and the annual reports of outbreaks of contagious diseases in these lands show what a firm footing the disease has gained among their flocks and herds.

Should an invasion of this disease ever be mistaken for foot-rot in sheep, the illusion will not be one of long duration. The eruptions which appear upon the feet of sheep in an attack of foot-and-mouth disease may, during the invasive period of the outbreak, bear a close resemblance to those of foot-rot, but they are more superficial in their effect, being devoid of the deep-seated, erosive passages which characterize the foot-rot lesion, and for this reason they are far more transient, disappearing voluntarily when the disease has run its course in all cases in which the attack reaches a favorable termination. The lesions of foot-and-mouth disease are more plainly to be seen, the destructive processes frequently extending up above the cleft of the foot in front or rear into plain view of the examiner. In uncomplicated cases there is never any tendency to fungoid growths, and the structure of the hoof retains its normal formation and does not become soft or crumbling, as it frequently does after an attack of foot-rot. The primary attack of foot-and-mouth disease is usually evidenced by the simultaneous affection of at least three of the feet of the animal. The infection spreads more rapidly through the flock, and not to the sheep alone, but to the cattle and hogs which are permitted to mingle with them. In addition to the eruptions on the feet the sheep suffering from foot-and-mouth disease will occasionally show reddened patches upon the membranes of mouth and lips which speedily develop into blisters of varying sizes. The tongue may be affected in the same manner. These blisters soon rupture, leaving raw, open sores. The teats and udders of affected ewes are frequently the seat of like eruptions. The temperature of the animal shows marked elevation during the invasion of the trouble (106° F.), but this does not persist after the rupture of the vesicles. Lesions of the mouth are not so constant in sheep as they are in members of the bovine family.

A number of European writers have in the past insisted that contagious foot-rot of sheep does not exist independently of foot-and-mouth disease; but the very fact that contagious foot-rot has for years been more or less prevalent among American sheep without ever having given rise to foot-and-mouth disease among the cattle and hogs of the same farms offers the most conclusive evidence that the diseases are independent one from the other and that they have their origin in separate, specific organisms.

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At a gathering of veterinarians held in Saxony an address was given by Martens\(^1\) in which he claimed, in direct opposition to the views held by a majority of his colleagues, that malignant foot-rot of sheep was by no means the same malady as foot-and-mouth disease. In the course of his remarks he said that the malignant foot-rot of sheep has been known in Europe for more than a century and has occurred on many sheep farms throughout all Germany, where it has proved to be a plague which has caused great damage. In some of the flocks it had existed for many years in spite of all attempts at its eradication.

In discussing the similarity of characteristics which exists between foot-and-mouth disease of sheep and contagious foot-rot in the same species of animal, Martens\(^1\) says that rapidity of spread of an outbreak among the animals of a flock is not always a certain indication that the disease in question is foot-and-mouth disease, as he has seen over 30 per cent of a flock attacked with foot-rot in the course of a single week during a season of warm, humid, or stormy weather.

**Prevention.**

The prevention of foot-rot, a matter of absorbing interest to the sheep owner, may be successfully attained by means of careful management.

When purchases of sheep are to be added to a healthy flock the buyer can not exercise too great caution in his examination of the newcomers, and holding them for a few days in isolated quarters before permitting them to join the main flock, may prove to be time and effort well spent. Another precaution which will in some cases prove beneficial may be found in the regular examination at stated intervals of the feet of each member of the flock, and the removal of all excessive growths of horn. A large percentage of lameness in the horse is due to an "unbalanced foot," and the first step in treatment should always be the paring of the hoof, or the formation of the shoe in such a manner that the foot of the horse, while he is standing at ease, will be perfectly level in its relation to the floor surface upon which he is standing. The same rule holds good in an application to the ovine race. Overgrown hoofs should be so trimmed that the plantar, or wearing, surface of the foot will present a natural angle to the direction of the bony shaft of the leg, and all superfluous length of toe should be removed. Overgrown toes frequently tend to forcibly spread the hoofs apart, the tension thus produced leading in many cases to strained tendons and to lessening of the natural resistance of the tissues of the region to injury.

A great amount of vital energy is unnecessarily expended in walking by a sheep with overgrown toes, especially if the animal is kept in yards or pens where cornstalks or other coarse litter are allowed to
FOOT-ROT OF SHEEP.

accumulate, or if it is pastured in stubble fields or where the grass has become long and tangled.

The heels of the hoofs seldom require any cutting, and the labor of trimming may consequently be entirely expended upon the toe. Soaking the feet for a time will be found to soften hoofs that are at first too hard to yield readily to the knife. It will be found satisfactory, where practicable, to select a time for trimming the hoofs when the flock may be brought up to the pens directly from an excursion through wet grass. The early morning following a heavy fall of dew is frequently selected for this purpose, or the work, if not neglected too long, may be deferred until a suitable rainy day.

Should the infection of foot-rot have been introduced into a sheep yard trimming of the feet will not prevent the spread of the disease, except as it indirectly assists nature in keeping the cleft of the foot free from dirt, and the wise shepherd will not relax his vigilance at the time of admitting fresh arrivals upon his premises, as it is at that time that he may most easily prevent the spread of this disastrous malady among his healthy animals.

Experience has shown that sound sheep may be safely pastured on land that has previously been occupied by sheep suffering from foot-rot, provided that a winter's frosts have been allowed to intervene. The contagion of the disease seems to be effectively subdued by this means, and pastures that have become contaminated one season may be considered safe for their customary usage during the following season. The sheepfold, however, must be carefully disinfected to prevent the recurrence of the disease, as this bacillus will retain its virulence under suitable conditions in or around stables for several years. The walls, racks, and troughs should be sprinkled with a solution containing 1 pound of pure carbolic acid to 5 gallons of water, to which enough lime has been added to make the sprayed area conspicuous. The manure and 4 inches of the surface soil should be removed and spread on a field that is to be tilled. In turning sheep on grass care should be taken to avoid low, marshy, or boggy lands, and to keep them, if possible, on high, dry pastures.

TREATMENT.

One of the first steps to be taken in the treatment of a flock of sheep affected with foot-rot is to separate all that are in any degree diseased from those that are healthy. After this has been accomplished much will depend upon the stage which the disease has reached among the animals of the flock in determining upon further action. Should the disease be in its earliest stage, with but few animals affected, it will doubtless be found sufficient treatment for those that appear sound to pass them through a shallow trough containing a solution composed
of 1 pound of chloride of lime to each 12 quarts of water. This solution should have a depth of at least 4 inches in the trough, and the animals should be made to pass through it slowly, allowing time for the mixture to apply itself thoroughly to all the cracks and fissures of the feet. Instead of the mixture of chloride of lime, a solution composed of 1 part of carbolic acid crystals to every 30 parts of water, or 1 pound of pure carbolic acid to 4 gallons of water, may be used as a foot bath for the sound part of the flock.

The trough used in this operation may be of wood, tightly constructed, 20 inches in width, and a foot or more in depth. The length should be proportioned to the size of the flock to be treated. For small lots that are accustomed to being handled, the trough need not be over 6 feet in length. In such cases, however, the animals should be allowed to stand for a moment in the solution before passing out. A greater length of trough would necessitate the preparation of a larger amount of fluid, and consequently would entail greater expense. Where a large number of sheep is to be treated the trough should not be less than 20 feet in length. Hurdles or portable racks may be so arranged by the sides of the trough and along the pathway leading to it that each animal may be obliged to pass through the bath with but very little urging.

After this treatment has been applied to the sound part of the flock, they should be at once placed in fresh, uncontaminated quarters. Although they are not likely to show any evidences of the disease after being treated in this way, the owner or shepherd should not neglect them, but should closely watch for any signs of lameness, and when discovered the affected animals should be promptly removed and subjected to more careful treatment. In case the flock from which the healthy sheep were separated is badly diseased, it would be advisable to have the sound animals pass through the bath as described above on several occasions. This may be done every second day until three or four treatments have been applied, special care being taken in the meantime to provide fresh, clean quarters for the animals, completely separated from the diseased portion of the flock.

While selecting treatment for that portion of the flock in which the disease has become actually established, it should be remembered that the principal requisites are to lay bare the affected surfaces and to destroy the infectious matter which has lodged upon them. The remedy which will accomplish this most readily, and at the same time without giving rise to harmful secondary conditions is evidently the one that should be given the preference.

The bacteria to which the disease is due yield very readily to the application of disinfectants, and the trouble which so many sheep men have experienced in the eradication of foot-rot from their flocks must
have been due to a failure to expose properly the affected surfaces to the action of the applied remedy.

During the present course of experiments many of the feet in which disease had been purposely produced have been healed up as soon as the true course of the affection had become evident, so as to avoid unnecessary lameness; and in these cases it was found that all advancement of the disease processes promptly stopped upon the application of a 5 per cent solution of carbolic acid, a few applications usually proving sufficient. In these cases, however, it must be admitted that the conditions for successfully healing the lesions were far more favorable than those which surround the average diseased flock upon the farm. In the first place, the erosions had not extended very deeply into the foot, and, secondly, the animal was not allowed to run in a muddy yard, but was kept upon a dry stable floor. The instances serve to prove, however, that the remedy need not be very poisonous or caustic to produce the desired results, and to emphasize the fact that one must constantly aim, while treating foot-rot in sheep, to expose the diseased areas to the action of the disinfectant used.

Treatment of the affected animals should not be deferred, as more satisfactory results will be obtained by attacking the outbreak as soon as discovered than can be expected if the disease is permitted to spread among the flock or to penetrate deeper into the tissues of the affected feet. This is accepted as a very practical fact by the English shepherds who attend shipments of thoroughbred sheep on their transatlantic voyage to this country for breeding purposes. The statement is made by them that none but negligent or inexperienced shepherds will ever allow foot-rot to spread through a flock of which they are in charge, as thorough trimming and antiseptic treatment of the hoof of the first animals seen to be lame will surely save the balance of the sheep from an attack.

The treatment already suggested for the sound portion of the flock will be found very efficacious for early stages of the disease, but after the animal has become more seriously affected one should carefully examine each of its feet, and, if necessary, pare away all shredded or loosened portions of the horny tissue. This will often prove to be a very laborious undertaking, but the operator should persist until the loosen horn has been thoroughly removed and all of the ulcerous fissures have been exposed.

The foot must be carefully cleaned and every portion of loosened and detached horn cut away, as the horny tissue once separated from the sensitive parts beneath will never unite with them again, but will remain as a source of pain and inflammation and also a protection for the disease-producing organisms while they attack and destroy the internal structures. Should fungoid granulations be met they should
be removed with a knife or pair of curved scissors. All clippings and trimmings that are removed from the diseased feet, whether composed of bits of horn, shreds of tissue, or fungoid growths, should be carefully gathered up and burned or disinfected, as they may serve to spread the disease further if left where passing sheep may come in contact with them.

If this work has been thoroughly done, standing the sheep for ten minutes in a strong solution of copper sulphate (blue vitriol) made as warm as can be borne by the hand, will in most cases effect a cure. This solution may be prepared by dissolving 4 pounds of copper sulphate in 5 gallons of warm water. The footbath should be repeated if necessary.

An attendant should remain stationed by the side of each sheep whose feet are badly affected to prevent the animal from lying down while it is in the copper-sulphate solution, as sheep of this class, because of the pain produced during their efforts to stand, are liable to drop to their knees or even to lie down in the trough during the application of the treatment. Soft bandages should be applied, after the sheep are removed from the footbath, to all feet that have required deep cutting, not only for the purpose of protecting the sensitive tissue from becoming bruised, but in order that particles of dirt may be kept from the raw surfaces, and that nature may be assisted in the formation of new protective coverings.

It sometimes happens that the disease assumes an aggravated form in several of the sheep, involving the deeper sensitive tissues and necessitating the application of hand dressings to the feet. In such cases all the loose and diseased tissue should be cut away and the affected parts washed thoroughly with a 5 per cent solution of carbolic acid. An antiseptic astringent powder, consisting of 4 parts of carbolic acid, 2 parts of tannic acid, and 94 parts of exsiccated alum, is then dusted upon the ulcerated surfaces, and a bandage applied to afford the parts the desired amount of protection.

The most earnest efforts should be made to conquer the disease before the advent of warm weather, as it will be found more difficult to deal with during the latter period. On the contrary, cold weather and dry seasons are unfavorable for the development or spread of the disease, although they will not cure it.
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