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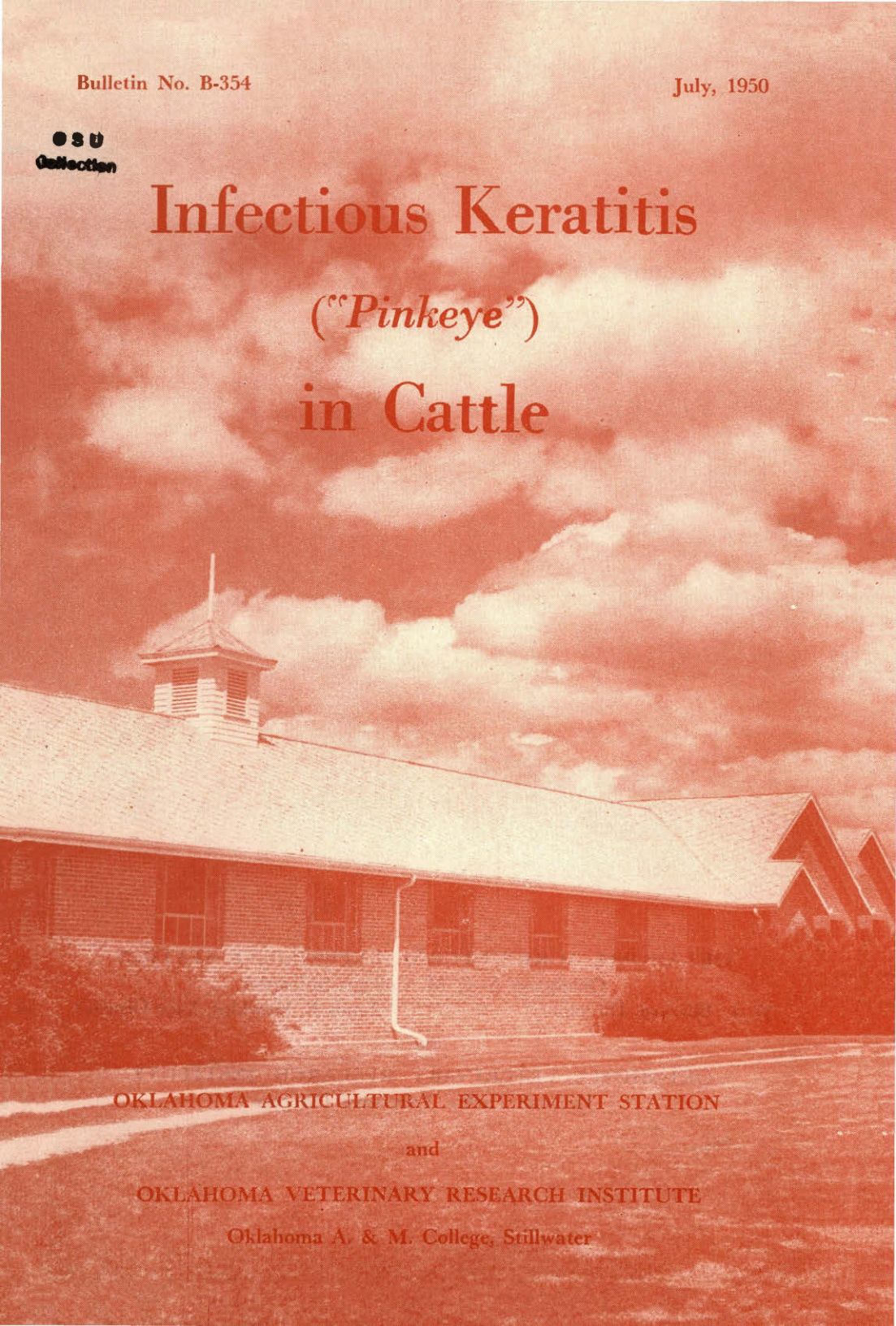
Infectious Keratitis ("*Pinkeye*") in Cattle



OKLAHOMA AGRICULTURAL EXPERIMENT STATION

and

OKLAHOMA VETERINARY RESEARCH INSTITUTE

Oklahoma A. & M. College, Stillwater

OKLAHOMA AGRICULTURAL EXPERIMENT STATION
Oklahoma A. & M. College, Stillwater
W. L. Blizzard, Director Louis E. Hawkins, Vice Director

and

OKLAHOMA VETERINARY RESEARCH INSTITUTE
Herman Farley, Executive Director

ON THE COVER

A view of the Stillwater Field Laboratory of the Oklahoma Veterinary Research Institute. This laboratory is located west of the Oklahoma A. & M. College campus.

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INFECTIOUS KERATITIS ("Pinkeye") IN CATTLE

By HERMAN FARLEY, L. E. FOOTE, C. C. PEARSON, W. E. BROCK, and I. O. KLIEWER*

Keratitis, more commonly called "pinkeye," is an infectious disease which attacks the eyes of cattle and sheep. Few animals die from the disease; but the loss in beef and milk production is immense, as ranchers and dairymen well know. In some herds in the Midwest and Southwest, control of keratitis may mean the difference between profit and loss.

There is some indication that "pinkeye" may occasionally be due to improper nutrition rather than a germ infection; but the infectious type is more common. Although both cattle and sheep show the same symptoms, it seems probable that two different germs are involved, one affecting only cattle and the other only sheep. The "pinkeye" appearance may occasionally be due to mechanical injury; such cases, of course, do not spread to other animals in the herd.

This publication deals only with the infectious form of keratitis as it affects cattle. Research on this disease was started by the Oklahoma Veterinary Research Institute in 1946. This research is aimed at:

(1) Finding the cause of the disease;

(2) Finding a more effective medicinal treatment for active cases; and

(3) Determining the best method of prevention, including search for a satisfactory vaccine or other immunizing agent.

Progress of this research is reported in Part II of this bulletin. Part I summarizes presently existing knowledge, including methods of diagnosing and treating "pinkeye" in cattle under Oklahoma conditions.

PART I
What Is Now Known About Keratitis

Infectious keratitis has been known as a cattle disease in the United States for more than 70 years. It is now spread over wide areas, due to increased transportation of cattle from one part of the country to another.

The loss in weight caused by keratitis during the grazing season, when range cattle should be building a profit, makes "pinkeye" one of the most costly beef cattle diseases in Oklahoma. In dairy herds, keratitis causes serious loss in milk production.

*Members of technical staff, Oklahoma Veterinary Research Institute. Research reported in Part II was supported entirely by funds of the Oklahoma Agricultural Experiment Station.

What Keratitis Is

GENERAL DESCRIPTION

The infection of keratitis is limited to the eye. The inflammation begins in the outer covering of the eyeball (cornea), and in the surrounding membrane (conjunctiva). This membrane partially lines the eyesocket and is the inner lining of the eyelids. The extent of the disease in the eye depends upon whether or not the infection is mild, acute, or chronic. The cornea of the diseased eye becomes pink or white, due to accumulation of white blood cells, red blood cells, degenerated epithelial cells, and other structures. The small blood vessels around the margin of the eyeball are swollen and inflamed or reddened. The conjunctiva also becomes swollen and congested. The pink color of the eyeball in some stages of the disease gives it the common name, "pinkeye."

All ages and breeds of cattle are apparently susceptible; but young cattle, less than one year of age, are particularly likely to contract this disease.

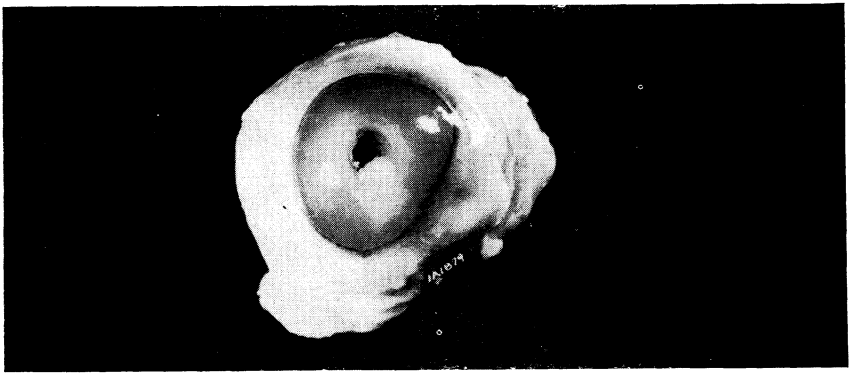
TYPES OF THE DISEASE

Keratitis is known to exist in three forms: mild, acute, and chronic. All three types have been observed at the same time in a herd where the infection is widespread. In other outbreaks, the infection may be limited to one type.

Mild Infection.—Watery secretion from the eye and a slight cloudiness of the cornea are always observed in the mild type of infection. Blood vessels of the cornea show a slight congestion. This type of infection tends to disappear within a few days, provided the diseased animal is isolated promptly in a darkened stall where flies, dust, wind, or other irritants will not aggravate the diseased eye tissue.

Acute Keratitis on Fifth Day of Disease.

Ten days after this animal was placed in a dark stall the surface of the eye lost its cloudy or milky color and sight had returned. The affected eye usually heals quickly when a non-chronic case is placed in a dark stall free from sunlight, wind, dust, and flies.



An Eye Ulcer Developed During Acute Keratitis.

The black area in the center of this eye is an ulcer resulting from keratitis infection. The eye was removed from a sacrificed animal for laboratory study. An eye this seriously infected may remain totally blind, though the animal usually recovers. Deaths from keratitis are rare, but the economic loss due to reduced weight gains and milk production is high.

Acute Infection.—The type of keratitis most commonly found in cattle herds is an acute infection. It usually appears suddenly, without warning, and without knowledge as to origin. The progress of the disease is rapid. Eye secretion runs continually over the face. There is congestion of eyeball and conjunctiva, with the color becoming pink to white, depending upon the degree of cloudiness of the cornea.

The infection may appear in only one eye, or in both eyes at the same time. However, the infection usually develops first in one eye, and may run its course without involving the opposite eye. At a

Acute Keratitis on Sixth Day.

A raised area of the cornea can be seen below the center of the eye (arrow). It somewhat resembled a blister, and was confined to the outer layers of the eyeball. It broke two days after this picture was taken, and the eye was apparently normal 30 days later.

later date the other eye may become infected. However, once an eye has apparently recovered from acute infection, it remains immune to reinfection.

If the diseased eye is examined at the beginning of the infection, a white or grey spot can be seen on the cornea just below the center or pupil of the eye. A small raised area may appear at this point; and this raised area may break and form an ulcer.

Acute infection can be checked to some extent by prompt isolation of the diseased animal before the infection has had an opportunity to spread to other cattle in the herd. Diseased cattle tend to make a rapid recovery without medicinal treatment when isolated in dark stalls away from flies, wind, and dust. Unfortunately, the infected animal usually does not come to the attention of the cattleman until the disease is well advanced, and often not until a number of animals in the herd show infection.

Chronic Infection.—Acute and chronic infections are similar except that chronic infection involves more extensive changes in the cornea. If the acutely infected eye does not start to clear within approximately two weeks, or if the cornea ruptures and allows pus-forming bacteria to invade the eyeball, this classifies the animal as a chronic case of keratitis. The third eyelid (often called the "haw") usually becomes thickened and inflamed to the extent that it partially covers the eye. Some stockmen suspect that the third eyelid interferes with vision and should be removed by surgical means; however, this is not necessary. The third eyelid usually returns to normal as the animal recovers. If pus develops within the eyeball and the lens of the eye escapes through a break in the cornea, the animal remains permanently blind in the eye involved. A reddish yellow discoloration of the cornea persists.

Chronic infection is common in range cattle that are continually exposed to the elements while allowed to remain in the herd. It is probable that chronic infection would not develop if cases of mild and acute infection were isolated promptly and placed under more favorable conditions.

DIAGNOSIS

The appearance of keratitis is recognized readily by the cattleman. The laboratory worker has no decided advantage over the stockman in diagnosing this disease, because the primary cause or the germ has not been found.

Factors probably sufficient for recognizing keratitis under range conditions include: Increased eye secretion, which causes tears to flow continuously; sensitiveness to light; general discomfort; loss of interest in grazing; a pink to white discoloration of the eyeball, with partial or complete blindness; and the ease with which the infection spreads through the herd if infected animals are not isolated.

Most cases occur during summer or early fall.

A few isolated cases that are not transmitted to susceptible cattle indicates nutritional keratitis, but this form is less common than the infectious type.

"Pinkeye" which results from mechanical injury is, of course, not transmissible. If the cornea is not badly bruised or torn, the injured eye usually recovers quickly.

METHODS OF TREATMENT

Treatment of keratitis is expensive because each animal has to be restrained and treated individually. This method is not satisfactory for cattlemen to use, and the excess handling increases the weight loss caused by the disease. A type of medicinal treatment that can be used on a group of cattle without the necessity of repeated treatments has not yet been found. Prompt isolation of the first cases by placing them in dark stalls will often prevent the infection from spreading through the herd, and is more effective

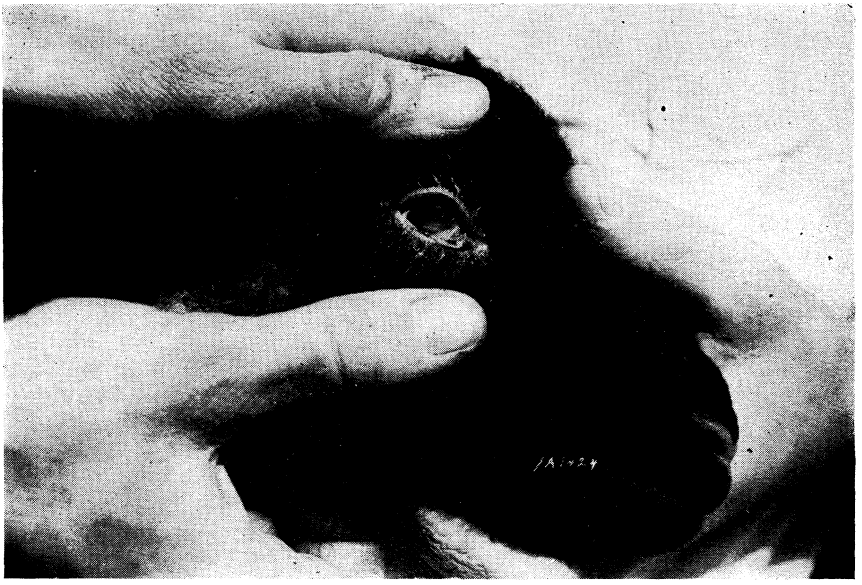
than medicinal treatment in curing the affected animal. The exposed surface of the eyeball (cornea) quickly repairs itself when the mildly or acutely infected animal is placed in a dark stall free from wind, dust, and flies, which are factors known to aggravate and prolong infection in the diseased animal.

With range cattle, isolation is often impractical. In these cases, medicinal treatment must then be resorted to. Sulfa-urea powder dusted over the infected eye has shown increasing benefit with field and laboratory cases. Sulfathiazole powder is also very effective. Penicillin has been used in the eyes of several cases of acute keratitis, but additional cases will have to be treated before its effectiveness can be determined. Additional drugs are being used by workers at this Station in treating active cases of keratitis. Other drugs that have been used by livestock owners for years include calomel, silver nitrate in 2% solution, mercurochrome, argyrol, and 5% boric acid solution.

In a chronic infection where blindness is permanent, it is sometimes necessary to have the eyeball and conjunctiva removed surgically.

TRANSMISSION AND IMMUNITY

Keratitis often appears suddenly in a herd without definite indication of its origin. It is transmitted within the herd by mechanical means, such as rubbing heads with diseased cattle while eating, drinking, or crowding together in barns, corrals, or under shade trees. House



Acute Infectious Keratitis in a Lamb.

This picture was taken five days after exposure with eye secretion from another lamb having acute keratitis. Eye secretions from infected sheep will not produce pinkeye in susceptible cattle, nor will those from cattle produce it in sheep. The symptoms are the same in both types of livestock, but the causative organism apparently is different. The symptoms in both cases include sensitivity to strong light, inflammation of the conjunctiva (membrane surrounding the eyeball), watery secretion from the eye, and partial blindness.

flies and stable flies may transmit the infection from diseased to susceptible cattle at short range. There may be other means of transmission that have not yet been determined.

Sheep apparently are not susceptible to cattle keratitis, and vice versa, though the diseased eyes of sheep and cattle show the same symptoms. In Oklahoma keratitis is not as prevalent among sheep as it is among cattle.

Some cattle possess a natural immunity to infectious keratitis. Cattle which recover from a mild infection are not immune to reinfection at a later date. Those which recover from acute or chronic keratitis are immune; but they retain the infection for several months, or possibly longer, and serve as a source of infection to other cattle in the herd.

Immunity following acute keratitis is confined to the infected eye. The non-infected eye remains susceptible. It often happens that one eye remains unaffected while the other eye undergoes an attack of the disease, and then becomes infected at a later date.

No method has yet been found for vaccinating cattle to produce immunity to infectious keratitis.

PART II

Keratitis Research in Oklahoma

(A Brief Progress Report)

Research on infectious keratitis was started by the Oklahoma Veterinary Research Institute in the summer and fall of 1946. Objectives of this work are:

(1) To determine the causative agent or agents.

(2) To develop satisfactory methods for prevention and treatment.

(3) Continue the search for a satisfactory immunizing agent.

Billings (1)* in 1888-89 recorded the first evidence of keratitis in this country, giving a good clinical description of the disease as he observed it among cattle in Nebraska. He stated further that keratitis was not a new disease. His efforts to establish the cause were unsuccessful. Poels (2) isolated *Bacillus pyogene* from active cases of keratitis and reproduced the disease by injecting cultures of this organism between the layers of the cornea. He stated that *B. pyogenes* was the cause of keratitis in cattle in Holland. Morax (3) isolated a diplobacillus from cases of conjunctivitis in man. This organism resembled the gram negative bacillus isolated by Poels (2), Allen (4), and Jones and Little (5). Allen (4) isolated a gram negative bacterium from eye secretions of cattle affected with keratitis, but was unable to reproduce the disease in a calf with cultures of this organism. Jones and Little (5) isolated a bacterium from cattle affected with "infectious ophthalmia," a disease that resembled keratitis with the exception that the cornea did not become cloudy with consistency. Their organism reproduced infectious ophthalmia. Farley (6) isolated several types of bacteria found in the eyes of keratitis cases but was unable to reproduce the disease in susceptible cattle with these bacteria. He found all common breeds of cattle susceptible to keratitis and stated that it probably existed in every section of the country where cattle were raised. Farley (6) also found that cattle keratitis was not transmitted to sheep and vice versa, and that filtrates prepared from eye secretions of active cases of the disease would not reproduce keratitis in susceptible cattle. Baldwin (7)

*Numbers in parentheses refer to "Literature Cited," page 15.

isolated a bacterium from diseased eyes of cattle that was apparently the same as that described by Allen (4) and by Jones and Little (5). He reproduced keratitis in 12 of 15 calves exposed with the organism *Hemophilus bovis*. Farley, Kliewer, Pearson, and Foote (8) could not reproduce keratitis in cattle by using cultures of *H. bovis*. They suggested that *H. bovis* was not the primary factor in the production of keratitis, but only a secondary invader along with other bacteria that have been isolated from both diseased and normal eyes.

Studies Under Way at the O.V.R.I.

Since Baldwin (7) definitely established that *Hemophilus bovis* was the etiological agent in cattle keratitis, an avenue of attack on this disease has been established. At the Oklahoma Veterinary Research Institute, the disease is being attacked from several angles.* Working facilities have been set up at the Oklahoma A. & M. College at Stillwater, and also at a field laboratory in Osage County, Oklahoma, where keratitis has been an economic problem for cattlemen for more than forty years. At both locations, equipment, personnel, and animals are available for experimental purposes.

One of the first problems was to establish the role of *H. bovis* in keratitis infections. A series of five experiments was set up at Stillwater and at the field laboratory in Osage County, near Pawhuska. Through the kindness of Dr. Baldwin, three cultures of *H. bovis* were obtained for use in these studies.

Experiment No. 1.—Five cows and four calves were exposed with 24-hour broth cultures of *H. bovis* to which was added 5 percent horse serum. The animals were held in screened, fly-proof stalls during the experiment. Exposures were made by dropping cultures of *H. bovis* over the surface of the cornea, under the eyelids, and beneath the *membrana nictitans* of both eyes in each animal. The exposures were continued at 24-hour intervals for 6 days. All exposed eyes were normal after three weeks. It was assumed that the cattle were naturally resistant, or that the experimental animals would not contract the disease because of the environmental conditions provided by indoor stalls free from sunlight. All nine animals therefore were checked for susceptibility to keratitis by subjecting them to infected eye secretions obtained from field cases. This material produced typical unilateral cases of keratitis in three of the calves. The exposures were made at the same intervals and in the same manner as with *H. bovis*. The disease developed three days after the exposures were started.

Experiment No. 2.—Six rabbits and six guinea pigs were each exposed with 24-hour cultures of *H. bovis* washed from blood agar slants. All animals were normal two weeks after the fifth exposure made at 24-hour intervals. Allen (4) could not reproduce keratitis in rabbits and guinea pigs. Farley (6) could not infect sheep, swine, guinea pigs nor rabbits with virulent eye secretions of cattle origin.

Experiment No. 3.—Twenty-four-hour cultures of *H. bovis* washed from the surface of blood agar with physiological saline solution were used to expose 10- and 12-day-old chick embryos. The embryos did not hatch when injections were made beneath the inner shell membrane. When injections were made on the surface of the inner shell membrane, the the emmbryos invariably hatched. Apparently there is a variation in the pathogenicity of *H. bovis* for chick embryos. In

* The work is at present supported entirely by funds provided through the Oklahoma Agricultural Experiment Station.

Chick Embryos Inoculated in Keratitis Culture Study.

Laboratory technician inoculating chick embryos with various bacterial cultures common to keratitis cases. The purposes of this type of study are to increase the virulency of cultures and produce a vaccine from this type of tissue should these cultures prove pathogenic for chick embryos.

additional studies, 24-hour cultures of *H. bovis* injected into the allantoic cavity have not interfered with hatching. Additional inoculation studies of this nature will be continued.

Experiment No. 34.—Fertile eggs that have been incubated from 9 to 12 days have been inoculated with 24 hour cultures of *H. bovis*, and with similar organisms that were isolated from diseased and normal eyes. Some inoculated embryos are hatched without interruption,

while others fail to hatch. Attempts to recover the inoculated micro-organisms from the allantoic cavity have not been successful. This type of study will be continued.

Experiment No. 4.—Since *H. bovis* could not be caused to produce keratitis in cattle held under laboratory conditions, an environment more favorable to development of the disease was provided at the field laboratory near Pawhuska. Twenty Hereford calves approximately six months of age were obtained from herds where keratitis had not appeared the year before. These calves were divided into two lots of ten each. Each group was exposed with cultures at 24- and 48-hour intervals until six exposures had been made. All exposed calves were normal after two and three weeks. All 20 calves were then exposed with known virulent eye secretions obtained from field cases. Five of the 20 exposed calves developed keratitis.

Experiment No. 5.—Since the original laboratory cultures of *H. bovis* had not produced keratitis, fresh cultures of this organism were isolated from field cases of the disease and were used to expose susceptible cattle. Five calves held under range conditions and exposed with the *H. bovis* cultures would not develop keratitis even though numerous exposures were made, using 24-hour cultures in each case.

Summary of the Experiments.—Eight of the 34 head of cattle used in these experiments proved susceptible to keratitis when exposed with virulent eye secretions of field origin. It is possible that a greater percentage of these cattle that resisted *H. bovis* cultures would have developed keratitis following exposures with virulent secretions from field cases if inclement weather had not terminated this part of the experiment.

Plans for Future Research

Laboratory and field studies have indicated that keratitis is a local infection confined to the eye, and that immunity results from active or chronic infection. Vaccines and filtrates will be prepared and administered to the ocular tissue intradermally, and subcutaneously into the cornea, sclera, and conjunctiva, in an effort to produce immunity in this manner.

Efforts to isolate the causative agent from diseased and normal eyes will be continued. Vitamins will be administered to susceptible calves as a possible means of preventing the disease. However, the causative agent must be determined before a reliable and effective immunizing agent can be developed.

Pathology

The authors observed that the lesions of keratitis depend upon whether the disease is mild, acute or chronic.

Conjunctivitis appears in conjunction with inflammation of the cornea. When the diseased animal is examined early in beginning infection, a white spot may be seen just below the pupil. The cornea becomes pink to white, depending upon the amount of leucocytic infiltration. There is a wide variation among individual animals in the amount and rapidity of infiltration of the cornea. A small raised area may appear on the cornea, usually near and below the pupil. This area may be rapidly resorbed, or it may break and form an ulcer. The ulcer is usually saucer shaped, and its walls may project above the general surface of the cornea. There is a rapid infiltration of white cells which causes a grey zone of infiltration. The ulcer may spread in

breadth and depth and eventually lead to perforation and pyogenic infection of the anterior chamber. If Bowman's membrane is destroyed, there is permanent opacity and impairment of vision. If the epithelium alone is affected, the cornea may clear without opacity.

The small raised area of the cornea suggests the possibility of pressure from the anterior eye chamber, but this is not the case. The raised area involves only the upper layers of the cornea, and in some cases is rapidly resorbed without forming an ulcer. When an ulcer breaks through the cornea and the aqueous escapes, the iris and lens are driven forward, which may cause rupture of the suspensory ligament and expulsion of the lens. Hypopyon due to pyogenic infection is commonly encountered in the bovine with perforation of the cornea.

Isolation of Bacteria From Diseased and Normal Eyes

H. bovis, Escherichia coli, Staphylococcus, aureus, St. albus, and occasionally streptococci have been isolated from the diseased eye. Recently an organism which resembles *H. bovis* has been isolated from normal calves. This type of study will be continued until the causative agent is determined.

Treatment

These studies suggest that the cause of keratitis has not been established. Until the etiological factor is determined, it will be necessary to treat the condition symptomatically. It is necessary to isolate infected cattle and place them in darkened stalls during treatment. It has been noted that acute and chronic cases make a recovery without medicinal treatment when isolated by placing in darkened stalls free from sunlight, wind, and dust. It is not practical to treat this type of animal while it remains in the herd.

Sulfa-urea powder dusted over the surface of the eye and conjunctiva has shown encouraging results. Sulfathiazole powder has also proved very effective. Evidence of the effectiveness of these drugs as bacteriacides is seen in the difficulty of isolating bacteria commonly found in eye secretions of diseased calves for three to five days following treatment. Penicillin has been used as a local application to the diseased eye and in intramuscular injection. Its effectiveness cannot be determined until additional cases have been treated. Additional drugs will be used on diseased calves during summer months when environmental conditions cause the greatest number of acute and chronic cases. Medicinal treatment will have to be effective under range conditions if it is to be considered practical.

Conclusion

From observations in the course of the experiments reported above and previous work by Farley (6), and by Farley, Kliewer, Pearson, and Foote (8), it appears likely that *H. bovis* is not the primary factor in the production of keratitis in Oklahoma cattle, but only a secondary invader along with other bacteria that have been isolated previously from diseased and normal eyes. However, additional studies will be made before *H. bovis* is entirely eliminated as a possible etiological factor.

Summary

1. Keratitis or "pinkeye" has been recognized as an infectious disease in cattle for at least 70 years.

2. The cause of the disease has not been definitely established.

3. It has been found by cross-infection studies that cattle cannot be infected with sheep keratitis and that sheep cannot be caused to develop keratitis of cattle origin.

4. Keratitis is known to exist in three forms—(1) mild, (2) acute, and (3) chronic. The pathological lesions depend upon the type of infection present.

5. Keratitis is readily transmitted from diseased to susceptible cattle when in close contact under range and barn lot conditions.

6. Thirty-four head of cattle were used in an experiment to determine the part that *Hemophilus bovis* has in keratitis infection. All exposed cattle remained free from keratitis infection. Later when these animals were exposed with infected eye secretions from field cases, eight head developed typical cases of the disease.

7. *Hemophilus bovis, Staphylococcus aureus, St. albus, Escherichia coli,* and occasionally streptococci are isolated from cattle affected with the disease.

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The Oklahoma Veterinary Research Institute

HERMAN FARLEY, Executive Director

The Oklahoma Veterinary Research Institute was created by the Board of Regents of the Oklahoma A. & M. College July 1, 1945, in conformity with an Act of the 13th Legislature of the State of Oklahoma providing for research work at the College in animal disease control.

The Institute works in close cooperation with the Oklahoma Agricultural Experiment Station in conducting studies of the various livestock diseases of Oklahoma.

Livestock diseases are investigated in the order of their importance. Research studies are directed at cause, economic importance, and the best means of control.

The Institute keeps contact with other State and Federal disease control agencies that are studying diseases common to Oklahoma livestock in order to further strengthen the disease control program in this state.

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