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D. E. SALMON, D. V. M., Chief of Bureau.

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TAKOSIS, A CONTAGIOUS DISEASE OF GOATS.

A PRELIMINARY REPORT ON ITS NATURE,
CAUSE, AND PREVENTION.

BY

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., March 2, 1903.

SIR: I have the honor to submit herewith a manuscript on "Takosis, a contagious disease of goats: A preliminary report on its nature, cause, and prevention," by Dr. John R. Mohler and Dr. Henry J. Washburn, chief and acting assistant chief, respectively, of the Pathological Division of this Bureau.

During the fall and winter of the past year reports of a chronic, highly fatal disease, which seemed to threaten the Angora goat industry in certain districts, reached the Bureau from several different States; and as the symptoms and postmortem lesions were entirely unlike any of those accompanying the known diseases which affect this species of animals, it was decided to investigate thoroughly the nature of the disease in question and, if possible, to determine the cause of the affection. Laboratory work soon resulted in bringing to light a micrococcus (*Micrococcus caprinus*) in the blood of the heart, lungs, and spleen, which experiments proved to be the cause of the disease. Filtrates were made and a series of experiments undertaken with the purpose in view of securing a preventive, and possibly a cure, of the disease. The paper submitted herewith shows that these efforts met with some success. The work so far done is fully described in this paper, and suggestions for preventing the disease are offered. It is believed that all this will be useful to the industry which has so recently received such widespread attention, and I therefore recommend the publication of this manuscript as Bulletin No. 45 of this Bureau.

Respectfully,

D. E. SALMON, *Chief of Bureau.*

Hon. JAMES WILSON, *Secretary.*

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TAKOSIS, A CONTAGIOUS DISEASE OF GOATS: A PRELIMINARY REPORT ON ITS NATURE, CAUSE, AND PREVENTION.

By JOHN R. MOHLER, V. M. D.,

Chief of Pathological Division, Bureau of Animal Industry,

AND

HENRY J. WASHBURN, D. V. S.,

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PRELIMINARY REMARKS.

It will surprise many readers to learn that there exists a disease of any kind sufficiently virulent to kill a goat. As popularly regarded, this animal haunts the backyards and alleys in the suburban districts of our cities, where he picks up various articles of sustenance which would prove fatal if consumed by any other species of animal. Kept under these conditions, he usually presents such a cheerful and healthy appearance that he would at once be pronounced able to combat successfully anything that should come his way, even an infectious disease.

While admitting that the common goat (*Capra hircus*) is susceptible to comparatively few ailments, it will be shown by the following article that the Angora, after many generations of careful breeding and selection under favorable conditions, has developed a perceptible retrogradation in vitality and power of resistance against disease and has been seriously and fatally affected in many sections of the country by a disease not accredited to its prototype. During the fall and winter of the past year, reports of a chronic, highly fatal contagious disease, which seemed to threaten the Angora goat industry in certain districts, reached this Bureau from several different States; and, as the symptoms and postmortem lesions described in the letters were entirely unlike any of those accompanying the known diseases which affect this species of animals, arrangements were made to secure the viscera of an animal that had died after showing characteristic symptoms of the disease in question, in order to investigate the nature, and, if possible, the cause of the affection. As a result, the entire viscera, including the head and intestinal canal of a goat that succumbed to the disease, was received in good condition from Pennsylvania during December, 1901.

The inoculated culture media and cover-glass preparations made from the heart's blood, lungs, and spleen showed a small micrococcus arranged in the form of a diplococcus, and occasionally in tetrads or short chains. Two other organisms were obtained from the liver and lungs—one a large spore-bearing rod and the other a motile, peptonizing bacillus; but, after a bacteriological examination and inoculation tests, they were shown to be obvious contaminations, the result of postmortem invasion. A similar study of the micrococcus isolated from the heart's blood revealed its pathogenic properties to mice and guinea pigs, and it was thereupon determined to make a more extended investigation of the disease. Shortly after, one of the writers was enabled to visit a large flock of Angora goats, among which the disease was prevalent, with deaths occurring daily, and it is principally from the information acquired from an investigation of the disease in this outbreak that the following article has been prepared.

NAME OF DISEASE.

Takosis.—It is with considerable hesitation that a specific designation for the disease in question is suggested at this time, and although generally the coinage of names is to be avoided, still it seems essential and preeminently of importance to individualize this affection by means of a descriptive term. For this purpose the name *Takosis* is proposed. It is derived from the Greek *τῆκω*, meaning to waste, to cause to waste away, and is thought sufficiently descriptive and accurate to meet the desired requirements.

HISTORY OF OUTBREAK.

On arriving at the farm where the Angora goats were kept, it was learned from the owner that goats had been maintained on the premises for several years, but the majority of the flock had been purchased in Texas six weeks before the outbreak. The disease had commenced its ravages in November, when the animals had been on brush land in the mountains. Laurel poisoning was suspected, as several goats had died from this cause during the previous summer, but on closer observation this opinion was disregarded, not only on account of the different symptoms manifested, but also from the chronic course of the disease. The general weakness, loss of flesh, and extreme debility of the animals then suggested intestinal parasites as the cause, and worm powders were administered for a period sufficiently long to obtain results but without success. It was then thought desirable to change the pasture, and accordingly the goats were brought down from the mountains to the farm, where they were stable-fed. The majority were placed on the ground floor of a large hillside barn in various-sized pens to accommodate the several bunches into which the animals had been graded.

The remainder were allowed the freedom of the yard and hillside and were stabled on the barn floor proper between two haymows. Feeding troughs and mangers had been erected, and this provision was in every way satisfactory for the purpose for which it was designed. The barn, pens, and yards in which the animals were kept appeared to be in good sanitary condition and well adapted to the sheltering of goats. The feed consisted of corn, oats, and hay in ample quantities and in proper proportion, and the goats at all times took readily to this diet, even up to the time of death. In fact, it was a curious circumstance to observe, on postmortem examination of a large proportion of these animals, that the stomachs were filled with recently partaken food. And the goats could be seen eating hay sometimes with evident relish, at other times in a listless manner, when their vitality was so reduced as to make standing impossible. Despite the change from the mountain pasture, including an entire change of surroundings as well as diet, deaths continued with alarming frequency, and the services of the Bureau were solicited in combating the affection.

The continuance of the fatalities after a complete change of diet and shelter, the regularity of the course of the disease, the apparent similarity of the symptoms in all the affected animals as well as the evident spread of the affection from one animal to another, led the owner to be strongly suspicious that he was dealing with a contagious disease, and he therefore constructed a pen in a corner of the basement wherein all the affected goats were placed. This proved to be a step in the right direction, but the disease became so prevalent that an additional pen was brought into service. As no endeavor had been made to separate the latter hospital from the remaining pens, the results were not so beneficial as they might have been had this pen been entirely isolated, as was the original hospital. As it was, the larger unaffected does and bucks were able to hurdle the fence and thus carry the infectious principle back to the healthy goats. This was at once brought to the notice of the owner, and steps were immediately taken to keep the healthy animals out of the infected pen as well as to isolate more thoroughly the inclosed goats by securely boarding up these quarters. This method of segregating the diseased animals, together with the disinfecting measures adopted, probably resulted in confining the ravages of the affection to a minimum.

SYMPTOMS.

The disease presents many of the symptoms usually accompanying a parasitic invasion and is characterized by great emaciation and weakness, with symptoms of diarrhea and pneumonia. In the early stages of the affection there is usually little to indicate that anything is seriously amiss with the animal. The first observable symptom mani-

fested is the listless and languid appearance of the animal, evidenced by its lagging behind the flock, and is usually accompanied by a drooping of the ears and a drowsy appearance of the eyes. The pulse is slow and feeble and the temperature is elevated slightly at first, but becomes subnormal a few days before death. The highest temperature observed in the natural disease was 104.1° , and the lowest, in a prostrated animal a few hours before death, registered 99.7° F. Snuffling of the nose, as in a case of coryza, with occasional coughing is sometimes in evidence.

As the disease advances the animal moves about in a desultory manner, with back arched, neck drawn down toward the sternum, and with a staggering gait. Rumination is seldom impaired. The appetite, while not so vigorous, is still present, though capricious, and the affected animal shows plainly that the ravages of the disease are rapidly overcoming the restorative elements derived from the food. The fleece is usually of good growth and presents a surprisingly thrifty appearance when the condition of the animal is taken into consideration. All the exposed mucous membranes appear pale and the respirations are accelerated and labored. The goats finally become so weak that they are readily knocked down and trampled upon by their fellows. If picked up they may move off slowly and eat a little, but within a few hours are down again, and in this way linger for several days, shrinking to about half their natural weight, and occasionally bleating or groaning, with head bent around on the side or drawn down to the sternum. A fluid discharge from the bowels of a very offensive odor is usually observed in the last few days of life, but this symptom is not constant.

COURSE AND SUSCEPTIBILITY.

This disease may assume a subacute or chronic type, usually the latter. According to our own observations, the animal dies of inanition in from eight days to six or eight weeks. Several owners have reported deaths after only two or three days of illness, but the goats doubtless had been affected for a longer period, although not noticed on account of their mingling in the flock. It is the consensus of opinion among the breeders interviewed that many of the animals succeeded in living for weeks, but gradually became weaker and more debilitated, finally dying in a comatose condition. In no instance have we observed or heard of the natural recovery of an animal after once the symptoms of takosis were noticed.

The younger goats seemed to be the most susceptible to the disease, although the old animals were by no means immune. The does, wethers, and also the bucks became affected, and for a period of almost two months (December and January) newly diseased goats varying in number to as many as 11 were removed to the hospital daily on the

Pennsylvania farm where the disease was investigated. Owing to the preponderance of does at this place, it appeared that the affection was most virulent for them, but this fact has not been sustained by reports subsequently received from other sections.

PATHOLOGICAL ANATOMY.

As already indicated, the general appearance of the carcass simulates that produced by a wasting disease. The visible mucous membranes are pale and anemic, while the fleece, which appears somewhat dry and lusterless, furnishes a shroud for the extremely emaciated condition that becomes plainly perceptible on skinning. This masking quality of the hair prevents an accurate estimate of the condition of the animal by the eye alone, and necessitates handling of the individual to appreciate to the full extent the inroads made by the affection. The same anemic condition of the subcutaneous and muscular tissues is observed on eviscerating the carcasses. The lungs in most cases are the seat of a peculiar diversified inflammation, never of a remarkable extent. The external appearance of these organs is at times mottled, caused by a few congested areas, several patches of an iron-gray color similar to areas of pneumonia during the process of absorption, and normal tissue. On section through the reddened patches, a frothy mucus may exude from the bronchioles, and in one case numerous punctiform hemorrhages were observed on the sides of the incision. This tissue, while not so buoyant as a normal portion would be, nevertheless floats when placed in water.

The heart in all cases is pale and dull, its tissue soft and flabby, while inflamed areas, more or less penetrating, are present at times on the epicardium about the auricular appendages, and at other times on the endocardium, especially that lining the ventricles. These hemorrhagic patches consist of either pure extravasated blood or blood mixed with serum, which gives them a more diffuse appearance and a gelatinous consistence. The pericardium is slightly thickened, and usually contains a small increase of fluid tinged with blood. The liver usually appears normal, although the gall bladder is frequently distended with pale-yellow watery bile. The kidneys are anemic and softened. The cortex appears slightly thicker and paler than normal, and contrasts strongly with the darker pyramids. The capsule strips off easily from the parenchyma of the organ. In one instance several pale areas simulating anemic infarcts were observed under the capsule extending into the cortex, which probably resulted from the compression of the capillaries by the swollen parenchymatous cells. The presence of albumin in the urine was detected by the nitric-acid test. The spleen appears atrophied and indurated, and on section the fibrous tissue far exceeds the splenic pulp. Attachments by fibrous adhesions may fix the spleen to the diaphragm or the neighboring organs. The

intestines may contain normal fecal matter or semifluid feces of a disagreeable odor. The surface of the mucous membrane is at times covered with a slimy mucus or plastic exudate, and the appearance is that of a chronic catarrh associated with necrosis of the mucosa. The brain and spinal cord of four cases were examined, but without discovering any apparent alterations. As an illustration of the ravages of this disease, the following brief notes are recorded upon two Angora goats which were sent from the same flock to the laboratory in order that work previously done and facts already established might be confirmed.

The larger of these was a female, one year old, greatly emaciated, and was at no time after its arrival at the laboratory able to stand alone, even when lifted up and placed on its feet. It was still able and willing to eat and drink, but it showed plainly that the ravages of the disease were rapidly getting the best of the reconstructive forces. The fleece was of good length, and appeared more glossy than that naturally found on animals so seriously emaciated. All of its exposed mucous membranes were pale. Temperature subnormal, pulse imperceptible, and heart's action feeble and irregular. Occasional bleating was heard, and the goat seemed in great distress. Because of the helpless condition of this animal it was killed the second day after its arrival, and at the autopsy the following conditions were noted:

Muscular tissue pale and anemic; lymph glands enlarged, but of normal color; the superficial inguinal glands were especially noticeable in regard to this condition. The lungs were affected throughout with a finely diversified pneumonia. There were three small areas (0.5 cm. to 2 cm. in diameter) of complete hepatization irregularly located near the surface of the left lung, while the remaining portions of both lungs were grayish red in color. The pleura showed no lesion. The heart muscle was pale, and directly beneath the epicardium were a number of dark hemorrhagic areas which ranged in size from a pin head to a large bean.

The pericardial sac contained from 250 to 300 c. c. of slightly reddened nonviscid fluid. Liver apparently normal. Spleen shrunken and pale. The kidneys appeared anemic and somewhat flabby. The bladder contained about 30 c. c. of albuminous urine. The small intestines were inflamed and their internal surface was covered, wherever the inflammation existed, with a slimy, malodorous deposit. The stomachs and large intestines were normal, as were also the brain and spinal cord. The general appearance of the affected animal would lead one to suspect a verminous affection of the alimentary tract. The emaciated, anemic condition of the animal, as well as the persistent appetite associated with diarrhea, would strengthen such an opinion. For this reason a careful examination of the stomachs and intestines was made. The only result, however, was the discovery of three

specimens of the comparatively harmless *Cysticercus tenuicollis*, which were attached to the external surface of the rumen. There was no trace of animal parasites to be found in the stomachs, intestines, or other organs.

Cultures made from the heart, lungs, spleen, liver, and mediastinal lymph gland proved positive, and in most of these instances the micrococcus was grown at once in pure culture.

The smaller of the two goats received at the laboratory during the latter part of March was a wether about one year of age. It was much emaciated but still active on its arrival. Its appetite was unimpaired. Physical examination made on the day previous to its death showed a temperature of 102.5° F.; respiration, 32; pulse, 112, irregular and somewhat fluttering. The exposed mucous membranes were pale and the eyes dull and lusterless.

This animal died on the third day after its arrival at the laboratory. At the postmortem examination there was found to be general emaciation of the muscular tissues, which appeared whitened and bloodless. About 200 c. c. of fluid was present in the pericardial sac. It was reddish, thin, and appeared like greatly diluted blood. The lungs floated in water, but presented the same grayish red appearance that has already been noted in the lungs of its mate. The spleen was small, pale, and firm. The kidneys appeared swollen and anemic. The bladder was empty. The liver showed no lesions. The mucosa of the abomasum was slightly congested. The intestines were empty throughout, and appeared but moderately inflamed in the region of the duodenum and jejunum. The rumen contained a large quantity of undigested food and was in a normal condition. The brain and spinal cord presented an equally healthful appearance. Search for animal parasites was without result, although the visceral organs were carefully scrutinized.

Positive cultures were obtained from the pericardial and peritoneal fluids and from the liver and lungs.

BACTERIOLOGY.

During the visit to the affected flock, several goats were slaughtered in various stages of the disease and tubes of agar media (on account of their ease of transportation) were inoculated from the various organs and heart's blood as well as cover-glass preparations obtained from the juices of these tissues. Subsequent examination of the cultures and slides showed the presence of a micrococcus, usually arranged in the form of a diplococcus, which was found to be in pure cultures from the heart's blood, spleen, kidneys, and pericardial fluid, and essentially so in the tubes inoculated from the other organs. Inoculations made from the spinal cord were negative. Identical organisms have since been obtained from Angora goats affected with the disease from several

different localities and their identity proved by cultural examination and inoculation tests. Various other micrococci to which the one under consideration bears a resemblance were carefully compared, but we have not been able to identify the latter with any of the previously described organisms, although it presents in a parallel series of cultures many characteristics in common with the *Staphylococcus pyogenes albus*. Owing to the scarcity of any preeminently conspicuous lesion in the affected goats, and to the absence of any typical morphologic or cultural characteristic of the micrococcus, it was thought desirable to derive its name from its host, especially as it did not appear to be pathogenic for pigs, dogs, and chickens which fed upon the diseased carcasses on one of the infected premises, or for horses, cattle, and sheep that were quartered in an adjoining portion of the same stable. Therefore the name *Micrococcus caprinus* sp. nov. is suggested.

MORPHOLOGY.

The specific organism of takosis appears in fresh bouillon cultures as a spherical or oval micrococcus with a diameter of 0.8 to 1 μ . In these cultures it is single or in chains of two, three, or four elements, but most frequently in pairs, as diplococci (Pl. I, fig. 1), with a diameter transverse to the axis of the chain greater than the longitudinal diameter. There is quite a variation in the size of the cocci, probably due to the increase in the size of the organism preparatory to the act of fission. As the cultures become older the cocci develop a stronger tendency to form chains, and after remaining in the incubator at 37° C. for three or more days chains of four to six elements are at times observed, as are also irregular clumps of cells which collect in masses of varying sizes. When they assume this grouping tendency no oval forms are to be found and each of the organisms is strictly spherical in outline. In the tissues they are frequently seen to deviate from the spherical and assume somewhat of a lancet shape, with the pointed extremities in apposition. This same form has been met in samples of blood freshly drawn from the ear of an affected goat. The elements forming pairs are frequently very unequal in size and are not always of uniform shape. (Pl. II, fig. 1.) They are seen to possess the ability of executing strong Brownian movements, but make no progress across the field of the microscope. No capsule has been observed surrounding these micrococci either in the blood or when obtained from cultures, nor have spores, vacuoles, or crystals been seen. The organism stains indistinctly and with difficulty with Loeffler's methylene blue and the standard aqueous aniline dyes, with the exception of gentian violet, but carbol-fuchsin and Gram's and Gram-Weigert's stains give clear uniform coloration to the cells.

BIOLOGY.

The organism develops as an aerobe, but it also supports an active growth when deprived of oxygen, and is, therefore, a facultative anaerobe. It grows both on solid and in liquid culture media with the usual degree of alkalinity, but also multiplies in those that give an acid reaction of +1.5 phenolphthalein.

A temperature of 37° C. is most favorable for its development, but it will also grow at room temperature. In the latter case the growth is more tardy and not so profuse.

CULTURAL CHARACTERISTICS.—*Bouillon*.—In neutral (phenolphthalein) peptonized beef broth a slight uniform cloudiness is caused by the growth of the organism within ten hours at 37° C. This condition increases until, after twenty-four hours at the above temperature, the cloudiness has become quite marked and uniform. At this time a deposit may be noticed beginning to gather on the bottom of the tube. In three days this sediment has increased in volume and the turbidity of the supernatant fluid has been lost. The deposit is pearl gray in color, and on agitating the tube it rises slowly in the shape of a twisted, ropy, coherent mass. A delicate marginal ring on the side of the tube is usually produced. No pellicle is formed nor can any characteristic odor be detected. The reaction of bouillon in which this organism has been growing for five days becomes decidedly acid, +1.7 phenolphthalein, and continues to increase in acidity subsequently.

Agar.—Growth upon the surface of slant agar occurs in twenty-four hours in the form of a white, glistening granular streak composed of numerous confluent colonies. This narrow line of growth becomes more extensive and reaches its maximum width on the third or fourth day, when it shows a ceraceous, at times granular, surface, with irregular wavy margins. In stab cultures the growth appears within 24 hours as profuse, small, grayish white, closely aggregated globules, so densely packed together as to give an irregular nodulose appearance macroscopically along the entire length of the line of puncture. The only colony which develops at the point of entrance of the needle is at first pearly white, but after twenty-four hours it assumes a grayish color in the center, with a lighter periphery of an equal breadth. It has a slightly granular center, a regular border, and is from 8 to 10 mm. in diameter. The surface growth on agar plates appears as smooth white, flatly convex, ceraceous colonies, about 1.5 mm. in diameter, with entire borders. By reflected light these surface colonies appear homogeneous, but, observed by transmitted light, they present a white center and pearly margin. The submerged colonies develop as light brownish foci with regular outlines. They may be round or lentil shaped, but are always minute in

size. No characteristic differences in growth of this organism have been observed when sown on glycerin-agar or on serum-gelatin-agar.

Gelatin.—In this medium the growth is slower, evidence of fertility not appearing until forty-eight hours. In stab cultures the line of puncture is occupied by numerous nodulose milk-white colonies that have apparently coalesced, and which extend to the extreme end of the track. When examined by the aid of the hand lens, they appear as closely aggregated individual colonies, with regular outlines and presenting a beaded appearance. These colonies are more minute than in agar, and the growth that appears on the surface, though similar in consistence, is likewise thinner and less profuse than parallel agar colonies. The organism will not liquefy gelatin until several generations have been grown upon artificial media. After a number of sub-inoculations the peptonizing of the gelatin commences on the seventh or eighth day, and later as early as the fourth or fifth day, when the surface growth is seen to sink, following which liquefaction is very rapid, and may reach the bottom of the tube in forty-eight hours, leaving a funnel-like track in its wake. The adjoining medium is then attacked, and within ten days after inoculation the contents become fluid, with a white pellicle on the surface. The appearance of the gelatin-plate colonies which develop on the second or third day is probably of a more milk-white color, and thinner and slightly smaller than those in agar, but otherwise are similar. Liquefaction does not commence until the fourth or fifth day, sometimes the seventh day, and this occurs only after continued subinoculations.

Blood serum.—The organism grows steadily on coagulated blood serum. The colonies coalesce, forming a narrow, compact line of whitish color, with edges slightly elevated above the level of the body of the growth. The water of condensation at the base of the serum slant is clouded and contains a white sediment. As the cultures become older, or after seven or eight days' growth, they assume a brownish color. In this work the serum used was obtained from the blood of a dog and was freshly prepared immediately preceding its use.

Potato.—When a loopful of a vigorous bouillon culture is sown upon the surface of potato, the growth that ensues along the line of inoculation inside of thirty-six hours is slight, moist, and glistening. In forty-eight hours it appears granular and rather feeble, like a cluster of dewdrops. Growth ceases by the third day, at which time the granular surface, with the aid of the hand lens, appears to be made up of minute individual raised colonies of a ceraceous nature that have become confluent.

Milk.—Growth develops rapidly when tubes of this medium are inoculated, but the only manifestation of the development during the first twenty-four hours is a slight deposit observed at the bottom of the tube. No change occurs in the appearance of the milk until the

DESCRIPTION OF PLATE I.

FIG. 1. Twenty-four-hours'-old bouillon culture of *Micrococcus caprinus* stained with gentian violet. Camera lucida drawing made at stage level with Zeiss No. 4 compensating ocular and 2 mm. oil immersion.

FIG. 2. Forty-eight-hours'-old milk culture stained with gentian violet. Camera lucida drawing made at stage level with Zeiss No. 4 compensating ocular and 2 mm. oil immersion.

DESCRIPTION OF PLATE II.

FIG. 1. Cover-glass preparation from lung of goat No. 2, dead as a result of natural infection. Stained with gentian violet. Camera lucida drawing made at stage level with Zeiss No. 4 compensating ocular and 2 mm. oil immersion.

FIG. 2. Cover-glass preparation of blood from posterior auricular vein of Angora goat No. 23, removed aseptically seven days before death from takosis. Stained by Gram's method, followed with eosin. Drawing with camera lucida at stage level with No. 6 compensating ocular and 2 mm. oil immersion and increased six diameters.

Fig. I.

Fig. II.

Haines, del.

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MICROCOCOCCUS CAPRINUS FROM
(1) BOUILLON AND (2) MILK CULTURE MEDIA

Fig. I.

Fig. II.

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MICROCOCCUS CAPRINUS FROM THE
(1) LUNG AND (2) BLOOD OF ANGORA GOATS

ANGORA GOATS NOS. 31 AND 32 AFFECTED WITH TAKOSIS; PHOTOGRAPHED 24 HOURS BEFORE DEATH.

ANGORA GOAT NO. 27, SIX DAYS BEFORE DEATH FROM TAKOSIS.

FIG. 1.—ANGORA GOAT FROM MARYLAND FLOCK; PHOTOGRAPHED THREE DAYS BEFORE DEATH.

FIG. 2.—SAME AS FIG. 1. POSITION ASSUMED AFTER EXHAUSTIVE EFFORTS TO REGAIN ITS FEET.

third or fourth day, when the medium becomes firmly coagulated in one mass. Within the following twenty-four hours the coagulum becomes partially peptonized and a transparent odorless whey is collected at one side of the slightly inclined tube, or at the top, if the tube is kept in a vertical position. This separation has been observed in various instances to commence from the fourth to the eighth day, and is usually completed after twenty-four to thirty-six hours, at which time the solid curd takes up from one-third to one-half of the volume of the medium, and either adheres to one side or occupies the bottom of the tube.

Litmus milk is changed to a delicate pink on the third day, owing to the development of acids, but no coagulum occurs until the fourth or fifth day, when a similar separation of the curd and whey takes place, as in plain milk with a greater tendency of the coagulum to form flocculi.

Fermentative action.^a—The growth in bouillon, to which 1 per cent lactose, dextrose, and saccharose has been added, is rapid, especially with saccharose, but without any formation of gas. Inside of twenty-four hours the bulb becomes uniformly turbid in all these fluids, with a slight sediment in the branch and the appearance of growth at the extreme bottom of the closed tube. A faint marginal ring, but no pellicle, is observed. After three or four days the closed branch is uniformly clouded throughout, and remains so until the partial gravitation of the suspended elements, which occurs in six or seven days. Lactose bouillon cultures develop 5.1 per cent acid in growing for five days at 37° C., while dextrose cultures produce 3.9 per cent and saccharose bouillon cultures 3.5 per cent acid in the same time and under the same conditions. In sixteen days these media gave, respectively, a reaction of 7.7 per cent, 5.5 per cent, and 10.1 per cent. After thirty days' development the production of acid in lactose, according to the phenolphthalein test, was 9.2 per cent, dextrose 6.2 per cent, and saccharose 11.8 per cent. The production of acids is constant in all media.

Indol.—Cultures that have grown in Dunham's solution for two, seven, ten, and thirty days, respectively, were tested for the presence of indol by the method of Kitasato. In each case the result was negative.

Phenol.—Bouillon cultures of ten days' development, when submitted to Weyl-Lewandowski's test for phenol, threw down a precipitate of fine crystals which by microscopic examination proved to be phenol. The distillate failed to show the reaction for indol.

Thermal death point.—Tubes containing 1 c. c. each of bouillon cultures of a twenty-four hours' growth were exposed to a temperature

^aThe titre of these media was 1 phenolphthalein.

of 50° C. for varying periods of time, and fresh tubes of bouillon inoculated from them immediately afterwards. By this means it was shown that the tube which remained in the bath for three hours and fifteen minutes produced growth, although it was slight and tardy and the germ was evidently attenuated, while all that were exposed for three hours and twenty minutes or longer remained sterile. At 58° C. growth fails to occur after an exposure of only ten minutes. At 62° C. the organism was killed in six minutes, while it resisted a temperature of 70° C. for three minutes.

Desiccation.—The results obtained by the desiccation of the germ for twelve hours in the incubator at 37° C., with its subsequent exposure to the diffuse light of the room for a period of nine days, were sufficient to prove that sterility is thus produced.

Temperature requirements.—As previously mentioned, this micrococcus develops profusely at incubator temperature, while at 20° to 22° C. the growth is more tardy and less profuse. The maximum temperature at which the organism would multiply was found to be between 45° and 46° C. No growth developed at 47° C.

Effect of low temperature.—Tubes that were placed in a freezing mixture twice daily and kept in the ice chest under these conditions for four days were subsequently incubated at 37° C., with the result that they became fertile in every instance.

Action of disinfectants.—When the organism was subjected for twenty-six minutes to a 1-2,000 solution of bichloride of mercury, no growth followed, but an exposure to a 1-1,000 solution proved fatal in thirty seconds. A 1 per cent solution of carbolic acid sufficed to prevent development only after an exposure of fifty-seven minutes, while a 2.5 per cent solution caused the death of the micrococcus in thirty seconds. Formalin, in the strength of a 2 per cent solution, required an exposure of thirty-one minutes to prevent the subsequent development of the organism. These disinfecting solutions were all used at room temperature (about 21° C.).

PATHOGENESIS.

In order to demonstrate the pathogenic properties of the *Micrococcus caprinus* and to establish its etiological significance in the disease in question, the following inoculation experiments were conducted upon white mice, white and brown rats, guinea pigs, rabbits, chickens, dogs, sheep, and goats.

EXPERIMENTS WITH MICE.

Subcutaneous.—On January 11 a white mouse was inoculated intramuscularly near the base of the tail with 0.1 c. c. of an original bouillon culture from the spleen of Angora goat No. 2. In a few days it became languid and soon developed a diarrhea which termi-

nated in death on the twelfth day. The postmortem showed the small intestines to be greatly darkened and inflamed. The lungs presented localized areas of congestion. The kidneys were enlarged and anemic and the spleen dark and swollen. The specific organism was recovered in pure culture from the lungs, heart, and spleen.

Intraabdominal.—The second mouse was inoculated intraabdominally on July 30 with 0.1 c. c. of a culture (sixth generation) which had been originally obtained from the lung of guinea pig No. 798 on February 2 and had been subjected in the meantime to repeated transplanting on slant agar. On August 2 the mouse was dull and stupid, with hair ruffled, and it remained crouching under the cotton in its cage the entire day. These conditions were very manifest on the following day, and on August 4 purging was established, which also continued on the 5th. The mouse was very languid and quiet on August 6 and 7, and died on August 8, nine days after the inoculation.

On postmortem the heart, liver, and lungs appeared normal. The intestines were inflamed and empty. The spleen was light in color and somewhat swollen. The glands of the lymphatic system, especially those of the throat and neck, were enlarged and congested.

Ingestion.—Mouse No. 3 was fed for four days, beginning July 30, upon bread that had been moistened with 8 c. c. of a bouillon culture of the same description as that used in the preceding test. On August 7 the mouse began purging, which continued until August 9, when it died. The autopsy showed that the lesions were confined to the digestive organs, the heart and lungs appearing normal. Cultures of the micrococcus were recovered from the heart, liver, and kidneys of the two last-mentioned mice.

EXPERIMENTS ON RATS.

Both the white and brown rats appear to be totally immune, although submitted to subcutaneous and intraabdominal inoculations with 0.5 c. c. of fresh virulent cultures. They evinced no apparent disturbance of any of their organic functions.

Feeding experiments were likewise accompanied with negative results.

EXPERIMENTS ON GUINEA PIGS.

Guinea pigs have proved susceptible in every inoculatory case, and the course of the disease evinced by these animals is very typical. They show gradual emaciation and wasting, with symptoms of pneumonia appearing a few days previous to death. Numerous cases developed enteritis with its consequent purging, but this condition was by no means constant. Convulsions, which so frequently attack rabbits during the latter stage of this disease, were not at any time observed in the guinea pig. The peculiar form of pneumonia already noted as appearing in the goat is seen to affect the guinea pig with

great regularity. The organism was readily recovered from the heart, lungs, liver, kidneys, and spleen; in fact, it was found to be distributed throughout the blood of the circulation. Examinations of the flocculent sediment occasionally found in the urine resulted negatively.

A few typical cases of the disease in guinea pigs as a result of various forms of inoculation may be briefly given as follows:

Subcutaneous.—On January 3 guinea pig No. 707 received subcutaneously 0.25 c. c. of a bouillon culture of twenty-four hours' growth from the spleen of goat No. 2. The animal soon began to give evidence of an insidious disturbance of its nutrition, which continued until January 26, when it died, having in the meantime gradually reached a condition of extreme emaciation. The organism was recovered from the lungs, heart, spleen, and mesenteric glands. The period of life following the subcutaneous inoculation of doses ranging from 0.25 to 0.5 c. c. varied from sixteen to twenty-three days, and averaged twenty and one-half days.

Intramuscular.—On January 3 guinea pig No. 710 received 0.25 c. c. of the same culture used in the test with No. 707, injected intramuscularly. Eight days later, or on January 11, the animal died.

Postmortem examination showed the carcass seriously emaciated. Liver and spleen enlarged, lungs congested, and the kidneys pale and softened.

Intramuscular inoculations of from 0.25 c. c. to 0.75 c. c. of a twenty-four hour bouillon culture resulted in the death of the guinea pigs in from eight to thirteen days, with an average of nine days.

Intraabdominal.—Guinea pig No. 801 was inoculated intraabdominally on January 20 with 0.75 c. c. of a bouillon culture from the spleen of goat No. 2. Nine days later the animal died and the postmortem examination disclosed the usual picture of a wasted carcass, occluded lungs, inflamed intestines, fatty degeneration of the liver, and anemic kidneys. The average period of life following an injection of 0.25 to 0.75 c. c. by this method was twelve days, although death occurred in some cases as early as the eighth and as late as the twentieth day.

Ingestion.—After being deprived of food for twenty-four hours, guinea pigs Nos. 1413 and 1417 were fed 40 c. c. of a twenty-four-hour bouillon culture soaked in bread crumbs. No deleterious results were observed as a result of this feeding experiment.

EXPERIMENTS ON RABBITS.

These animals possessed a certain degree of immunity, many of those used in the various tests remaining unaffected. Those that became ill showed a marked rise of temperature, which diminished slowly after reaching its crisis, and for twenty-four hours preceding death was subnormal. Diarrhea and wasting uniformly appeared, and the subject frequently died in convulsions or tetanic spasms.

Intraabdominal.—The intraabdominal inoculation of 1 c. c. of a bouillon culture produced death in twenty-five days. The postmortem examination showed the lungs to be normal, the heart pale and flabby, liver enlarged and hyperemic, with gall bladder greatly distended. Spleen shrunken and showed excess of fibrous tissue. Intestines contained much gas and a small amount of fluid ingesta. The mucosa of the small intestines presented a catarrhal inflammation. Pure cultures were obtained from these affected organs.

Intratracheal.—Rabbits Nos. 382 and 383 were injected intratracheally with 1.5 and 1 c. c. of a bouillon culture, which resulted in death on the twenty-ninth and twenty-second day, respectively. Rabbits Nos. 381 and 472, each receiving 0.5 c. c., remained unaffected. The postmortem examination of No. 382 showed the mucous membrane of the trachea to be inflamed in patches, especially along the anterior portion. Both lungs were hepatized in numerous localized areas. Heart flabby, liver dark, and gall bladder filled with watery bile. Spleen indurated and reduced in size. Intestines catarrhal and empty. Bladder distended with albuminous urine.

On postmortem examination of rabbit No. 383 the hide was found to be very tightly attached to the subcutaneous tissue and extremely dry. The pharynx and trachea were inflamed throughout. Cephalic lobes of both lungs hepatized. The auricles were distended and the heart muscle pale. Spleen shrunken. Kidneys dry and flabby. Liver dark in color, with distended gall bladder. Intestinal contents fluid.

Culture media inoculations were positive in both the above cases.

Intravenous.—Rabbit No. 219 was inoculated intravenously on January 3 with 0.5 c. c. of bouillon culture from spleen of goat No. 2. It remained unaffected.

On January 15 rabbit No. 233 received 1 c. c. of the second generation of a bouillon culture obtained from the spleen of goat No. 2. On January 23 it refused to eat and on the following day it died in tetanic spasms. Microscopic and cultural examinations demonstrated the presence of the *Micrococcus caprinus* in the heart, lungs, and liver.

Ingestion.—After twenty-four hours' abstinence from food, rabbit No. 728 received the organism mixed in its food for two consecutive days, commencing on April 17. The animal remained unaffected for a period of three months, at which time it was withdrawn from the experiment.

Rabbit No. 296 was subjected to the same feeding test on April 17. On May 7 the rabbit seemed partially paralyzed in hind limbs; had fallen away greatly in flesh, and was a mere skeleton. May 8, hind limbs fully paralyzed. May 11, died after a period of twenty-five days.

Postmortem examination showed the animal to be very anemic and

emaciated. Lungs appeared reddened and filled with blood. Heart normal. Liver enlarged and greatly darkened with the gall bladder distended with bile. Spleen showed an apparent atrophy and dryness of the splenic pulp. Kidneys of normal size but pale in color. Bladder greatly distended and filled with albuminous urine. It was attached at its fundus to the cecum by frail bands of fibrous tissue. The ileum was likewise adherent to the parietal peritoneum and to the liver. The stomach contained normal food, but its mucosa was covered with a thick glutinous mucus. The stomach wall appeared tender and was readily torn. Its pyloric end and the beginning of the duodenum was greatly thickened and the mucosa inflamed and convoluted. Inflammatory mucus could also be observed throughout the entire extent of the small intestines. Cover-glass preparations from the juices of the liver and lungs showed the presence of the specific organism.

EXPERIMENTS WITH CHICKENS.

The inoculation of fowls proved that the micrococcus possessed purgative properties for these birds, but in no case was the result fatal.

Intravenous injections of 1 c. c. and subcutaneous inoculations of 3 c. c. were made on four chickens, with uniform results. On the day following the inoculation the fowls become dull and listless. On the second day they refuse their food and are affected with diarrhea, which may persist for forty-eight hours, but in no case under our observation did it last longer. Recovery of normal condition is rapid after cessation of the purging.

It may also be mentioned at this time that the carcasses of the goats having died of takosis on a Pennsylvania farm were fed by the owner to his chickens and swine, but in neither case was any unfavorable result observed.

EXPERIMENTS WITH DOGS.

These animals, like rats, appear to be totally immune to the action of the organism. They were subjected to intravenous inoculations of 0.75 c. c. of a fresh bouillon culture, but without developing any untoward results.

EXPERIMENTS WITH SHEEP.

Sheep have proved nearly as resistant as dogs. Two animals received intravenously and subcutaneously 1 and 2 c. c., respectively, of a twenty-four-hour bouillon culture. In the case of each sheep there was a temporary rise of temperature following the inoculation, which lasted about twenty-four hours. These animals were kept under careful surveillance for thirty-eight days, and during that time no after effect from the action of the organism was noted.

In connection with this experience it should be recalled that a num-

ber of Shropshire sheep were in immediate contact with the goats on the Pennsylvania farm where the disease was first observed. In no case have sheep contracted the disease by such exposure.

EXPERIMENTS WITH GOATS.

Nicole and Refik Bey, when writing of an infectious disease which was decimating the flocks of goats near Constantinople, said that, although the disease spread rapidly from goat to goat when the sick were pastured with healthy animals, they had found goats in the laboratory to be very resistant to all attempts at artificial inoculation. The results in the present instance warrant us in fully indorsing their conclusion regarding the resistant nature of goats, especially the common goat, when subjected to similar conditions.

The first goat upon which inoculation tests were made was a large aged male that had spent much of his life in harness in the vicinity of this city. He received intravenously 2 c. c. of a three-day-old bouillon culture on April 14, when his temperature was 102° F. There was no sudden marked change, but after several days 103.2° F. was recorded. The fever gradually subsided until normal was reached. No evidence of any effect from the inoculation, other than this rise of temperature, was noticed. On June 7 he was reinoculated intra-abdominally with 5 c. c. of bouillon culture obtained from the liver of a guinea pig which had died but three days previously. His temperature just previous to inoculation was 102° F., but it immediately rose until it reached 104.6° F. on the evening of the same day. On the following day 104° F. was recorded, 103.1° F. on the third day, and normal on the fourth. No indication of any other disturbance as a result of the inoculation was noticed at any time.

An aged female goat that had been previously kept in the city as a milk producer was inoculated intravenously with 5 c. c. of a bouillon culture (fourth generation) on June 20. Temperature at time of inoculation was 102° F. The first rise in temperature was noted on June 23, when 102.6° F. was recorded, with 103° F. on June 24. On the following day 103.4° F. was reached and the animal refused the greater part of its food. On June 26 inappetence continued and purging began, while the temperature dropped to 102.8° F. The following day, the seventh after inoculation, the patient was purging freely a quantity of slate-colored feces. Temperature, 102.2° F. On the 28th, although the excreta were still soft and whitish in color, there was no distress from diarrhea. The animal still refused food. On the following day, the ninth of the test, the appetite began to return, and the goat soon recovered its normal condition.

On July 10 goat No. 14, a small mature female, received intra-abdominally 4 c. c. of a bouillon culture obtained from the heart of a guinea pig. During the four days following the inoculation the goat

neither ate nor drank. The maximum temperature was reached on July 16, when it registered 103.8° F. On July 24 diarrhea, with whitish mucous discharge, developed, which persisted for seven days, during which period the patient's appetite was again greatly impaired and capricious. The condition and strength of the animal rapidly wasted away. She remained incubent much of the time, and when obliged to move walked with a staggering gait. Her illness was so serious at the crisis of the attack that her ultimate recovery was a matter of great surprise to those who were caring for her. Her convalescence was rapid as soon as the diarrhea was overcome, and she soon began to eat well and to make daily improvement in flesh and spirit.

Goat No. 15, a young native female, was fed 200 c. c. of a bouillon culture on July 23 and a like amount on the day following. Aside from a transitory rise in temperature of 1.4° F., there was no result apparent.

Another experiment was made on a grade Angora goat, No. 1741, the subject being a young female which received intraabdominally, on October 2, 1 c. c. of a bouillon culture from guinea pig No. 1140, which was inoculated with goat bouillon culture. Her temperature reached its highest elevation on October 8, when it registered 104.5° F., and no material change was noted until the decline developed about twenty-four hours before death. October 10 the subject became dull and inactive and diarrhea began to make itself manifest. On the following day violent purging had become established, the feces being thin, watery, and nearly white in color, the animal at this time appearing noticeably shrunken and weakened. On October 12 the purging still continued and the subject began to manifest extreme weakness. On the morning of the following day, the eleventh day of the test, the animal died. No indications of any respiratory disturbance were evidenced at any time during the course of the disease, although the lungs were found to be affected at autopsy. On post mortem examination the carcass showed great emaciation of the muscular tissues, which appeared whitened and bloodless. The mucous membranes were anemic. The heart was seen to be pale, with a few slight petechial hemorrhages beneath the epicardium around the superior border of the ventricles. Pulsations had stopped during diastole, leaving the ventricles filled with blood. The lungs showed a moderate attack of the characteristic pneumonia. The liver appeared darkened, in color, while the gall bladder was distended to the size of a man's fist. The fluid which caused this distension lacked the oily viscid characteristics of normal bile, but appeared like water of a greenish color.

The spleen of this animal was pale and shrunken to about one-half of its normal size. The kidneys were softened and anemic and the bladder contained albuminous urine. Rumens, reticulum, and omasum

were, with their contents, in normal condition, but the mucosa of the abomasum showed a slight congestion, and a mucoid exudate was found to cover its entire internal surface. No food was found in the fourth stomach, its contents consisting of liquid only. A like congestion and slimy exudate were seen to extend through the duodenum. The large intestines were bloodless and empty, but the lymphatic glands of this region appeared slightly hemorrhagic. The blood vessels of the brain were somewhat congested, while the spinal cord presented nothing abnormal.

At the beginning of this experiment the weight of the goat was 45 pounds. Weighed again immediately after death, it was shown that there had been a loss of $7\frac{1}{2}$ pounds during the course of the disease.

Pure cultures of the specific micrococcus were recovered from the tissues of this animal.

PRODUCTION OF TOXINS.

In order to ascertain if the micrococcus under consideration produced a toxin, a number of inoculation experiments were made both with the sterile filtrate of bouillon cultures and with the sterilized cultures.

The filtrates used in this experiment were obtained by growing a flask of bouillon culture for ten days at a temperature of 37° C. Afterwards the culture was filtered through a Chamberland filter (F), and, if proved sterile by media inoculations, the filtrate was then ready for use.

Four guinea pigs were used, each receiving the filtrate subcutaneously. No. 1151 received 1 c. c. of the filtrate February 25, but because of an accident it was necessary to remove the animal from the experiment before the test was completed. No. 1152 received 1.5 c. c. of the filtrate February 25, and seventeen days later, March 14, an inoculation of 0.5 c. c. of a virulent culture was injected. The guinea pig remained active and hearty, save for a temporary disturbance following the inoculation on February 25, until October 16, when it suddenly succumbed to an attack of pneumonia. The carcass was not emaciated, but, on the contrary, was well supplied with fat. Cultures made from the various organs failed to produce the *Micrococcus caprinus*.

No. 1153 received 2 c. c. of the filtrate on February 25, and seven days later 0.5 c. c. of a virulent culture, which was followed by a reinoculation of 0.5 c. c. of virulent culture ten days afterwards. Shortly after the application of the first inoculation of filtrate the animal was affected by dullness and loss of appetite, but after three days these symptoms disappeared, and the animal recovered its previous condition of perfect health, which it retained until October 18, when it died of enteric hemorrhage. The carcass of this animal was

well nourished and showed no traces of wasting or emaciation. The lungs contained numerous circumscribed pigment areas, the remains of former hemorrhagic infarcts. As two hundred and twenty-eight days had elapsed since the animal received its first inoculation with a virulent culture of the *Micrococcus caprinus*, it was, of course, impossible to establish an undisputable relation between the lesions of the lungs and the action of this germ, but it is not at all impossible that these ecchymosed areas were former centers of inflammation resulting from the inoculation of March 14. Cultures made from the organs of this guinea pig gave negative results.

No. 1154 was inoculated with 3 c. c. of filtrate on February 25, which was followed by a rise of temperature and slight indisposition. Seven days later 0.5 c. c. of a virulent culture was injected, and ten days subsequently 2 c. c. of the filtrate. The general appearance of this animal for six weeks following its inoculation with virulent culture showed nothing amiss, but during the latter days of April it became affected with lameness in all its feet. Fissures gradually developed on the plantar surface of each foot, and the inflammation later extended to the joints of the legs. This condition continued to become more aggravated until the animal died, on May 12. In addition to the lesions of the legs and feet, there was a slight dropsical effusion within the abdominal cavity at the time of holding the autopsy, but cultures obtained from the tissues failed to show the micrococcus under consideration.

The effect of heat upon the toxins was obtained by heating the filtrate for thirty minutes at 60° C. Four guinea pigs were then inoculated, respectively, with 1, 2, 3, and 4 c. c. of this material, at the same time that four others received the same quantity of the filtrate which had not been subjected to such heating. Three days later these eight animals, together with two control guinea pigs, were inoculated intra-abdominally with 0.5 c. c. of virulent culture. The four guinea pigs receiving, respectively, 1, 2, 3, and 4 c. c. of the heated filtrate died in twenty-one, sixteen, nine, and twelve days, respectively, after the injection of the virulent culture, while the check animals lived for nine and thirteen days. Three of those guinea pigs that received the unheated filtrate are at present writing in an apparently healthy condition, while guinea pig No. 2832, that was inoculated with 1 c. c. of the filtrate and three days later 0.5 c. c. of a virulent bouillon culture, died of typical takosis on the seventeenth day.

It appears from these experiments that the unheated filtrate possessed bactericidal properties and conferred limited power to prevent an attack of takosis, but when subjected to a temperature of 60° C. for thirty minutes its toxin was presumably destroyed, as no protective action was observed following its use.

In order to test further (see also remarks on treatment, p. 42) the immunizing effect produced by the administration of the toxins

in the filtrate, 5 c. c. of this fluid were injected subcutaneously on September 18 into each of four goats, two being affected with scours and greatly enfeebled, and two healthy animals, Nos. 1936 and 721. The first two died within forty-eight hours, as was expected, but the latter two are still healthy. The extent of immunity conferred by this filtrate was the subject of further consideration, and for this purpose goat No. 1936 alone was used. The animal was a young female Angora goat weighing 48 pounds and received intravenously, on October 2, 1 c. c. of a bouillon culture prepared from the heart of a guinea pig that had died from a culture of goat spleen. At that time her temperature was 102.4° F. An elevation was noted on October 6, when 103.5° was recorded; on the 8th, 104°; and on the 10th, 105.2°, at which time purging became established. On October 11 the animal refused food, was unwilling to stand, and was purging freely, the feces being very light in color and covered with mucus. October 12, still purging; feces nearly white; temperature 104.2°. October 14, feces firmer, but still white; temperature normal; weight, 44 pounds; appetite improving; circulation of extremities impaired to such an extent that they feel cold to the touch; normal conditions quickly returned after this time. After an interval of twenty-five days from the time of first injection another inoculation was made with 2 c. c. of a virulent culture intraabdominally, since this method has always shown more positive results. In this instance the goat became dull and languid, which conditions, however, quickly passed away, and her temperature never exceeded 102.4° F.

That the immunity was conferred by the 5 c. c. of filtrate received on September 18 must appear evident when taken in connection with the results obtained with the check animal, goat No. 1741 (see p. 24), which died eleven days after the inoculation with a similar culture. After one month had elapsed from the date of the complete recovery goat No. 1936 was bled aseptically, and the sterile serum procured for further experimentation. Five guinea pigs were inoculated, respectively, with 1, 1.5, 2, 2.5, and 3 c. c., and three days subsequently received 0.5, 0.25, 0.75, 0.50, and 0.30 c. c., respectively, of virulent culture, which killed the check guinea pig in eleven days after an intra-abdominal injection. At the present time three of these guinea pigs show no inconvenience as a result of the inoculation, while the third and fifth guinea pigs, that received 0.75 and 0.3 c. c. of the culture, died on the forty-first and thirty-ninth day, respectively, the latter with takosis and the former of an intercurrent disease.

It will be seen at once that the immunizing properties of blood serum obtained from an immune goat were not perfect in their action when applied to the guinea pigs in this test, although the protection of three of the animals (Nos. 1, 2, and 4) offers sufficient encouragement to warrant further investigation along this line. Had the pro-

tective powers of the serum been theoretically effective, the guinea pig that died with takosis (the fifth of the test group) would have been the last one of the number to show the effects of the disease, as it received the largest amount of the serum and one of the smallest amounts of the virulent culture. Comparison of the duration of the affection in the case of the guinea pig that died of takosis thirty-nine days after the virulent culture was applied, with its course of only eleven days in the animal used as a check, indicated further that the serum exerted some retarding action upon the advance of the disease in this animal. This same serum has been subjected to a practical test on twenty goats in a flock of two hundred and fifty in which the disease is now prevailing. The results of the above treatment can not be obtained in time for this publication. The test with blood serum as an immunizing agent against takosis is at present too incomplete to warrant any accurate estimate of its protective value, and, although the few experiments herein recorded show encouraging results, the immunity has not yet been proved sufficiently constant or reliable to justify at present a recommendation of serum for general use as a protective agent.

After observing the apparent bactericidal properties possessed by the filtrate it was decided to ascertain the effect of the sterilized bouillon cultures. These were prepared by growing the culture for ten days in 5 per cent glycerinized peptone bouillon, then killing it by an exposure of thirty minutes to 60° C., and afterwards filtering through sterilized cotton. From this study it would appear that the toxins are extracellular and that they are destroyed by the above temperature, as the injection of this fluid failed to produce the least reaction in the inoculated guinea pigs; nor were the guinea pigs protected in the slightest degree from a subsequent inoculation of a pure culture, as will be seen from the following:

Six guinea pigs inoculated on November 7 with the sterilized cultures in doses ranging from 1 to 3 c. c. subsequently received, subcutaneously, 0.5 c. c. of a virulent culture simultaneously with two check animals. Deaths followed among the first group of animals on an average of sixteen days, while the two control animals died on the fourteenth and eighteenth days, respectively. Inoculation experiments were begun at the same time on a small flock of goats, each animal receiving 3 c. c. subcutaneously, which was repeated in ten days. The preliminary report in this instance confirms the work done on guinea pigs, and shows rather conclusively that the immunizing properties of sterilized cultures are practically nil.

MICROSCOPIC LESIONS.

Lungs.—Microscopically, the terminal bronchioles and alveolar passages present swollen walls and contain various amounts of mucous

exudate and desquamated cells as a result of a catarrhal inflammation. In most cases where the diseased areas in the lungs of the goat were examined there has been found little pneumonic consolidation, but bronchiolitis is quite prominent. Some small areas of consolidation are seen with the alveoli and air sacs filled with granular debris and variable numbers of epithelial cells, red-blood corpuscles, and leucocytes. An active desquamation and proliferation of the epithelial lining membrane is present. The interalveolar septa show a considerable round cell infiltration. The blood vessels of the septa are distended and surrounded by migrated leucocytes. Frequently a bronchus is found affected, with the lumen containing a small number of desquamated epithelial cells and slight fibrinous exudate and leucocytes. A round cell infiltration is seen in the neighborhood of the bronchus, the walls of which are swollen, indurated, and granular in appearance. The surrounding peribronchial tissue shows in most cases an inflammation by contiguity. The pulmonary lesions observed in the guinea pig present the characteristics of a bronchopneumonia. The organism is occasionally found in the fibrinous exudate and in the blood vessels.

Liver.—In the liver of the guinea pig there appears to be a congestion of the blood vessels, especially in the portion lying beneath the capsule, and is accompanied by focal areas of fatty degeneration occupying the peripheral zone of the acini in the form of numerous small globules, which in some cells completely obscure the nucleus. The protoplasm of the hepatic cells is extremely granular. In the organ obtained from the goat there is no congestion, but the areas of fatty degeneration are observable, although in a small degree, and always in insular patches.

Kidneys.—The kidneys present the microscopic appearance usually observed in catarrhal or parenchymatous nephritis, with the most marked changes occurring in the cortex. Certain Malpighian tufts show an increase of cells due to the proliferation of the vascular epithelium, obscuring and compressing the capillaries. Increase of the cells of the tufts sometimes occurs. The intercapsular space is dilated and contains an albuminous exudate. The convoluted tubules show the epithelium to be swollen and granular, and in some cases desquamated, while the lumina of these tubules also show the presence of an albuminous deposit. As the micrococcus has not been found in the kidney on microscopic examination, the lesions here are presumably the result of the toxins.

Heart.—Localized areas of parenchymatous degeneration may be observed, involving isolated fibers or groups of fibers. Their contents are found to be fine granules of an albuminous nature, which do not completely obscure the striations or the nuclei of the muscle. In some fibers a more advanced stage has occurred, which results in the production of small, dark granules, accompanied with small droplets

of fat. In the heart of the guinea pig the interfibrillar connective tissue shows a proliferation of the nuclei, and there is a slight indication of a round cell infiltration.

Spleen.—A microscopical examination shows a thickened capsule, which is wrinkled and contracted. An increase in the thickness of the fibrous trabeculae proceeding from the deeper layer of the capsule and from the walls of the small blood vessels is the conspicuous feature, with the accompanying atrophy of the Malpighian corpuscles and splenic pulp. The connective tissue cells and delicate strands of fibrillated tissue are very noticeable among the lymphoid elements.

Small intestines.—The appearance of these tissues, especially of the duodenum, is that of a productive inflammation with exudation, associated with more or less necrosis of the mucosa. The mucous membrane of the small intestine shows extensive desquamation of the epithelial lining and at times a superficial or even complete necrosis of the glandular layer. The mucosa may also present a typical productive inflammation with exudation of a fibrinous character and small cell infiltration around the engorged blood vessels. The solitary follicles are hyperplastic. The serous coat is thickened and the blood vessels visibly distended. Scattered profusely throughout the exudate and within the blood vessels of the submucosa, as well as in the intact mucosa, are the specific micrococci.

BLOOD EXAMINATION.

The attention of one who is called to examine a goat suffering with takosis is at once attracted by the anemic, bloodless appearance of all the exposed membranes. So prominent is this symptom that efforts have been made to determine the effect of the disease upon the blood. The germ (*Micrococcus caprinus*) is readily recovered from the blood of the circulation in any part of the body of animals that have died as a result of the test inoculations or of the natural disease. It is found in the plasma, but never within the cells themselves. Ellenberger (Physiologie der Haussäugethiere) and R. Meade Smith (Physiology of Domestic Animals) give the number of red corpuscles in a cubic millimeter of normal goat blood as varying from 9,000,000 to 10,000,000. A count was made from the blood of several goats obtained for experimental purposes in the laboratory and the result was confirmatory of this statement in a very satisfactory degree. The average result of the count in these cases gave the number as 9,976,000 per cubic millimeter and about 9,200 leucocytes in the same amount of blood. Later a count was made from the blood of an Angora goat sent to the laboratory during the last stages of the disease.

The animal was greatly emaciated, of an anemic, debilitated appearance, and was suffering from profuse diarrhea. We have no means of knowing how long this goat had been affected by the disease, but

evidently it had been ailing for some weeks. The count of red corpuscles in this instance gave 11,208,000, showing a material increase above the normal number. Other counts were made from the blood of two Angora goats that had been received at the laboratory in a healthy condition and afterwards inoculated with *Micrococcus caprinus*, one receiving 1.5 c. c. of a bouillon culture intravenously and the other 1 c. c. intraabdominally. Violent purging ensued in eight days in both cases. The count of the corpuscles of the blood was made before the animals recovered fully from the effects of their inoculation and when the purging was quite profuse. The result obtained by counting the corpuscles under these conditions was that the blood in the first contained 11,190,000 red-blood cells and 20,560 white cells per cubic millimeter, while in the second case the red and white cells numbered 12,160,000 and 18,420, respectively. The leucocytosis in these instances was chiefly due to an increase in the number of polymorphonuclear leucocytes and the eosinophiles. In another case affected with the natural disease the red corpuscles numbered 10,208,000 and the white corpuscles 14,860.

It will be seen from the few blood counts thus far made that the number of red corpuscles is not diminished; in fact, it is sometimes increased (polycythemia), especially during the presence of the diarrhea, and is probably only relative, coincident with the removal of the watery constituents of the blood. The individual red cells are small (normal size 4.1μ .—Ellenberger), pale, and light in weight, presumably the result of the loss of nitrogenous material. They are also changed in outline, particularly in the later stages of the disease, when they assume an irregular, misshapen form (poikilocytosis). The increase in the number of leucocytes (leucocytosis) is absolute and dependent upon the chronic nature of this infection. In explaining the phenomenon in this instance we are inclined to ignore the overproduction theory of Virchow and Ehrlich and accept the idea advanced by Von Limbeck, Jakob, and Goldschneider, who hold that the bacterial toxins circulating in the blood act in a chemotactic manner to attract into the blood stream leucocytes which were previously in the lymph channels and spleen, and that these white corpuscles added to those already in the blood produce the leucocytosis. The specific gravity of the blood was taken in a number of instances with the average record of 1.031. It is utterly impossible to determine the amount of hemoglobin present by means of the Von Fleischel instrument, as the greenish tint of the blood is not comparable to the red of the index glass. However, the amount of hemoglobin was relatively ascertained as 56 per cent by a modification from Schmaltz (*Pathologie des Blutes und die Blutkrankheiten*, Leipzig, 1896), considering the normal specific gravity of the blood of the goat as 1.042.

TECHNIQUE.

For the histological study of the pathological alterations, the tissues were fixed in either Graf's chrome-oxalic fluid, Zenker's fluid, or gradually ascending strengths of alcohol and hardened in dilute chloroform. They were then infiltrated and embedded in paraffin and cut in serial sections. In bringing out the pathological lesions various staining preparations were employed, including hematoxylin and eosin, Weigert's fibrin stain, Bismarck brown and eosin, Gram's method followed by eosin, alum-carmin, and carbol-fuchsin counterstained with methylene blue, the best and most distinct sections resulting from the first two mentioned agents.

DESCRIPTION OF PREVIOUS EPIZOOTICS OF ALLIED CHARACTER AMONG GOATS.

The first mention in foreign literature of any disease of goats simulating the one now under consideration seems to have been made by Pusch (12),^a of Dresden. The disease appeared in the fall of 1894 among a number of goats recently brought from the Simmenthal of Switzerland for breeding purposes. Upon their arrival in Saxony they were sold to different breeders and in this way were scattered about in six neighboring towns and upon thirty various farms. Several days later a disease appeared simultaneously among the goats of this importation in five of the six towns in which they had been received, and it quickly spread to the neighboring goats with which they had been placed.

The animals were purchased on October 8, and were unloaded from the cars and delivered to their several owners on October 12. Nothing was seen to be wrong with them at this time, but after a few days complaints began to reach the authorities which stated that the goats were affected with cough and diarrhea. They were visited by Dr. Pusch on October 25, thirteen days after their arrival from the south. On the first farm which he visited, he found three imported goats and one native goat sick. All of them coughed in response to percussion with a short, superficial, painful cough. The native goat seemed to be more seriously affected than those recently arrived from Switzerland. Its temperature was 40.5° C., respiration 35, and pulse 110; mucous membranes yellowish; nostrils widely distended; breathing labored and painful; appetite poor. The animal was so sluggish that she refused to stand. On another farm he found that one of the goats had been killed and its viscera buried. The heart and lungs were recovered and examined, but under the existing circumstances the results were not satisfactory. The heart was seen to be gray-red and very poor in fat. Pneumonia was present, accompanied with enteritis. Mice inoculated

^a These figures refer to bibliography at end of this article.

from these lungs gave negative results. On this farm the disease spread among the native goats to a serious extent. The incubation period was about ten days. Sheep kept in the same pasture were not affected. The greater part of the imported goats sickened after their arrival, and, as they were all bought in the Simmenthal and were not unloaded en route, infection during transportation was impossible. The disease appeared simultaneously among most of the goats of this importation, and quickly spread to the natives with which they had been herded, causing great loss among the latter animals.

The infected farms were quarantined until the diseased animals had either died or recovered, which required but a few months, as the affection disappeared voluntarily during that time.

Another outbreak of a very similar disease among goats was reported by Storch (14).

The native goats of Schmalkalden are of large size, rugged, good producers of milk, and, until the importation of Saanen goats from Switzerland, they were very healthy.

Twenty Saanen goats were imported and placed among the native flocks in May, 1894. In July the disease had become so widely spread that the authorities sent Schutz and Storch to investigate. Storch states that the report of Pusch, 1894, is the only one in German literature describing a disease which resembles this in any way, while Hutcheon's pleuro-pneumonia of goats in South Africa may be the same thing, but he is unwilling to decide.

Of 620 goats in Steinbach-Hallenburg 331 became affected, and many of these died, but no accurate statement of the number of deaths was obtainable. In the acute form the goats refuse food, become dull and depressed, and lie down most of the time. Their breathing becomes labored and painful; pulse often reaches 120 to 140 per minute; cough is always present. About one-half of these cases are fatal, many of the animals dying in convulsions and opisthotonos.

In the chronic form, a cough is always present, frequently accompanied by nasal discharge. The disease is lingering and persistent, but apparently does not affect the appetite.

Examination of the lungs showed collapsed areas in one or both anterior lobes. Mucous membranes of the bronchi were reddened, thickened, and covered by a slimy coating. Bacteriological examination revealed the presence in the lungs of numerous oval to round bacteria, frequently in pairs, but occasionally single, while the blood, spleen, and liver proved negative. White mice inoculated subcutaneously with cultures showed a staring coat and dullness, but recovered. A rabbit two months old, inoculated with scrapings from a diseased lung, died atypically in three days. Hepatized areas had developed

in its lungs, however, and the presence of the organism in these tissues was established.

Healthy goats placed in isolated stalls in stables sheltering diseased animals became infected.

Susceptibility appeared to increase with age, since young kids were not affected. Mortality of the acute and chronic forms considered together reached about 25 per cent.

Careful inquiry failed to give any trace of a similar disease in the Simmenthal where these goats were purchased. Further importations of goats into the Kingdom of Saxony were prohibited at once as a result of this outbreak.

Various experiments were made in the matter of treatment, but the best results were derived from the inhalation of creolin.

Nicole and Refik Bey (10), of Constantinople, describe a pneumonia among the goats of the region adjacent to the Gulf of Ismid, it having been brought there by goats purchased in the interior of the country.

The symptoms were first fever, then loss of appetite, cough and nasal discharge, disturbed breathing, and soon the animal began to lag behind the flock, appearing dull and languid. The disease lasts a long time and the animals become somewhat paralyzed four or five days before death. The attack is not commonly accompanied by enteritis. Calves and sheep kept in the same flock were not affected. Microscopic examination showed red and gray hepatization, and the vessels filled with leucocytes. The pleura was thickened, and exudation into the pleural cavity was moderately abundant.

They have constantly isolated a cocco-bacillus from the lungs. It is sometimes alone and sometimes in association with the colon bacillus or with *Bacillus pyocyaneus*. It was never found in the blood. It seems both by its form and character to belong to the hemorrhagic septicemia group. The bacillus does not retain its stain when treated by Gram's method. On liquid media it appears sometimes as a diplococcus, and again as a lance-shaped bacillus, resembling in its contour and size the pneumococcus of Talamon-Fraenkel. When the nutriment in the media is abundant, its form is round and there is a decided tendency to form chains. Mice were most susceptible to this germ. A very small quantity of culture injected subcutaneously caused death in ten to twelve hours from septicemia. Two cubic centimeters subcutaneously kills rabbits in eight days, forming abscesses in the lungs. A test goat died in four weeks, emaciated, and with limbs paralyzed during the last few days of life. Cocco-bacilli were recovered from all visceral organs. Another goat recovered. A third goat showed diarrhoea and fever the day after being inoculated and then recovered. It was subsequently reinoculated with fluid from a hepatized lung and died in one month. All goats tested in the

laboratory proved very resistant. Calves and dogs were inoculated with 5 c. c. of a pure culture without results.

The men who were first interested in introducing well-bred Angora, Thibet, and Cashmere goats into this country encountered some thoroughly discouraging experiences, which were very probably due in a measure to the ravages of the disease under consideration. As early as the year 1854 a prospective purchaser of Thibet goats living in the State of Georgia was warned by a naturalist of note against completing his purchase for the reason that these goats, "like the llamas of the Andes, could not be successfully acclimated in a locality under 10,000 feet above the ocean." The purchase was consummated in spite of the friendly warning of the naturalist, and the final owner (2), in recounting his experiences later, wrote: "His opinion proved to be correct, as all of the Thibet goats, pure and grades, in my flock died in a few years after I had purchased them, from a disease of their lungs combined with dysentery."

A writer (1) in the *Country Gentleman* of February 4, 1875, also reports serious losses in a flock placed in his care on a farm at Rapidan, Va. Although he records no specific symptoms, the following quotations have great interest to all who are making a study of takosis:

In the early cold weather the goats began to sicken. I had the sick ones removed to other quarters, and wrote for remedies to Mr. E. I studied Randall also, but nothing cured them. They died, and more were taken sick. I sent for Mr. E., the owner of the goats, and when he came he said the difficulty was cold and hunger, though they had more than a "little hay and fodder" besides additional meal, much more in proportion than my sheep, which at that time were running at large without shelter and doing well. * * * The next morning a fine young buck which had been apparently well the night before was brought out in a dying condition. Mr. E. examined it closely and said it was a decided case of liver disease, an infectious epidemic which Angora goats were subject to in their own country, and regarded as so fatal by the Turkish shepherds that they said of it, "There is no cure but Allah."

Pegler (11) in the year 1885 described what he termed "A disease peculiar to goats." It will be seen upon reading the following excerpt from his work that his description of the scourge that appeared among the members of his flock might, in most particulars, very well be applied to a flock affected with takosis. From the page describing symptoms were borrowed the following:

The first thing that is noticed is a falling off of appetite, which may at first be slight, but soon gets worse until it is a difficult matter to get the animal to eat at all. The result, of course, is that it rapidly loses flesh and falls away to a skeleton. Sometimes, however, the appetite remains good, but the emaciation goes on just the same, though the process is slower. The breathing is sometimes labored and the breath nearly always very unpleasant. A cough is very often an accompaniment of the disease, leading one to suppose, with other symptoms, that the lungs were affected, but this is seldom the case. The one prevailing feature which can never be overlooked is the general bloodlessness of the animal. This is shown by the pale color of the gums and inner surface of the lips, and also of the membranes lining the eyelids, which in health are of a bright red.

Before the disease is far advanced diarrhea sets in, which begins with a slackness of the bowels. This soon gets worse, however, and, though it may be stopped for a time, it is almost sure to break out again, owing to the failure of the digestive organs from the impoverished condition of the animal. The diarrhea may last for several weeks, but as it advances it often takes the form of dysentery. The poor creature then becomes too weak to stand, and it generally dies uttering plaintive cries and moans. There are other symptoms which occasionally manifest themselves, such as swelling beneath the jaws and weakness about the limbs, the animal always standing with its head down and back arched, looking the picture of misery and dejection.

Strange to say, in nearly all the postmortems which have been made and reported to me, there has been no organic disease. Internal parasites are sometimes discovered, but not in sufficient quantities to greatly affect the animal's health, much less cause its death, which in all cases is due to exhaustion.

ECONOMIC IMPORTANCE.

A few years ago the flocks of Angora goats in this country were comparatively unimportant in number, and they were nearly all of them kept in southern latitudes, but during recent years the raising of these animals has received a remarkable impetus. New uses have been discovered for the fleece, they have been widely exploited as brush eradicators, and their flesh has been more readily accepted as a food product, until at present they have reached an established, settled value in many of the larger live-stock markets. As a result of the widespread interest thus awakened in them, many stock raisers have made purchases of foundation stock with the intention of establishing therewith a profitable flock. Others have made larger purchases at the start, being unwilling to wait for the slow natural increase in numbers of their animals. By means of numerous transactions the animals have been placed in widely distributed northern localities to which they were formerly strangers, but the serious losses caused to these investors by outbreaks of takosis served as a check to many prospective purchasers, and the Angora goat industry was, in consequence, subjected to a discouraging setback, and has not expanded to the proportions which it would otherwise have reached.

Now that the cause of the trouble has been determined, one may be warranted in claiming that the disastrous effects of all outbreaks up to the present time may in the future be avoided in large measure. The owner of the flock of goats will now see the importance of deciding upon the nature of the ailment afflicting them just as soon as any general disease is noticed; and when takosis has appeared and been identified, if he will at once apply the precautionary measures and the course of treatment to be recommended later in this work, he should avoid many of the discouraging experiences of his predecessors.

As has already been stated in this article, the most serious losses that have come to our notice have occurred among goats that were removed from southern localities to new regions far to northward, and that had not become fully acclimated in their new surroundings. In many

instances the trouble has appeared very soon after the arrival of the animals at their destination, even before they have recovered fully from the serious strain incident to the long journey by rail.

There is always a value to be derived from the confirmatory statements of many witnesses. Various observers are sure to offer a variety of observations upon any subject in which they may have a common interest, and for the purpose of presenting to the reader as generalized a knowledge as possible of the effects of takosis upon a flock of goats, and also for showing how diversified is the territory in which the ravages of the disease are being felt, it has been deemed advisable to present the following extracts received by this Bureau with reference to the disease.

From Knapp, Wis., the following was received:

I have in my charge about five hundred goats, and they have been dying from what I called stomach worms; but of late I have come to the conclusion that something else is the matter with them. They lose their appetite, grow thin in flesh, cough and get weak, and then lie down and die. Some linger along two or three months. There is from one to five in the flock that show the symptoms all the time, and from one to two die per week. They first cough, then lag behind the flock at night when coming to the barn. Then there is lack of appetite, they grow poor and weak and look gaunt all the time as though they have been starved.

A letter of inquiry from Pittsburg, Pa., asks:

Would some of you let me know what the proper feed is for goats through the winter when they have no pasture? I bought a few Angora goats and so did a few of my neighbors, and they are dying. The flock that we obtained them from was very poor; in fact, I never saw anything poorer to live than the goats were when we received them. I feed mine on corn and oat chop, half and half, and corn fodder, and cut some apple brush, but for all I would do my goats died with scours.

A writer from Langhorne, Pa., sends the following record of his observations:

To look at our goats in the yard you would say they looked fine, and you could hardly pick out one that you might think was not quite up to the average, yet to-morrow morning you would find four or five down on their sides or otherwise. If picked up they might move off slowly and eat a little, but the next morning they would be down again. The animals will not get up or stay up, but will linger in this manner for some days, smelling badly and bleating occasionally or groaning, with head bent around on side or under them, and finally die. Sometimes, as a result of lying so long, they get apparently choleraic discharges from the bowels, which is offensive, but this does not show at first, and is not the primal cause.

Tioga County, Pa., has for several years had a flock of Angora goats, representing among its members some excellent specimens of the breed. The owner of this flock, in describing the course of takosis, writes:

None of the diseased goats recovered. It took a long time for many of them to die. They tried very hard to live, and some of them succeeded in living for weeks, only getting weaker and weaker and finally just fading away. Some had diarrhea but many did not.

In making a report of postmortem findings, a correspondent from Iowa mentions one of the characteristic symptoms of takosis as follows:

The amount of bile is from one-fourth to three-fourths of a pint in each goat. A healthy goat only has, as I find, about a tablespoonful. This goat has been ailing for two weeks, but only refused to eat for two days. I have lost one-third of my flock and have not been able to save even one goat that has become sick.

A breeder in western Illinois states that he has lost one hundred out of a flock of four hundred, and that two of his neighbors have suffered proportionate losses. These goats were all well sheltered. He considers the disease some sort of cholera, reasoning from the fact that the animals were all affected with diarrhea.

The following extracts, from a letter received just as this paper was ready for the press, from the owner of a large flock of Angora goats in Michigan, confirm several of the statements made in the introduction of this article:

We personally suffered a loss last winter in animals that we had brought from Texas in November, 1901, from this disease, and thus learned of the trouble. * * *

We gathered together a herd of all grades of goats for the purpose of studying them and finally arrived at the conclusion that, so far as the Angora goat is concerned, the animal most susceptible to the disease, was the result of careless breeding, or to be more exact, too much inbreeding, thus lowering its vitality and leaving it open to the attack. * * *

The care, feed, and shelter of the various grades of animals we have had was all alike, and it resulted, as stated, in the survival of the carefully bred, free from inbreeding Angora goat.

Other reports of like nature have been received from goat owners in Oregon, Missouri, Massachusetts, Virginia, and Maryland, all describing the affection as an incurable weakening and wasting away, usually accompanied by uncontrollable diarrhea and occasionally cough. The death rate has been very high in the flocks from which reports have been obtained and ranges from 30 to 85 per cent.

Another feature of takosis, which is of great economic importance to the breeder of goats, is experienced in the unavoidable tendency to abortion which is manifested by all pregnant females that are affected with the disease. Females of the sheep and goat families will never reproduce in a prolific manner if in a wasted, emaciated condition during the breeding season. Many of them will fail to come in heat, and others, although passing through the period of estrum normally, will fail to conceive. Takosis is essentially a wasting disease, and one of the marked results of its attack upon a flock of breeding goats is seen in the shrunken kid crop of the following season.

It is rare indeed for a pregnant doe to complete her term of gestation if attacked during this period by takosis. Abortion follows almost invariably. As might naturally be expected, the accident of abortion under these circumstances always ends fatally, as the animal is unable, in her already weakened condition, to withstand the shock

incident to delivery. Many times the fetus dies in utero, and thus becoming a foreign body to the maternal organism, it but hastens the eventual collapse of the doe. In holding autopsies on the bodies of affected pregnant does, it has been occasionally noted that the death of the fetus preceded that of the mother by a few days, and the fetal decomposition present has indicated that it played a prominent part in causing the death of the adult.

One flock has been brought to our notice which contained about 1,600 does at the commencement of the breeding season in the fall of 1901. They were seriously affected with takosis at this time, and in consequence there were but seventeen living kids produced in the following spring.

Another instance is reported where the total increase of a flock of over 1,000 does for the year was limited to eleven living kids.

DIFFERENTIAL DIAGNOSIS.

PARASITISM.

The condition which will most frequently be mistaken for takosis in goats is parasitism. In common with sheep, goats serve as hosts for a formidable array of animal parasites, and the loss directly or indirectly due to parasitic invasions must annually serve as a serious tax upon the goat raisers of the country.

The effects of internal parasites upon the goats are very similar in many of their outward manifestations to the symptoms of takosis. There is a persistent unthriftiness, although the appetite of the animal remains good. The fleece does not retain its proper luster. There may be considerable snuffling of the nose, accompanied by frequent coughing. The animal may become affected with diarrhea, more or less severe, and its accompanying weakness. The eyes lose their brilliance and gradually assume a dull sunken appearance. The formation of an edematous tumor beneath the jaws is frequently noticed during the later stages of a serious invasion. These, in a general way, are the symptoms resulting from an attack by animal parasites, but it must be remembered that there are species of worms that find their natural habitat in some particular organ, and that, in consequence, it is impossible to give an accurate enumeration of the symptoms that may be manifested in any given case under the general heading of parasitism.

The symptoms produced by the local disturbance of the affected part will predominate, while others, frequently caused by parasitic invasion, will be entirely lacking. Careful postmortem examination will quickly disclose the presence of parasites. A differential diagnosis previous to death of the animal may, however, be made by giving due consideration to the various symptoms manifested by these

diseases. First of all, the infectious nature of takosis, when compared with the enzootic course of a parasitic invasion, will justify one in making a definite diagnosis. In attacks of takosis, symptoms of pneumonia will be frequently noted, especially labored breathing or rapid respiration. These symptoms are not diagnostic of parasitism. The edematous lump under the jaw, so frequently present in cases of parasitism, fails in takosis. The luster of the fleece is less affected in takosis, while diarrhea is more frequently noted. Continuous coughing and snuffling, while diagnostic of the presence of lungworms, are not characteristic of takosis and are noted only occasionally in cases of this disease, unless there is a complication with some other affection.

ANEMIA.

In goats this is very rare, and when it does occur it is usually secondary to some previously existing disease, such as chronic pneumonia, peritonitis, or to poor food and starvation. It does not assume an infectious nature, and may be differentiated from the anemic condition accompanying takosis by the absence of the specific organism on microscopic examination.

WATERY CACHEXIA, OR HYDREMIA.

This usually results from poor feeding, innutritious food, or pasturing on low ground. The natural goat pasture is high dry land. The animal is weak, readily exhausted, breathes rapidly, and its heart palpitates. The mucous membranes of the eyes, nose, and mouth are pale and swollen. The edema which is present about the head, neck, and abdomen will serve to differentiate this disease from takosis. This edema of the head disappears when the animal lies down. Icterus may accompany the disease when the discoloration of the mucous membrane easily establishes the nature of the affection. A change of pasture and a more nutritious diet are accompanied by a return of health to the flock.

CONTAGIOUS PNEUMONIA.

There have been several instances recorded in which flocks of goats have been affected with a contagious pneumonia.

Hutcheon (6) has met with this epidemic in South Africa; Steel (13) has seen it in East India; and it has also been brought to the attention of French (3 and 8) and Italian (9) veterinarians.

Soon after the outbreak of this disease in the flock many of the animals will become affected with a cough. The temperature rapidly rises until occasionally as high as 107° F. is recorded. The appetite becomes disturbed or disappears altogether, and there is slight nasal discharge. The conjunctiva appears brownish or bronzed, the vesicular murmur of the lungs becomes modified, the pulse quickened, and the

breathing accelerated, labored, and painful. The affected animals always evince pain when pressure is applied between their ribs.

The postmortem examination of these cases shows the lesions to be chiefly confined to the thoracic cavity. The visceral pleura is usually adherent to the thoracic walls. The diseased lung is solidified and enlarged throughout one-half to three-fourths of its substance. It is covered with a firm elastic fibrinous membrane.

Respecting the nature of the disease, Dr. Hutcheon writes:

It was a specific infectious form of pleuro-pneumonia, affecting goats only, cattle and sheep remaining free from infection, although constantly exposed to it. The disease was introduced into the Cape Colony by a shipment of Angora goats from Asia Minor, where the disease is represented as being indigenous.

At the present time contagious bovine pleuro-pneumonia has no existence among the flocks or herds of America, but since the goats of other countries have been proved susceptible to an analogous disease, the above mention of its leading characteristics may not be out of place.

TREATMENT.

PROPHYLAXIS.

In the study of takosis four points have been brought prominently into view which may properly be grouped together when considering measures for the prevention of the disease. It has been shown that the most destructive outbreaks have occurred among the goats that just previously have been shipped from a southern locality to a more northern latitude, and this fact suggests the need of caution in the removal of animals in this direction. Sudden climatic changes should be avoided so far as possible, and when shipments of goats for breeding purposes are to be made which necessitate their transportation northward over considerable distances the changes should be made during the months of summer or late spring, and not in the fall or winter, when the contrast of temperature will be so much greater.

Earlier writers have called attention to the fact that Angora goats do not take kindly to transportation from one climate to another. Hobson (4) states that the native proprietors of Angora flocks in Asia Minor unanimously assert that this goat can not be transported from the place where it was born to a neighboring village of a different altitude without suffering a deterioration, and although able to resist both heat and cold they can not withstand much humidity, either in their pastures or folds.

The second precautionary measure is closely allied to the first, namely, Angora goats should be provided with stables that are thoroughly dry, not alone in their ability to shed rain, but on account of being erected upon ground that has perfect natural drainage, and these should be accessible by them at all times, as the effect of rains

upon the general health and strength of these animals has been frequently proved to be very disastrous. So great is their natural aversion to a wetting that they will seldom get caught out in a shower if shelter is within their reach, but will leave their browsing and march under cover before the downpour arrives. The reason for this is obvious. Their fleece is wholly lacking in yolk; consequently it will not shed water in the least, and a fall of rain immediately soaks the animal clear to the skin.

As a third measure of prevention may be mentioned careful feeding. No animal is as well fortified against the attack of an infection when reduced by lack of nourishment as it is when in vigorous, thriving condition. Among the predisposing causes of disease usually enumerated by general pathologists will be found debility due to insufficient or unsuitable food, and, although the reason for this may not be established beyond the reach of argument, it is pretty generally conceded that the continued lack of proper nourishment establishes in the blood of an animal an abnormal degree of alkalinity which grants an increased susceptibility to the inroads of pathogenic organisms.

Another preventive measure to be mentioned here is one that is applicable only after the disease has made its appearance in the flock. The segregation or isolation of all affected animals as soon as they evince any symptoms of the disease will be found a most valuable means of protection for those that remain unaffected, and a strict quarantine over all of the diseased members of the flock should be maintained so long as the disease remains upon the premises.

In our previous experiments for the purpose of procuring an immunizing agent against this disease, the results were such as to warrant a practical application of the sterile filtrate previously described (p. 26) to several flocks of goats generously placed at our disposal. The fluid thus prepared has been injected into the skin over the shoulder of goats in doses of 3 c. c., with varying results. One flock, originally consisting of eighty-two animals, had been decimated by takosis until it numbered but thirty-two. These animals received two inoculations ten days apart, and immediately after the last injection they were transported in wagons late in November to a point thirty-eight miles away. On account of the condition of the roads, the trip required about two days. During this time the goats were without food or drink and were not unloaded. Two of them died, one on its arrival at the farm and the other not till three days later, although it was scouring badly upon reaching its destination. The remainder of the band seem in a healthy condition and are the most sturdy of the flock of six hundred to which they have been added. At a later test of this filtrate, made in one of the Western States, upon a flock of goats, the effect of treatment was most unsatisfactory. The goats were inoculated twice with the remedy with an interval of ten

days. Recent letters from the owner state that there is no improvement in the condition of the flock, but that the fatalities continue to occur with the usual frequency. He has since been advised to make use of the medicinal treatment mentioned below. From another Western breeder a most flattering report has been received. He states that after the use of the prophylactic treatment the disease disappeared from the premises, and up to the time of writing all of the animals on the place had remained in a thriving condition.

THERAPEUTICS.

Medicinal treatment has proved unsatisfactory in many of the cases of takosis to which it has been applied. Previous to the study of the disease the treatment was directed against the pneumonia, and for a short time marked improvement followed; but it was merely coincidental, as deaths occurred later with the usual regularity. Then intestinal disinfectants and astringents were suggested, but these did not prove efficacious. The most pleasing results that have been derived from the use of drugs in our experiments at the laboratory have followed the administration of calomel given alone in 0.10-gram doses twice daily for two days, to be followed by powders composed of arsenic, iron, and quinine, as follows:

	Grams.
Arsenious acid	1.40
Iron, reduced	12.00
Quinine sulphate	6.00

Mix and make into twenty powders, giving one to each adult goat morning and evening at the conclusion of the administration of calomel. After an interval of two days, this treatment is repeated. In case the diarrhea persists, the sulphate of iron has been substituted for the reduced iron, with beneficial effects.

CONCLUSIONS.

As a result of the present preliminary investigation, the following conclusions have been reached:

1. The disease here described as takosis has appeared in many parts of this country, but particularly in the Northern States, where it has caused great loss to many breeders of Angora goats.

2. It is a progressive, debilitative, contagious disease, characterized by great emaciation and weakness, with symptoms of diarrhea and pneumonia, and causes a mortality of 100 per cent of those affected and from 30 to 85 per cent of the whole flock.

3. From the carcasses of numerous animals that have succumbed to this disease a new organism, *Micrococcus caprinus*, has been recovered in purity and is presumably the etiological factor.

4. This micrococcus possesses pathogenic properties for goats.

chickens, rabbits, guinea pigs, and white mice, but not for sheep, dogs, or rats.

5. Although the disease has been described before (11), so far as could be ascertained no bacteriological investigations have been previously made.

6. Medicinal treatment was attempted with varying success, while the immunizing experiments thus far conducted (although too few to permit of any conclusive statement or accurate estimate as to their protective value), have shown highly encouraging results. When accompanied with measures of isolation and disinfection, the treatment may prove of great assistance in the suppression and eradication of the disease in an infected flock.

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