

Diagnosis of Lamziekte.—Having stated that the post-mortem examination does not show any characteristic lesions and that the microscope does not reveal any organisms or any typical changes, we are entitled to the statement that from a dead animal no definite diagnosis of lamziekte can be made, unless we know the history of the case during the life. This point is in contradistinction to the majority of all other diseases, e.g., Lung-sickness, East Coast fever, Horse-sickness, etc. *The main characteristic seems to be the absence of typical characteristic lesions and a negative post-mortem report.* Accordingly for our diagnosis we have to completely rely on the history of the living animal, on the knowledge of the conditions under which it has contracted the disease, with due reference to the locality in which the animal is found, viz., whether in a lamziekte area or not. When weighing out all these points we may then arrive at a definite conclusion. The animal with its definite course of symptoms during sickness and the negative post-mortem reports point to the diagnosis of lamziekte.

THE NATURE OF LAMZIEKTE.

Failing to find on post-mortem examination any typical lesions indicating definitely the seat of the disease, we can for the time being only form a theory as to its probable nature.

For this purpose we have almost entirely to rely on what we see during the life of the sick animal ; the negative results of the post-mortem support our conclusions by analogy with other diseases. The paralysis, which is apparently the most striking feature, suggests an affection of the spinal cord, a paraplegia, viz., a paralysis of the hind-quarter. We can understand that from there the morbid process would extend to the forequarter and reach the medulla oblongata, viz., the spinal cord of the neck, explaining the paralysis of the pharynx, the tongue, and the maxilla, since the enervation of these organs emanate from there. As long as it was accepted that in lamziekte an increase in liquid in the spinal cord was present, such a statement was in support of the opinion that the seat of the disease would be there, as it could be thought that this liquid is somehow connected with either an inflammatory or transudatory process. But even in the absence of any liquid the seat may still be in that cord. It is not necessary that visible changes exist in order to explain the symptoms. For instance, poisoning with strychnine and other similar alkaloids which act on the nervous system produce death without leaving any signs. We must also accept the idea that a somewhat similar specific poison causes the symptoms in lamziekte; what the nature of this poison is and how it enters the system will be explained later. Although I do not wish to exclude the spinal cord as one of the places where the toxin is deposited I am inclined to think that it is not the organ principally attacked, and if so at all, only in a secondary manner. The first symptoms noticed in lamziekte, *i.e.*, walking heavily, stiffness in the shoulders, and subsequent paralysis can be better explained by looking at the muscular system as the seat of the disease. It is somewhat difficult to understand that an affection of the lower end of the spinal cord, diagnosed by paralysis of the back, should show itself, first in the movement of the forelegs, and there as a stiffness and not as a paralysis. But when we accept the theory that the muscular tissue is at-

tacked we have no difficulty to explain why the disease shows itself first in the shoulder. The weight of the body hangs on the muscles of the forequarter and these must naturally suffer first. The muscles of the hindquarter suffer next; their function being that of a motor power, they fail to perform this action and the animal goes down as if struck by paralysis. The muscles of the tongue and the pharynx being of less bulk become affected last of all or perhaps only when there is an enormous amount of poison present. Although there are symptoms of paraplegia the paralysis is not a complete one. The animal, unless in a state of coma and too far gone, when as in many other diseases the head bends back, has not lost its reflex action, and if pinched in the hindlegs or tail it responds and even moves the legs. The functions of defæcation and urination are maintained, and in sub-acute cases the animal can even drag itself about. The pronounced stiffness in chronic cases particularly point to the seat being in the muscles since there are no lesions in the bones or in the feet as in the case of stijfziekte. It is true we have not yet seen any definite lesions in the muscles, at least not with the naked eye, but this does not speak against the muscular substance, or perhaps the nerve endings in the muscular substance being the seat of the disease. In curare poisoning, a plant poison much used in physiological experiments, the end plates of the nerves are paralysed, the animal cannot perform any voluntary movement, and if it is killed by an overdose no lesions are found. In small doses, veratrum, another plant poison, has a stimulating effect on the muscle substance, and in large doses a paralytic one causing death, in which latter case no visible lesions will be found on post-mortem examination. There is a disease of horses, called azoturia, due to an affection of the muscles, in which we can recognize definite changes particularly in those of the hindquarters and occasionally in those of the forequarters. The disease shows symptoms similar to lamziekte, the animal going down paralyzed and is unable to stand when lifted up. As in an acute case of this disease the muscles of the back are principally attacked, the paralysis shows itself suddenly. In sub-acute cases, however when the lesions are not so pronounced as to cause paralysis, stiffness can be observed. The lesions found in the stomach and intestines in lamziekte cases are of a secondary nature. As in many other diseases where toxins are the cause of death, they can be explained to be due to the toxins being excreted through the intestinal walls and causing an irritation in passing through the mucosa. Also, the enlarged gall bladder with an increased amount of bile which is frequently present, can be explained as being due to an irritation of the liver cells caused by the toxins. Taking all these points into consideration, I think the conclusion is justified that lamziekte is principally a *disease of the muscular system*, the nervous system being only secondarily attacked.

EXPERIMENTS TO TRANSMIT LAMZIEKTE BY MEANS OF INOCULATION OR BY DRENCHING WITH MATERIAL OF CATTLE SUFFERING FROM THE DISEASE.

These experiments were undertaken for the purpose of ascertaining whether the disease can be transmitted from sick to healthy animals. They were started in Deelpan (Lichtenburg) by Dr. Frei. In

1910 they were continued in Schoonheid (Christiana) by Mr. Walker, M.R.C.V.S., and again in 1911 in Smitskraal (Boshof, Orange Free State), by Mr. Mitchell, M.R.C.V.S. My assistants were instructed to settle, in the first instances, the question of the possibility of transmission, and hence the large number of experiments with almost any material used in different methods. The experiments are numbered in chronological order.

I.—*Experiments undertaken in Deelpan by Dr. Frei.*

1. One cow No. 68 was drenched on the 14th December, 1908, with fresh dung obtained from a cow which was visibly affected with lamziekte, and at the same time injected subcutaneously with 15 c.c. milk of the same cow. Result: Negative.

2. One cow No. 69 was drenched on the 14th December, 1908, with dung obtained from a cow which was visibly affected with lamziekte, and at the same time injected with 150 c.c. of milk of the same cow. Result: Negative.

3. One cow No. 60 was injected subcutaneously on the 17th December, 1908, with 10 c.c. saliva and 130 c.c. blood of a cow visibly affected with lamziekte. Result: Negative.

4. One cow No. 5 was both injected subcutaneously and drenched on the 19th December, 1908, with material obtained from the sick cow referred to in No. 3, and which died two days after it was noticed to be sick. The materials and quantities given were as follows:—

Injected 40 c.c. emulsion of kidneys.
 „ 40 c.c. emulsion of spleen.
 „ 30 c.c. emulsion of liver.
 „ 40 c.c. emulsion of mesenteric glands.
 „ 40 c.c. of pericardial liquid.
 „ 95 c.c. of bile.

Drenched 400 c.c. contents of jejunum.
 „ 700 c.c. contents of omasum.
 „ 700 c.c. contents of rumen.

Result: Negative.

5. One ox No. 65 was both injected subcutaneously and drenched on the 19th December, 1908, with material obtained from the cow referred to in No. 3. The materials and quantities given were as follows:—

Injected 30 c.c. emulsion of kidneys.
 „ 40 c.c. emulsion of spleen.
 „ 40 c.c. emulsion of liver.
 „ 40 c.c. emulsion of mesenteric glands.
 „ 30 c.c. of pericardial liquid.
 „ 100 c.c. of bile.

Drenched 500 c.c. contents of jejunum.
 „ 700 c.c. contents of omasum.
 „ 700 c.c. contents of rumen.

Result: Negative.

6. One heifer No. 38 was both injected subcutaneously and drenched on the 19th December, 1908, with material obtained from the cow referred to in No. 3. The materials and quantities given were as follows:—

Injected 30 c.c. emulsion of kidneys.
 ,, 40 c.c. emulsion of spleen.
 ,, 30 c.c. emulsion of liver.
 ,, 30 c.c. emulsion of mesenteric glands.
 ,, 30 c.c. of pericardial liquid.
 ,, 100 c.c. of bile.
 Drenched 500 c.c. contents of jejunum.
 ,, 700 c.c. contents of omasum.
 ,, 700 c.c. contents of rumen.

Result: Negative.

7. One heifer No. 43 was both injected subcutaneously and drenched on the 24th December, 1908, with material obtained from a cow which was killed four days after it was noticed to be sick. The materials and quantities given as follows:—

Injected 80 c.c. emulsion of mesenteric glands.
 ,, 50 c.c. emulsion of spinal cord.
 ,, 25 c.c. emulsion of brain.

Drenched: Contents of rumen.

Result: Negative.

8. One ox No. 49 was injected subcutaneously on the 25th December, 1908, with 120 c.c. blood of a cow which was visibly affected with lamziekte. Result: Negative.

9. One cow No. 72 was both injected subcutaneously and drenched on the 31st December, 1908, with material obtained from a cow which died after having been noticed to be sick the previous day. The materials were obtained *fifteen hours after the animal had died*.

Injected 7 c.c. exudate of the subdural space.
 .. 15 c.c. emulsion of spinal cord.
 ,, 25 c.c. emulsion of mesenteric glands.
 ,, 40 c.c. emulsion of brain.

Drenched: Contents of colon and small intestines.

Result: Died two days later of acute septicaemia.

10. One ox No. 70 was injected intrajugularly and subcutaneously on the 16th January, 1909, with material obtained from a cow which died of lamziekte. The materials and quantities given were as follows:—

Intrajugularly 15 c.c. emulsion of brain.
 ,, 15 c.c. emulsion of mesenteric glands.
 ,, 8 c.c. emulsion of tonsillae.
 Subcutaneously 25 c.c. emulsion of abomasum.
 ,, 50 c.c. emulsion of jejunum.

Result: Negative.

11. One ox No. 55 was drenched on the 22nd January, 1909, with the contents of the rumen and omasum of the cow referred to in No. 6. The material had been exposed to the air since the 19th December, 1908. The same ox ate bonemeal from a cow which died of lamziekte about twelve months previously, the bones having laid in the open air during this time. Result: Negative.

12. One cow No. 69 was transfused with 1,400 c.c. of blood from a cow suffering visibly from lamziekte. Result: Died twenty-three days later of poverty.

13. One heifer No. 75 was injected intrajugularly on the 16th February, 1909, with 25 c.c. emulsion of brain of a cow which died of lamziekte. Result: Negative.

14. One cow No. 76 was injected intrajugularly on the 16th February, 1909, with 30 c.c. emulsion of fresh mesenteric glands of a cow which died of lamziekte. Result: Killed on 24th May, 1909, owing to poverty.

15. Ox No. 81 was injected intrajugularly on the 1st March, 1909, with 18 c.c. emulsion of tonsillae of a cow which died of lamziekte the same day. Result: Negative.

16. One cow No. 82 was injected subcutaneously on the 1st March, 1909, with 100 c.c. contents of colon (taken from immediately behind the caecum) of a cow which died of lamziekte the same day. Result: Negative

II.—*Experiments undertaken in Schoonheid by Mr. J. Walker, M.R.C.V.S.*

Nos. 17 to 92 undertaken between 21st February, 1910, and 11th September, 1910, the details of which appear in the article by J. Walker, "Investigations into the disease Lamziekte in Cattle."

III.—*Experiments undertaken in Smitskraal by Mr. D. T. Mitchell, M.R.C.V.S.*

Nos. 93 to 111, undertaken between March 12th and December 8th, 1911, the details of which appear in the article by D. T. Mitchell on "Lamziekte."

EXPERIMENTS TO TRANSMIT LAMZIEKTE WITH BONES OF ANIMALS THAT DIED OF LAMZIEKTE.

Nos. 112-118, *vide* article by D. T. Mitchell on "Lamziekte."

EXPERIMENTS TO TRANSMIT LAMZIEKTE INTO GOATS.

Nos. 119-123. *Vide* article by J. Walker, "Investigations into disease of Lamziekte in Cattle."

EXPERIMENTS TO NOTE WHETHER THE BLOOD OF RODENTS AND OTHER SMALL ANIMALS FOUND ON LAMZIEKTE FARMS WOULD PRODUCE THE DISEASE WHEN INJECTED INTO SUSCEPTIBLE CATTLE.

124. *Vide* article by J. Walker.

EXPERIMENTS TO TRANSMIT THE DISEASE BY CULTURE, OBTAINED FROM
CATTLE THAT HAD DIED OR WERE KILLED BY LAMZIEKTE.

Nos. 125 to 141. *Vide* article by J. Walker.

EXPERIMENTS TO TRANSMIT LAMZIEKTE BY MEANS OF TICKS.

The ticks were obtained from cattle suffering from lamziekte. They were sent to the Laboratory at Onderste Poort where their further development took place. In the case of redleg adults the stages subsequent to that in which they were collected were placed on susceptible cattle (adults and larvae).

The adult bontlegs were bred in the Laboratory on rabbits until the adult stage, in which alone they attack cattle. Bontleg ticks were also collected in their nymphal stage on wild animals, and after moulting in the Laboratory into their adult stage were placed on cattle. The bontleg tick undergoes its larval and nymphal stage on smaller animals and the adult stage on cattle. A transmission would, therefore, only be possible by adults.

142. One cow, No. 567, was infested on the 21st December, 1910, with redleg adults and redleg larvae collected off three different cows suffering from lamziekte. Result: Negative.

143. One cow, No. 678, was infested on the 21st December, 1910, with bontleg adults (six times) collected from koorhaan, partridge, and hares killed on a lamziekte farm. Result: Negative.

144. One cow, No. 650, was infested on the 7th December, 1909, with bontleg adults originally collected as engorged females off a cow suffering from lamziekte; they underwent their larval and nymphal stage on rabbits in the Laboratory, Onderste Poort, Pretoria. Result: Negative.

Conclusion.—All experiments to transmit the disease by ticks collected off sick cattle or off wild animals on lamziekte farms failed to transmit the disease.

EXPERIMENTS WITH BONEMEAL AS A PREVENTIVE FOR LAMZIEKTE.

Special mention was already made on this subject in the notes collected from the late Dr. Hutcheon's reports. There is no doubt that the experiment carried out in the Witte Clay Rug in 1895 under the supervision of Mr. Borthwick was to the effect that when bonemeal was given *daily in doses of 3 oz.* no disease was noted in the cattle so treated, whereas a number of controls died.

145. In the lamziekte experiments undertaken by Mr. Spreull in Koopmansfontein, Cape, twenty cattle were dosed exclusively with three tablespoonfuls of fine bonemeal *three times a week* during 1907, or 154 times in all. No lamziekte appeared amongst these cattle; two cases occurred in the lot where the cattle had free access to bonemeal; nine cases occurred amongst twenty other cattle which were not treated in any way, but which acted as controls to the treated batch.

146. In the last experiment undertaken at Yarrow by Mr. Robertson, thirty cattle were *fed daily from the end of July, 1909, with 2 oz. of bonemeal*, and were allowed to graze on lamziekte veld with another batch of eighty-one cattle which acted as controls. Nine

deaths from lamziekte occurred amongst the control lot (seven cows and two heifers), but up to the end of June, 1910, only one doubtful case occurred amongst the bonemeal lot.

Result.—It is remarkable that in all experiments where bonemeal was given frequently cattle did not contract lamziekte, whereas deaths occurred in the control animals. This can hardly be considered to be a mere coincidence, and the bonemeal has apparently had some influence.

Attention must be drawn to the fact that the bonemeal was given *daily* in Borthwick's and Robertson's experiments.

EXPERIMENTS TO FIND OUT IN WHICH WAY LAMZIEKTE IS CONTRACTED.

147. *Vide* article by D. T. Mitchell.

RESULT OF INVESTIGATIONS OBTAINED FROM THE FARMERS IN REPLY TO THE QUERIES SENT OUT, FROM INTERVIEWS, CORRESPONDENCE, AND FROM LETTERS TO THE *Agricultural Journal*.

The following conclusions represent the experience of the farmers. They were compiled from the sources stated above.

In order to come to some understanding about the cause of lamziekte a hypothesis will have to be formed which must be based on the evidence collected from the farmers and on the experiments carried out by us. This hypothesis must explain at least the striking facts known about this disease. It sometimes appears that there are a great number of contradictory statements, but we can explain some of them satisfactorily by referring to our experiments, which we must accept as convincing.

Taken as a whole the majority of observations are uniform, and it is on this majority that I have placed most value. There are also a good many individual observations which I have included, as from the personality of the writer I could see that they were based on practical experience.

Historical Notes, Geographical Distribution, and Spread of the Disease.

1. Lamziekte has been reported to exist in the following Districts:—Cape Province: Mafeking, Vryburg, Taungs, Kuruman, Barkly West, Kimberley, Hay, Herbert, Campbell, Gordonia, Kenhardt, Albany, Bathurst, Uitenhage, Port Elizabeth, Humansdorp, Somerset West, Somerset East, Bredasdorp, Swellendam, Mossel Bay, Riversdale, Peddie, Alexandria, Graaff-Reinet, and Van Rhynsdorp. Very likely it exists in all western districts. Transvaal Province: Bloemhof, Lichtenburg, Wolmaransstad, and Christiana. Orange Free State: Boshoff, Hoopstad, Bloemfontein, Fauresmith, Winburg, Kroonstad, and Jacobsdal.

2. In Bechuanaland the home of the disease has been considered to be on the Kaapsche Berg or Kaap Plateau, from which it is believed to have gradually extended.

3. The disease is said to have spread within the last two years in the western districts of the Orange Free State and the Transvaal, and to have appeared on farms known previously to be healthy and considered to be free from the disease.

4. The disease has, in the past, been noted to occur sporadically within the lamziekte area, but within the last two years it has occurred more severely throughout Bechuanaland, Western Transvaal, and the western area of the Orange Free State. It is generally stated that in these areas the disease was at its worst during the years 1910-11.

5. The disease has not been reported to exist in the bushveld of Bechuanaland or the Transvaal adjoining the lamziekte regions.

6. It is stated in the Transvaal and in the Orange Free State that the disease creeps slowly from west to east. In the Free State the railway seems to be the dividing line between lamziekte and healthy areas.

7. In Alexandria District the first outbreak of the disease is generally dated back to about forty years ago, previous to which time it is stated not to have existed. Its introduction is connected with transport riding going on in those days. One farmer states, however, that a lady of eighty years of age remembers the existence of the disease when she was a child, and another farmer dates it back to over fifty years ago.

8. In the Herbert District all people call lamziekte a "veld-ziekte."

9. The native name for lamziekte in Bechuanaland is "makukumal." In the Free State it was given as "leelem."

10. In the Humansdorp District the disease is generally dated back to the time of the big fire which occurred at the end of the sixties and raged from George to Uitenhage. As a result of this fire it is stated that the sour bush invaded the pastures.

11. In Griquatown it was known in 1886, and at that time it was already considered to be an old-established disease.

12. In recent years the disease has been noted in the north-western districts to appear almost on any farm within the lamziekte region without there having been any movement of cattle to the farm, and under the conditions that during many years previous no cases of lamziekte were known.

13. In Graaff-Reinet the disease is stated to have existed on one particular farm for the last thirty years, and it is further stated that only within the last seven or eight years it appeared on the immediate adjoining farms. These farms are situated in the grassveld. The opinion has been expressed that the disease was introduced with transport oxen in the days of transport riding.

14. One farmer expresses the opinion that the introduction of the disease into the Kimberley District must be dated back to the days of the transport to the diamond fields, and that it was brought by oxen from the Alexandria District.

15. In Riversdale District it is stated that the disease only occurs in the sour parts of the "duineveld." On the "strand veld" it is only noted on farms in a patch of sourveld. It is not noted in the "duine ruggens," and when it occurs it is only in the "vlaktes" where there are springs and the veld is sour. In the middle veld,

between the mountains and the dunes, only one farm is said to have the disease, and this is a sour veld farm. The veld of the "ruggens" consists of "rhenosterbosch," and in most cases of sweet grass. The sour veld is along the Langeberg Range and the first row of farms along the mountains. All "voor duineveld" is sour. The general statement is made that the disease is only on the sour veld and never on the sweet veld.

16. In the Bredasdorp District it is stated that the disease occurs but rarely in the "duineveld." It occurs frequently on the flats of the "strand veld," and it is prevalent along the mountain ranges in the "strand veld." The real lamziekte veld is said to lie between the dunes and the "ruggens." The disease is not known in the "ruggens" where the veld is sweet.

17. Many statements have been made to the effect that, generally speaking, the disease has been more prevalent since the war than before, and that previous to that time it was unknown or anyway much less spoken of than now.

18. It is frequently stated that in former years the disease was not so virulent as recently, there being more animals which recovered. The disease of that time was called the true lamziekte in contradistinction to what is now reported to be gal-lamziekte.

19. It has been stated that although cattle have been moved into the Karroo veld and have died there, yet no case of lamziekte has ever occurred in the Karroo veld itself.

20. No case has as yet been recorded within recent years where cattle from an unhealthy area moved into a healthy area outside and some distance from the lamziekte region, have started a new centre of the disease.

Sex, Breed, and Condition of Cattle Affected.

21. Lamziekte principally attacks heifers in calf and cows with their first, second, or third calves.

It is stated that cows in milk contract it in greater proportion than cows and heifers in calf. Cows usually go down with the disease from eight to fourteen days after calving. Generally speaking, young heifers and tollies from eighteen months to three years of age are also subject, so are oxen, although not to the same extent. The proportion is said to be one ox to ten cows. Bulls have occasionally been noted to sicken and die. One farmer states that the disease is the most troublesome when the cows are in milk. It is also generally stated that the fattest stock sicken first, and that old animals contract it in a much lesser degree.

22. The disease has been noted to appear equally in cattle kraaled at night as well as in cattle running in the veld.

23. In some instances lamziekte has been found to run in families.

24. Afrikaner cattle are in many instances considered to be more susceptible than pure or cross-breds.

25. It is stated by many observers that cattle born and bred on a farm are more liable to contract the disease. Cattle introduced from elsewhere seem to be free of the disease for some time after their arrival. After a lapse of twelve months there seems to be no longer any difference.

26. It has been noticed that the mortality varies greatly. Frequently, whether treatment was resorted to or not, a great number of cattle recovered, whereas at other times, under similar conditions and treatment, none survived.

27. There is no difference in the mortality of oxen, whether grazing alongside of the breeding stock or kept separately in camps. In most instances under observation oxen and breeding stock were grazing together.

28. No definite observations or statements are at hand which would show the total losses per annum in any part of the lamziekte region. From individual statements it can be gathered that the mortality varies considerably, from a small percentage to almost a complete destruction of all cattle within a few years. It has been stated by many farmers that for several years they were not able to increase the number of their herd, the disease carrying away a number of the old stock equivalent to the number of calves born yearly.

29. In some instances it has been noticed that of cattle belonging to two different owners, grazing and watering together during the day, the cattle of one owner will not die of lamziekte, whereas the other may lose heavily. It has also been noted that in the succeeding season the reverse may take place (werf theory).

30. It has been noticed that frequently within a comparatively short time, or almost simultaneously in a herd, a number of cattle go down with the disease, subsequently followed by a period of freedom.

31. Some farmers state that when the disease has made its appearance in a herd it can be noticed that something is wrong with the cattle. Others state that they can frequently spot an animal some time before it actually goes down with the disease.

32. All blood smears of lamziekte animals submitted for examination by microscope were returned by the various examiners as negative. It was only rarely that complications with redwater or gall-sickness were recorded.

33. It has been noticed in several instances that cows grazing together (mates) were found to be attacked simultaneously by the disease and died within a short time of each other.

Susceptibility of other Animals.

34. Horses are stated not to be liable to lamziekte, but in several instances sheep and goats are alleged to have sickened and died. It has also been stated that goats contracted it a second time. So far no scientific investigations into lamziekte of sheep and goats have been made.

35. In the coastal districts some farmers expressed the opinion that the increase of ostriches is to some extent responsible for the increase of lamziekte in those parts of the country.

36. It is also stated that ostriches are affected by a disease in which paralysis of the legs is the striking symptom.

37. In Kuruman District it is stated that goats, ostriches, and donkeys were noted to sicken after they had eaten the dung of lamziekte animals.

38. Carcasses of animals that died of lamziekte were consumed in many instances by whites and natives without any ill effects.

Immunity.

39. It is generally admitted that animals which have had one attack of the disease are more liable to a second one than animals which have not yet sickened. Hence the practice of selling such cattle after their recovery.

One farmer stated that in 1906 twenty-two of his animals sickened and recovered within the year, and these were the first to sicken and die the following year.

40. The above observations led to the general acceptance that in lamziekte no immunity results from one recovery. New attacks may occur within a few months. According to Spreull a new attack may occur within a fortnight to four months of the date of the previous illness. This conclusion is supported by the experience of many farmers.

41. Animals may sicken several times. It is generally admitted that if a second attack does not prove fatal a third will. There are exceptions to this rule. Cases are recorded where a fourth and fifth attack occurred, but they are quite exceptional.

Depraved Appetite and Craving.

42. It is generally admitted that on such farms where lamziekte is present cattle show an unusual craving for bones or for anything abnormal, such as skins, leather, tins, hoop-irons, fencing wire, hide, horns, clothing, grain-bags, earth, bark of trees, limestones, manure, etc. So noticeable is this craving on certain farms that farmers consider this a sure symptom of the approach of the disease. Where cattle do not crave for bones, as is said to be the case on the Fish River, and in the Karroo, cattle do not die of lamziekte.

43. It is stated that the craving for bones may start almost suddenly without any previous indication, and that the animals which previously kept to the veld come around the homesteads and huts and begin chewing anything they can find. A few days later the disease is noticed to break out.

44. It has been pointed out that on some farms within the lamziekte region the craving for bones is less than on adjoining ones, and that on such farms there was no lamziekte.

45. A craving for bones seems to be found in cattle which are grazing on the sour veld. It is specially noticeable in cattle brought from sweet to sour veld, and it disappears after the cattle have returned to the sweet veld. When the veld is poor there are more cases of craving than when the veld is in good condition.

46. The farmers who came to Bechuanaland from other parts of South Africa state that the craving is more noticeable amongst the cattle of Bechuanaland than anywhere else in South Africa.

47. Cattle grazing on "brakveld" show but little craving for bones.

48. It has been noted that cattle which have access to ganna-bush do not take to salt licks.

49. One farmer stated that the craving for bones in cattle ceases or becomes much less when the herd is divided up and more veld is allotted to them for grazing.

50. It is also stated that oxen show less craving for bones than cows, and amongst these it is more marked in cows in calf, or with calves at foot than in dry cows.

51. It is generally stated that a liberal supply of salt and bone-meal or of chopped bones does not always arrest the abnormal craving in lamziekte areas.

Condition of Veld and Grass.

52. In Bechuanaland it is stated that this disease occurs in grassveld, thornveld, "vaalboschveld," and on veld containing the "resin bush," "blauwbosch," and "taaibosch." In the Orange Free State it is stated to occur in grassveld, thornveld, and "gebroken veld," but under no conditions in the "Karroobosch veld" (boschjesveld). In the Transvaal the conditions were similar to those of Bechuanaland.

53. In the Uitenhage and Alexandria Districts the disease is known on farms with bushveld. This bushveld is, however, not identical with the bushveld of the northern districts.

54. In the Graaff-Reinet District the disease has been met with on a farm where the vegetation is mostly prickly pear; the undergrowth, however, appeared to be grass, and the farm lies in the grass region.

55. It is stated in the Eastern Province that along the rivers coming down from the Karroo the disease is but little known.

56. It is frequently stated that the disease is more frequently contracted on "bults" than on "laagtes." In the Kuruman District it is stated that on mountains the disease is less prevalent, the pasturage being partly sour and partly sweet veld.

57. In the coastal districts of the Eastern Province the disease is stated to occur principally on the sour veld, and not at all on the sweet veld. A change from the sour to the sweet veld or the duine veld stops the disease soon after removal of the cattle. Returning from sweet to sour veld causes the disease to reappear after some time.

58. In the Mossel Bay District the disease is stated to occur both on mixed and on sour veld. Sour veld is "zuikerboschveld."

59. The statement is made that although the veld of lamziekte areas looks perfect, the disease may nevertheless occur, since it has not sufficient "strength" on account of want of rain, which only falls during a few months of the year.

60. In the Bredasdorp District it is said that the disease appears in the camps of the sour veld containing "waterboschjes" and "steekrietjes."

61. It has been stated by one farmer, formerly a transport rider, that the "rooi grass" of the "zuurveld" in the Albany District is not so nutritious as that up-country, he having observed that oxen eat at least three times as much in order to satisfy their wants.

62. The "wilting" and withering of grass after a shower of rain has occurred, succeeded by a scorching sun, is most frequently accused of being the cause of the disease. A similar statement is made of "brands," where the young grass withers as a result of dry weather.

63. It is considered to be in favour of lamziekte when the grass does not mature before the frost has set in. This was particularly stated to be the case in the years 1910-12.

64. It is generally considered that on farms which have much gannabush the disease is not known.

65. Many Free State farmers are of opinion that the grassveld in which cattle contract the disease principally consists of "rooi-grass," "zuurpol," and "beestegrass"—some connect it with the "beestegrass" and others state that it is more frequently contracted in "rooi-grass" bulks.

66. It has frequently been noted that on two farms apparently with the same veld cattle on one side of the boundary fence will die, whilst those on the other side will not. It is also stated that a few months or a year later the reverse has been noted.

67. Many farmers are of opinion that a herb, possibly a drought-resisting herb, is the cause of the disease. In Humansdorp, where the burning of the veld out of season is generally accused, an "op-slag" is considered to be the cause.

68. In the coastal districts attention has been drawn to the observation that on veld grazed over by sheep lamziekte seems to occur more rarely, and finally seems to die out.

*Condition of Soil, Geological Formation, Altitude, and Situation
of Farms.*

69. In Bechuanaland it is generally stated that the disease occurs under all possible conditions of soil, in sandy as well as on hard soils.

70. There is no geological uniformity throughout the lamziekte region, although it is stated that the disease occurs most extensively in the lime and dolomite formation. It is stated where "Jonas klip" (dolomite) is present the disease will occur.

71. In most instances farmers suspected particular places on their farms to be more unhealthy than others; there is, however, no uniform characteristic of such places by which they could be recognised.

72. Farms situated along rivers are generally considered to be more healthy than others, or on such farms the camps alongside the river are known to be more healthy than the rest of the farm. The Vetrivier Valley, in the Free State, is described to be a healthy valley.

73. In Kimberley District lamziekte has been noted to occur on a farm on which no cattle have been introduced since the war.

74. Some farmers make the statement that as long as the ground is wet lamziekte does not occur, or if so, to a much lesser degree.

75. Some farmers state that when the soil is deep, less lamziekte is known, and that the lamziekte farms are those where the soil is shallow.

76. Some farmers state that the disease has been noticed on old lands.

77. In the Alexandria District it is stated that the farms along the edge of the bushveld are all sweet, and the disease is not known there. On the grass farms the disease is said to be more prevalent. Farms on the banks of the Bushman's River with deep alluvial soil do not know the disease.

78. In the Albany District some farmers state that the disease is prevalent on the sour hills; these hills are all rock and yellow clay and covered with grass; the higher they are the more sour is the veld.

79. In the Free State it is generally stated that it principally

occurs in sandy soil and not, or but rarely, on hard soils; some farmers give as the reason for this that in sandy veld the grass, after slight rains, grows quicker and withers more. In Kuruman District the disease is stated to occur both on hard and sand veld.

80. Relative or absolute altitude does not seem to have any influence on the occurrence of the disease. In Bechuanaland the general opinion is that it occurs on both high and low-lying grounds.

81. Some farmers accuse the vleis as the places where lamziekte is contracted, and make a habit of keeping the cattle off them by fencing. There is a statement, however, to the effect that cattle kept on damp vleis suffer less.

82. It is stated that cattle kept in damp places suffer less from the disease.

83. Cattle do not contract lamziekte in river veld of a tidal river; this veld is called sweet brak veld.

Condition of Water Supply.

84. The drinking water supply has apparently no influence on the presence or absence of the disease. It is noted on farms where the animals are watered in the river, in dams, from springs, boreholes, rain water, spring water, or borehole water collected in dams or in troughs.

85. It has sometimes been stated that small watering places containing foul water are the cause of the disease; others connect it with the waste water from boreholes collecting around the pump. Some farmers accuse the so-called "padda" water collecting after the rainfall.

86. A few farmers connect the disease with brackish water, and some say that the supply of brackish water keeps the disease away.

Grass Burning.

87. The opinions concerning the effect of grass burning on the appearance, prevalence, and disappearance of lamziekte vary considerably in the different regions. In Bechuanaland the majority of farmers state that no influence in whatever way is noticeable either after burning in or out of season. In other parts it is held that the young grass of a "brand" after the effect of a scorching sun acts as a cause of lamziekte, particularly on "brands" which occurred out of season. In Humansdorp District it is held that the burning out of season leads to the disease only after the lapse of a year or eighteen months.

88. Generally speaking, the safest time to burn the grass in the northern districts is said to be in mid-winter. "Brands" at any other time are considered to be unhealthy. In the Orange Free State the proper time to burn was said to be from August to the 15th October. In Bredasdorp District the proper time was stated to be from the beginning of February to the end of March, namely, before the rains set in. In the Riversdale District it is stated that the disease only occurs after untimely burning of the sour veld. Sweet veld does not matter, and so long as the veld is not burnt at the proper time again the disease will remain on that farm. The voorduine and low veld has to be burnt in June and July, and the "ruggens" or mountain veld in December and January.

89. It has been stated that the burning of the veld keeps the sour veld alive.

Influence of Changing of Veld, Trekking, Working, and Feeding.

90. Fencing of farms has had no influence on the appearance or disappearance of lamziekte. It occurred on fenced-in farms as well as on unfenced farms. There seems to be an idea that the prevalence of the disease in certain parts is due to the fencing of the farm. It has been pointed out that in previous years the disease was less prevalent, because, owing to the absence of fences, farmers were able to trek about with their cattle. Some farmers, however, think that more camping-down would keep the disease out.

91. It is unanimously stated that oxen which are worked—particularly oxen used in the plough—are less susceptible to the disease than oxen put up for fattening or for a rest, and that cows used for heavy work behave similarly. Moving or driving cattle for three to six hours will stop the disease for a short while. Swimming is said to have a similar influence.

It is also said that cattle which sicken after trekking frequently show the disease in a milder form. Many farmers state that the more the cattle trek about the healthier they are.

92. It is stated that trekking from unhealthy to healthy areas stops the disease absolutely soon after the arrival of the cattle. Trekking from unhealthy to unhealthy areas also has a similar influence, but in this case it is only of a temporary nature. It is said that the trekking on to farms on which no cattle would live was beneficial, the cattle remaining free from the disease for some time after their arrival. Other farmers have not noticed any good results from trekking or changing of veld.

93. Farmers in the coastal districts (George, Stellenbosch) occasionally change their cattle from the sour veld into the duine veld, and they state that this keeps the cattle healthier.

94. It has been stated that whilst cattle were dying on a particular farm, strange cattle brought there during that period and grazed together with the farm cattle did not contract the disease.

95. Cattle brought from unhealthy areas into lamziekte areas do not contract the disease until some time has elapsed after their arrival. The time is stated to vary from a few months to a year. Some farmers are emphatic that on certain farms cattle are quite safe during the first year.

96. It has been stated that when cattle have been feeding for some time on Karroo veld and are then brought back to the grassveld they do not contract the disease so soon, and appear to be safe for some time.

97. In the Bredasdorp District it is stated that cattle from the "ruggens" or dunes, where lamziekte is unknown, remain in good health here for the first year that they run on lamziekte veld.

98. It has been noticed that cattle stabled and fed on foodstuffs such as oats, bran, etc., and cattle which are grazing but obtain a supply of similar foodstuffs, or cattle which are turned into a lucerne field, are less liable to contract the disease.

99. It has been stated by one farmer of Somerset West that when he feeds his animals at night and lets them run in the veld all day, he does not notice any disease.

100. It has been stated that the feeding of greenstuffs, such as green barley, is beneficial to animals sickening with lamziekte, provided the disease has not gone too far.

Influence of Rain and Season.

101. The rainfall within the last years in various places in which the disease was prevalent, has been under the average. The following figures relate to a recording station in the lamziekte areas of the three Provinces:—

Area.	1908-09.	1909-10.	1910-11.	Average during preceding ten years.
	Inches.	Inches.	Inches.	Inches.
Cape (Vryburg District)	25·03	12·14	12·71	17·77
Transvaal (Christiana District) ...	—	10·71	12·50	14·64
Orange Free State (Boshof District)	23·52	9·86	15·79	16·54

It is generally stated that in former years there was more rainfall than there has been during the last few years.

102. The majority of observers state that the frequency and prevalence of the disease is more noticeable in dry seasons with hot winds than in seasons with normal rainfall.

103. It is also stated that on certain farms the disease appeared under almost any conditions of rain and temperature.

104. The disease may occur at any time during the year, but the period of prevalence is considered to be the months from September to March, more particularly the months September, October and November.

105. It has been noticed that the disease is less prevalent during cold weather, and is practically absent during the winter months; in recent years, however, many cases have been recorded during the winter months.

106. It is also stated that in years with a normal rainfall the disease may appear after a spell of dry weather. Attention has been drawn to light showers followed by very hot weather, when cases will frequently occur.

107. The disease is said to be arrested by good rains. It appears, however, that the rainfall must occur at the proper time of the rainy season. Late rainfalls do not seem to completely check the disease. The years in which the disease is not noted are those in which the rains are abundant and well distributed over the season. A heavy rain may stop the disease for a while.

108. A farmer in Herbert stated that with the decreasing rainfall during the last years, the cattle under his observation became much smaller, and that a noticeable feature is the thinness of their skin.

Inoculation and Dipping.

109. It has been shown that the dipping of cattle has no influence on the occurrence and prevalence of lamziekte.

110. One farmer stated that when rinderpest swept through the Eastern Province cattle were at the time dying in great numbers from lamziekte. After the bile inoculation, followed by virulent blood, had been carried out, no cases occurred for practically the following four years.

111. Much use has been made of the vaccination with anthrax vaccine against lamziekte. In many cases a direct influence has been noted, the disease disappearing directly after vaccination. There does not, however, seem to be any lasting immunity produced, the disease appearing again later, when a second inoculation did not have the same result. Some farmers still adhere to the practice of vaccination, whilst by the majority it has been given up as useless. It has not been stated by these farmers how soon after inoculation new cases occurred.

112. A similar observation has been made with the inoculation of redwater, the disease disappearing soon after inoculation. The disease reappeared, however, at a later period.

Value of Bonemeal.

113. There is a difference of opinion as to the value of bonemeal as a preventive against lamziekte. By far the greatest majority of farmers state that the supply of bonemeal in no way influences the disease. A small minority claim that it has a protective influence; these are principally amongst the farmers of the Eastern Province. Practically all farmers admit a remarkable influence due to bonemeal on the condition of an animal. Some farmers state that it stops stijfzieke.

Disease caused by Eating Bones.

114. The idea has been advanced that eating the bones of cattle which died of lamziekte is the cause of the disease, and accordingly the recommendation has been made to bury all such bones. Although there is a difference of opinion on this point, the majority of farmers state that burying the bones and carcasses carried out over a number of years has in no way decreased the number of lamziekte cases.

115. It is stated that in some instances the feeding of cattle on "pensmist" of a lamziekte animal was followed by death. There are also statements with contrary results.

116. In some instances it has been stated that the feeding of bones of lamziekte or any other animals, and more particularly rotten bones, caused the disease in cattle.

117. In the area in which lamziekte is known anthrax also exists, and farmers admit that probably, in many instances, mistakes between the two have undoubtedly occurred.

118. The opinion is truly expressed by farmers that the disease is not infectious or contagious. Others explain its apparent spread under such an assumption.

Conclusion.—Comparing the results obtained from farmers with those collected by the late Dr. Hutcheon in the eighties of last century, of which a *resume* has already been given in the first part of this article, an almost complete agreement of statements can be noted, and any discrepancies occurring there are also to be found here. There is apparently no change in the conditions under which the disease is now noted to those known then.

THEORIES ABOUT THE CAUSE OF LAMZIEKTE.

1.—*The Infection Theory.*

The generally admitted facts that within recent times lamziekte has been enormously on the increase, at least in the north-western districts of the Union, that it appeared in a rather alarming manner on places where previously the disease was but little known, that it appeared on farms which were known or at least thought to be healthy, and that apparently it was extending, although in an indefinite manner, on the border of the known lamziekte area, all gave rise to the idea of the disease being infectious. We have repeatedly heard the statement made that the disease is spreading, although it is spreading slowly. I do not deny that there are certain observations, which on first sight seem to support this view, yet I do not think that we have sufficient data to hand which would in an unmistakable way prove such an assumption to be true. I do not deny the possibility of it spreading, but I have a difficulty in understanding it. If we go through the history of the disease we find that it existed over one hundred years ago in the Western Province of the Cape; we find that in most districts in which it now exists it was known over a generation ago and even longer (Bredasdorp, Bechuanaland, Eastern Province). Since human memory is not infallible, we have reason to believe that at one time or another the disease existed in all the districts that are now infected. There are certain years in which the disease is prevalent; there are years in which it is absent. There are series of years, perhaps even long ones, in which the disease was not heard of, and naturally the younger generation cannot know of what has passed previous to their days, especially since few records are kept and our forefathers who experienced it in the early times are no longer in the land of the living. More than usual interest is only taken in a disease when it begins to affect us directly or indirectly in our every-day occupation. The disease is known so far only in certain areas (we may say in the western South Africa), and considering that during the last twenty years, and especially since the railways were built, movements of cattle took place from the western into the eastern region, and yet no epidemic has been noted in these latter ones. All these facts speak against an infection. Under an infection we understand a disease caused by some organisms, bacteria or protozoan, commonly known as micro-organism, or also by some larger parasites,

such as worms, arachnoids, and insects. They are either directly transmitted from animal to animal and are then called contagious, or indirectly, passing into the soil and from there back into the animal directly or through an intermediate host, viz., a tick or insect which lives on an animal, or within an animal, like some of the intestinal worms and other parasites. All directly contagious diseases in South Africa known to be due to such organisms, *e.g.*, rinderpest, pleuropneumonia, glanders, scab, etc., have been spreading in the past at certain times or are still spreading. The indirectly contagious ones, redwater, gall-sickness, anthrax, and black-quarter (sponziëkte) are by this time uniformly present in all parts and more or less prevalent; for instance, East Coast fever has been steadily extending within recent times. No boundaries, real or artificial, have stopped them. We can hardly imagine an organism which would stop spreading in such a definite manner as is the case with lamziëkte, inasmuch as most organisms are dependent on a living animal. Some of them can even be spread by part of the dead animal (flesh or skin), or articles which have been in contact with them.

Our first undertaking was to prove or disprove the existence of an organism as the cause of lamziëkte. For this purpose the blood of all cases which came under our personal observation was examined, and in addition to these an equally great number of blood smears were sent by farmers from Bechuanaland, Western Transvaal, Orange Free State, and Cape Province. We did not find any new organisms; we did not find any blood lesions. Knowing well that there are blood diseases in South Africa caused by ultraviolet organisms (such as horse-sickness, blue tongue, heartwater) and accordingly invisible under the microscope, we undertook a large series of experiments to endeavour to transmit the disease by inoculation. As indicated under the heading of transmission experiments, parts of practically all organs of a sick beast in the different stages of the disease, the beginning as well as the end, were made use of. All inoculations failed to produce lamziëkte, and we were therefore entitled to conclude that at least in such organs as we have experimented with no micro-organisms are contained which could be transferred by inoculation. In addition to the experiments, cultures were made from various organs, and whenever a growth was obtained the culture was injected. The question might be put here: "But when the organs do not transmit the disease, why should cultures do so, and when on microscopical examination there are no organisms present how is it possible to grow any in cultures?" This apparent discrepancy can be explained. Notwithstanding microscopical examination some bacteria may only be present in such small numbers that microscopically they can be overlooked, and that in the inoculated material they are not sufficiently numerous to get a start for a growth in the animals. Bacteria were found in various organs in this way as had to be expected. When injected all these cultures gave negative results, thus proving that they had nothing to do with lamziëkte. It was also thought that the intestinal tract might contain organisms which will only develop there and nowhere else, so that they might produce the toxin which would be absorbed in the body and result in the disease. Such an organism would either belong to the vegetable or animal kingdom, be either a bacterium, a fungus, a protozoon or a worm. If it was one of the

latter it would have been detected by the naked eye or by microscope if it was a visible organism. The experiments to transmit the disease by drenching of the contents of the intestines, which was carried out in many instances and with different material, would have given positive results if any specific organisms had been present in the intestines. It is true that from drenching with the intestines of an animal in an advanced state of putrefaction death was caused in some instances, and the symptoms during life resembled somewhat lamziekte, but when repeated with fresh material the results were negative, proving that the putrefaction was responsible. Many farmers had stated that the "pensmist" (contents of first stomach) caused the disease when eaten by cattle, sheep, goats, and even ostriches. The experiment was repeated in several instances on cattle and goats; but we failed in all instances. Very frequently the statement was made that the eating of bones of a beast which died of lamziekte was the cause of the disease. In one of our experiments with rotten bones death was caused, again resembling lamziekte somewhat, but when repeated it failed, proving in this instance also that putrefaction was responsible. The experience of most farmers is to the effect that burning or burying of carcasses or of bones (that means removing the infection if it is connected with carcasses) did not cause the disappearance of the disease.

Accordingly the statements of those farmers who have seen death occur after cattle have been eating "pensmist" or bones must be interpreted in a different way if poisoning caused by putrefaction can be excluded.

It must be remembered here that the area in which lamziekte occurs is also an anthrax area, and it is quite feasible that in such cases mistakes occurred in the diagnosis. That an intermediate host in the form of a tick or an insect could carry an ultraviolet and not inoculable organism had to be excluded by direct experiments with ticks collected off sick cattle bred in the Laboratory and subsequently placed on healthy cattle, and above everything by the observation that dipping had no influence on the absence of the disease.

That worms in one way or another can be excluded was proved by the direct examination of the various organs. Worms could not have escaped the observations of the earlier investigations.

The fact that in lamziekte we do not find any fever and that recovery from the disease does not produce any lasting immunity, but makes the animal more susceptible, speaks against an infection in the shape of a micro-organism.

We have not overlooked the fact that there are certain micro-organisms, viz., tetanus, which remain localized and do not spread at all beyond their original seat, growing and multiplying very slowly, causing a virulent toxin which when absorbed causes the disease. In such cases there is almost constantly a wound present, giving entrance to the micro-organism. Special attention was given to the search of the skin of dead animals, but no parts of entry could be detected for such an infection.

The strongest experimental proof that micro-organisms cannot be held responsible for lamziekte is the muzzling experiment. As stated, a lot of fifty cattle were muzzled and turned out to pasture daily with a lot of unmuzzled cattle acting as controls. The former received their feed in the kraal, consisting of hay from a healthy area. There was