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The Occurrence and Identification of Bluetongue in Cattle—the so-called Pseudo-Foot and Mouth Disease in South Africa.

By

J. G. BEKKER, B.Sc.Agric., D.V.Sc., Veterinary Research Officer, Onderstepoort,

G. v. d. W. DE KOCK, M.R.C.V.S., D.Med.Vet., D.Sc., Deputy Director of Veterinary Services and Animal Industry, and

J. B. QUINLAN, F.R.C.V.S., D.Med.Vet., D.V.Sc., Sub-Director of Veterinary Services and Animal Industry, Onderstepoort.

INTRODUCTION.

Up to the present (1932) it has been accepted that bluetongue (Catarrhal fever) is a disease specifically and exclusively confined to sheep. No observations have been recorded of the disease occurring naturally in cattle, and attempts to produce reactions in animals other than sheep, have generally failed.

Spreull (1905) demonstrated that calves and goats inoculated with blood of sheep affected with bluetongue retained the virus for some time. He found the blood of such calves still infective when tested on sheep on the 21st day after inoculation, but after 35 days the blood was found to be sterile. Subsequently he again inoculated these calves with virus material, but says: "The calves did not again become virulent". Apart from a "slight reaction" in one of these calves he apparently did not observe any typical bluetongue symptoms or lesions. The fact, however, that the blood of these calves did not become virulent, when inoculated a second time, would seem to indicate that the calves had undergone a reaction. The reaction was, however, imperceptible as no symptoms or lesions were observed. When the virus was introduced in the second instance it was apparently destroyed by immune bodies which had developed after the first inoculation.

More recently Neitz (1933) found that the blesbuck (*Damaliscus albifrons*), although developing no perceptible reaction to bluetongue virus, can in a similar way act as a "reservoir" for this virus. He could demonstrate the presence of the virus in the blood of the blesbuck up to the 17th day after inoculation (a period corresponding closely to Spreull's 21 days in the case of calves). Neitz puts forward

the interesting hypothesis that the disease bluetongue was originally transmitted from game to sheep: " The game acting as a reservoir for this virus in the same way as the blue and black wildebeeste act as a reservoir for Snotsiekte ". This contention, however, appears to be somewhat misleading, and the analogy made between bluetongue and snotsiekte is not strictly correct. In the case of snotsiekte outbreaks have only been noted where cattle come into very close contact with wildebeeste (Mettam, 1923). Furthermore, under natural conditions there is no evidence of the disease spreading from cattle thus infected. On the available evidence the wildebeeste do seem to serve as a reservoir for snotsiekte virus. In the case of bluetongue, however, the presence of game is not a requisite factor and the epizootology of the disease is entirely different from that of snotsiekte. Therefore, the suggestion that game should be inculpated as the immediate reservoir of bluetongue virus cannot be entertained.

The intensive veterinary campaign of 1932-33 to combat the outbreak of foot and mouth disease in Southern Africa brought to light the occurrence of an undescribed " stomatitic " disease of cattle which made its appearance in localities scattered over an extensive area of the Union (*vide* Appendix C). In practically every instance where the disease was reported the owners suspected foot and mouth disease and widespread consternation resulted. These outbreaks were particularly common on Transvaal and Free State highveld farms.

At the beginning of March, 1933, the disease broke out in a herd on the farm Welgezegend in the Standerton District. Three cows developed very severe symptoms. In this instance also the owner suspected foot and mouth disease, and as the farm was not very far from Rooikop No. 15 (near Germiston), where foot and mouth disease had been diagnosed, the probability of another outbreak seemed very real.

Transmission experiments were decided upon and carried out on this farm. These experiments were in the first place designed to exclude foot and mouth disease and, in the event of its exclusion to attempt to ascertain the nature of this new condition.

The results of these Welgezegend experiments and of subsequent investigations undertaken at Onderstepoort, are the subject of this paper.

With the available experimental data it would appear that the virus causing the well-known bluetongue of sheep is also the factor concerned in the aetiology of this stomatitic disease of cattle.

For the sake of convenience and to prevent misunderstanding, it is proposed to refer to the disease as *Bluetongue of cattle.* It should, however, be understood that, although the term bluetongue is now almost exclusively used to designate this disease in sheep, it is an undesirable nomenclature when applied to the disease in cattle, since the blue or cyanotic condition of the tongue, as observed in sheep, is not usually manifested. A very regular change is a localized inflammation with necrosis of the buccal and nasal mucosa

and a popular term such as "seerbek" or "sore mouth" would have been more appropriate. By the adoption of the name *Bluetongue in cattle*, it is, therfore, not intended to refer to pathological or symptomatological changes in this disease, but rather to the aetiological factor concerned.

HISTORICAL.

Keppel and Robinson (1932) report on an outbreak of an "*Ulcerative stomatitis*" in cattle on several farms in the Eastern Free State and Basutoland. From their description of this disease there appears to be no doubt that they were also dealing with bluetongue in cattle. Keppel and Robinson suggested that the symptoms are to some extent reminiscent of three-day-stiffsickness. They undertook transmission experiments on a very limited scale, but failed to reproduce the condition. According to them, F. A. Verney, the Principal Veterinary Officer of Basutoland, encountered the disease at least 17 years ago. From evidence gathered from farmers there is reason to believe that the disease is not new to South Africa.

No serious notice was taken of the condition, for usually only a single bovine or at the most a few become affected, and such animals usually recovered. It was when a differential diagnosis became imperative that it received the serious attention of the Veterinary Research Division.

The term "*Ulcerative stomatitis*" and the less appropriate one of "*Pseudo-Foot and Mouth disease*", have been used to describe the condition. Farmers in the Free State now refer to the disease as "*seerbek*" (i.e. sore mouth).

Various theories and suggestions have been advanced by veterinarians and farmers as possible explanations for the cause of the disease. Keppel and Robinson (*loc. cit.*) mention that the stomatitis, described by them, might be a symptom of a general septicaemia such as may be caused by a filterable virus. It has been put forward that a poisonous plant might be responsible, but in view of the occurrence of the disease over a very wide area (*vide* Appendix C), and in localities differing markedly in their floristic constitution, this suggestion may be dismissed. Chemical irritants, such as caustic soda, carbolic acid preparations, etc., were also suggested, but this must also be ruled out for in many instances there was no history of the presence of such chemicals. A specific bacterial infection has been thought of. In cases where there was a lingual protrusion the disease was confused with lamsiekte (bovine botulism).

One of the authors (J. G. B.) whilst investigating some of these cases in the Standerton area, expressed the opinion that this disease was similar to, if not identical with, bluetongue in sheep.

CLASS OF ANIMALS AFFECTED.

It would appear from the cases which come under observation that all breeds of cattle are susceptible. The disease was observed in the Friesland, Afrikander, Shorthorn and Hereford breeds. Age

is apparently not an important factor as animals of varying ages contracted the disease. It is noteworthy, however, that the disease was not encountered in very young calves. In all the cases which came under observation the disease occurred in cattle pastured on the open veld. It was not seen in cattle which were housed. The absence of the disease in calves can probably be accounted for by the fact that, under the fairly intensive farming conditions of the Transvaal and Free State areas, where this disease was particularly prevalent, the calves are usually kept in kraals or stables, particularly at night, and are not allowed to run with their mothers. In this way they probably escaped the dangers of natural infection. The possibility, however, that young calves may be relatively less susceptible to the disease than older ones might also account for it's infrequent appearance in very young stock.

EPIZOOTOLOGY.

As has already been mentioned, this disease was observed over a wide area of the Union during 1933. According to du Toit (1933) reports of a similar disease have been received from territories outside of the Union, e.g. Northern Rhodesia.

During 1933 the outbreaks were encountered during the late summer and autumn, and most cases were reported during March and April. Keppel and Robinson (*loc. sit.*) also encountered an "*Ulcerative stomatitis*" during the same time in 1932. As far as it known no outbreaks have been noticed during the winter months. Just as in the case of bluetongue in sheep, further outbreaks are probably arrested by the first frosts. A fairly constant feature of the disease in cattle would seem to be that a comparatively small number (about 0·5 to 2 per cent.) in a herd become affected, but according to a communication received from J. J. Keppel, Senior Veterinary Officer of the Free State, the disease may assume alarming proportions. He mentions an outbreak where practically all the animals in a herd became affected.

There is no evidence to show that the disease can spread by contact. Even in instances where diseased cows were confined with their calves in a small stable and where the calves suckled or attempted to suckle the sore teats, the disease did not spread.

As in the case of bluetongue of sheep and horsesickness the outbreaks occur sporadically. It should be mentioned that during the 1933 season, when so many outbreaks of this disease in cattle were encountered, horsesickness and bluetongue in sheep were prevalent over a very large area of South Africa and even occurred in areas where it was practically unknown before. These two diseases actually occurred simultaneously with the disease in cattle on some of the farms where the outbreaks were investigated.

The same epizootological factors concerned in the occurrence of bluetongue of sheep and horsesickness are apparently also operative in this disease in cattle. It is, of course, well known that horsesickness and bluetongue do not always occur with the same severity, nor are the diseases as widespread in some years as in others. By analogy it can be inferred that this disease in cattle

does not occur to the same extent every year, in fact during some years it may actually not even make its appearance. The telluric conditions during 1933 were probably particularly favourable for its occurrence and apparently the same was the case 17 years ago when F. A. Verney (*vide* Appendix C) observed a widespread outbreak of an apparently similar condition in Basutoland.

AETIOLOGY.

Transmission experiments were undertaken with blood from twelve cases of this cattle disease in eight different outbreaks on the following farms, some of them very widely situated from one another: *Welgezegend*, *Kromdraai*, *Darling* and *Elandslaagte* (all in the Standerton District), *Novo* (Wepener), *Onlangs* (Frankfort), *Montague* (Smithfield) and *Swartland* (Northern Potgietersrust).

The presence of the virus in the blood of the affected cattle was ascertained by inoculating normal sheep and noting the reactions which followed. Investigations were also undertaken to determine whether calves were susceptible to the virus. The results of these transmission experiments are fully described in Appendix A and are summarized in the following table:—

SUMMARY OF TRANSMISSION EXPERIMENTS.

Serial Number of Experiment.	Source of virus.	Normal sheep.			Normal calves.	
		No. inoculated.	Result.		No. inoculated.	Result: No. of reactors.
			No. of reactors.	No. of deaths.		
1 (*a*)	Welgezegend—Cattle—Cows...	15(1)	15	9	5	4
1 (*b*)	Welgezegend—Cattle—Cows:..	6	6	4	16(2)	12
1 (*c*)	Welgezegend—Cattle—Ox.....	16	16	6	3	3
2	Kromdraai—Cattle.....	14	14(3)	8	2(4)	2
3	Darling—Cattle.....	4	4	2	—	—
4	Elandslaagte—Cattle.....	2	2	1	—	—
5	Novo—Cattle.....	4	4	1	—	—
6	Montague—Cattle.....	2	2	0	—	—
7 (*a*)	Onlangs—Cattle (Case I).....	6	0	0	—	—
7 (*b*)	Onlangs—Cattle (Case II).....	4	4	0	—	—
8 (*a*)	Swartland—Cattle (Case I)....	2	0	0	—	—
8 (*b*)	Swartland—Cattle (Case II)...	4	0	0	—	—
9	Novo—Sheep.....	18	18(5)	3	—	—

NOTE.—(1) Does not include two sheep which received an intranasal injection of virulent blood and developed no reaction.

(2) Includes five calves which were injected intranasally with a mixture of milk, urine, emulsified necrotic tissue and blood from three affected cows. Four out of these five calves developed definite reactions.

(3) Includes one doubtful reaction.

(4) *Vide* experiment 10 (*d*).

(5) Does not include sheep which reacted to cattle strains and where a slight reaction again developed to this sheep strain, e.g. one animal in experiment 1 (*a*) (*vide* table of the Summary of the Immunity Tests).

In the outbreak at Swartland [i.e. experiments 8 (*a*) and 8 (*b*)] subinoculations failed to demonstrate the presence of an incitant in the blood of two affected cases. It should be mentioned that blood was collected from these animals in the final stages of the disease and the avirulence of the blood could probably be attributed to this. Even in field outbreaks of bluetongue in sheep, where there is little doubt about the diagnosis of the disease, it is not always possible to recover the virus from every case.

It would seem advisable to collect blood for experimental purposes during the initial stages of the disease, there being more certainty of recovering the virus in this way.

In the outbreak at Onlangs, blood samples were taken from two cases. The blood from one animal (an advanced case) was found to be inactive; but that from the other case, which showed the disease in the initial stages at the time when the blood sample was collected, proved to be virulent.

The immunity of a number of sheep which had recovered from very severe reactions produced by the infective material contained in the blood of cattle affected with this disease, was tested against a virulent bluetongue virus collected from sheep on the farm Novo in Wepener district. The virulence of this sample of blood was thoroughly tested (*vide* experiment 9). The susceptibility of sheep which had been inoculated with and had reacted to Onderstepoort bluetongue vaccine strain was also determined. (Virulent bluetongue virus becomes attenuated by continuous passage through a number of generations in sheep, and it is this attenuated virus which is used as a vaccine. The reactions provoked by the vaccine are of an abortive nature, i.e. a rise in body temperature occurs after a more or less definite incubation period, and in very rare cases a slight hyperaemia of the buccal mucosa is noted.)

The results of these immunity tests are summarized in the following table:—

SUMMARY OF IMMUNITY TEST.

Serial Number of experiments.	A.—Tests in sheep which recovered from reactions produced by various field strains.				B.—Tests in sheep which recovered from bluetongue vaccine reactions.		
	Strain from which sheep recovered.	Immunity tested with.	No. inoculated.	Result: No. which reacted.	Immunity tested with strain from.	No. inoculated.	Result: No. which reacted.
1 (*a*)	Welgezegend cattle (ex. cows)	Novo sheep strain (natural B. T. outbreak)	4	1	Welgezegend cattle (ex. cows)	4	0
1 (*c*)	Welgezegend cattle (ex. ox)	,, ,,	2	0	Welgezegend (ex. ox)	5	0
2	Kromdraai cattle.	,, ,,	2	0	Kromdraai cattle	5	0
3	Darling cattle....	,, ,,	2	0	Darling cattle..	5	0
4	Elandslaagte cattle	,, ,,	1	0	—	—	—
5	Novo cattle.....	,, ,,	2	0	—	—	—
6	Montague cattle..	,, ,,	2	0	—	—	—
7 (*a*)	Onlangs—Neg. reactors (ex. Case I)	,, ,,	5	5	—	—	—
7 (*b*)	Onlangs cattle (ex. Case II)	,, ,,	4	1(2)	Onlangs cattle.	5	0
8 (*a*)	Swartland — Neg. reactors (ex. Case I)	Welgezegend cattle	2	2	—	—	—
8 (*b*)	Swartland — Neg. reactors (ex. Case II)	,, ,,	2	2	—	—	
		Novo sheep virus	2	2			
9	Novo sheep.....	Welgezegend cattle	1	0	Novo sheep....	5	2(3)
		Kromdraai cattle.	2	0			

NOTE.—(1) A very doubtful reaction.

(2) A very doubtful reaction.

(3) The reaction in one of these two sheep was very doubtful and consisted only of a rise in temperature. In the other case it was of a very mild nature, i.e. rise in temperature and slight injection of the buccal mucosa.

It is clear that:

(1) Sheep which had reacted to cattle strains of this infective material were immune to virulent bluetongue virus obtained from a sheep. Only one breakdown [experiment 1 (*a*)] occurred.

(2) Sheep immunized with bluetongue vaccine were resistant to experimental infection with strains of virus obtained from natural outbreaks in this cattle disease and from a field outbreak of bluetongue in sheep. Only three breakdowns occurred in the 29 tested animals and of these two reactions were very doubtful.

Incidentally these tests again illustrated the high efficacy of the Onderstepoort bluetongue vaccine. It would also appear that as far as the immunology is concerned no very marked difference occurs in the various field strains, as is, for instance, encountered in strains of the closely analogous disease horsesickness. Where reactions occurred in the immunity tests they were of a very mild nature in comparison with those in susceptible sheep.

(3) Sheep which had reacted to the virulent Novo sheep strain of bluetongue (experiment 9), were found to be immune to cattle strains.

(4) In experiments 7 (*a*), 8 (*a*) and 8 (*b*) where no reactions were observed with apparently avirulent cattle blood no immunity resulted.

From the results of these investigations the following inferences are made:—

I. *That the infective agent present in the blood of affected cattle in various outbreaks of this "stomatitic" disease is the same as the virus which causes bluetongue in sheep, for—*

(*a*) *the very characteristic syndrome of bluetongue* was observed to develop in sheep which were experimentally infected with strains collected from different outbreaks;

(*b*) *an actual immunity was produced which was found to be specific*:—

(i) Bluetongue vaccinated sheep were found to be immune to various strains; and

(ii) susceptible sheep, which recovered from the reactions produced by virus obtained from cattle, were found to be resistant to a tested virulent strain of bluetongue virus recovered from a sheep in a natural outbreak.

(*c*) The *in-vitro* characteristics of the various cattle strains are like those known and described for bluetongue virus recovered from sheep [*vide* du Toit (1929), Theiler (*loc. cit.*)], e.g. they remained active in—

(i) *O.C.G. mixture* (approximately in the following proportion: blood 50 per cent., glycerine 25 per cent., water 25 per cent., potassium oxalate $\frac{1}{4}$ per cent., and carbolic acid $\frac{1}{4}$ per cent.).

(ii) In a mixture of 50 per cent. blood and 50 per cent. glycerine.

(iii) In decomposed blood.

II. *That this virus is the cause of this cattle disease,* since—

(*a*) *the presence of the virus* could be demonstrated in this diseased condition of cattle where,

(i) the *lesions*, especially those noted in the buccal and nasal cavities were similar to those observed in bluetongue of sheep, and

(ii) *histological* examination revealed similar morbid changes in tissues of analogous organs in cattle and in sheep.

(*b*) *The epizootology of the disease* is similar in both cattle and sheep.

(*c*) *The susceptibility* of cattle was proved in transmission experiments.

Calves inoculated with virus containing blood developed a perceptible reaction and the virus was again recovered from them. A syndrome was observed in these calves which could be closely correlated with that seen in natural cases of this disease in cattle and of bluetongue in sheep. In one case at least (calf 5263) an exact reproduction of the changes in the mouth and nose and on the muzzle as seen in typical natural cases of the disease in cattle was clearly observed; but the reaction was of a comparatively mild nature.

Although the experiments clearly indicate the susceptibility of cattle to this virus, it can also be concluded that bovines are generally far more resistant than sheep, since the reactions produced in the experimental calves were not nearly as severe as in the sheep. It would appear that only a comparatively small number of bovines are peculiarly susceptible and when such an individual becomes infected alarming symptoms manifest themselves. The fact that the disease has hitherto been observed in more or less isolated outbreaks and, furthermore, that only a few individuals in such a herd usually become affected supports this contention.

The supposition that the cattle which were suffering from this stomatitic disease could have been mere carriers of bluetongue virus and that this agent may not be the real cause of the disease, may be dismissed for the following reasons:—

(*a*) From a consideration of the facts enumerated under (1) and (2) above.

(*b*) As far as is known, this is the first time that bluetongue virus has been recovered from blood of veld (field) cattle. In this connection it may be mentioned that in numerous investigations, for instance, in heartwater, many samples of bovine blood collected in the field during all seasons of the year, have been inoculated into sheep and no such cattle carriers of bluetongue virus have ever been discovered.

The sheep used in the Welgezegend experiments were obtained from a flock on a neighbouring farm. They appeared healthy when introduced into the experiments. The possibility, however, that some of these sheep might have been in the incubation stage of a natural bluetongue infection could not be overlooked. The chance of such accidental contamination was excluded by keeping a group of uninoculated sheep in contact with the experimentally infected animals and by repeating some of the tests with original material on sheep at Onderstepoort. Confirmatory results were obtained with other strains where the experimental work was entirely carried out under laboratory conditions at Onderstepoort.

The investigations were designed with the express purpose of establishing the cause of this cattle disease, but at the same time interpreting additional information in connection with certain aspects of bluetongue were obtained and it will not be irrevelant to mention some of these details here:—

(*a*) *The Pathogenicity of the Virus in Blood Samples.*

It will be observed when studying the mortality of the sheep in the various generations of the different strains that in most instances the virus proved to be a particularly virulent right from the first generation, and a large percentage of infected sheep died. In others, e.g. *Kromdraai strain*, the virus appeared to be less virulent when the results of the first generation are considered, but in subsequent ones it proved to be very potent. It is significant that in these cases where such mild reactions were observed, the blood samples were collected from the cases at a fairly late stage of the disease. It would seem as if the pathogenicity of the virus present in samples collected from individuals in the recovering stage of the disease is probably considerably modified by immune bodies already present in the animals. This is borne out by studying the results of *Experiment* 10.

In this experiment it will be noticed that severe reactions developed in the first group of 5 sheep and 2 animals actually died. The blood taken on the 14th day after infection from two of the recovering animals in this group set up distinct reactions in 4 sheep, but none died. On the 28th day after infection a further 4 animals were inoculated and now only two developed very mild reactions whilst the other two did not react at all. However, the latter two reacted severely when inoculated with blood collected from the original donors on the 9th day after infection. The reactions were at their height on that day in those animals. On the 42nd day blood was again taken from the two sheep and no reactions could be observed in 4 inoculated sheep.

This experiment clearly indicates that in these two cases the blood became sterile within a period of less than 42 days and that the pathogenicity of the virus contained in the blood of the recovering animals gradually became modified probably by the immune bodies which appeared in the blood of the animals.

(*b*) *The Presence of the Virus in Foetal Material* [vide *Experiment* 10 (b)].

Two pregnant ewes used in experiment 2 died from the reactions and material was collected aseptically from the contained foetuses. In each case two sheep were inoculated. One foetus was apparently sterile, but definite reactions were produced with the blood of the second foetus. On the first occasion 1 c.c. of this foetal blood was inoculated into two sheep and one developed a peracute reaction and died, but no reaction developed in the other animal. However, when 5 c.c. of the same foetal blood was injected a very severe reaction was produced.

It would seem as if the virus was not present in any great concentration in this foetal blood and 1 c.c. was apparently the minimum infective dose.

(*c*) *The Disease can be Transmitted by Means of an Intranasal Injection of Virus-containing Material.*

In the early experiments at Welgezegend 5 calves received an intranasal injection of suspected material and four developed definite reactions. The virus was found to be present in the blood from one of the calves [*vide* experiment 1 (*b*)]. Subsequently [*vide* experiment 10 (*d*)] it was found that sheep could also be infected in this way.

Investigations on the physical and chemical properties of the virus obtained from cattle are at present in progress and these are being compared with those of known sheep bluetongue strains.

Addendum by R. A. Alexander.

Transmission of the Virus to Mice, Rats and Guinea-pigs.

To facilitate research into the biological properties of virus an attempt was made to establish the virus in mice, rats and guinea-pigs in the following manner:—

(*a*) Mice by the intracerebral and intraperitoneal routes.

(*b*) Rats by the intracerebral, intraperitoneal and subcutaneous routes.

(*c*) Guinea-pigs by the intracerebral, intraperitoneal and plantar pad routes.

As the source of virus, use was made of virulent blood, a virulent emulsion of the early stomatitic lesions of cases of " pseudo-foot and mouth " in sheep, as well as virulent blood of a known laboratory strain of Bluetongue of sheep.

The results were uniformly negative so that it may be concluded that so far all attempts to infect mice, rats and guinea-pigs with the strains of the two viruses available have been unsuccessful.

THE SYMPTOMATOLOGY.

(*a*) As Observed in Cattle in Natural Outbreaks.

According to the course and the development of the disease the cases may be considered as: (1) *typical* and (2) *atypical*.

(1) *Typical Cases.*

The usual history presented by the owners.—The affected cattle are noticed to stop grazing and do not move about with the rest of the herd. Marked stiffness and lameness are observed. At this stage the disease is not regarded seriously. The owners suspect either *three-day-stiffsickness* or a vague diagnosis of *gallsickness* it attempted. About two or three days later, however, slight frothing from the mouth and even salivation is seen and in quite a number of cases the tongues protrude prominently. It is at this stage that attention is directed to the condition of the mouth and redness and soreness of the buccal mucosa is discovered. Foot and mouth disease is immediately suspected and the presence of the condition reported as such.

For convenience the symptoms will be described under various headings.

Habitus.—In most cases the animals are to be found lying down and those still standing show little inclination to move. When forced to move the sick cattle are noticed to be distinctly lame and stiff. No attempt is made to feed and rumination is in abeyance. Frequently chewing movements and grinding of the teeth is observed.

There is a rapid loss of condition, and in lactating cows a marked reduction in milk yield takes place. Sometimes this loss in milk is the first symptom of malaise noted by the owners.

The temperature.—In the early stages a high temperature is usually present. The temperature apparently soon becomes normal or only slightly elevated in the stage when the mouth lesions are well developed (this is also the case in sheep). It is at this stage that field cases are usually reported, and the temperature is therefore not of much value for diagnostic purposes.

The symptoms and lesions in the buccal and nasal cavities.—These are most important, and it is proposed to describe them in detail.

Frothing at the mouth is frequently evident and becomes pronounced after manipulation for the purpose of examination (*vide* Figs. 1 and 2).

Sometimes salivation may be noted and this is especially marked in cases where the tongues protrude.

The lesions in the buccal and nasal cavities are essentially those which are due to a hyperaemia of the mucosa and a localized inflammation with necrosis of the mucous membrane.

In comparatively *mild cases* the unpigmented portions of the mucosa are reddened and superficial lesions of a localized stomatitis with necrosis are to be found on the dental pad, borders of the lips, ventral aspect of the apical portion of the tongue, etc. These lesions are not very well defined, and their borders gradually merge through a hyperaemic zone into the normal mucosa. The lesions present the following appearance—the epithelium has a yellowish colour and is usually still partially attached to the underlying tissues giving an impression of a membranous deposit. Where the epithelium is detached the underlying tissues are reddened and bleed easily.

FIG. 1.

Onlangs Case: Note frothing and salivation and dried mucus on nostrils, etc., and catarrh of eyes.

In the *more severely affected* cases these lesions are more extensive. The lips, muzzle, external nares, tongue, dental pad, conical papillae of the cheeks, etc., are all involved. A marked reddening of the unpigmented portions of the buccal mucosa is seen, this is particularly marked where actual lesions occur. On pigmented areas the necrosis presents a dirty greyish appearance.

At this stage there is usually a fairly copious nasal discharge which may be catarrhal, muco-purulent and even muco-haemorrhagic. Presumably on account of the painful condition of the tongue and mouth little attempt is made to clean the nostrils with the result that the nasal discharge dries on the surfaces of the external nares (*vide* Fig. 3).

FIG. 2.
Onlangs Case: Note frothing at the mouth and incrustations on muzzle.

FIG. 3.
Onlangs Case: Note extensive excoriations and incrustations on muzzle, lips, and dried nasal discharge on external nares.

The lips are swollen and the skin of lightly pigmented areas reddened. Necrotic lesions develop along their borders and on inner surfaces. These lesions are particularly evident on the areas immediately opposite the incisor teeth (*vide* Fig. 4).

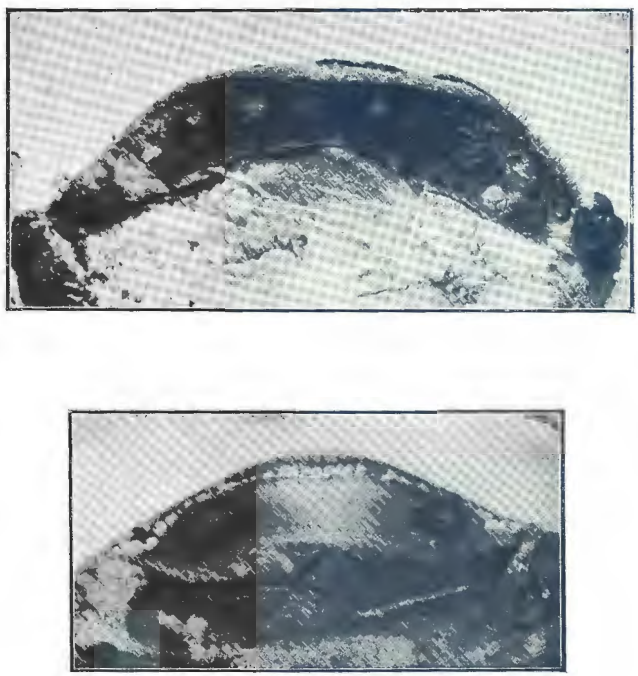

FIG. 4.

Necrotic lesions on lower lips.

(*a*) *Above:* In a natural cattle case, note impressions of incisor teeth.

(*b*) *Below:* In an experimental sheep case (Sheep 8, Expt. 1B). Note lesions opposite lateral incissors.

The tongue is swollen and red. In some cases it is even bluish (cyanotic) in colour. It may be enlarged to such an extent that it protrudes from the mouth and 7 or 8 inches of the organ may be exposed. This protruded portion becomes dry. The tongue appears to be partially paralyzed in such instances since it cannot be properly held in its normal position. The lingual papillae are dark red in colour and on the ventral surface of the apical portion extensive necrotic lesions are usually to be found (*vide* Figs. 5 and 6).

In some cases the mucosa along the frenum linguae only is affected and such lesions are usually linear in shape.

Deep seated and extensive necrotic lesions may be present on the tongues of some individuals. These lesions are usually found on the dorsal and lateral aspects of the middle portion.

FIG. 5.
Onlangs Case: Note extensive necrotic lesion on ventral aspect of tongue.

FIG. 6.
Novo Case: Necrotic lesion on ventral surface of tongue in stage of healing.

When the necrosis on the dental pad is extensive, it is usually confluent with similar lesions on the upper lip. The injured mucosa has a distinct grooved appearance at the junction of the lip and pad.

Lesions are sometimes evident on the gums and these are usually present on the floor of the mouth just posterior to the incisor teeth.

Where such extensive mouth changes are present the odour of the breath is very offensive.

Healing commences after about 3 or 4 days. The muzzle now becomes covered with a thick scab, which subsequently peels off leaving a clean and fresh looking surface without formation of cicatrices. The lesion on the ventral surface of the tongue takes somewhat longer to heal. In the later stages a peculiar wrinkled appearance is noticeable (*vide* Fig. 7).

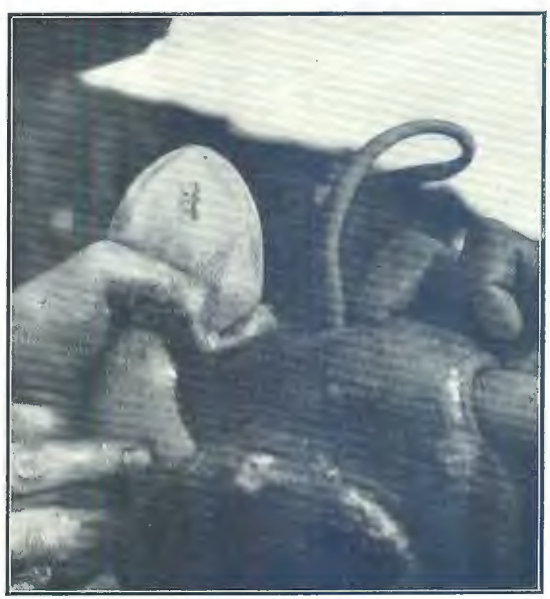

Fig. 7.

Montague Case: Necrotic lesion along the frenum linguae in advanced stage of healing.

The deep seated necrotic ulcers on the tongue take a longer time to heal and all the processes of repair can be followed.

The teat and udder symptoms.—Lesions of the teats are only observed in cows which were actually in milk.

The teats become markedly inflamed and where pigmentation is light or absent, they are dark red in colour. The surfaces are raw and any handling is intensely resented. After a few days a hard and fairly thick scab is formed and this in time peels off *in toto* like the finger of a glove. The newly formed epithelium then has a fresh and clean appearance.

Small localized skin lesions are sometimes found on the udder. These lesions are usually about 1 cm. in diameter and are covered with a soft yellow scab, which, when removed leaves a moist surface and a slight reddening of the underlying tissues. The entire skin of the udder is sometimes involved in an extensive dermatitis. These extensive skin changes will be described under the next heading.

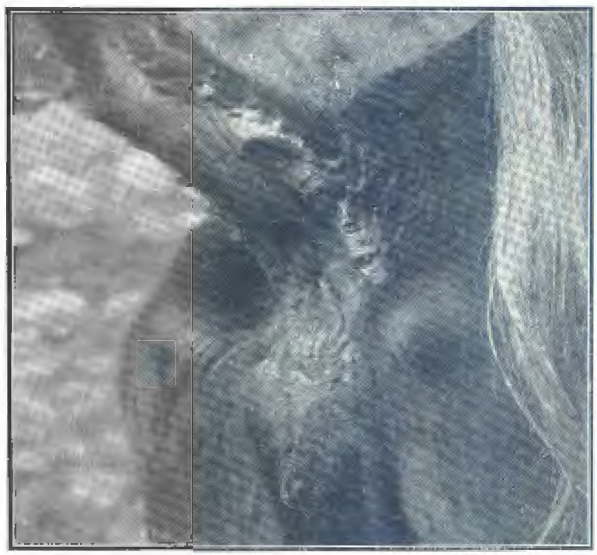

FIG. 8.

Montague Case: Sloughing of epidermis underneath the tail, etc.

The skin changes.—Skin lesions are usually observed in severe reactions. In mild affections they may be entirely absent or localized to the thinner portions, e.g. in the flanks, at the root of the tail, on the udder, etc. (*vide* Fig. 8).

During the early stages symptoms of an acute dermatitis are present. The skin is reddened on the unpigmented portions. It appears swollen and is painful, especially along the back. A small amount of straw coloured exudative material collects on the surface. This exudate dries and the basal portions of the hairs become matted together. Soon hard crusts and scabs are formed. The hardened condition in this stage resembles the condition of the skin observed in the later stages of sweating sickness of calves ,*vide* du Toit, 1923.)

A distinct photosensitivity becomes evident and such affected animals are usually found sheltering underneath trees or in the shade of a wall or a shed. When driven out of such places they immediately seek another shady locality. The scabs are at first firmly adherent, and if forcibly removed the underlying tissues are found to be moist and bleed easily. Healing progresses and later these scabs peel off. The hair comes away with the desquamated epidermis.

In the severe reactions the dermatitis is fairly generalized (*vide* Figs. 9, 10, 11).

FIG. 9.

Kromdraai Case: Extensive dermatitis followed by hardening of the skin and the formation of scabs.

FIG. 10.
Kromdraai Case: Extensive skin lesions on udder, etc.

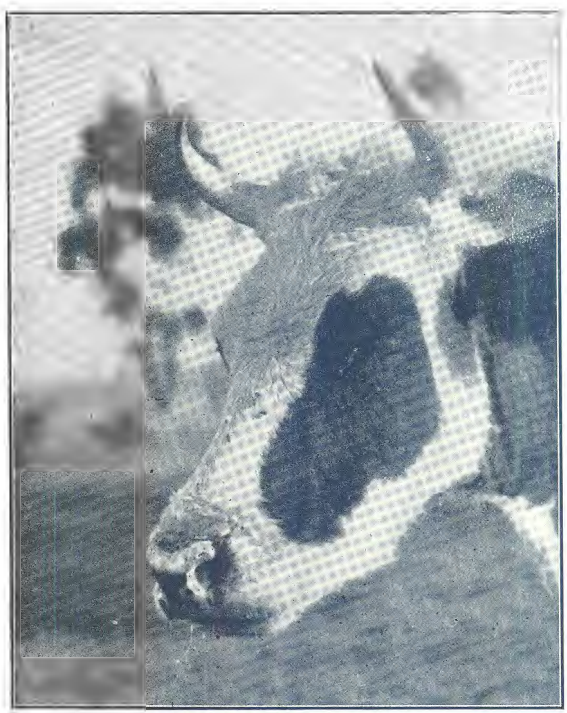

FIG. 11.

Kromdraai Case: Note the formation of crusts and scabs on skin of muzzle.

It will be noticed that a lesion in the case at Montague (*vide* Fig. 12) is confined to an unpigmented portion of skin of the upper portion of the flank.

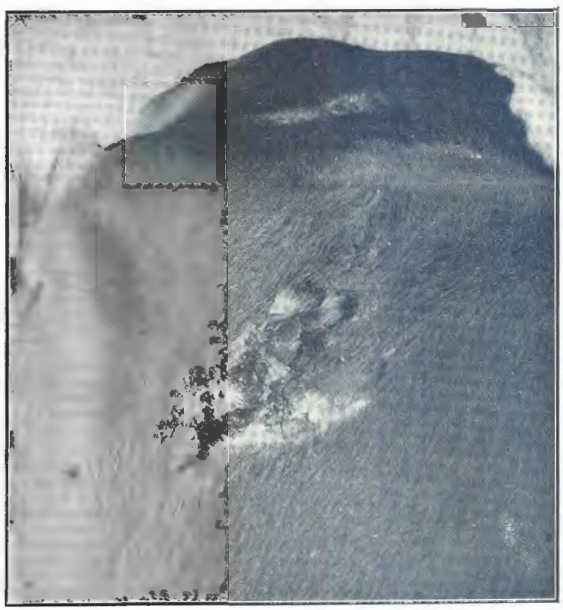

FIG. 12.

Novo Case: Skin lesions confined to an unpigmented portion of the skin.

The feet lesions.—It has been mentioned that lameness and stiffness are usually the first symptoms which become evident. On examination the lower portions of the limbs are found to be swollen, the swelling usually extends from the coronet to the fetlock and all four feet are affected to the same extent. In some cases the swelling may extend to the knees and hocks. The skin, particularly on the plantar surface in the region of the accessory digits is reddened and a small amount of straw-coloured exudate is usually present on the surface.

In a number of cases an excoriation of the epidermis in the interdigital space was observed. In such instances partially detached epidermis may still be found to be adherent to the excoriated areas and this may convey the impression of a recently ruptured vesicle.

Usually the hyperaemia and swelling of the skin disappears without further changes, but frequently the dermatitis progresses and later lesions develop on the skin of the digit similar to that described in other regions.

Rarely (*vide* Fig. 13) a separation of the claws along the coronary bands becomes evident. In such cases the anterior portion of the interdigital space present a raw and granulating surface. It

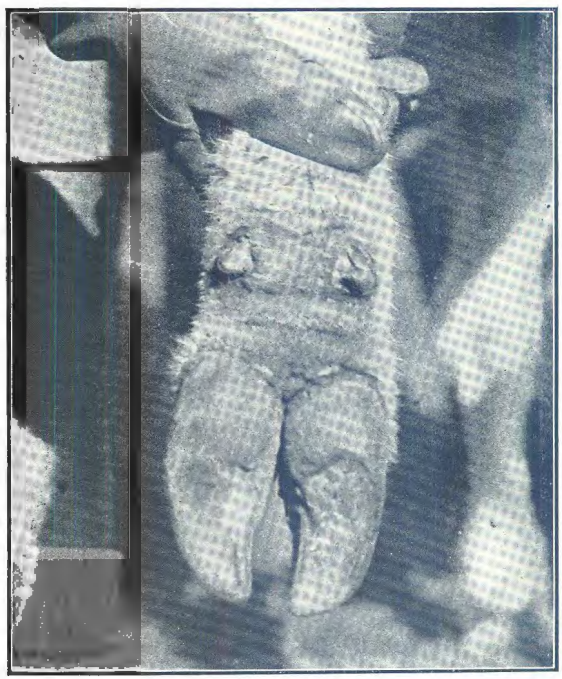

FIG. 13.
Verblyden Case: Note fissures at the coronets.

would appear that this type of lesion is apt to develop in cases which are forcibly walked during the acute stages. This lesion would appear to be due to a coronitis, as is observed in sheep.

According to a report received from a farmer (*vide* Appendix C), exungulation may occur.

Eye lesions.—Usually no eye lesions are noted, but in some instances a slight watery discharge may be present which later becomes catarrhal.

(2) *Atypical Cases.*

(*a*) *Cases resembling three-day-stiffsickness.* — Keppel and Robinson (*loc. cit*) state that the symptoms noted in their " ulcerative stomatitis " to some extent resembled three-day-stiffsickness. Further in an outbreak at Oudehoutsdraai, Volksrust (*vide* Appendix C) Williams and Dickson encountered two typical cases of this disease. In this particular herd several more animals were observed which, according to them, were showing symptoms of three-day-stiffsickness. They did not find any mouth lesions in these cases.

It would seem very probable that such cases of so-called "stiffsickness" could be due to the same cause, i.e. bluetongue virus. The only symptom of a reaction which became evident, was a rise in temperature and stiffness. These cases may be compared with the "abortive" reactions commonly noted in sheep, where the only indication of a reaction is an elevation in body temperature.

(*b*) *Peracute reactions.*—Only one instance of a fatal peracute reaction in cattle came to our notice. The symptoms observed in this case are fully described in Appendix A (experiment 4).

This animal died within three days after the first symptoms became obvious.

The following changes are of interest and importance with regard to the symptoms and lesions which may be noticed in such a peracute reaction:—

FIG 14.
Elandslaagte Case: Necrotic lesions on gingiva (peracute reaction).

(1) The marked hyperaemia, and the presence of numerous petechiae and ecchymoses in all the visible mucosae, e.g. of the nostrils, lips, hard palate, tongue, cheeks and conjunctiva.
(2) The marked muco-haemorrhagic nasal discharge and slight epistaxis.
(3) Superficial localized inflammation with necrosis on the buccal mucosa, e.g. on the gingiva (*vide* Fig. 14), dental pad, hard palate, etc.
(4) The swelling of the vagina (*vide* Fig. 15), and the marked hyperaemia of the vaginal mucosa with numerous petechiae and ecchymoses.

FIG. 15.

Elandslaagte Case: Swelling of vagina and skin lesions (peracute reaction).

(5) The swelling of the lower portion of the limbs.

(6) The presence of superficial skin lesions (*vide* Fig. 16).

FIG. 16.

Elandslaagte Case: Skin lesions on metatarsal region (peracute reaction).

(*b*) As Observed in the Experimentally Infected Calves.

A considerable number of calves were used in the transmission experiments (*vide* Appendix A). In some of these no perceptible reactions could be ascertained, but in the majority definite and constant changes were observed. These reactions were mild in comparison with the very severe symptoms and lesions seen in natural infections, but were sufficiently evident to enable one to conclude that the calves reacted to the virus.

The first symptom usually noted is a rise in body temperature which is, of course, indicative of a general or systemic reaction. A number of representative temperature charts are included (Appendix D) and may be referred to (*vide* Charts VIII to XI). There is an incubation period of from two to three days.

With the rise in temperature lesions appear with constant regularity on the buccal mucosa. They were found to be usually confined to the mucosa of the upper and lower lips. These lesions commence as small raised areas, about the size of a millet seed. Their centres have usually a yellow colour and the surrounding tissues are slightly injected. Soon the epithelium appears to become destroyed and excoriations result. These excoriated areas can become quite extensive (*vide* Fig. 17).

Fig. 17.

Calf No. 5407: Lesions on the lips observed in transmission experiments in calfs.

Frequently the loosened epithelium is still partially attached to the borders of the lesions, which resemble recently ruptured vesicles. It should be noted, however, that the formation of actual vesicles was never observed. The lesions have an irregular shape

and may be longitudinal, circular, oval, etc. They occur with marked regularity opposite the lateral incisors on the inner surface of the lower lips, but are also frequently seen on the borders of the lips and at the commissures of the mouths.

In a few instances such lesions developed without any noticeable rise in body temperature.

The nasal mucosa was sometimes also involved and the excoriations were usually present on the septum nasi. In these cases a slight catarrhal nasal discharge was evident. The lesions usually persist for about four or five days. Healing then commences and after about 10 days they disappear completely.

In several instances hyperaemic areas were seen on the hard palate and in a few a distinct diffuse injection of the mucosa of the lips, cheeks, etc., become noticeable. This was particularly evident in calf 5263 [*vide* experiment 1 (*b*)]. The hyperaemia of the buccal mucosa was first noticed six days after the day of inoculation. On the next day the lower lip appeared swollen and reddened with a few petechiae. In addtion the apical portion of the tongue was reddened and a few of the papillae distinctly enlarged and dark red. The ventral surface of this part of the tongue was excoriated in several small areas where the underlying tissues had a slightly granulated appearance. Excoriations and numerous petechiae were also noted on the borders of the lips. Several of the conical papillae of the lips and cheeks appeared enlarged and reddened while the tips were yellowish grey. The picture of the mouth as seen in this calf resembled that of typical cases in natural outbreaks of a mild nature.

Several of the experimental calves became visibly ill. They stopped feeding and lay down frequently. Fairly extensive ulcers developed on the tongues of a few of these experimentally infected calves (*vide* Figures 28 and 29).

In one calf [No. 10 of experiment 1 (*b*)] a marked dyspnoea developed on the 12th day after infection. The animal was destroyed and very extensive necrosis and ulcers were found on the lateral aspect of the tongue and in the larynx. Similar lesions were noted in some of the experimentally infected sheep.

No feet or skin lesions were observed in any of these calves.

(*c*) As Observed in Experimentally Infected Sheep.

The sheep used in the transmission experiments were kept under very close observation and provided suitable material for studying the course and symptoms of the disease in sheep. Spreull (*loc. cit.*) and Theiler (1905) have described the symptoms of bluetongue in sheep in fair detail and our observations on the reactions produced by virus recovered from cattle do not materially differ from theirs.

The incubation period after artificial infection.—This was found to vary considerably as will be evident from an analysis of the incubation periods of the following 66 cases:—

No. of days after inoculation.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
A.—Sheep infected with virus recovered from cattle. No. of cases.....	1	7	9	6	9	8	5	1	1	1
B. Sheep infected with virus recovered from sheep. No. of cases...	—	1	1	3	7	4	1	1	—	—

It will be noticed that the incubation period may be as short as one day and may be delayed for as long as 10 days. The onset of a reaction is usually indicated by a rise in temperature, but occasionally an injection of the mucosa of the lips and slight frothing at the mouth become noticeable before the temperature rises.

The Temperature.—Generally the temperature rises gradually and the acme is reached after three or four days, but sometimes a very sudden pronounced rise takes place, and in such instances the acme may be reached within 24 hours. The fever is usually of a *continued* type, lasting for 6 or 7 days, but temperature reactions of a distinct *intermittent type* are quite commonly noted. In such cases the period of apyrexia does not usually last longer than from 24 to 36 hours. In a small percentage of cases the temperature reaction is of very short duration, in fact some of them may be regarded as *ephemeral.*

In a few cases severe clinical reactions were observed without the occurrence of a rise in body temperature. Such reactions may be considered as *afebrile.*

Typical temperature charts are included (*vide* Appendix D, Charts I to VII).

The Habitus.—In the early stages only slight disturbances can be observed. The sheep usually stop feeding and ruminating. They lie down frequently and peculiar chewing and licking movements become noticeable. After the rise in temperature dyspnoea becomes fairly evident and the nostrils are dilated. As the reaction progresses dullness becomes evident; the head hangs down and the ears droop. When the temperature is very high the animals drink water frequently. In severe reactions the sheep lie down continuously and assume the attitude noted in Fig. 18.

The lesions and symptoms in the mouth and nose.—An injection of the mucosa is usually seen soon after the commencement of the temperature. The hyperaemia is particularly noticeable on the inside of the lips which assume a cherry-red colour. The redness may extend to the skin and the lips and nose becomes distinctly pink. The lips now become swollen and in some cases even oedematous (*vide* Fig. 19).

FIG. 18.

Sheep 37812: Characteristic attitude assumed during severe acute stage.

FIG. 19.

Sheep 37812: Marked swelling (oedema) of lower portion of the head.

The nostrils and muzzle are at first dry, but a catarrhal discharge soon develops. This usually changes to muco-haemorrhagic. When the discharge dries, thick incrustations are formed at the nasal orifices, and these interfere considerably with breathing.

The mouth is now extremely painful and handling is resented.

Petechiae and ecchymoses now become noticeable on the buccal mucosa and are particularly evident on the lips, tongue, nose, palate, dental pad and cheeks.

The petechial stage is soon followed by the appearance of excoriations of the mucosa. These lesions are usually localized and vary in extent. They occur regularly on the following sites: borders of the lips; on the inner surfaces of the lips opposite the lateral incisors (c.f. in experimentally infected calves); at the commissures of the mouth; on the ventral surface of the tongue (particularly along the frenum linguae); the dental pad; on the gums (especially on the portion posterior to the incisor teeth); on the lateral surfaces of the medial portion of the tongue and inside the cheeks opposite the molar teeth. The conical papillae of the lips also become red and the tips assume a greyish-yellow colour. At this stage a cyanosis usually becomes evident.

FIG. 20.

Sheep 37328: Lesions on lips, muzzle and nose. Note slight cattarhal discharge eyes.

The *typical blue condition of the tongue* from which the name of the disease is derived, is seen when the following changes are present in this organ: swelling, hyperaemia and cyanosis, petechiae and ecchymoses and the initial stages of an inflammation of the mucous membrane. Sometimes the tongue becomes markedly swollen and in such cases an oedema of the subcutis is usually also evident. The skin of the nostrils, lips and muzzle also becomes excoriated and scabs are formed (*vide* Fig. 20); when the encrusted discharge from the nostrils or the scabs covering the excoriated lesions are forcibly removed the underlying tissues present a granulated appearance.

When the mouth is manipulated, bleeding from the injured buccal mucosa can be easily provoked. When these lesions are present, the breath is foetid. When recovery sets in, the injured mucosa heals fairly rapidly, but fairly deep-seated ulcers may develop on the tongue and these take a considerable time to heal (*vide* Figs. 27 and 29).

Skin Lesions.—The skin of the lips and muzzle is usually injected, but frequently a redness of the ears and at the bases of the horns becomes noticeable and in a few instances the entire skin is somewhat flushed.

Changes in the Eyes.—The conjunctiva sometimes becomes slightly affected and petechiae and ecchymoses are occasionally noted. Slight lachrymation is seen in such cases and in the later stages a small amount of catarrhal discharge may be present.

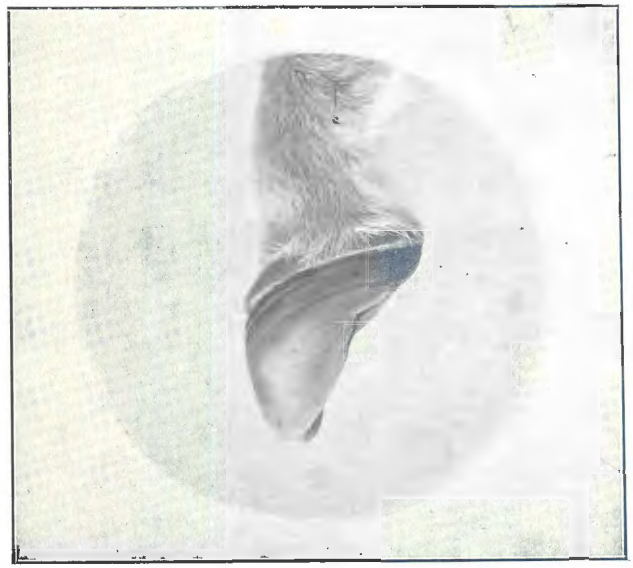

FIG. 21.

Sheep 37071: Partial exungulation of claws (three months after infection).

The vagina usually becomes swollen and reddened with petechiae and ecchymoses. Frequently the borders assume a dark bluish-red colour and later excoriations may even develop.

The Feet Lesions.—On about the 9th to the 12th day after the onset of the reaction a marked coronitis develops. The claws first become hot and soon the coronary bands assume a dark red colour. This redness usually extends to the bulbs. The coronitis may persist for about a week, but frequently it disappears after a few days. The feet lesions usually develop after the temperature has subsided and when the mouth lesions have begun to heal. The animal lies down frequently and when forced to walk the gait is distinctly laminitic. No instances of complete exungulation were noticed, but in several

instances deep grooves (partial exungulation) became noticeable (*vide* Fig. 21) on the claws. These feet lesions were noted in about 50 per cent. of the cases.

Henning (*loc. cit.*) states that one, two or three, or all feet may become affected and, according to this author, a correlation is said to exist between the severity of the feet and mouth lesions, he makes the following statement: "Sometimes the feet of animals suffering from a comparatively mild attack of bluetongue become seriously affected, whereas the feet are seldom badly inflamed in those cases where extensive mouth lesions have developed". This phenomenon was not observed in these experimental cases and furthermore when a coronitis developed all four feet were found to be affected to the same extent.

Apart from the cessation of feeding and rumination no other serious digestive disturbances became manifest in the majority of cases. In a few instances, however, diarrhoea developed shortly before death.

FIG. 22.

Sheep 37085: Torticollis, a symptom frequently observed in severe reactions.

There is a rapid loss of condition and it takes a considerable time for the sheep to recover the loss of flesh. In a number of cases marked debility followed the reaction and some of the animals became so weak that they had to be destroyed. The mouth and feet lesions had by this time completely healed. [In several cases a marked *torticollis* developed prior to death (*vide* Fig. 22.]

Frequently a swelling (oedema) of the head and neck developed and the condition was not unlike that noticed in dikkop horsesickness. In these cases a further complicating symptom was the discharge of ingesta through the nostrils (*vide* Fig. 23). Presumably this is due to a paresis of the oesophasus. Theiler (1918) describes such a complication in horsesickness

The following stages in the course of the disease can be distinguished:—

Firstly, an elevation of body temperature, which is followed in a day or two by a swelling of the lips and redness of the buccal mucosa. Petechiae and ecchymoses now appear, to be followed soon by a localized inflammation, necrosis, and excoriation of the mucosa.

During the stage of severe mouth lesions the temperature commences to drop. After about the 10th day following the onset of the reaction the coronitis appears.

FIG. 23.

Sheep 37328: Note lesions on lips and muzzle, also a marked discharge of mucus and ingesta from nostrils and oedema of head.

The above course may at any stage be interrupted by either recovery or death. Thus in some sheep a hyperaemia of the buccal mucosa may be the only clinical condition that becomes perceptible, whilst in others localized in flammatory lesions with necrosis also become evident, but no feet lesions develop. The experimentally infected sheep died at irregular intervals after the date of infection as is indicated in the following table:—

No. of days after inoculation	5	6	7	8	9	10	11	12	13	14	16	17	18	19	20	21
No. of sheep which died on this day.....	—	2	3	—	2	1	1	3	5	3	1	1	3	—	1	—

It is possible to distinguish:—

(*a*) *Peracute reactions*, where the reaction ceases (either by death or recovery) with hyperaemia or petechiae;

(*b*) *acute reactions*, where the reaction resolves itself into a localized inflammation with necrosis of the buccal mucous membrane, the animal either dying or recovering in this stage;

(*c*) *subacute*, where a coronitis develops, or where the animals become very debilitated and may even die.

In these later stages a paresis of the oesophagus and the formation of extensive oedema frequently becomes evident.

Partial or complete shedding of the wool was observed to occur in a few of the experimental animals. This may be considered a sequel of the reactions and such a shedding of the wool is also seen in field outbreaks of bluetongue.

(*d*) A Comparison of the Symptoms in Cattle and Sheep.

With reference to:	In *cattle* as seen in natural outbreaks.	In experimentally infected calves.	In experimentally infected sheep.
The incubation period	Not known.....	About 4 days.....	Varies considerably, but usually about 4–5 days. May be as short as 24 hours and as long as 10 days.
The temperature....	Temperature of more than 106° F found in several cases. Most cases, however, came under observation in the later stages, when the mouth lesions are well developed and temperature had apparently already subsided	Definite temperature reactions observed in many cases. A maximum temperature of 106° F recorded in several instances. In some of the calves no serious disturbance in body temperature noted	Temperature reaction a very constant and usual feature of the reactions. Occasionally an afebrile reaction encountered.
Stiffness, lameness, and swelling of lower parts of the limbs in the early stages	A feature observed in the majority of cases. Sometimes the first symptom noted by the owners	Not observed.....	Not observed.

With reference to:	In *cattle* as seen in natural outbreaks.	In experimentally infected calves.	In experimentally infected sheep.
The oral changes	Consist essentially of a hyperaemia of the mucosa and localized inflammation with necrosis of the mucous membrane. Particularly evident on the following sites: upper and lower lips; gums and dental pad; tongue (especially on the ventral surface of apex); muzzle and external nares. In one case (considered as a peracute reaction) petechiae and ecchymoses predominated	Hyperaemia was generally localized, but in a few cases diffuse hyperaemia of the buccal mucosa noted. Usually localized excoriations develop on the inner surface of the lips. On the lower lip these lesions appeared with marked regularity opposite to the lateral incisors. In one case a re-production of the changes in natural outbreaks in cattle was reproduced but of a mild nature	These changes commence with a diffuse hyperaemia of the buccal mucosa, especially of the lips. The hyperaemic stage is soon followed by the appearance of petechiae and ecchymoses and soon excoriations and necrosis of the mucous membrane develop. These lesions are particularly evident on the following sites: lips, tongue (especially along the frenum linguae), inside of cheeks, dental pad, gums, muzzle, and external nares.
Deep seated necrotic ulcers on the tongue	Such necrotic ulcers were very marked in two of the cases encountered on the farm Welgezegend	Observed in at least two experimental cases	Observed in several sheep and here it can be definitely stated that these ulcers developed from the usual superficial necrotic process.
Discharge from nostrils and subsequent incrustation	The discharge usually mucoid or mucopurulent, and marked encrustations formed. A muco-haemorrhagic discharge observed in one case	A watery discharge, sometimes slightly mucoid noted in several cases	The discharge is first mucoid but soon becomes muco-haemorrhagic. In a few cases ingesta passed through the nostrils. Marked formation of incrustations.
Salivation.....	Very marked in cases where tongue protrudes. Marked frothing and slight salivation is a usual feature	Slight frothing observed in one or two cases	Frothing at the mouth common symptom, especially in early stages.
Discharge from the eyes	A slight catarrhal discharge noted in a few cases	A watery discharge (lachrymation) seen in a few	Watery discharge observed in some cases with a tendency to become catarrhal in later stages.

With reference to:	In *cattle* as seen in natural outbreaks.	In experimentally infected calves.	In experimentally infected sheep.
Teat lesions.....	Regularly observed in lactating cows. The teat lesions consist of marked reddening of the skin, destruction of the epidermis and later the formation of hard scabs	Not observed, but suitable animals not available	Not observed. Note: Only two ewes in milk inoculated, but unfortunately both developed peracute fatal reactions.
Localized skin lesions on the udder	Noted in a few lactating cows. Lesions about 1 cm. in diameter, covered with yellow scab and the underlying tissues slightly red or moist	Not observed.....	Not observed.
General skin lesions	Very marked skin lesions, either localized to thinner portions of the skin, or diffuse and general, a common, although not constant symptom. These skin lesions develop in the later stages and consist of reddening, slight exudation, later a hardening and formation of crusts, which in course of time sloughs off, the hair also coming away	Not observed.....	A reddening of the skin of lips and nose frequently observed. Some times also of the ears and in rare cases the entire skin becomes flushed. Shedding of the wool as a sequel.
The vulva.....	Swelling of the vulva with petechiae and ecchymoses observed in one case	Not observed.....	Swelling of the vulva with necrotic changes on the borders and petechiae and ecchymoses in the mucosa commonly observed.
Oedema of subcutis	According to Robinson and Keppel (*loc. cit.*) a swelling of the neck was observed in one of their cases. A case at Elandslaagte showed a distinct swelling of the lower portion of the head	Not observed.....	Very extensive subcutaneous oedema of the head and neck observed in several animals. In these cases a "paralysis" of the oesophagus frequently ensued.

With reference to :	In *cattle* as seen in natural outbreaks.	In experimentally infected calves.	In experimentally infected sheep.
Swelling of the tongue	Very marked in several cases which results in a protrusion of the tongue from the mouth	Not observed.....	Extensive swelling of the tongue seen in several cases, but actual protrusion of the tongue not very evident.
Torticollis.....	Not observed.....	Not observed.....	Fairly frequent symptom generally noticed some hours before death.
Intestinal disturbances	Not observed.....	Not observed.....	Diarrhoea observed in a few instances.
Claws.....	In one case a distinct separation of the skin and claw of the coronets was observed. In this case all four feet were affected. Whether this was preceded by a hyperaemia of the coronets (a very characteristic symptom in sheep in the later stages) is difficult to say. In several cases an excoriation of the epidermis in the interdigital space was seen. (Note : exungulation has been reported by a farmer, *vide* Appendix C)	No changes observed	A hyperaemia and an acute inflammation of the coronets developes 12–14 days after infection. The coronets become dark red in colour and the redness extends to the bulbs. The animals become very lame. Partial exungulation was observed.
Debility in the later stages	Noted in a few cases. Such animals were found in a moribund condition and destroyed	Not seen.....	Noted in several cases.

PATHOLOGY.

In Appendix B a summary will be found of the most important macroscopical and microscopical changes observed in the *natural cattle cases* killed for post-mortem examination and in the *experimental sheep cases* which died or were killed during different stages of the disease. An attempt will be made to classify the characteristic pathological changes in the different organs, and to compare these with the observations of former investigators (Theiler and Spreull).

Localized hyperaemia of an active type or *diffuse hyperaemia* of a venous nature was seen in the skin, especially on the teats of the udder, the tongue, lips, rumen (including the oesophageal

groove), reticulum, omasum, abomasum, large and small intestines, larynx, trachea, pharynx, myocardium, kidneys, liver, nasal mucous membrane. It was significant how seldom the spleen was affected in the experimental cases. Where tumour splenis occurred it was usually associated with a complication (e.g. a sequel of perforation of the rectum). It was only in the later stages of the disease that hyperaemia and inflammation of the coronets revealed themselves.

Multiple haemorrhages varying from petechiae to suggillations occurred frequently in connection with the skin, the lips, the mucous membrane of the lips, tongue, dental pad, buccal cavity, small intestine, myocardium, epicardium and endocardium, less frequently in the trachea, nasal cavity, bladder, urethra, pulmonary artery, pleura.

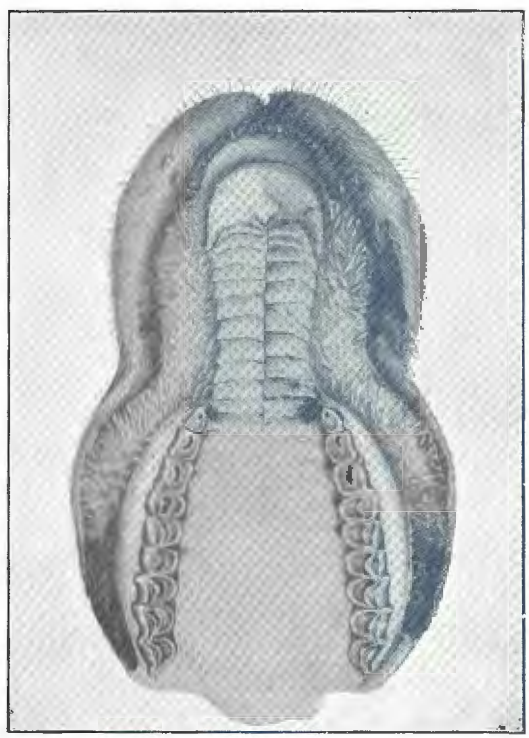

FIG. 24.

Swelling of lip and multiple haemorrhages with necrotic lesions along borders of lip, inside of cheeks, hard palate, etc. (From drawing.) Sheep 37691.

These *haemorrhages* were usually multiple, circumscribed and about $\frac{1}{2}$ cm. in diameter. They were confined to the mucous membranes, but in the case of the heart they were also seen in the substance of the myocardium. In case of the epicardium in a large number of cases the apex showed a diffuse reddish patch about 1-1$\frac{1}{2}$ cm. in diameter, more or less encircling the apex. Interesting were also the circumscribed haemorrhages around the root of the hairs within the follicles of the skin.

The localized necrotic areas followed by ulceration were usually seen on the lips opposite the incisor teeth, the dental pad, at the apex of the tongue, on the ventral aspect, and usually on the dorso-lateral aspect of the tongue opposite the fourth molar teeth, the mucous membrane of the rumen, the pylorus of the stomach, the external nares. (*Vide* Figs. 24–30.)

FIG. 25.
Necrotic ulceration on lateral aspect of tongue and cheeks, particularly marked opposite prominent molar teeth. Sheep 37691.

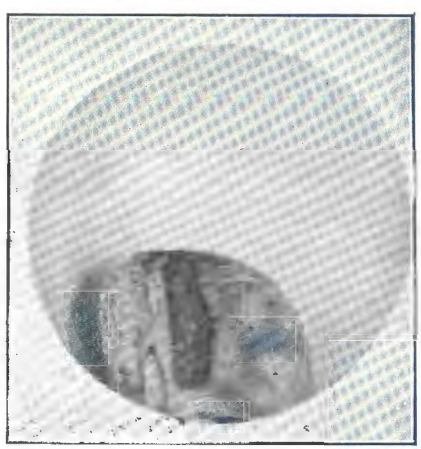

FIG. 26.
Necrotic ulceration along frenum linguae. (Sheep 8, Expt. 1B.)

1. 2. 3.

FIG. 27.

Various stages of ulceration on tongues of sheep.

1. Sheep 8 of Expt. 1 (*b*). 13 days after infection.
2. Sheep 1 of Expt. 1 (*a*). 9 days after infection.
3. Sheep 12 of Expt. 1 (*c*). 13 days after infection.

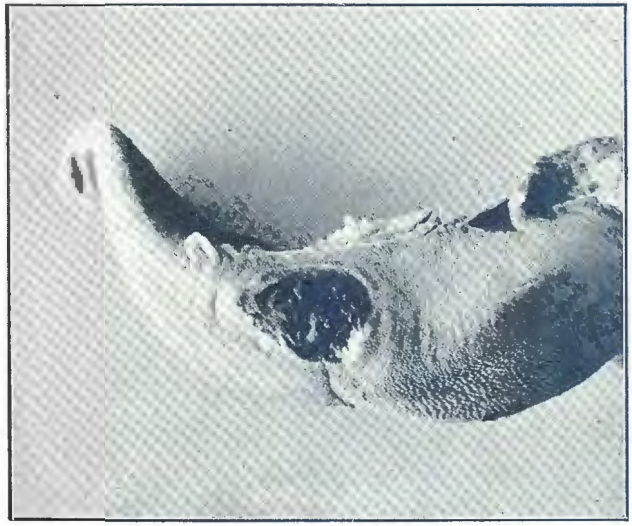

FIG. 28.

Extensive ulcer lateral aspect tongue. Calf 10, Expt. 1 (*b*). 18 days after infection.

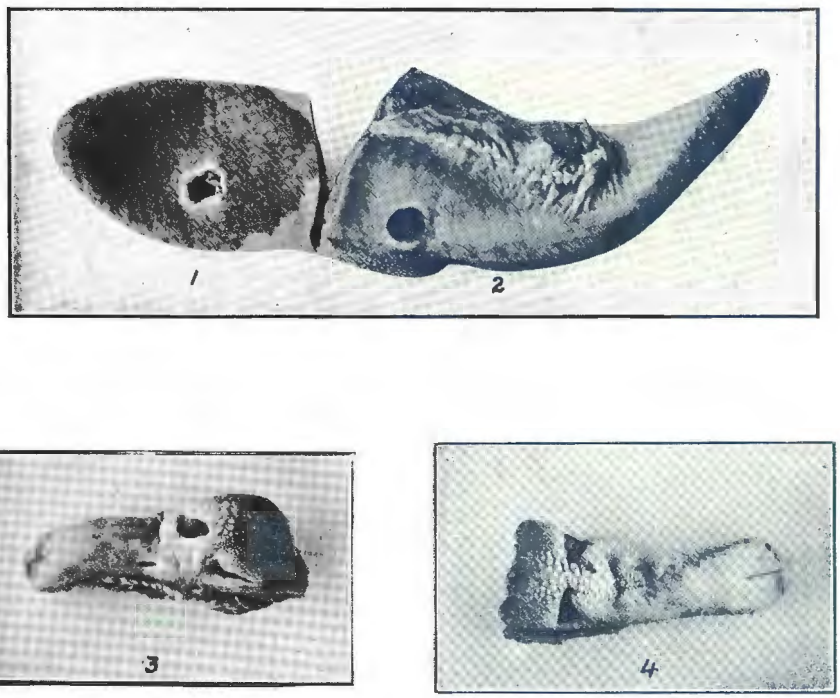

FIG. 29.

Ulcers on tongues in the process of healing.

1. Calf 7, Expt. 1 (*b*), 20 days after infection.
2. Calf 1, Expt. 1 (*a*), 27 days after infection.
3. Sheep 17, Expt. 2, 25 days after infection.
4. Sheep 16, Expt. 2, 25 days after infection.

Microscopically these lesions in the acute stage could, in the majority of cases, be distinguished from the vesicles of foot and mouth. They either showed a necrosis or a subsequent ulceration with an hyperamic zone. At the periphery of the ulcer one could always recognize the presence of some of the adhering necrotic material. At no stage of the disease did it disclose anything of the nature of the frayed out and irregular remains of the wall of a ruptured vesicle of foot and mouth. Neither was the base of the ulcer like the usual foot and mouth lesion, namely, of a bright red granulating surface. These necrotic areas or ulcers were circumscribed, well defined, and often multiple. In the natural cases of bovines at Welgezegend some of the necrotic areas on the tongue reached large dimensions, and penetrated into the muscular substance of the tongue. In one case it revealed multiple necrotic foci in the lung, but apparently caused by *B. necrophorus*.

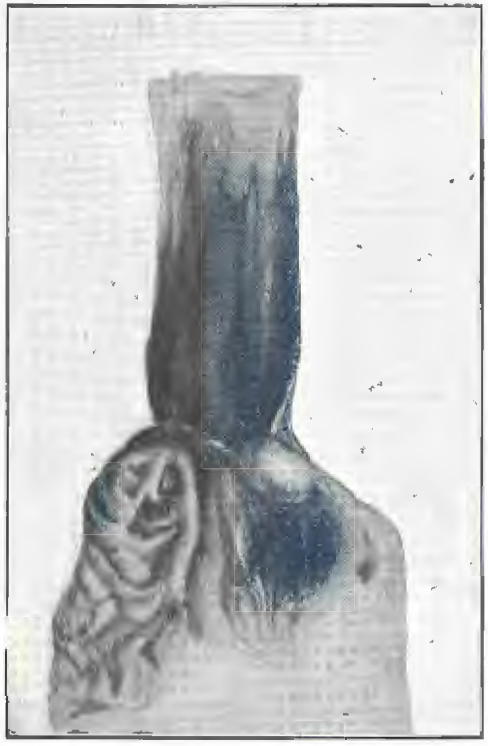

FIG. 30.

Acute enteritis and haemorrhages in pyloris (from drawing). Sheep 37454.

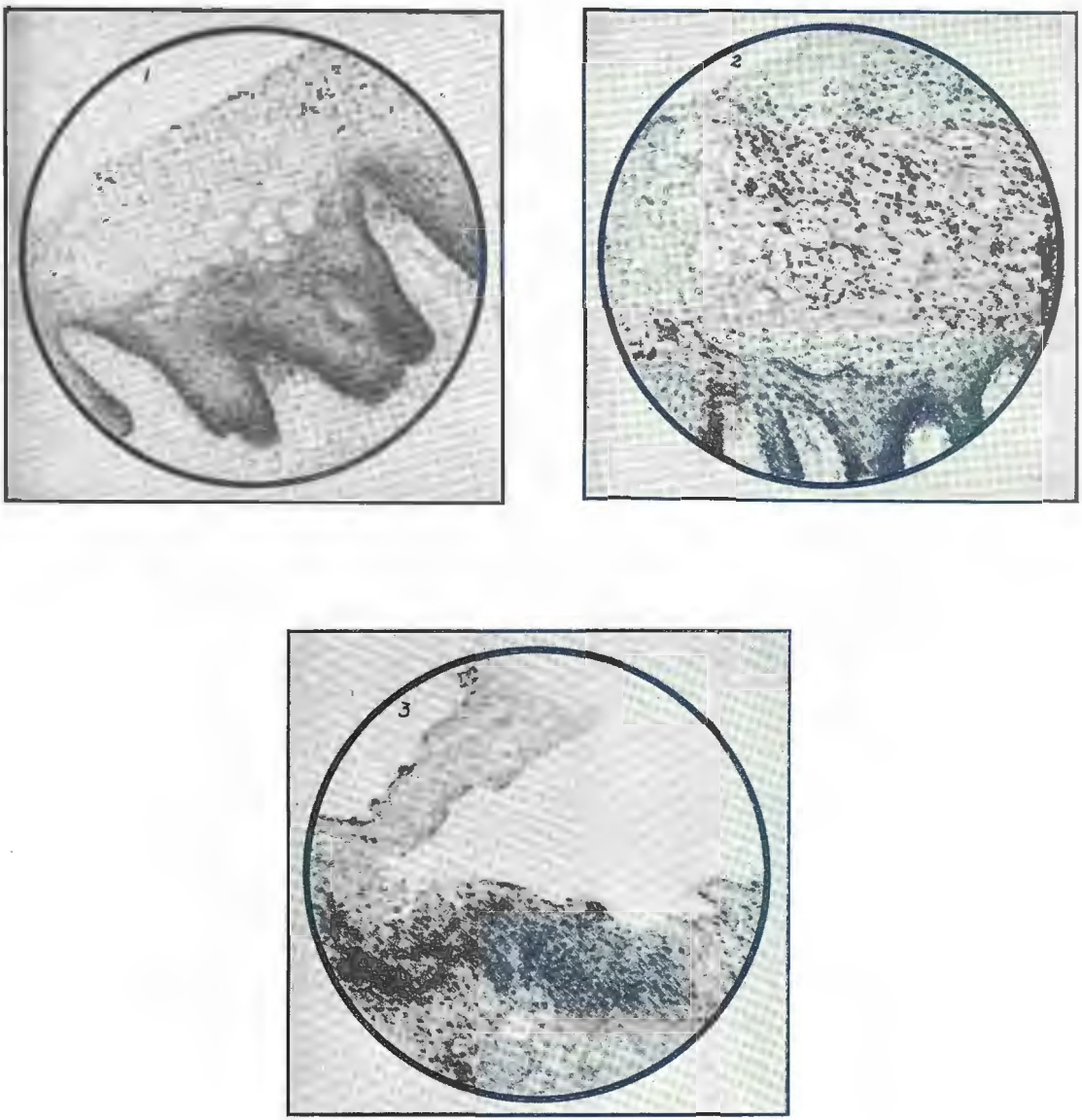

FIG. 31.

Tongue, showing three stages of bluetongue lesions.
(Spec. 13961, sheep expt. case.)

1. "Ballooning" of stratified epithelial cells.
2. Infiltration of epithelial cells with neutrophiles.
3. Desquamation of necrotic material forming ulcers.

Fig. 32 (1).

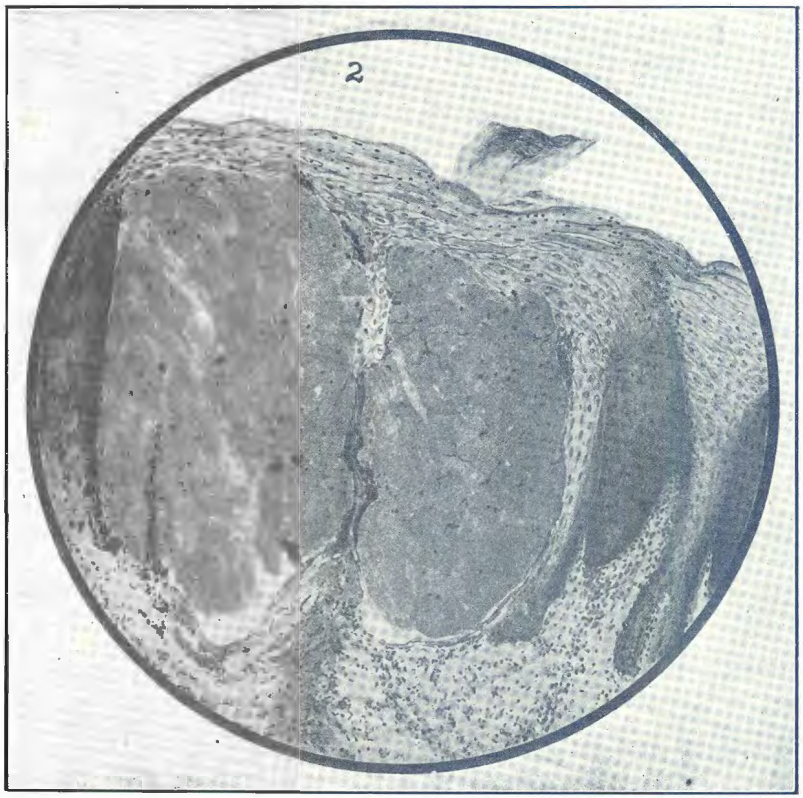

FIG. 32 (2).

Tongue: Haemorrhages in stratified epithelium and corium of mucous membrane. (Spec. 14065, Expt. sheep case.)

Microscopically (*vide* Figs. 31 and 32), it was seen that these necrotic areas and ulcers were produced by a process of " ballooning " of the epithelial cells of the stratified epithelium of the mucous membrane of the *tongue, lips, rumen, etc.* This was followed by a pustular stage in which the spaces in the epithelial cells became loosely infiltrated with neutrophiles. This was followed by necrosis and ulceration of the mucous membrane in which the corium becomes secondarily involved. The underlying corium revealed hyperaemia, haemorrhage, infiltration with neutrophiles, and necrosis. In all these cases the base of the ulcer was formed by a necrotic mass, practically unassociated with any proliferation of connective tissue.

The healing process sets in rapidly; but frequently, however, well defined depressions develop in the mucous membranes, about $1\frac{1}{2}$ cm in diameter to $\frac{1}{8}$ in depth with the edges sharply cut and clean. At this stage the lesions may be mistaken for healing-out lesions of foot and mouth and like in case of foot and mouth it is surprising how rapidly and completely healing of the mucous membranes takes place.

Oedema of the lips and tongue was an early lesion to occur and was usually fairly prominent, in some cases the tongue protruded from the mouth as a result of its increased size, due to swelling. The subcutis of the ears, supra-orbital fossae, mandibles, intermandibular space, ventral aspect of the upper third of the cervical region, the peritracheal and perioesophageal connective tissues were also frequently affected.

In a number of cases there was oedema of the glottis and lungs, as well as a hydropericardium, and hydrothorax. In sheep 37452 oedema of the glottis was so marked that it caused asphyxia. Some of these cases in view of the transudation of fluid into the connective tissues of the cranial aspect of the body resembled the dikkop form of horsesickness.

Some cases showed inflammation of the intestines, urinary bladder, and degenerative changes in the parenchymatous organs. A large number of these were examined microscopically, e.g. brain, spinal cord, liver, kidneys, spleen, a large number of lymphatic glands without evidence of any specific changes.

Some animals that died in the later stages of the disease showed general anaemia and cachexia as the dominant features.

In describing the lesions found in bluetongue in sheep Theiler (*loc. cit.*) maintains that one can consider as typical only those found in such cases where death supervened in the acute stage. He says, " The mouth is the principal part affected, showing excoriations on the lips, gums of the upper jaw, sloughing off of the epithelium of the tongue . . . . mucous membrane of the nasal septum is usually strongly congested . . . . lesions in the first stomach showing red patches and stripes . . . in severe cases the mucous membrane of the fourth stomach is of a purple colour, swollen, either uniformly discoloured or perhaps in patches. . . . Lungs are as a rule normal, but symptoms of even complete oedema are occassionally met with. . . . In acute cases tumefaction of the spleen is usually present, but does not reach large dimensions. . . . Petechiae are found in almost every acute case on the left endocard and sometimes on the epicard.

The post-mortem lesions in cases of long duration leave nothing typical. Usually there are lesions of extreme emaciation, paleness of the flesh and organs. The lesions in the mouth have as a rule already healed out."

The post-mortem appearances of bluetongue in sheep described by Spreull (*loc. cit.*) are fairly exhaustive and it is significant how these correspond with those changes seen in experimental sheep infected with virus obtained from cattle. " Frothing at the mouth, swelling of the lips, particularly the upper lip, catarrhal discharge from the nostrils, cyanosis of the buccal mucous membrane, dental pad and inner surface of the lips are raw and excoriated. Sores appear inside the cheeks in the region of the molars and even on the rugae of the hard palate . . . . the tip of the tongue becomes sore . . . . in a few cases the tongue becomes extremely oedematous, quite fills the mouth . . . . there is occasionally an oedema of the lower parts of the face and especially of the skin and tissues under

the jaw, extending through rarely for a short distance down to the under surface of the neck. . . . The rumen often shows inflamed patches more especially affecting the pillars. . . . There may be one or two ulcers at the pylorus. . . . As a rule death occurs from debility and the mouth and other lesions have generally healed by that time . . ."

It is most significant how the changes in natural bluetongue in sheep as described by Theiler and Spreull correspond to those seen by the writers.

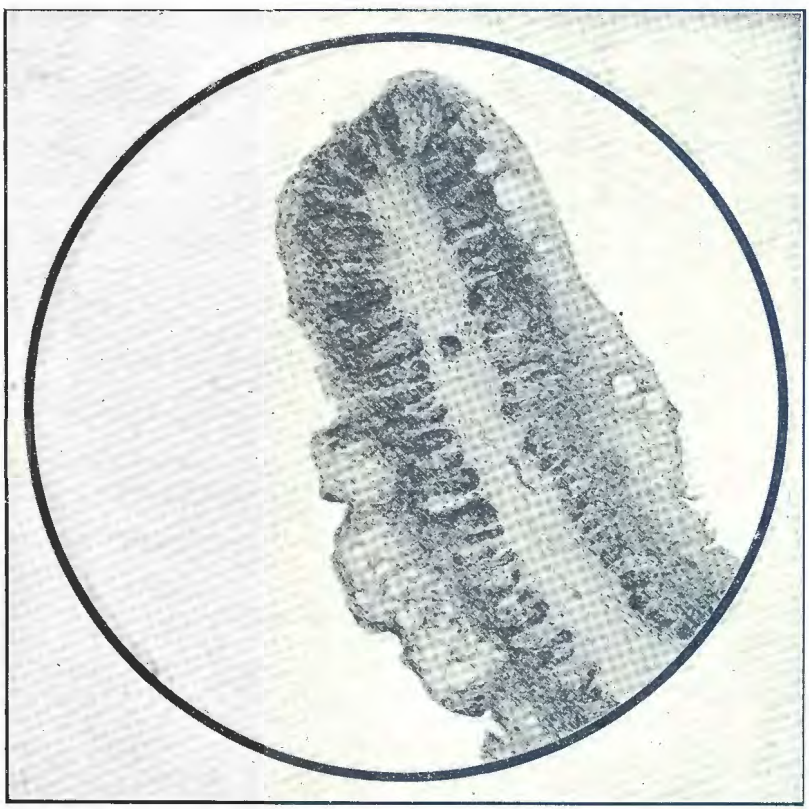

FIG. 33.

Papilla of rumen: Showing "ballooning" of stratified epithelial cells. (Expt. sheep case.)

PATHOGENESIS.

In the Third Progress Report (1928), it is said that the question has often arisen why the lesions of foot and mouth disease should be confined to such very limited areas of the body as the skin, feet, and mucous membrane of the mouth and tongue. . . . It must be supposed that it is only in the superficial layers of the plantar and

palmar skin and of mucous membrane of the tongue that favourable conditions for the multiplication of the virus occur, but what the conditions may be is mysterious. . . . . From the experiments of Maitland it would appear that the position of vesicles is evidently not determined entirely by the structure of the tissues affected . . . . the mild irritation caused by movement and pressure would appear from these experiments to be a necessary condition. . . . With freedom from pressure, the local conditions are less favourable for the propagation of the virus, whether directly implanted or brought by the blood stream. . . .

In bluetongue, especially in the experimental cases where all stages could be carefully watched, it was significant how regularly lesions developed in certain situations, e.g. on the lower lips opposite the incisors, on the dorsal-lateral aspect of the tongue opposite prominent molars, on those parts of the fore-stomachs (muscular pillars, oesophageal groove) and pylorus where function seems more prominent than in other parts; parts of the integument subjected to pressure, etc. In case of the tongue certain parts which were brought into closer contact with the molar teeth became particularly affected (*vide* Fig. 25).

Microscopical scrutiny of the internal organs in foot and mouth disease was undertaken by the Research Committee, but no lesions were discovered in them . . . . it is concluded that, although the virus established itself in certain restricted areas alone it speedily dies out or succumbs to the natural defences of the body.

Interesting histological observations made in respect of experimental cases of bluetongue bear some resemblance to those referred to on page 10 of the Third Progress Report, viz., " Where the earliest evidences of a lesion were observed in the epithelial tissue covering the tongues of rabbits and guinea-pigs . . . . a few epithelial cells lost their ordinary fusiform shape and became spherical . . . . their protoplasm had changed its staining property and their nuclei degenerated . . . . in the centre of the lesion the altered cells were broken up and infiltration of the infected area with a few neutrophiles had occurred . . . . both degenerated epithelial cells and infiltrating cells are subsequently disintegrated and the lesion becomes successively a vacuole, a vesicle, a vesicopustule. . . . The latter finally ruptures, leaving an ulcer which heals under a crust. . . ."

In experimental bluetongue the earliest lesions in some of the cases manifested themselves in the epithelial cells in the vicinity of the " germinal layer " and even in cells of the basal layer where the cells become spherical, swollen and the cytoplasm shows a diffuse slightly stained hyaline appearance sometimes resembling droplets with a disappearance of the nuclei.

At this stage, as in foot and mouth lesions in rabbits and guinea-pigs, usually no histological changes in the corium could be identified. This stage resembles the condition of " ballooning " sometimes also seen in actively growing papillomata of bovines (*vide* Fig. 31).

At the next stage these cells become disintegrated and their spaces become loosely filled with neutrophiles. These neutrophiles together with the remaining epithelial cells then undergo necrosis, while inflammatory changes also now make their appearance in the underlying part of the corium.

At the next stage portion of the superficial necrotic mass becomes dislodged and leaves a bed composed of necrotic tissue extensively infiltrated with cells and in which the layers of the stratified epithelium are no longer in evidence. Other similar lesions of the mucous membranes did not show typical vesicle formation but transformed immediately into pustule, necrosis and ulceration. Almost identical lesions with " ballooning " of the epithelial cells, infiltration with neutrophiles, necrobioses, etc., were also observed in localized areas on some of the papillae of the rumen.

In foot and mouth disease in rabbits and guinea-pigs characteristic vesicles are only observed on the tongue, whereas extensive histological examination of the liver, brain, spleen, kidney, spinal cord, lung, heart muscle, ovary, testicle, adrenal, parotid of infected guinea-pigs and rabbits failed to disclose any departure from the normal. The Foot and Mouth Disease Research Committee felt justified in concluding that the initial lesions occur in the epithelium of the tongue and that the corium is only secondarily affected and that the histology of the lesion indicates an affinity of the virus for epithelium. The appearance suggest a true intra-epithelial culture.

Rivers (1928) also refers to the effects produced in cells by viruses, especially in respect of the epidermis . . . . " they are subjected to forces not impinging in the same way upon the other cells of the body . . . . they are under the direct influence of a variety of mechanical injuries . . . . whether the virus acts on the surface of the cell or penetrates into it is not known . . . . both the injury to the cell and the multiplication of the virus still have to be explained."

The process of " ballooning " of some of the cells of the stratified epithelial cells has frequently been seen in some of the papillomata of the skin of bovines. The etiology of these multiple papillomata believed to be transmissible has not yet been settled. It certainly does not exclude a virus factor and the possibility of a subsequent immunity, especially in view of their spontaneous disappearance. It will be of great interest to determine whether these changes in the cell cytoplasm observed in bluetongue is of the nature of a degeneration either due to the multiplication and action of the virus or to traumatic influences (e..g pressure of teeth on swollen mucous membranes as a result of oedema or exaggerated function in the vicinity of the pillars of the rumen, etc.

Does the virus multiply and propagate only in those epithelial cells which become previously injured by pressure, etc.?

In spite of a careful examination of sections stained with Giemsa it was not possible to identify anything of the nature of " inclusion bodies ". It is realized that failure to identify such

bodies by the above method does not exclude their presence. On the other hand, in some of the experimental cases this " ballooning " process of the epithelial cells was not seen, but multiple haemorrhages into the epithelial *layers of the mucous membranes*. It is, however, at the present moment not possible to offer any explanation of the actual relation of the epithelial cells of the skin and mucous membranes to the virus, and how this virus multiplies and propagates, especially in those cases where only multiple haemorrhages were observed.

The transudation of fluid at certain stages of the disease into the subcutis of the mandibles, the intermandibular space, the supra-orbital fossa, the lips, the tongue, the upper part of the ventral aspect of the cervical region, the peritracheal and peri-oesophageal connective tissues, lungs, into the body cavities (hydrothorax, hydropericard) forms an interesting pathological manifestation in several diseases (e.g. dikkop horsesickness, bluetongue, dunkop horsesickness, *cucumis* poisoning). No explanation has yet been given as to why this " transudation " process is so specifically confined to the cranial aspects of the body. It is only in extensive transudation that it may encroach on to upper part of the fore-limbs and on to the region of the shoulder. In dunkop horsesickness it is characteristically confined to the lungs, thorax, and submucosa of the respiratory tract. In the experimental bluetongue cases the course of the transudation followed more the condition as it occurred in dikkop horsesickness, but in bluetongue morphological changes of the myocardium were never of the same degree as those seen in horsesickness. In fact in bluetongue the myocardium in a number of cases showed no morphological lesions and if this transudation was at all associated with the action of the heart then is was probably of a nervous cheracter.

Quin (1929) in his observations on *cucumis* poisoning speaks of a primary pulmonary oedema, and seems to think that vasomotor disturbances accounting for the oedema seems remote. The poison appears to exert a marked injurious influence on the endothelial lining of the minute vessel walls, so causing a sudden and marked increase in permeability. If we accept a similar explanation for transudation in bluetongue, it will be difficult to co-ordinate that with the extraordinary characteristic localization in the cranial aspects of the body.

THE COURSE AND PROGNOSIS.

In comparatively *mild reactions* the prognosis is favourable. The animals are visibly ill and off their feed for about a week. Recovery is rapid and uneventful.

In *severe affections* a guarded prognosis must be given. There is a rapid loss of condition and marked weakness follows. On account of the extensive changes in the buccal mucosa the appetite remains precarious. Should a dermatitis develop, the recovery is even slower and the injured skin, especially round the mouth, is frequently struck with blowflies.

In several instances the disease terminated in death. In such fatal reactions death usually takes place in the early or acute stages. It would seem that a recovery could be hoped for when once the acute reactions have passed off, but in the later stages cases have been encountered in a moribund condition due to weakness and debility.

Extensive and deep seated necrotic ulcerations have been noted on the tongues of some cases, e.g. in two of the Welgezegend cows. It is very probable that the more or less superficial injury of the mucosa by the virus provides *loci minorum resistentiarum* for the invasion of bacteria, which then contribute towards the formation of the extensive injuries. In one of the Welgezegend cows more than half of the middle portion of the tongue was found at post-mortem examination to be necrotic and gangrenous. It is very probable that, if this animal had been allowed to live the anterior portion of the tongue would have sloughed off.

In some of the experimentally infected calves and sheep similar, although not so extensive, ulcers developed on the tongues. Such lesions took a considerable time to heal and were present a month after the date of infection when all the other lesions had healed.

DIAGNOSIS.

In typical cases the lesions are sufficiently characteristic for a diagnosis to be made. The following changes are important:—

(1) The superficial localized inflammation with necrosis on the lips, conical papillae, dental pad, external nares, muzzle, and ventral aspect of the apical portion of the tongue.

(2) The swelling of the lower portions of the limbs and the marked hyperaemia of the skin particularly in the region of the accessory digits.

(3) The condition of the teats in milking cows; this consists of a necrosis of the epidermis with subsequent scab formation.

(4) In the later stages the dermatitis and subsequent formation of crusts and hard scabs.

For diagnostic purposes the temperature is not of much value. As in sheep, the temperature is elevated during the initial stages of the disease, but as most cases come under observation only in the later stages, i.e. when the mouth lesions, etc., are well developed, a normal or only slightly raised temperature is usually found. Furthermore, under field conditions a temperature diverging only slightly from normal is very difficult to interpret.

The epizootology of this disease in bovines is most important when considering a diagnosis. The disease makes its appearance in late summer and autumn, and generally only a few individuals in

a herd become affected. The disease occurs sporadically. The prevalence of horsesickness and bluetongue in sheep in localities where this disease may make its appearance should be taken into consideration. In cases of doubt, e.g. in some of the atypical cases which may be encountered, the diagnosis may be confirmed by inoculating suspected blood into normal sheep. In this connection Merino sheep, raised under conditions where natural infection is excluded, e.g. the Karroo, are most suitable.

DIFFERENTIAL DIAGNOSIS.

(*a*) Foot and Mouth Disease.

The following differences are important:—

1. *The Epizootology.*—Foot and mouth disease is a contagious disease and a new outbreak can usually be traced to some source of infection. In the case of bluetongue of cattle outbreaks occur sporadically and there is no evidence that the disease can spread by contact. The latter disease occurs seasonally and simultaneously with horsesickness and bluetongue of sheep.

2. *The lesions.*—The same parts, viz., buccal cavity, feet and udder (teats) are affected in both diseases, there is, however, a distinct difference in the nature of the lesions. In bluetongue the pathological changes are essentially those of a localized inflammation with necrosis of the mucous membrane and the characteristic vesicles of foot and mouth disease are not observed. In bluetongue the lesions show a zone of necrosis bordering on the periphery of the lesion, whereas in foot and mouth disease the frayed irregular remains of the ruptured vesicle can usually be identified. In the later stages the ulcers that are formed in both diseases are somewhat similar and it might be difficult to make a distinction. It should, however, be remembered that the skin lesions are usually observed in the later stages of bluetongue and this is of value in making a differential diagnosis.

Animal reactions.—Foot and mouth disease can be excluded by inoculating sheep. Merino sheep are very susceptible to the virus of bluetongue, and the characteristic reaction of bluetongue is observed.

(*b*) Snotsiekte.

Here the history of close contact with wildebeeste is a most important factor. Furthermore, well marked and distinguishing pathological changes occur, e.g. the enlargement of the lymphatic glands and the acute catarrhal and pseudo-membranous inflammation of the mucosa of the upper air passages resulting in a profuse muco-catarrhal discharge from the nostrils. Snotsiekte is an acute and nearly always fatal disease and is of the nature of a lymphatic aleucaemia. Very severe eye lesions, keratitis and conjunctivitis, are other important distinguishing features.

According to Mettam (*loc. cit.*) sheep are not susceptible to the virus of snotsiekte.

(*c*) Malignant Catarrhal Fever.

In his discussion on the differential diagnosis of snotsiekte Mettam (1923) makes the following statement:—

"Malignant catarrhal fever occurs sporadically in South Africa, but to what extent is not known." No reference is given for this information. He refers to this malignant catarrh as a disease accompanied by a high fever and he mentions acute eye and nasal symptoms, rapid emaciation, spreading of the inflammation of the mucous membranes lining the sinuses to that of the horn cores, which often came away in the hand during manipulation. He further states that in many cases of malignant catarrhal fever skin lesions are found in the form of papular exanthema and often in the later stages a profuse scaling of the epidermis. According to Mettam the condition cannot be reproduced in cattle by blood inoculations and he mentions this as a distinguishing feature from snotsiekte. From this description it would appear that this is the same disease that occurs in European countries. Recently Götze (1932) maintained that malignant catarrhal fever and snotsiekte are, if not identical, then very closely related diseases. This conclusion is arrived at by a consideration of the fact that both diseases can be transmitted to susceptible cattle by blood inoculations and because the clinical and pathological-anatomical changes are very similar in both diseases. Götze suspects sheep playing a rôle in malignant catarrhal fever analogous to that which the wildebeest plays in snotsiekte in South Africa.

As far as is known outbreaks of snotsiekte in South Africa have only been observed under circumstances where cattle come into very close contact with wildebeeste. It is not known whether sheep can serve as a reservoir for the virus of snotsiekte in a way similar to that suspected by Götze in the case of outbreaks of malignant catarrhal fever in Germany.

In view, however, of the findings of Götze, further investigations will have to be carried out to establish the exact relationship between snotsiekte and malignant catarrhal fever. It is most important to ascertain whether malignant catarrhal fever does exist as a disease *sui generis* in South Africa. The possibility that the disease, referred to by Mettam as malignant catarrhal fever, might have been the same as this bluetongue of cattle should also be considered.

(*d*) Sweating Sickness (Sweetsiekte or Nat-kalwersiekte).

This disease has been described by du Toit (1923), who found the condition usually confined to calves only. Later observers, Clark (1933) and A. D. Thomas (in a personal communication), maintain that the occurrence of sweating sickness in older animals is by no means rare. Clark describes a typical case in a three-year-old cow.

The disease apparently occurs enzootically in certain parts of South Africa, such as the Lowveld of Swaziland, Zululand, Natal, in the Bushveld of Northern Transvaal, and Bechuanaland. The aetiology of the condition is still unknown, but du Toit (*loc. cit.*) suggested that a filtrable virus may be the responsible factor.

There are certain resemblances between sweating sickness and certain forms of bluetongue of cattle, in particular the same seasonal incidence and certain clinical conditions, for instance, the hyperaemia and necrosis (ulcers) on the buccal mucosa and the condition of the skin in the later stages. But a condition of sweating has not as yet been observed in cases of bluetongue in cattle, and although older animals may be affected with sweating sickness, the disease is most common in calves, whereas bluetongue has been observed to occur in older cattle.

In view, however, of certain similarities between the two conditions it would be essential to determine whether reactions could be produced in sheep with sweating sickness material and if any relationship exists between the two diseases.

(*e*) Three-day-Stiffsickness (Ephemeral fever).

The first symptoms usually observed in bluetongue of cattle is marked with stiffness and lameness. These are usually the only symptoms observed for a day or two by the owners before the mouth lesions become obvious. It has already been suggested (*vide* symptomatology) that cases described as three-day-stiffsickness, especially where they are found in association with typical bluetongue reactions in cattle, may also possibly be atypical forms of the same disease.

In true three-day-stiffsickness a relatively large number of animals (10 to 50 per cent.) are usually affected. Except for the stiffness, slight lachrymation and elevation of temperature no other important symptoms or lesions develop.

According to Theiler (1907) the disease can be transmitted to susceptible cattle by means of blood inoculation. He succeeded in setting up characteristic symptoms of three-day-stiffsickness in a heifer by inoculating her with 20 c.c. defibrinated blood from a natural case.

(*f*) Lamsiekte.

A complete or partial paresis of the tongue is a common symptom observed in lamsiekte. In severe reactions of bluetongue a protrusion of the tongue occurs and in such cases this disease may be confused with lamsiekte. It should be remembered that in lamsiekte no visible lesions are present in the mouth or on the tongue and a complete paralysis of the locomotory system is also evident in practically all cases.

Furthermore, lamsiekte can usually be excluded by carefully considering the epizootology and the various aetiological factors concerned.

(*g*) Rinderpest.

In bluetongue the lesions on the lips, dental pad, muzzle and external nares to some extent resemble those seen in the early stages of rinderpest, but the subsequent alarming intestinal disorders of the latter disease do not develop. Furthermore, bluetongue is usually observed in a few individuals in a herd and there is no evidence of the disease spreading by contact, whilst rinderpest is

a highly infectious condition and spreads very rapidly. A further distinguishing characteristic is the very high mortality in rinderpest; bluetongue in comparison is a relatively benign disease.

(*h*) Stomatitis due to Traumatic or Chemical Agents.

Such factors can usually be excluded by carefully considering the history of each case. Traumatic agents, e.g. the awns of certain grass seeds are usually found *in situ*. It should be remembered that sick animals in South Africa are often subjected to rather drastic and severe treatment and irritating chemical substances such as caustic soda, carbolic acid preparations, etc., are sometimes used. The stomatitis resulting from the use of such substances should be considered when arriving at a diagnosis.

(*i*) A Form of Panaritium.

This is frequently encountered in South Africa and such an outbreak occurred for instance on a farm Bouwlust in the Koedoesrand area during April, 1933. Apparently this condition is due to contamination of the feet by mud around the drinking water and in hut kraals. In the outbreak at Bouwlust the condition was apparently exaggerated by the fact that the cattle had to be driven over a long distance to the Magalakwin river for watering purposes. The hind limbs in this case were most affected and no mouth lesions were observed.

From the present South African point of view the above conditions are, no doubt, the most important which should be taken into consideration in making a differential diagnosis. However, since this disease in some clinical respects resembles foot and mouth disease, and, furthermore, since it first came into prominence during a campaign against the latter in South Africa, the differential diagnosis would be incomplete without including certain other conditions which are usually brought under review in a consideration of the diagnosis of foot and mouth disease.

Eaton (1933) has recently presented an excellent review of conditions of the mouth and feet of cloven-footed animals in a discussion of the diagnosis of foot and mouth disease. The following are some of the conditions included in his long list:—

1. *Vesicular stomatitis.*—Here only mouth lesions develop and consist of vesicles, usually seen only on the tongue, but occasionally on the gums. Important differential characteristics are the absence of feet lesions and no locomotory disturbances.

2. *A non-specific catarrhal and ulcerative stomatitis.*—These conditions are usually noted in animals which are poor and unthrifty. In the case of the catarrhal form heaped-up epithelial deposits are to be observed on the tongue, hard palate, and inside the upper and lower lips. In the ulcerated form the ulcers heal slowly.

3. *Calf diphtheria.*—Confined to calves. The mouth lesions area caused by the *bacillus necrophorus* after a preliminary injury to the buccal mucosa such as is caused by teething. The yellow necrotic patches are to be seen on the dorsum of the tongue and inside the cheeks. Large sloughing of the affected parts often follows and death is a common sequel.

4. *Pustular stomatitis.*—According to Eaton this condition is met with by itself or with an accompanying dermatitis in young cattle, and also in sheep. The lesions are found on the inside and outside of the lips. Pus is discharged which forms crusts on the outside of the lips.

Under this heading the well-known South African disease Vuilbek (*Ecthyma contagiosum*) of sheep and goats can be conveniently considered. Vuilbek is a benign disease when compared with bluetongue of sheep and foot lesions are absent. Ordinarily very little difficulty is encountered in distinguishing it from bluetongue in sheep, but when lesions occur on the inside of the lips and cheeks it might be necessary to resort to biological tests.

Eaton discusses conditions such as Dirty tongue (Armagh disease), Actinomycosis of the tongue, Actinobacillosis of the dental pad, traumatic and dental injuries of the buccal mucosa, which could from a pathological-anatomical consideration be confused with foot and mouth disease. He also draws attention to choking, lactation tetany, disturbances of the salivary glands, etc., where salivation is a conspicuous symptom, and may thus also be confused with foot and mouth disease.

SUMMARY AND CONCLUSIONS.

During the autumn of 1933 an undescribed disease referred to as pseudo-foot and mouth disease, made its appearance in cattle in herds scattered over an extensive area of South Africa. From evidence obtained it would appear as if this disease is not a "*new*" condition, *but that it has been observed* for some considerable time. Unfortunately no serious notice was taken of it and it thus escaped the attention of veterinarians until the beginning of 1933 when all possible veterinary resources were organized to deal with a possible spread of foot and mouth disease throughout the Union.

In practically every case where this so-called pseudo-foot and mouth disease broke out the owners considered it either as foot and mouth disease, or, at any rate, very suspicious. Since lesions appeared on the buccal mucosa, the feet and on the udders, veterinarians experienced considerable difficulties in definitely excluding foot and mouth disease. It, therefore, became essential to undertake experimental investigations in order to ascertain the nature of this condition.

In the experiments undertaken it was possible to indicate the presence of the well-known virus causing bluetongue of sheep in the blood of most of the cattle suffering from this "pseudo-foot and mouth disease." Very characteristic reactions of bluetongue developed in the experimentally infected sheep, and, furthermore, the specificity of the virus was established by immunological tests.

It was also shown that calves, although less susceptible than sheep, undergo a definite reaction when infected with virus originally obtained from cattle affected with this disease.

In the discussion of the pathogenesis of bluetongue reference was made to the significance of the lesions, especially in relation

to the stratified epithelial cells of some of the mucous membranes, and the question of transudation into the connective tissue, especially of the subcutis of the cranial aspect of the body.

From an actual economical aspect the occurrence of bluetongue in cattle is apparently of minor significance, for in most of the outbreaks which were investigated only a small percentage of animals were affected, and these cases usually made an eventful recovery. It is from a differential diagnostic point of view, especially in connection with foot and mouth disease that the occurrence of bluetongue is of very great importance.

The knowledge that cattle are susceptible to the virus of bluetongue may perhaps throw further light on certain cattle diseases of South Africa where the aetiology is still somewhat obscure. This is especially the case in connection with sweating sickness of calves, the alleged occurrence of malignant catarrhal fever, and some of the so-called cases of three-day-stiffsickness.

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APPENDIX A.

TRANSMISSION EXPERIMENTS.

Introduction.

Transmission experiments were undertaken with material obtained from various outbreaks. These experiments were commenced on the farm Welgezegend and continued later at Onderstepoort. It is convenient to give the results under various headings indicating the source of the infective material:—

(1) Experiments with *Welgezegend* cattle virus:—

(*a*) Series with a strain recovered from a sick cow (case 1).

(*b*) Series with a strain recovered from a calf which was "infected" intranasally with a mixture of blood, urine, milk, and emulsified necrotic tissue from three sick cows (cases 1, 2, and 3).

(*c*) Series undertaken with a strain recovered from an ox which developed a fairly mild reaction and later recovered.

(2) Experiments with *Kromdraai* cattle virus.

(3) Experiments with *Darling* cattle virus.

(4) Experiments with *Elandslaagte* cattle virus.

(5) Experiments with *Novo* cattle virus.

(6) Experiments with *Montague* cattle virus.

(7) Experiments with *Onlangs* cattle virus.

(8) Experiments with *Swartland* cattle virus.

(9) Experiments with a strain of bluetongue virus recovered from a sheep at *Novo*.

(10) Miscellaneous experiments.

Each chapter is arranged in the following way:—

A. A description of the outbreak.

B. Table indicating the transmission experiments to which the various strains were subjected.

C. Tabulation of experimental results.

Note.—The reactions which were observed in the calves are fully described, but as far as those in the sheep are concerned only the nature of the reaction is mentioned. The reactions were typical and are fully described in first part of the paper (*vide* symptomatology). Any complications are specially mentioned.

D. Summary of the results:—

(1) Calves 1-14 were used in the Welgezegend experiments.

(2) Sheep 1-19 were used in the Welgezegend experiments.

(3) All the remaining calves and sheep were kept under laboratory conditions at Onderstepoort.

(4) The sheep used in the Onderstepoort experiments were all originally from the Karroo, i.e. reared under conditions where bluetongue does not usually occur.

(1) Experiments with Welgezegend Cattle Strains.

History of the Outbreak.

A total number of 308 head of cattle were kept on the particular portion of the farm Welgezegend where this outbreak occurred. The cattle were in low condition on account of a drought, but they were free of specific disease. On the 10th March three cows became ill. They were noticed to be slightly stiff and lame. No serious attention was given to the condition and a vague diagnosis of "gallsickness" was attempted. The animals were accordingly drenched. Three days later, however, marked salivation was observed and in one case the tongue was protruding from the mouth. The months were now examined and alarming "sores" discovered. Foot and mouth disease was immediately suspected and the disease reported to the veterinary officer.

Condition of the Cows on 15th March.

Case No. 1.—The animal, a young grade Friesland cow, was found lying down. There was marked salivation and the temperature 102·6°. The animal showed no inclination to feed and appeared very depressed.

The skin on the plantar region of the limbs, up to the fetlocks, appeared red and swollen. The epidermis in the interdigital spaces appeared excoriated and the underlying tissues necrosed and moist. Loose and partially detached epidermis was still adherent in parts. On rising a marked lameness in all four limbs was observed.

The udder showed a dermatitis in the stadium squamosa with a marked red discoloration of the teats.

A moderate amount of salivation was observed and in the mouth an elongated superficial necrosed area was present between the upper lip and dental pad. Similar lesions were present on the border of the lower lip. On the left side of the tongue there was a large area, extending from the middle third to the posterior third which appeared necrosed. This area was covered with a greyish-yellow material. The borders of this lesion were very red. Extensive necrotic lesions were noted on the dental pad. These were also covered with yellowish material. Superficial necrosis and ulceration was also noted along the borders of the nose. The muzzle was dry and encrustated.

Case No. 2: *A Young Grade Friesland Cow.*—The condition of this cow was similar to case 1, with the following exceptions:—

The necrosis on the tongue was confined to the ventral aspect of the apex. The lips and dental pad were more extensively involved. The tongue appeared swollen and was hanging from the mouth. The lesions in the interdigital space were not so marked. Salivation was much more profuse.

Case No. 3: *A Young Grade Friesland Cow.*—This was a comparatively mild case. No feet lesions were to be found. The udder was only slightly affected and the mouth lesions not so marked. An elongated necrosed area was present in the space between the upper lip and dental pad and similar lesions on the dental pad. A few irregular and fairly small necrosed lesions were noted on the lateral aspect of the apex of the tongue. Small irregular necrosed areas were present on the nose.

The above cows were destroyed. Post-mortem examinations were undertaken and are described in Appendix B.

Subsequently (17th April) two further cases were discovered on this farm. The affected animals were in both cases mature oxen. The lesions were comparatively mild and necrotic lesions were noticed on the dental pad, the upper and lower lips, and the ventral surface of the apex of the tongue. The lower parts of the limbs appeared swollen and the skin on the plantar region of digit was red. Fairly high temperatures (more than 105° F.) were recorded on several occasions. These oxen ultimately recovered.

A series of three experimental investigations were undertaken with material from these cases:—

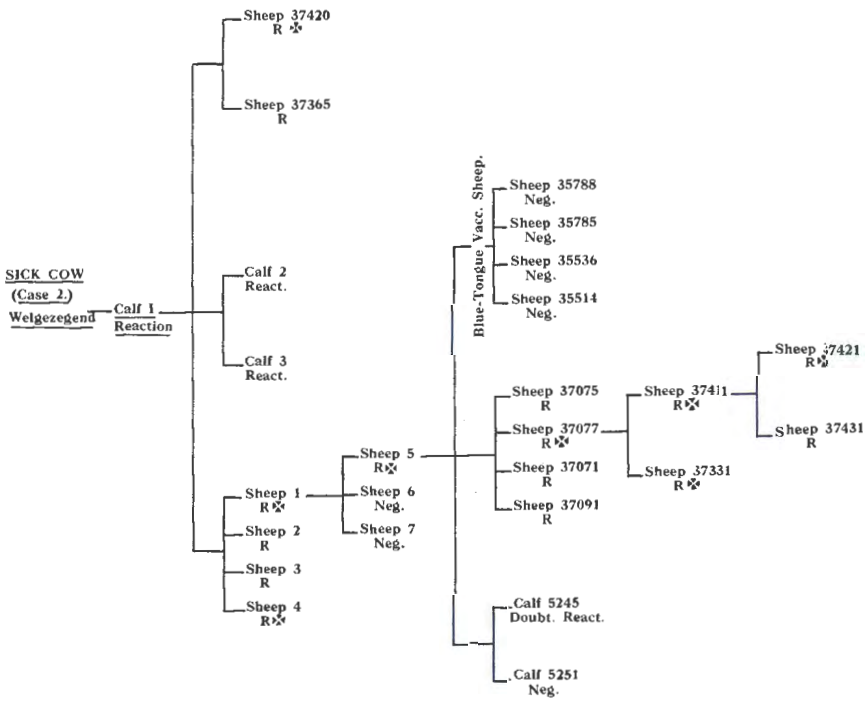
1 (*a*) with a strain recovered from a sick cow (case 2, above).

1 (*b*) with a strain recovered from a calf which was "infected" intranasally with material from the cows (cases 1, 2, 3).

1 (*c*) with a strain recovered from one of the affected oxen.

EXPERIMENTS 1 (*a*).

Table to indicate the transmissions undertaken with virus from affected cow (case 2).



Note: R=Blue Tongue Reaction.
R✠=Blue-Tongue Reaction terminating in Death.

Experiments with Welgezegend Virus recovered from sick cow (case 2).

Table 1 (a).

No. of Animal.	Date of Inoculation and Origin of Virus.	Result.
Calf No. 1....	*17.3.33,* 20 c.c. fresh blood ex cow case (ii), intravenously	The temperature commenced rising on the second day and reached 106° on the fourth day. After that it gradually fell and could be considered normal on the 12th day. On the third day small superficial ulcers (± ·5 cm. in diameter) were seen on the mucous membrane of upper and lower lips; these ulcers commenced healing on the 14th day and gradually disappeared. The animal was killed on the 27th day, and a fairly large ulcerative area was found on the lateral aspect of the fixed portion of the tongue.
Calf No. 2....	*22.3.33,* 25 c.c. fresh blood ex calf No. 1, intravenously *Note.*—Blood collected on 5th day	Slight rise in temperature after third day and reached 104·4° on 6th. Temperature normal on 8th day. On the 6th day superficial ulcers were noted on the upper and lower lips, similar in appearance to those seen in calf No. 1. After the 16th day these areas showed distinct signs of healing and were completely healed on the 21st day, when the animal was destroyed. No unusual changes were present at post-mortem examination.
Calf No. 3....	,, ,,	Distinct temperature reaction beginning on 4th day. Acme (106°) on 6th day. On this day the animal appeared ill, it refused its milk and was lying down. The animal commenced feeding on the 11th day. A marked reddening of the mucous membrane of the mouth was noted on the 9th day. Ulceration of the gums especially along the incisors was subsequently observed. The gingivitis persisted to the 15th day, on this day a muco-purulent discharge developed from the eyes and nose and a slight excoriation of the interdigital spaces was observed. Destroyed on the 21st day.
Sheep No. 1..	*23.3.33,* 5 c.c. fresh blood ex calf No. 1, subcutaneously	Fatal peracute reaction. I.P.*—3 days. Died on 9th day.
Sheep No. 2..	,, ,,	Acute reaction and recovered. I.P.—5 days.
Sheep No. 3..	,, ,,	Acute reaction and recovered. I.P.—3 days.
Sheep No. 4..	,, ,,	Fatal peracute reaction. I.P.—very short about 24 hours. Died on 7th day.
Sheep No. 37365	*26.4.33,* 5 c.c. blood ex calf No. 1, intravenously *Note.*—Blood collected on 6th day, preserved in O.G.C. and stored for 45 days at ord. toom temperat.	Subacute reaction, complicated with peritonitis (perforation of rectum). I.P.—6 days. Died on 14th day.
Sheep No. 37420	,, ,,	Fatal acute reaction. I.P.—6 days. *In extremis* on 13th day and destroyed.

* I.P.—Incubation period.

Table 1 (*a*)—(contd.).

No. of Animal.	Date of Inoculation and Origin of Virus.	Result.
Sheep No. 5..	*30.3.33*, 5 c.c. fresh blood ex Sheep No. 1 subcut. *Note.*—Blood collected on 7th day	Acute reaction. In the later stages marked oedema of the lungs developed (c.f. dunkop horsesickness). I.P.—6 days. Died on 12th day.
Sheep No. 6..	*30.3.33*, 5 c.c. fresh blood ex sheep No. 1, injected intranasally *Note.*—Blood collected on 7th day	No reaction. (This experiment was undertaken to determine whether sheep could be infected by an intranasal injection of virulent blood.)
Sheep No. 7..	,, ,,	No reaction.
Sheep No. 35788 (B.T.V. sheep)	*19.4.33*, 1 c.c. blood ex sheep No. 5 *Note.*—Blood collected on 9th day, preserved in O.G.C. and stored at ordinary room temp. for 41 days	,, ,,
Sheep No. 35785 (B.T. Vacc. sheep)	,, ,,	,, ,,
Sheep No. 35536 (B.T. Vacc. sheep)	,, ,,	,, ,,
Sheep No. 35514 (B.T.V. sheep)	,, ,,	,, ,,
Sheep No. 37075	*22.3.33*, 25 c.c. fresh blood ex calf No. 1, intravenously *Note.*—Blood collected on 5th day	Mild acute reaction and recovery. I.P.—7 days. *Immunity Test.*—22nd day, 1 c.c. blood ex natural bluetongue reaction in a sheep at Novo. No reaction developed. *Note.*—Refer to experiment 9 for the tests to ascertain the virulence of this virus.
Sheep No. 37071	,, ,,	Subacute reaction and recovery. I.P.—5 days. *Immunity Test.*—As with sheep No. 37073—no reaction developed.
Sheep No. 37091	,, ,,	Mild acute reaction. I.P.—6 days. *Immunity Test.*—As with sheep No. 37075. Definite positive reaction. The following symptoms noted:—I.P.—5 days, high temperature, muco-haemorrhagic discharge nostrils, hyperaemia and excoriations of mucous membrane, nose, bucal cavity, and later coronitis.
Sheep No. 37077	,, ,,	Fatal acute reaction. I.P.—2 days. Died on 12th day.

Table 1 (*a*)—(contd.).

No. of Animal.	Date of Inoculation and Origin of Virus.	Result.
Calf No. 5245	*19.4.33,* 5 c.c. of sample of blood used in sheep No. 35788, etc.	Slight rise of temperature reaching 103·6° on 6th day No other lesions. Very doubtful reaction. *Immunity Test.*—On 4.5.33, i.e. 16th day, 5 c.c. fresh blood ex sheep No. 37265 (*vide* expt. Ib.) intravenously. No reaction observed.
Calf No. 5251	,, ,,	No reaction. *Immunity Test.*—As with calf No. 5245. No reaction observed.
Sheep No. 37331	*26.4.33,* 5 c.c. fresh blood ex sheep No. 37077 intravenously *Note.*—Blood collected on 8th day	Fatal peracute reaction. I.P.—36 hours. Died on 6th day.
Sheep No. 37411	,, ,,	Fatal acute reaction. I.P.—4 days. Died on 14th day.
Sheep No. 37421	*1.5.33,* 5 c.c. fresh blood ex sheep No. 37331, intravenously *Note.*—Blood collected on 6th day	Fatal acute reaction. I.P.—3 days. Died on 15th day.
Sheep No. 37431	,, ,,	Subacute reaction and recovery. I.P.—3 days. *Immunity Test.*—1 c.c. virulent blood ex sheep Novo. No reaction.

Summary of Results.

(1) Sheep experiments:—

(*a*) Fifteen normal sheep were inoculated intravenously or subcutaneously with infective material from this source and all reacted. Eight, or more than 50 per cent., died. Deaths occurred from the 6th to 16th day after infection. The incubation period varied from as short as 24 hours to 6 days.

(*b*) Two sheep "infected" intranasally with 5 c.c. active blood did not react.

(*c*) *Immunity*:—

(i) The immunity of four sheep which had recovered from this strain of cattle virus was tested with a virulent strain of bluetongue virus recovered from a sheep. Three proved to be completely immune, whilst one again reacted.

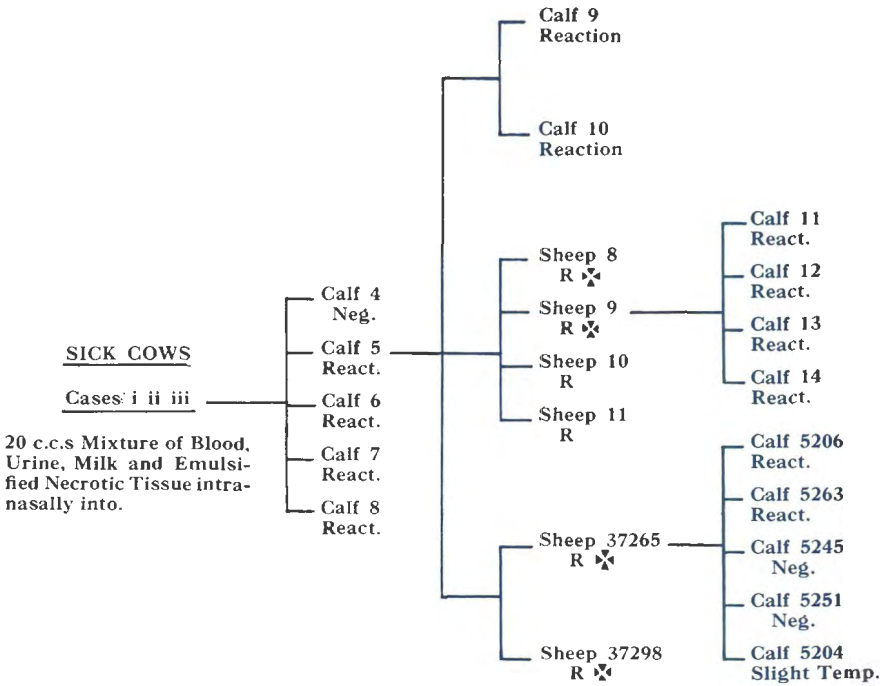
(ii) Four bluetongue vaccine sheep proved to be completely immune to virus originally recovered from the cow.

(2) Calf experiments:—

Five calves were inoculated with virus containing material and four developed definite reactions. The incubation periods and the temperature reactions resembled those of bluetongue in sheep, but the mouth lesions were not as characteristic. In most cases excoriations with subsequent slight ulceration appeared on the mucous membrane of the upper and lower lips.

EXPERIMENTS 1 (*b*).

Table to indicate the transmissions undertaken with virus recovered from affected cows (cases 1, 2, 3).



Note: R = Blue-Tongue Reaction.
R.✠ = Blue-Tongue Reaction terminating in death.

Table 1 (*b*).

Experiments with Welgezegend Virus.—(b) *From material of sick cows* (*cases I, II, III.*)

No. of Animal.	Date of Inoculation and Origin of Virus.	Result.
Calf No. 4..	*17.3.33,* 10 c.c. mixture of blood urine, milk, and emulsified necrotic tissues, collected at post-mortem of of cases I, II, and III, intranasally *	No reaction.
Calf No. 5....	*17.3.33,* infected as calf No. 5	Irregular temperature, which rose to 105° on 5th day. On the 3rd day small superficial ulcers appeared on the mucosa of the upper and lower lips. On the 4th day these ulcers were larger and the lips appeared slightly swollen. On the 10th animal appeared ill and mucosa of mouth reddened, the lesions still present on lips.
Calf No. 6....	,, ,,	No apparent rise in temperature. On the 3rd day superficial ulcers noted on the lower lip opposite lateral incisor teeth. On the 12th day marked dyspnoea noted. Animal destroyed on 13th day, and a fairly marked oedema of lungs found.
Calf No. 7....	*17.3.33,* 20 c.c. mixture of blood and urine collected from cases I, II, and III, intranasally	Steady rise in temperature from 5th day and 106·2° reach on 13th day. On the 8th day animal appeared to be ill and 12th day a muco-purulent discharge from the nose was observed. Superficial ulcers noted on the lips and later (20th day) a fairly extensive ulcer was noted on the dorsum of posterior part of tongue.
Calf No. 8....	*17.3.33,* infected as calf No. 6	No reaction.
Calf No. 9....	*22.3.33,* 25 c.c. fresh blood from calf No. 5, intravenously. (Blood taken on 6th day.)	Rise of temperature on 10th day, reaching 104·6° on 12th day. Temperature remained at this level until 18th day and then gradually fell. On the 5th day superficial ulcers appeared on upper lip and 8th day on lower lip. On 16th day slight excoriation was noticed in the interdigital spaces.
Calf No. 10...	*22.3.33,* inoculated as calf No. 9	On 5th temperature rose and reached 106° on 7th day. On the 3rd day small superficial ulcers noted on the mucosa of lower lip opposite lateral incisors. On the 10th day marked lachrymation noted and animal coughed frequently. On the 14th day muco-purulent discharge from nose. On 16th day discharge from eyes and nose marked. Lesions on lip still present and a fairly large necrotic ulcer on lateral aspect of tongue. 17th day animal ill lying down and marked dyspnoea present. On the 18th day animal destroyed and at post-mortem examination extensive and fairly deep-seated necrotic lesions found on lateral aspect of posterior portion of tongue and in the larynx.

* The injection of this material into the nasal cavities was primarily undertaken to exclude foot and mouth disease. During the outbreak of foot and mouth disease in Southern Rhodesia, Bevan found that the disease could be easily transmitted by injecting virus containing material into the nostrils of susceptible animals.

Table 1 (*b*)—(contd.).

No. of Animal.	Date of Inoculation and Origin of Virus.	Result.
Sheep No. 8..	*22.3.33*, 10 c.c. fresh blood ex calf No. 5, intravenously *Note.*—Blood collected on 6th day	Fatal acute reaction. I.P.—6 days. Died on 13th day.
Sheep No. 9..	,, ,,	Fatal peracute reaction. I.P.—4 days. Died on 7th day.
Sheep No. 10	,, ,,	Acute reaction and recovery. I.P.—5 days.
Sheep No. 11	,, ,,	Acute reaction and recovery. I.P.—3 days. In the later stages deep-seated necrotic ulcers on dorsal and lateral aspects of tongue.
Sheep No. 37298	*26.4.33*, 5 c.c. blood ex calf No. 5, intravenously *Note.*—Blood collected on 5th day, preserved in O.G.C. and stored at O.R.T. for 29 days	Fatal subacute reaction. I.P.—5 days. Moribund on 20th day and destroyed.
Sheep No. 37265	,, ,,	Peracute reaction. I.P.—5 days. Died on 9th day.
Calf No. 11...	*1.4.33*, 5 c.c. fresh blood ex sheep No. 9, intravenously *Note.*—Blood collected on 10th day	No definite rise in temperature. On the 6th day appeared ill and would not rise. On the 10th day excoriations noted on the inner surface of lips opposite lateral incisors.
Calf No. 12...	,, ,,	Irregular temperature. 104·3° F. on 3rd day and 105·3° on 9th day. On the 5th day muzzle appeared dry and a watery discharge from nose and eyes. Calf appeared ill and lay down frequently.
Calf No. 13...	*1.4.33*, inoculated as calf No. 11	Distinct rise in temperature which commenced on 3rd day. 104·6° on 9th day. On 6th day small superficial excoriations noted on the inner aspect of lower lips. These superficial ulcers increased in size. Animal destroyed on 13.4.33.
Calf No. 14...	*1.4.33*, inoculated as calf No. 11	After third day temperature rose steadily and reached 104·2° on 9th day. Except for slight watery discharge from eyes on 6th day no other lesions or symptoms developed.
Calf No. 5206	*4.5.33*, 10 c.c. fresh blood ex sheep No. 37265 intravenously (blood collected on 9th day)	Slight rise in temperature on the 10th. The mucosa of bucal cavity appeared reddened and small superficial ulcerative areas (± ·5 cm. in length) appeared on the mucosa of lower lip opposite the lateral incisors. The hyperaemia and lesions persisted for 4 days after which they disappeared. *Note.*—This animal was inoculated with 5 c.c. of blood on 19.3.33 from Onlangs, case I—the blood of this animal proved to be aviruleut [*vide* experiments 7 (*a*)].

Table 1 (*b*)—(contd.).

No. of Animal.	Date of Inoculation and Origin of Virus.	Result.
Calf No. 5263	*4.5.33*, inoculated as calf No. 5206	Slight rise in temperature on third day and remained more than 103° for 5 days. On the 6th day the mucosa of mouth appeared slightly red. On the next day the following changes were observed: the lower lip appeared slightly swollen and the skin red; the muzzle definitely red (white-faced animal); the apical portion of tongue reddened a few of the papillae dark red; the borders of the lip appeared reddened and some of the conical papillae (especially at the angle of the mouth) enlarged, their tips red and in a few the tips greyish-yellow; excoriations of the mucosa was noted on ventral aspect of apical portion of tongue and on the inner surface of the lower lip; in the vicinity of these excoriations numerous petechiae observed. Similar petechiae observed in the groove between the dental pad and upper lip. Lachrymation was observed from both eyes. After 5 days the lesions gradually disappeared. *Note.*—On 19.3.33 this animal was also inoculated with the avirulent blood from case I, at Onlangs.
Calf No. 5245	*4.5.33*, inoculated as calf No. 5206	No reaction. *Note.*—On 19.3.33 this animal inoculated with 5 c.c blood ex sheep No. 5 [*vide* experiment 1 (*a*)], and although no definite reaction was observed, it is more than likely that this animal was immunised as the blood was virulent.
Calf No. 5251	,, ,,	No reaction. *Note.*—This animal was inoculated on 19.3.33 as calf No. 5245.
Calf No. 5204	,, ,,	Temperature rose to 103·4° on third day and remained at this level for 6 days. No other lesions developed.

Summary of Results.

I. Calves.—Sixteen calves were used in this series of experiments, with the following results:—

(*a*) Four out of the five calves which had received an intranasal injection of mixture of blood, urine, emulsified necrotic tissue, and milk from the three sick cows reacted. The nature of the reactions were similar in each case and were like those noted in calves which reacted to a subcutaneous or intravenous inoculation of blood containing virus.

This method of infection was subsequently tested out in sheep, and it was possible to set up a reaction by an intranasal injection of virus containing material [*vide* experiment 10 (*c*)].

(*b*) Blood collected from one of the above calves (No. 5) proved to be virulent since reactions were provoked in sheep and calves.

(*c*) Calves 11, 12, 13, and 14 reacted to the virus after it had been passed through a sheep. The observations, however, were curtailed, as the experiments at Welgezegend had to be stopped.

(*d*) Calves 5206 and 5263 reacted after inoculation with blood from sheep 37265. The lesions observed in the buccal and nasal cavities of calf 5263 were like those seen in typical natural cattle cases, but of a comparatively mild character. Calf 5204 developed a slight temperature.

II. *Sheep.*—Six sheep were inoculated with this virus, and in all typical bluetongue reactions were observed. Four of these animals died.

III. *Immunity Tests.*—Calves 5245 and 5251, which were previously used in experiments 1 (*a*) did not react.

EXPERIMENTS 1 (*c*).

Table to indicate the transmission experiments undertaken with virus recovered from an affected ox.

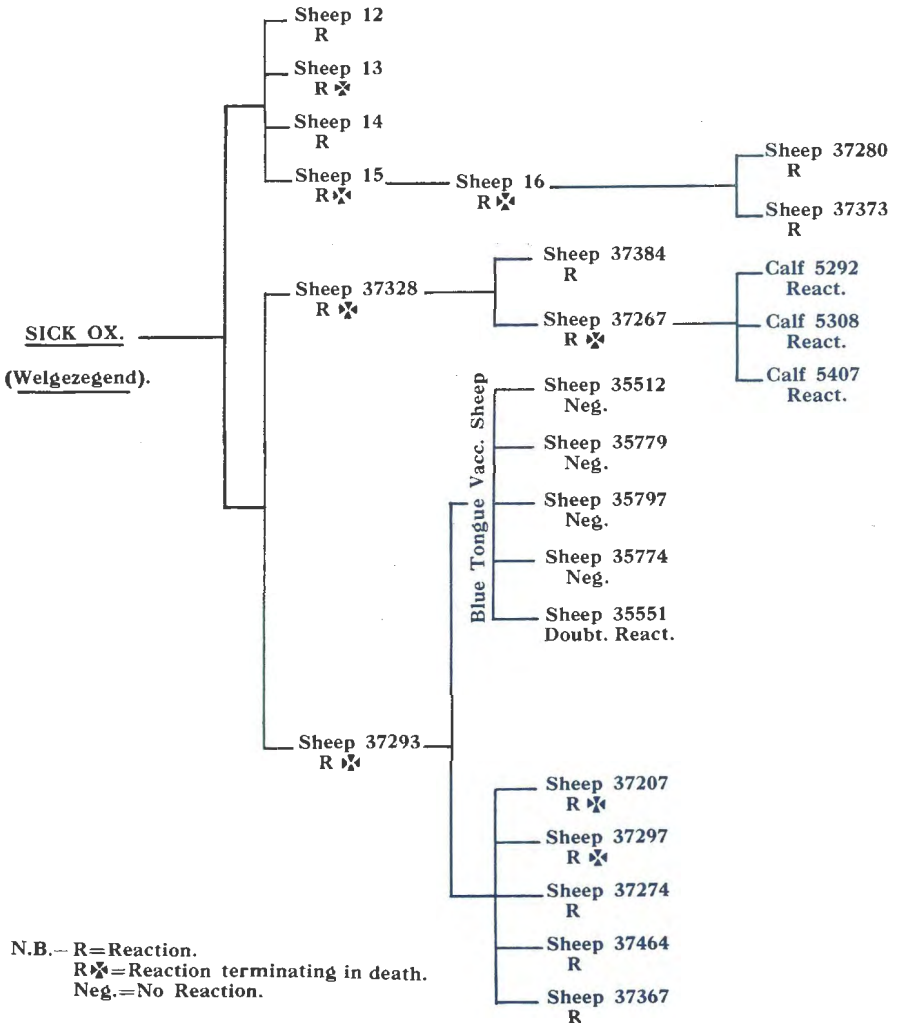


Table 1 (*c*).

Experiments with Welgezegend Virus.—From an affected ox.

No. of Animal.	Date of Inoculation and Origin of Virus.	Result.
Sheep No. 12	*22.3.33*, 2·5 c.c. fresh blood ex sick ox, subcutaneously	Fatal acute reaction. I.P.—3 days. Died on 13th day.
Sheep No. 13	,, ,,	Acute reaction and recovery. I.P.—3 days.
Sheep No. 14	,, ,,	,, ,, ,, ,,
Sheep No. 15	,, ,,	Fatal peracute reaction. I.P.—3 days. Died on 8th day.
Sheep No. 37328	*26.4.33*, 2·5 c.c. partially decomposed blood ex sick ox, intraven. *Note.*—Blood kept for 35 days at O.R.T. and no preservative added	Fatal subacute reaction. I.P.—3 days. Died on 16th day. In the last stages extensive subcutaneous oedema noted (c.f. dikkop horsesickness).
Sheep No. 37293	,, ,,	Fatal peracute reaction. I.P.—2 days. Died on 7th day.
Sheep No. 16	*30.3.33*, 5 c.c. fresh blood ex sheep No. 15, subcutaneously	Fatal acute reaction. I.P.—5 days. Died on 12th day. In the last stages marked discharge of serous material and froth through nostrils (c.f. dunkop horsesickness).
Sheep No. 37267	*10.5.33*, 1 c.c. blood ex sheep No. 37328, subcut. *Note.*—Blood collected on 9th day, preserved in O.G.C. and kept in cold storage	Fatal acute reaction. I.P.—5 days. Died on 12th day.
Sheep No. 37384	,, ,,	Fairly mild acute reaction and recovery. I.P.—7 days. *Immunity Test.*—27th day, 1 c.c. virulent blood ex sheep Novo.—No reaction.
Sheep No. 35512 (B. T.V. sheep)	*2.5.33*, 5 c.c. fresh defibrinated blood ex sheep No. 37293, subcut. *Note.*—Blood collected on 9th day	No reaction.
Sheep No. 35779 (B. T.V. sheep)	,, ,,	,, ,,
Sheep No. 35797 (B. T.V. sheep)	,, ,,	,, ,,
Sheep No. 35774 (B. T.V. sheep)	,, ,,	,, ,,
Sheep No. 35551 (B. T.V. sheep)	,, ,,	Mild acute reaction and recovery. I.P.—4 days. Slight swelling and injection of buccal mucosa only symptoms noted.

Table 1 (*c*)—(contd.).

No. of Animal.	Date of Inoculation and Origin of Virus.	Result.
Sheep No. 37207	*2.5.33*, 5 c.c. fresh defibrinated blood ex sheep No. 37293, subcut. *Note.*—Blood collected on 9th day	Fatal acute reaction. I.P.—6 days. Died on 12th day.
Sheep No. 37297	,, ,,	Fatal acute reaction. I.P.—6 days. Died on 14th day.
Sheep No. 37274	,, ,,	Subacute reaction and recovery. I.P.—3 days.
Sheep No. 37464	,, ,,	,, ,, ,, ,,
Sheep No. 37367	,, ,,	,, ,, ,, ,,
Sheep No. 37280	*26.4.33*, 5 c.c. blood ex sheep No. 16 *Note.*—Blood collected on 8th day, preserved in O.G.C. and kept at O.R. temperature for 18 days	Acute reaction. I.P.—7 days. After the 13th day temperature rose again and complication of broncho-pneumonia developed. Animal ultimately died from this. The broncho-pneumonia apparently a condition *per se*.
Sheep No. 37373	,, ,,	Subacute reaction and recovery. I.P.—6 days. *Immunity Test.*—On 27th day 1 c.c. virulent bluetongue blood ex sheep Novo—No reaction developed.
Calf No. 5292	*17.5.33*, 20 c.c. fresh blood ex sheep No. 37267, intravenously	On the 3rd day temperature rose to 105·2° C., and after that an irregular temperature was observed with increases to 104° C. On the 4th day excoriated areas were noticed on the mucosa of the upper and lower lips and localised hyperaemic areas noted on the rugae of the hard palate. On the 6th day lesions on lips showed definite signs of healing and were practically completely healed on the 12th day.
Calf No. 5308	,, ,,	Irregular temperature no definite elevation. On the 3rd day a slight amount of foam was noticed in the mouth, and on the left side of the lower lip a small area was noted, the mucous membrane of which appeared necrotic, this area was ·5 by ·3 cm. in size. Several hyperaemic areas were present on the rugae of the hard palate. Small excoriations were seen on the mucous membrance of the nostril close to the borders. On the 5th day several new superficial necrotic lesions were observed on the mucous membrane of the upper and lower lips and the hyperaemic areas on the hard palate appeared more extensive. By the 12th day the lesions appeared practically healed out.

Table 1 (*c*)—(contd.).

No. of Animal.	Date of Inoculation and Origin of Virus.	Result.
Calf No. 5407	*17.5.33*, 20 c.c. fresh blopd ex sheep No. 37267, intravenously	Rise of temperature on 3rd day and remained at 104° for 24 hours. On the 3rd day the lower lip appeared distinctly swollen and protruded slightly. The gums of the incisors appeared reddened and on the inside of the lower lip two fairly extensive areas (1·5 by 2 cm.) were present, the borders of these lesions had a distinct red zone (*vide* plate (xvii). Similar lesions appeared on other sites of the lower lip and also on the upper lip during the course of the next few days. Hyperaemic areas were also observed on the hard palate. On the 12th day the lesions were practically healed out.

Summary of Results.

1. *Sheep*:—

   (*a*) Fifteen sheep were inoculated with this strain, and all developed typical bluetongue reactions.

   (*b*) Seven died.

2. *Calves.*—Three calves reacted to the virus after it had been passed through two generations of sheep. The lesions were again very similar in all cases and like those noted in other experiments.

3. *Immunity*:—

   (*a*) Two sheep which recovered from this cattle virus were inoculated with virulent bleutongue virus recovered from a sheep and were found to be immune.

   (*b*) Five bluetongue vaccine sheep were inoculated and four proved to be completely immune, whilst one showed a slight reaction.

(2) Experiments with Kromdraai Virus.

Description of the Outbreak.

One animal became affected in this herd.

History.—The owner noticed a sudden reduction in the milk yield of the affected cow and at the same time observed a somewhat lame and stiff gait. On the next day marked salivation developed. Sores were discovered on the buccal mucosa. Foot and mouth disease was suspected and the case reported as such.

The Case.—A mature Friesland cow in poor condition.

The cow was first examined on 18th March, 1933. It was found standing with the back arched and head hanging down. It would not feed and rumination was in abeyance. There was fairly marked salivation and a profuse nasal discharge. This discharge was mucoid in nature. The muzzle was hot, dry, and very red. In places, especially towards the upper lip, the epidermis appeared necrosed. The temperature was elevated (104·5°, morning).

Fairly extensive superficial necrotic lesions were present on the dental pad, borders of the lips, and on the ventral aspect of the tongue. These areas were covered with a yellowish material.

The animal was distinctly lame, and the limbs in the region of the fetlocks swollen. The skin, particularly on the plantar aspect of the digit, was red and a small amount of partly dried exudative material on the surface. The teats were all very red, hot, painful, and covered with a thin tough scab.

This cow was kept under very close observation. About four days later the mouth lesions showed distinct signs of healing, but now an extensive dermatitis developed. A distinct reddening of the unpigmented portions was first seen, and a serous material appeared on the surface. At this stage the skin was distinctly sensitive to the sun, and the cow was usually found sheltering in the shade. Subsequently hard crusts and scabs formed on practically the entire skin. The animal was now in a pitiful condition and was frequently struck with blow flies, especially round the mouth and in the flanks.

Hard and thick scabs formed on the teats. The scabs on the teats, muzzle, and the skin subsequently peeled off.

The owner was greatly concerned with the condition of his beast and very carefully nursed it. There is no doubt that if it had not been for this care, the animal would have died. She ultimately made a complete recovery.

A sample of blood was collected on 20th March and the following experiments undertaken:—

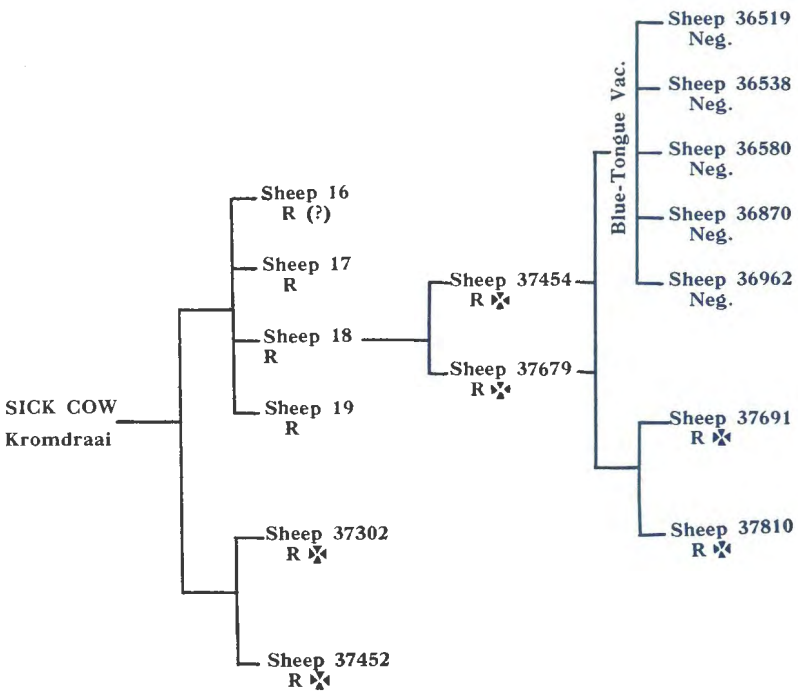


Table 2.

Experiments with Kromdraai Virus.

No. of Animal.	Date of Inoculation and Source of Virus.	Result.
Sheep No. 16	*22.3.33*, 5 c.c. blood ex cow at Kromdraai subcutaneously. *Note.* -About equal quantity of glycerine added as preservative	Fairly mild and somewhat delayed reaction. I.P.—9 days.
Sheep No. 17	,, ,,	Fairly mild acute reaction and recovery. I.P. -5 days.
Sheep No. 18	,, ,,	Fairly mild acute reaction and recovery. I.P. 6 days.
Sheep No. 19	,, ,,	Acute reaction and recovery. I.P.—5 days.
Sheep No. 37302	*6.5.33*, 2 c.c. blood ex cow Kromdraai, intravenously *Note.* –Equal quantity of glycerine added and stored at O.R. temperature for 47 days	Fatal subacute reaction. I.P.—9 days. Died on 22nd. *Note.* -In the later stages a marked discharge of ingesta through the nose (c.f. similar condition in horsesickness).
Sheep No. 37452	,, ,,	Fatal acute reaction. I.P.—9 days. Died on 14th day. *Note.*—A marked discharge of mucus through the nostrils in the later stages and a marked oedema of the glottis diagnosed at p.m. (*vide* appendix B).
Sheep No. 37454	*6.5.33*, 5 c.c. blood ex sheep No. 18 *Note.* - Blood collected on 6th day, preserved in O.G.C. and stored at O.R.T. for 39 days	Fatal peracute reaction. I.P. 4 days. Died on 9th day.
Sheep No. 37679	,, ,,	Subacute fatal bluetongue reaction. I.P. 7 days. Died on 17th day. *Note.*—On the 12th day a marked discharge of mucus from nostrils, subsequently complication of broncho-pneumonia developed, probably as a result of aspiration of food.
Sheep No. 37810	*16.5.33*, 1 c.c. fresh blood ex sheep No. 37454, subcutaneously *Note.*—Blood collected on 10th day	Fatal peracute reaction. I.P.—7 days. *In extremis* on 12th day and destroyed.
Sheep No. 37691	,, ,,	Fatal peracute reaction. I.P.- 6 days. Died on 10th day. *Note.*—Temperature never very high.
Sheep No. 36519 (B. T.V. sheep)	,, ,,	No reaction.

Table 2—(contd.).

No. of Animal.	Date of Inoculation and Source of Virus.	Result.
Sheep No. 36538 (B. T.V. sheep)	*16.5.33*, 1 c.c. fresh blood ex sheep No. 37454, subcutaneously. *Note*—Blood collected on 10th day	No reaction.
Sheep No. 36580 (B. T.V. sheep)	,, ,,	,, ,,
Sheep No. 36870 (B. T.V. sheep)	,, ,,	,, ,,
Sheep No. 36862 (B. T.V. sheep)	,, ,,	,, ,,

Summary of Results.

In Sheep:—

(*a*) Ten susceptible sheep were inoculated with this cattle virus and all reacted.

(*b*) In the first generation two out of six sheep inoculated died. In subsequent generations four sheep were inoculated and all died.

(*c*) Five bluetongue vaccinated sheep were inoculated with this strain and all were found to be completely immune.

(3) Experiments with Darling Cattle Virus.

Description of the Outbreak.

Only one animal, a black Friesland heifer, became affected in this outbreak. The heifer was first noticed to become lame; later salivation was observed. Sores were discovered in the mouth and the case reported as foot and mouth disease.

The Case.—The animal was examined on 12th April, 1933. Temperature: 106° (at 5 p.m.).

It was distinctly stiff and the lower portion of all four limbs somewhat swollen. A slight amount of salivation was observed. Superficial necrotic lesions were present on the dental pad, lips, and ventral surface of the tongue. The conical papillae were enlarged and their tips dirty grey in colour. Hyperaemia was masked by the natural pigmentation.

A sample of blood was collected and the following experiments undertaken:—

Table to indicate the transmission experiments with Darling cattle virus.

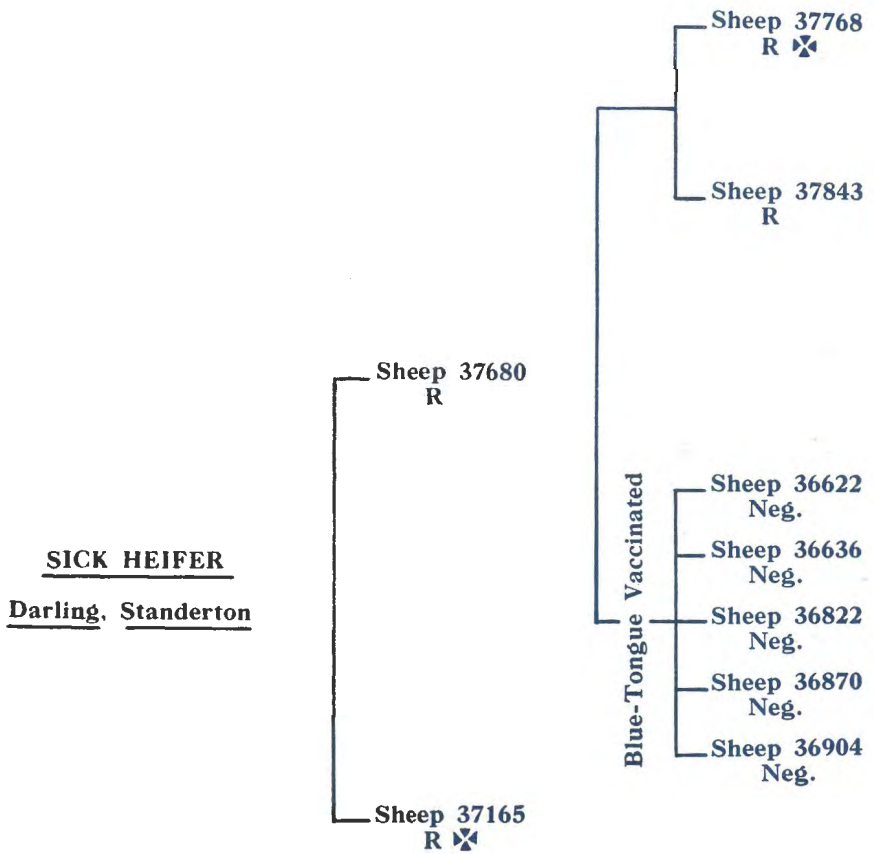


Table 3.

Experiments with Darling Virus.

No. of Animal.	Date of Inoculation and Source of Virus.	Result.
Sheep No. 37680	*6.5.33*, 5 c.c. blood ex cow Darling, intravenously *Note.*—Blood collected on 12.4.33, preserved in equal quantity of glycerine and stored at O.R. temperature	Subacute reaction and recovery. I.P.—4 days. *Immunity Test.*—On 30.5.33, i.e. 24th day, 1 c.c. virulent bluetongue blood ex sheet Novo—no reaction observed.
Sheep No. 37165	,, ,,	Fatal subacute reaction. I.P.—4 days. Died on 18th day.
Sheep No. 37768	*16.5.33*, 1 c.c. fresh blood ex sheep No. 37680, subcutaneously *Note.*—Blood collected on 10th day	Fatal acute reaction. I.P.—4 days. Died on 11th day. *Note.*—Extensive subcutaneous oedema and torticollis in later stages.
Sheep No. 37843	,, ,,	Acute reaction and recovery. I.P.—8 days. *Immunity Test.*—Tested as sheep No. 37680 and no reaction observed.
Sheep No. 36622 (B. T.V. sheep)	,, ,,	No reaction.
Sheep No. 36636 (B. T.V. sheep)	,, ,,	,, ,,
Sheep No. 36822 (B. T.V. sheep)	,, ,,	,, ,,
Sheep No. 36870 (B. T.V. sheep)	,, ,,	,, ,,
Sheep No. 36904 (B. T.V. sheep)	,, ,,	,, ,,

Summary of Results.

1. *In Sheep.*—Four normal sheep were inoculated with blood from this heifer and all developed typical bluetongue reactions. Two animals died.
2. *Immunity*:—
   (*a*) Two recovered sheep were immune to a virulent bluetongue virus recovered from a sheep.
   (*b*) Five bluetongue vaccine sheep which were inoculated with this cattle virus and were found to be completely resistant.

4. Experiments with Elandslaagte Cattle Virus.

Description of the Outbreak.

History.—Only one animal became affected in this herd. According to the owner, this heifer suddenly developed an illness on 23rd April. He observed a blood-stained mucous discharge from the nose. The lower portion of the head appeared swollen, and the hind limbs, from the hocks to the claws, were also swollen. On these parts superficial skin lesions were observed, from which a serous exudate escaped, and which later actually bled. The case was reported as an unknown disease, with strong suspicion of foot and mouth disease.

The Case.—The animal, an 18-months-old Friesland heifer, was examined on 25th April. It appeared slightly dull and did not feed. Rumination was in abeyance. The temperature was elevated (105·8°). Slight salivation was observed, and there was a marked nasal discharge. The discharge was slightly blood-stained and contained a few small pieces of coagulated blood.

Numerous dark red spots and areas (petechiae and ecchymosis) were seen on the injected mucosa of the nasal cavities, inner surfaces of the lips, cheeks, and tongue (particularly on the ventral surface of the apex). There was a slight watery discharge from both eyes, and numerous petechiae and ecchymoses were present in the mucosa.

The gum at the roots of the incisor teeth appeared excoriated and covered with dark grey coloured material. The underlying tissues bled easily. The hard palate appeared somewhat swollen, excoriations in the sulci, and the rugae markedly injected. The superficial necrotic process in the sulci was most extensive, and practically the entire palate was involved.

The vagina was markedly swollen and the mucosa reddened with numerous petechiae and ecchymoses. A fairly extensive, bleeding skin lesion was present on the side of the vagina. The hind limbs were swollen and a number of skin lesions similar to that near to the vagina were present.

Bloodsmears were examined, but no organisms were seen.

The heifer died that same night. Unfortunately, a post-mortem examination was impossible. A sample of blood was taken, and the following experiments undertaken:—

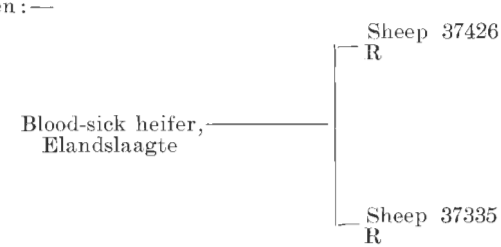


Table 4.

Experiments with Elandslaagte Virus.

No. of Animal.	Date of Inoculation and Source of Virus.	Result.
Sheep No. 37335	*26.4.33*, 5 c.c. defibrinated blood ex heifer, Elandslaagte *Note.*—Blood collected on 25.4.33	Subacute reaction and recovery. I.P.—4 days. *Immunity Test.*—On 22.5.33, i.e. 27th day, 1 c.c. virulent bluetongue blood ex sheep Novo, subsubcutaneously. No reaction.
Sheep No. 37426	„ „	Fatal subacute reaction. I.P.—7 days. *In extremis* on 18th day and destroyed. In the later stages extensive subcutaneous oedema and marked oedema of the tongue which protruded prominently. Also discharge ingesta through nostrils.

Summary of Results.

1. *In Sheep.*—Two sheep were inoculated with blood from this case, and both developed severe bluetongue reactions. The one animal was destroyed *in extremis*.

2. *Immunity.*—The sheep which recovered from the above reaction proved to be immune to Novo sheep strain of virulent bluetongue.

(5) Experiments with Novo Cattle Virus.

Description of the Outbreak.

History.—The disease made its appearance in a herd of Friesland milking cows on the above farm. In all five cases were observed. The owner suspected foot and mouth disease. The outbreak was first investigated by C. C. Wessels, Government Veterinary Officer. The usual description of the disease was given, viz., stiffness, followed by marked salivation, sores in the mouth, and later the teat and skin lesions.

Description of Cases.—The affected cows were again examined on 26.4.33, and most were now in a stage of recovery. The lesions noted in two of the cases deserve special mention. In one of these, the epidermis on a small unpigmented portion of the skin of the upper flank was peeling off (*vide* Fig. 12). The owner was very definite that this condition of the skin was associated with this stomatitic disease, evidence of which was still seen on the ventral surface of the tongue, where the mucosa along the frenum linguae was thickened and covered with a scab (*vide* Fig. 6). There appears to be little doubt that the dermatitis observed in this disease developed in this case, and the lesion was confined to a fairly small unpigmented portion of skin.

In the other case well-marked lesions were still present on the ventral surface of the tongue. The mucosa was thickened and covered with a fairly tough brown coloured deposit (*vide* Fig. 7). The epidermis of thinner portions of the skin, e.g. at the root of the tail, was peeling off (*vide* Fig. 8). Hard scabs were still adherent to the teats. A sample of blood was taken from this case, and the following transmission experiments were undertaken:—

Table to indicate the transmission experiments with Novo cattle virus.

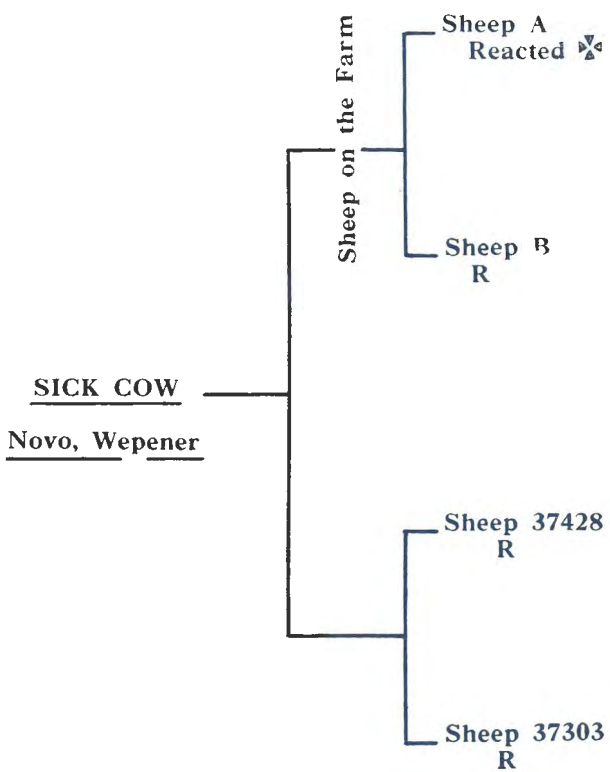


Table 5.

Experiments with Novo Cattle Virus.

No. of Animal.	Date of Inoculation and Source of Virus.	Result.
Sheep A.....	*26.4.33*, 5 c.c. fresh blood ex cow Novo	Fatal acute reaction. Died on 10th day. *Note.*—This animal was kindly provided by the owner and left on the farm. Mr. C. C. Wessels examined the animal after the onset of the reaction.
Sheep B.....	„ „	Acute reaction and recovery.
Sheep No. 37303	*27.4.33*, 10 c.c. defibrinated blood ex cow Novo, intravenously	Acute reaction and recovered. I.P.—10 days. *Note.*—Somewhat delayed reaction. *Immunity.*—On 22.5.33, i.e. 25th day, 1 c.c. virulent bluetongue blood ex sheep at Novo—no reaction observed.
Sheep No. 37428	„ „	Subacute reaction and recovered. I.P.—2 days. *Immunity.*—Tested as sheep No. 37303, and no reaction observed.

Summary of Results.

In Sheep.—Four sheep were inoculated with blood from one of the Novo cattle cases and all reacted. One died.

Immunity.—Two of the above sheep were inoculated with bluetongue virus recovered from a sheep on this farm and were found to be immune.

(6) Experiments with Montague Cattle Virus.

Description of the Outbreak.

Only one case was observed in this herd, and the owner suspected foot and mouth disease. The affected animal was a dry shorthorn cow. The typical stiffness was seen in the early stages, and subsequently mouth lesions and a swelling of the lower parts of the limbs were observed. The animal was examined on 26th of April, i.e. 12 days after the first symptoms had appeared. The mouth lesions were found to be practically healed, but evidence of the necrosis on the ventral surface of the tongue was still present. The mucosa along the frenum linguae appeared thickened, somewhat folded and covered with a brown coloured deposit. The epidermis of portions of the skin, e.g. at the root of the tail, was peeling off. No teat lesions were observed in this case. Blood was collected, and the following transmission experiments undertaken:—

The Transmission Experiments with Montague Cattle Virus.

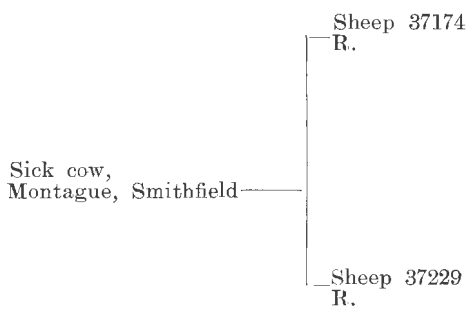


Table 6.

Experiments with Montague Virus.

No. of Animal.	Date of Inoculation and Source of Virus.	Result.
Sheep No. 37174	*28.4.33*, 10 c.c. blood ex cow, Montague *Note.*—Blood collected on 26.4.33 only defibrinated	Subacute reaction and recovery. I.P.—5 days. *Immunity Test.*—On 22.5.33, i.e. 25th day, 1 c.c. virulent bluetongue blood ex sheep Novo, subcutaneously. No reaction observed.
Sheep No. 37229	,, ,,	Subacute reaction and recovery. I.P.—5 days. *Immunity Test.*—Same as with sheep No. 37174. No reaction observed.

Summary of Results.

Two sheep were inoculated with this strain, and both reacted and subsequently proved to be immune to bluetongue virus recovered from a sheep.

(7) Experiments with Onlangs Cattle Virus.

History of the Outbreaks.

Three animals of a nondescript type were affected in this herd.

According to the owner the first case was observed on 4th of April. This animal suddenly became ill; she showed no inclination to feed and slight stiffness was observed. On the next day another case was discovered. By the 7th both animals salivated and sores were discovered in the mouths and teats. One of the affected cows died on the 8th. The occurrence of this unknown disease caused anxiety in the neighbourhood and a virulent form of foot and mouth disease was suspected.

The herd was inspected on 10th April, 1933, and the following cases were found:—

Case No. 1.—A red and white shorthorn cow in poor condition, about 8 years old, in milk. The cow was found lying down. When forced to rise it only stood for a few minutes. The feet were apparently very painful, and the animal could not support itself when one foot was raised for examination.

The temperature was only slightly elevated (103·8° at 4 p.m.). Foaming at the mouth was observed. The muzzle was very red and partly covered with a brown scab which was firmly adherent to the underlying tissues. Similar lesions were present at the opening of the nostrils, which were also encursted with partially dessicated mucus. The lips were swollen and along the borders covered with a yellowish deposit. The conical papillae, especially at the commissures of the mouth, appeared swollen and their tips were necrotic. Extensive necrotic lesions were present on the dental pad, in the groove between the upper lips and dental pad, and on the gums along the posterior aspect of the incissor teeth. The tongue was swollen and red, the mucosa of the ventral surface was excoriated. All the teats similarly excoriated and covered with a thin, tough scab. The lower part of all four feet from above the fetlock to the claws were swollen and the skin, especially on the plantar surface, red, hot, and painful.

Pathological-anatomical changes noted in this animal:—

(1) Necrosis of the epithelium of the muzzle, external nares, dental pad, upper and lower lips, gums, ventral aspect of the tongue.

(2) Diffuse superficial necrosis of the epidermis of teats.

(3) Acute dermatitis (stadium rubosa) of the skin of the digits.

Blood was taken from this animal, but as indicated on the following table the presence of bluetongue virus could not be established in the series of transmission experiments:—

Table to indicate transmission experiments undertaken with suspected virulent material, case 1, Onlangs.

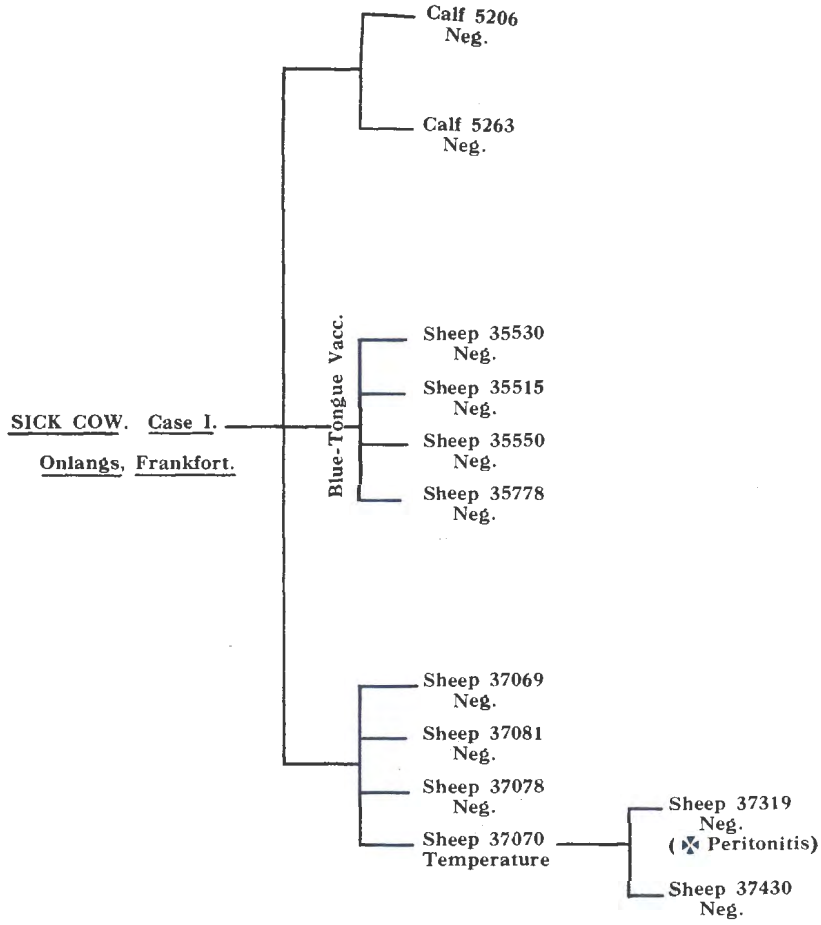


Table 7 (a).

Experiments with Onlangs Virus, case 1.

No. of Animal.	Reaction Tests.		Immunity Tests.	
	Date of Inoculation and Source of Virus.	Result.	Date of Test and Source of Virus.	Result.
Calf No. 5206	*19.4.33*, 5 c.c. blood ex case (i), Onlangs, subcut. *Note.*—blood in O.G.C. and stored for 14 days at O.R.T.	No reaction	*4.5.33*, 10 c.c. blood ex sheep No. 37265 subcut. (Welgezegend cattle virus)	Reaction. [Vide expt. 1 (*c*)].
Calf No. 5263	,,	,,	,,	,,
Sheep No. 35530 (B.T.V. sheep)	*19.4.33*, 1 c.c. blood of case (i), Onlangs, subcutaneously	,,	—	—
Sheep No. 35515 (B.T.V. sheep)	,,	,,	—	
Sheep No. 35550 (B.T.V. sheep)	,,	,,	—	—
Sheep No. 35778 (B.T.V. sheep)	,,	,,	—	—
Sheep No. 37069	,,	No reaction. (Vague temperature apparently of no significance)	*10.5.33*, 1 c.c. virulent B.T.V. blood ex sheep Novo	Subacute reaction. I.P.—4 days.
Sheep No. 37081	,,	No symptoms of bluetongue. (Rise in temperature and animal died on 4th day)	—	—
Sheep No. 37078	,,	No reaction. (Vague temperature, but no other symptoms)	*10.5.33*, as sheep No. 37069	Fatal acute reaction. I.P.—4 days. Died on 15th day.
Sheep No. 37070	,,	No reaction (?), slight rise in temperature on 6th and 7th days	,,	Acute reaction. I.P.—6 days.
Sheep No. 37319	*26.4.33*, 5 c.c. blood ex sheep No. 37070 subcut. *Note.*—blood collected on 7th day when a slight rise in temperature was noted	No symptoms of bluetongue. On 11th day rise in temperature and died same day. Cause of death perforation peritonitis (*vide* appendix C)	—	—
Sheep No. 37430	,,	No reaction	*22.5.33*, 1 c.c. virulent. B.T. blood ex sheep Novo	Subacute reaction. I.P.—6 days.

Summary of Results.

It was impossible to demonstrate the presence of virus in blood taken from this case. That the sheep were susceptible is proved by the reactions brought about by Novo sheep virus.

In several animals vague rises in temperature was recorded, but apparently this was of no significance, since blood taken from one such case was tested on sheep and found to be avirulent.

Case No. 2.—This was a more recent case and this heifer was first noticed to be ill on 9th April. The lesions were mild when compared to those seen in Case No. 1. The necrotic lesions were confined to a fairly small area of the dental pad, and only a few papillae showed pathological changes. The temperature was somewhat elevated (104·6°). A sample of blood was collected on the 10th and the following experiments undertaken:—

Table to indicate the transmission experiments with cattle virus recovered from case 2, Onlangs.

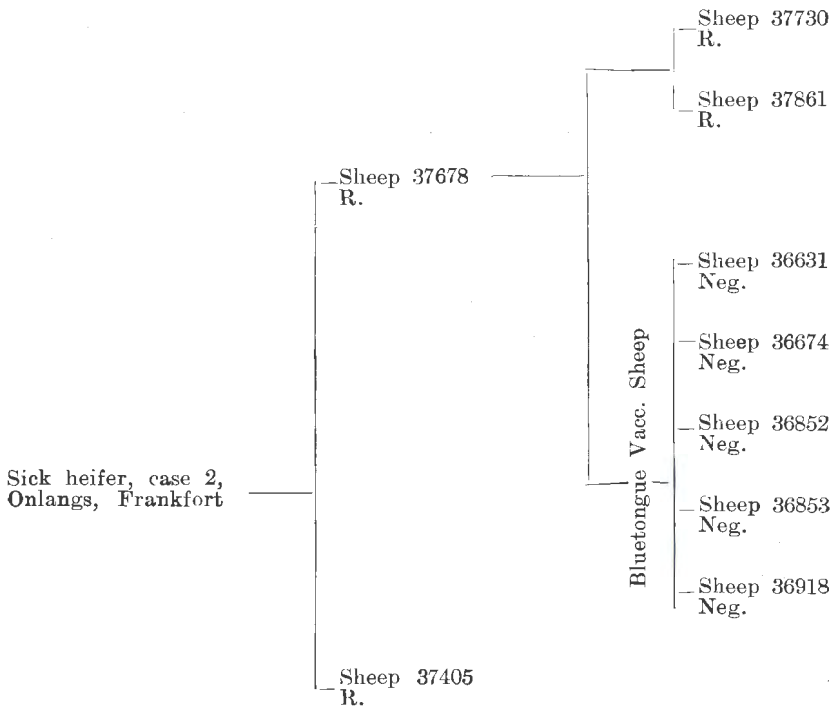


Table 7 (b).

No. of Animal.	Reaction Tests.		Immunity Tests.	
	Date of Inoculation and Source of Virus.	Result.	Date of Test and Source of Virus.	Result.
Sheep No. 37678	*6.5.33*, 5 c.c. blood ex cattle, case (ii), Onlaugs, intravenously *Note.*—Blood preserved in O.G.C. and stored for 27 days	Acute reaction. I. P.—3 days	*30.5.33*, 1 c.c. virulent bluetongue blood ex sheep Novo subcutaneously	Very doubtful reaction, i.e. slight rise in temperature and slight injection of buccal mucosa.
Sheep No. 37405	,,	Fairly mild acute reaction. I.P.—5 days	,,	No reaction.
Sheep No. 37730	*16.5.33*, 1 c.c. fresh blood ex sheep No. 37678 subcutaneously	Fairly mild acute reaction. I.P.—7 days	*9.6.33*, 1 c.c. virulent bluetongue blood ex sheep Novo, subcutaneously	,,
Sheep No. 37861	,,	Subacute reaction. I.P.—5 days	,,	,,
Sheep No. 36631 (B. T.V. sheep)	,,	No reaction	—	—
Sheep No. 36674 (B. T.V. sheep)	,,	,,	—	—
Sheep No. 36852 (B. T.V. sheep)	,,	,,	—	—
Sheep No. 36853 (B. T.V. sheep)	,,	,,	—	—
Sheep No. 36918 (B. T.V. sheep)	,,	,,	—	—

Summary of Results.

1. *In Sheep.*—Four susceptible sheep were inoculated with blood collected from this case (case 2) and all developed typical reactions.

2. *Immunity*:—

   (*a*) Five bluetongue vaccine sheep were immune to this cattle virus.

   (*b*) The four sheep which had recovered from the reactions produced by the cattle virus were tested with virulent bluetongue virus recovered from a sheep and three were immune. In one animal a very doubtful reaction resulted.

(8) Experiments with Swartland Virus.

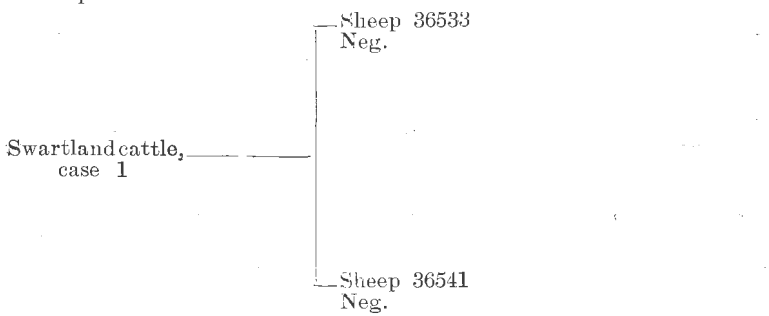
Description of Cases.

On the 11th May, 1933, the herd of 275 mixed cattle on this farm was examined and 25 animals were found affected with a disease of which the following is a description: "The animal stands dull and listless with the head hanging and the ears drooping. The feet are somewhat bunched together. There is marked lachrymation and profuse salivation, the saliva hanging in strings from the lips. There is a discharge of thick mucus from the nose.

The breath is extremely foetid. The borders of the lips are excoriated and covered with a diphtheritic deposit. The frenum linguae is ulcerated and covered with a diptheritic deposit. In most cases a similar lesion extends along the lateral portion of the fixed part of the tongue; the lesion is most extensive. In one case the whole dorsum of the tongue was necrotic and peeled off when handled. The palate in some cases also showed similar lesions, which, however, were less extensive.

The foot lesion was very similar in each case. It begins as an acute coronitis especially towards the anterior part of the cleft. It then extends around the coronet and through the interdigital space, and appears to be particularly acute on the bulbs of the heel. No very recent lesions were found in the various cases. The skin above the coronet was found to be in a state of dry necrosis. The necrotic skin was firmly adherent to the underlying tissues from which it was difficult to remove, leaving a bleeding surface."

Blood was collected from two of these cases, and the following transmission experiments undertaken:—



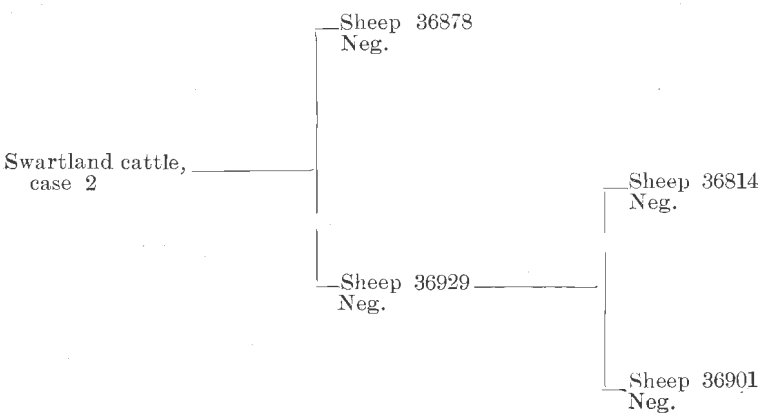


Table 8.

Experiments with Swartland Virus.

No. of Animal.	Date of Inoculation and Origin of Virus.	Result.	Immunity Test: Date and Origin of Virus.	Result.
Sheep No. 36533	*12.5.33*, 5 c.c. defibrinated blood ex case 1, Swartland	No reaction	*30.5.33*, 1 c.c. blood ex sheep No. 37331, i.e. Welgezegend cattle virus	Acute reaction and recovery. I.P.—6 days.
Sheep No. 36541	,,	,,	,,	,,
Sheep No. 36878	*27.5.33*, 5 c.c. defibrinated blood ex case 2, Swartland *Note.*—blood stored in ice chest for 15 days.	,,	*19.6.33*, 2 c.c. blood ex sheep No. 37328, i.e. Welgezegend cattle virus	Subacute reaction and recovery. I.P.—4 days.
Sheep No. 36929	,,	No reaction. (Slight rise in temp. on 12th day)	,,	Mild reaction. I.P.—4 days.
Sheep No. 36814	*9.6.33*, 2 c.c. blood ex sheep No. 36929	,,	*6.7.33*, 1 c.c. blood ex bluetongue sheep Novo	Subacute reaction and recovery. I.P.—6 days.
Sheep No. 36901	,,	,,	,,	Subacute reaction. I.P.—6 days.

Summary of Results.

It was impossible to demonstrate the presence of an infective agent in the blood of these cases. The avirulence of the blood can probably be attributed to the fact that both were old cases.

(9) Experiments with a Strain of Bluetongue Virus Recovered from a Sheep in a Field Outbreak on the Farm Novo, Wepener District.

History.—Sheep first noted ill on 24.4.33.

Description.—Examined on 26.4.33. A marked muco-haemorrhagic discharge from the nose was present and fairly extensive excoriations were noted on the nose, lips, tongue, cheeks, and vulva. The buccal mucosa was markedly injected.

A large sample of blood was taken from this animal and preserved in O.G.C. mixture. This sample proved to be virulent, as will be seen in the series of experiments given in Table 9. Virus contained in this sample was used for testing the immunity of sheep which had recovered from the reactions produced by cattle strains.

Note.—It will be noticed that a large number of sheep was inoculated with this virus; many of these sheep were used as contacts and controls of batches of sheep used in the experiments with the cattle strains. Some of these showed vague temperature reactions, and it became necessary to test their immunity.

Table to indicate the transmissions undertaken with bluetongue virus ex a natural case in a sheep at Novo.

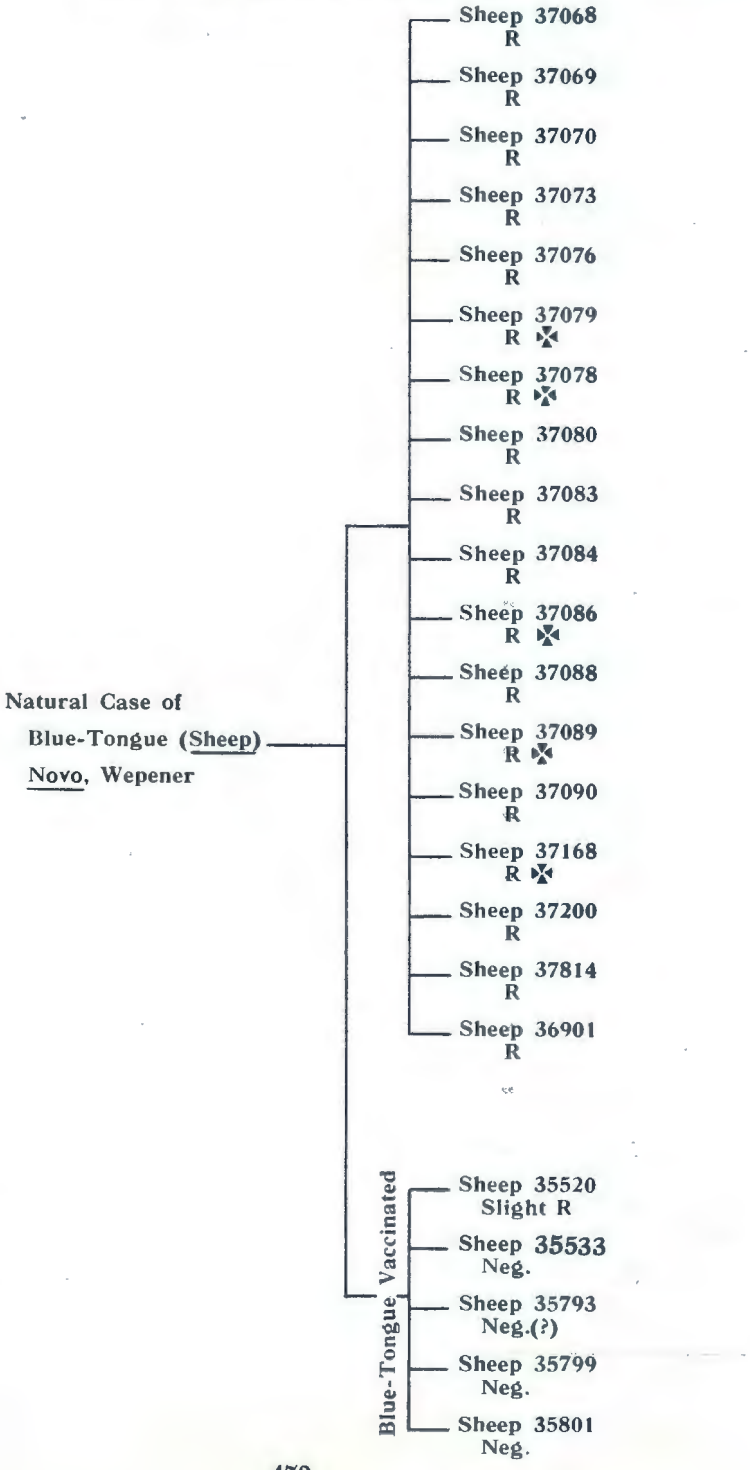


Table 9.

Experiments with Virulent Bluetongue Virus, ex Sheep, in a Field Outbreak at Novo, Wepener, O.F.S.

No. of Animal.	Date of Inoculation and Source of Virus.	Results.
Sheep No. 37168	*28.4.33*, 10 c.c. defibrinated blood ex sheep at Novo, intravenously *Note.*—Blood collected on 26.4.33	Fatal acute reaction. I.P.—3 days. Died on 11th day.
Sheep No. 37200	,, ,,	Subacute reaction and recovery. I.P.—6 days. *Immunity Test.*—On 25th day 1 c.c. fresh blood ex sheep No. 37328 (Welgezegend cattle virus). No reaction observed.
Sheep No. 37068	*10.5.33*, 1 c.c. blood ex sheep Novo, subcutaneously *Note.*—Blood collected on 26.4.33 and preserved in O.G.C. and stored in refrigerator	Subacute reaction and recovery. I.P.—4 days.
Sheep No. 37069	,, ,,	Subacute reaction and recovery. I.P.—2 days.
Sheep No. 37073	,, ,,	Mild peracute reaction and recovery. I.P.—4 days. *Note.*—Only temperature and injection of mucosa of buccal cavity.
Sheep No. 37070	,, ,,	Subacute reaction and recovery. I.P.—4 days.
Sheep No. 37076	,, ,,	Acute reaction and recovery. I.P.—5 days.
Sheep No. 37078	,, ,,	Acute reaction: Complication of peritonitis, the result of thermometer perforation of rectum. I.P.—5 days. Died on 12th day, result of peritonitis complication. *Note.*—Extensive oedema of subcutis noted on 8th day.
Sheep No. 37079	,, ,,	Fatal acute reaction. I.P.—5 days. Died on 14th day.
Sheep No. 37080	,, ,,	Acute reaction and recovery. I.P.—5 days.
Sheep No. 37083	,, ,,	Subacute reaction and recovery. I.P.—5 days.
Sheep No. 37084	,, ,,	,, ,, ,,
Sheep No. 37086	,, ,,	Peracute fatal reaction. I.P.—5 days. Died on 11th day.

Table 9—(contd.).

No. of Animals.	Date of Inoculation and Source of Virus.	Results.
Sheep No. 37088	*10.5.33*, 1 c.c. blood ex sheep Novo, subcutaneously *Note.*—Blood collected on 26.4.33 and preserved in O.G.C. and stored in refrigerator	Subacute reaction and recovery. I.P.—5 days.
Sheep No. 37089	,, ,,	Fatal acute reaction. I.P.—8 days. Died on 14th day.
Sheep No. 37090	,, ,,	Acute reaction and recovery. I.P.—7 days.
Sheep No. 35520 (B. T.V. sheep)	*22.5.33*, 1 c.c. blood ex sheep Novo	Mild acute reaction and recovery. I.P.—5 days Slight injection of mucus membrane of mouth noted on 7th day.
Sheep No. 35533 (B. T.V. sheep)	,, ,,	No Reaction.
Sheep No. 35801 (B. T.V. sheep)	,, ,,	Abortive reaction, i.e. only a rise in temperature. I.P.—5 days.
Sheep No. 35793 (B. T.V. sheep)	,, ,,	No reaction.
Sheep No. 35799 (B. T.V. sheep)	,, ,,	,, ,,
Sheep No. 36901	*6.6.33*, 1 c.c. blood ex sheep Novo	Subacute reaction and recovery. I.P.—6 days. *Immunity.*—(On 22.7.33 2 c.c. blood ex sheep No. 36812, i.e. Kromdraai cattle virus), subcutaneously and no reactions.
Sheep No. 36814	,, ,,	Subacute reaction. I.P.—6 days. *Immunity.*—Same as sheep No. 37901 and no reaction.

Summary of Results.

(1) *In Sheep.*—Eighteen normal sheep were inoculated with this strain of bluetongue virus recovered from a sheep. All reacted and three died. The reactions were typical and in all respects resembled those which resulted from the various cattle strains.

(2) *Immunity*:—

(*a*) Three of the sheep which recovered from the reactions produced by this sheep strain received cattle virus (Welgezegend and Kromdraai strains) and developed no reactions.

(*b*) Five bluetongue vaccine sheep were tested with this virus. Three proved to be completely immune. In one a very mild reaction developed, i.e. slight injection of buccal mucosa and a rise in temperature. In the remaining sheep only a rise in temperature was observed [abortive reaction(?)].

Miscellaneous Experiments.

Experiments 10.

(*a*) *The Presence of Bluetongue Virus in Foetal Material.*

Two ewes (Nos. 37691 and 37810) used in experiments 3 (Kromdraai cattle virus) were found to be pregnant at post-mortem examination. Material was collected aseptically from these foetuses and the following experiments undertaken:—

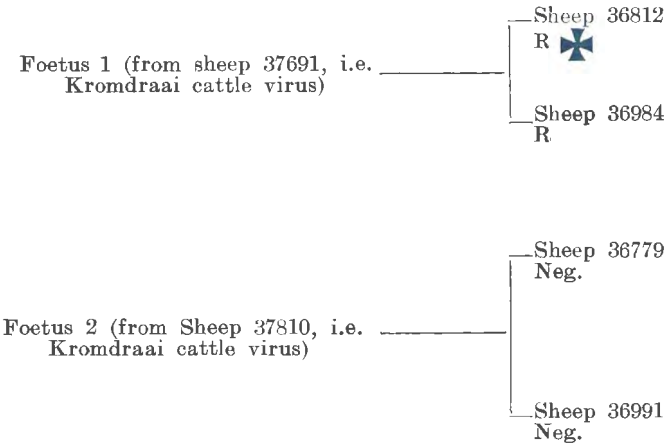


Table 10 (*a*).

To Indicate whether Foetal Material of Ewes Reacting to Bluetongue contain Virus.

No. of Animal.	Date of Inoculation and Source of Material.	Result.	Immunity Determination.	Result.
Sheep No. 36812	*27.5.33*, 1 c.c. fresh foetal blood ex sheep No. 37691, subcut.	Fatal acute reaction. Died on 13th day	—	—
Sheep No. 36984	*27.5.33*, 1 c.c. fresh foetal blood ex sheep No. 37691, subcut.	No reaction	*12.7.33*, 5 c.c. blood ex sheep No. 36812, subcut.	No reaction.
	17.6.33, 5 c.c. fresh foetal blood, same as used on 27.5.33, subcut. *Note.*—Blood stored in ice chest	Subacute reaction and recovery		
Sheep No. 36779	*27.5.33*, 5 c.c. saline emulsion of heart and spleen ex foetus sheep No. 37810, subcut.	No reaction	*6.7.33*, 5 c.c. blood ex sheep No. 36812 subcut.	Acute reaction. (Destroyed on 6th day for collection of path. material.
	17.6.33, 5 c.c. saline of liver of above foetus, subcut.	No reaction		

Table 10 (*a*)—contd.

No. of Animal.	Date of Inoculation and Source of Material.	Result.	Immunity Determination.	Result.
Sheep No. 36991	*27.5.33*, 5 c.c. saline emulsion of heart and spleen ex foetus sheep No. 37810, subcut.	No reaction.		
	17.6.33, 5 c.c. saline emulsion of liver of above foetus, subcut.	No reaction	*6.7.33*, 5 c.c. blood ex sheep No. 36812, subcut.	Acute reaction with recovery.

Summary of Results.

The blood of foetus 1 was active and contained virus. In this case 1 c.c. set up a reaction in one of two sheep. One animal did not react, but subsequently when 5 c.c. of the same foetal blood was inoculated a typical reaction followed. Later this sheep was found to be immune to the virus contained in the blood of the mother of the foetus. Foetus 2 was apparently sterile. The two sheep which were used for testing material from this foetus subsequently reacted to virus contained in the blood of one of the dams.

(*b*) *The duration of the Infection in the Blood of Sheep Recovering from a Bluetongue Reaction.*

Two sheep, Nos. 37464 and 37274, used in experiments 1 (*c*) were used for determining the above. Both of these animals developed typical bluetongue reactions. At 14-day intervals blood was collected from these animals and inoculated into normal sheep. The following is a summary of the results:—

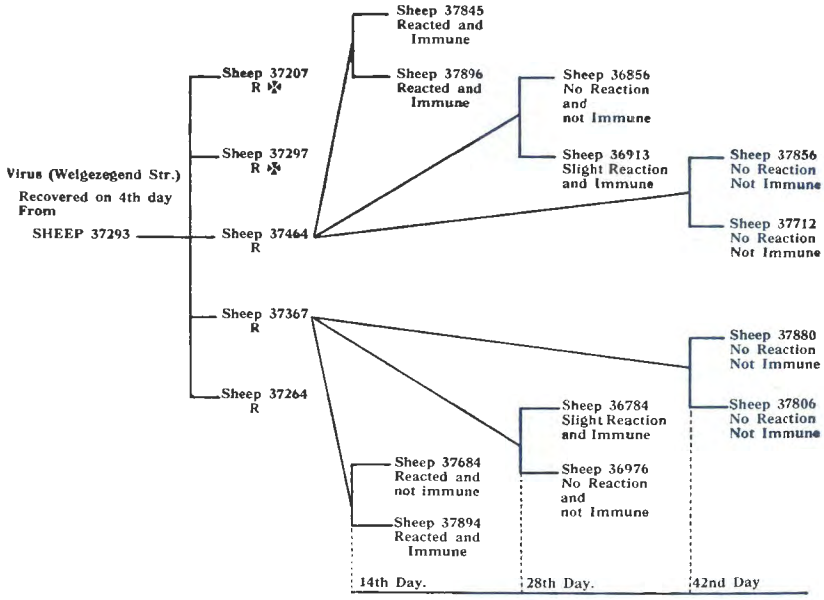


Table 10 (b).

To Determine the Duration of Infection in the Blood of Sheep Recovering from a Bluetongue Reaction.

No. of Animal.	Date of Inoculation and Source of Virus.	Result.	Date of Immunity Test and Source of Virus.	Result.
Sheep No. 37845	*16.5.33*, 5 c.c. blood ex sheep No. 37464 (14 days after infection)	Mild acute reaction and recovery	*9.6.33*, 1 c.c. Novo strain of B.T. virus ex sheep	No reaction.
Sheep No. 37896	,,	,,	,,	,,
Sheep No. 37684	*16.5.33*, 5 c.c. fresh blood ex sheep No. 37367 (14 days after infection)	Subacute reaction and recovery	,,	Mild acute reaction (i.e. rise in temperature and hyperaemia mucosa of buccal cavity.
Sheep No. 37894	,,	,,	,,	No reaction.
Sheep No. 36856	*30.5.33*, 5 c.c. fresh blood ex sheep No. 37464 (28 days after infection)	No reaction	*19.6.33*, 2 c.c. blood ex sheep No. 37464 *Note.*—Blood collected on 7th day	Acute reaction and recovery.
Sheep No. 36913	,,	Somewhat delayed mild acute reaction	,,	No reaction.
Sheep No. 36784	*30.5.33*, 5 c.c. fresh blood ex sheep No. 37367 (28 days after infection	Mild acute reaction	*19.6.33*, 2 c.c. blood ex sheep No. 37367 *Note.*—Blood collected 7th day after infection	,,
Sheep No. 36976	,,	No reaction	,,	Fatal acute reaction. Killed *in extremis* on 15th day.
Sheep No. 37856	*13.6.33*, 5 c.c. blood ex sheep No. 37464 (42 days after infection)	,,	*28.6.33*, 10 c.c. Seitz filtrate = 2 c.c. whole blood ex sheep No. 36812. *Note.*— Kromdraai cattle strain.	No definite clinical reaction. Animal died on 9.7.32 and bluetongue was not diagnosed at p.m.
Sheep No. 37712	,,	,,	*28.6.33*, 2 c.c. blood ex sheep No. 36812	Slight acute reaction. *Note.*—afebrile but definite hyperaemia and excoriations.
—	—	—	*18.7.33*, 5 c.c. blood ex sheep No. 36812	No reaction.

Table 10 (*b*)—(contd.).

No. of Animal.	Date of Inoculation and Source of Virus.	Result.	Date of Immunity Test and Source of Virus.	Result.
Sheep No. 37880	*13.6.33*, 5 c.c. blood ex sheep No. 37367	No reaction	*28.6.33*, 2 c.c. blood ex sheep No. 36812	Mild acute reaction.
			18.7.33, 5 c.c. blood ex sheep No. 36812	No reaction.
Sheep No. 37806	*13.6.33*, 5 c.c. blood ex sheep No. 37367.	No reaction.	*28.6.33*, 10 c.c. Seitz filtrate: 2 c.c. blood ex sheep No. 36812	No reaction.
			18.7.33, 5 c.c. whole blood ex sheep No. 36812	Fatal acute reaction. Killed *in extremis* on 12th day.

Summary of Results.

It will be noticed that—

(1) the virus recovered on the fourth day after infection from sheep 37293 (Experiment 1) set up severe reactions in five sheep, and two died;

(2) the blood of two of the recovered animals was still infective and active on the fourteenth day after infection. In each case reactions resulted in two sheep. Three of these animals were immune to the strain of Novo sheep virus, but apparently the immunity in one (sheep 37684) was weak, since this animal developed a mild reaction to this sheep strain of bluetongue virus;

(3) on the twenty-eighth day the blood from the same two animals in the same amounts was apparently less active since one of two inoculated sheep developed only slight reactions. These two animals proved to be immune to virus contained in a sample of blood taken on the seventh day from the original donors. The two non-reactors developed severe reactions to this sample of virus, and one died;

(4) Blood collected on the forty-second day failed to set up perceptible reactions. These sheep were subsequently used for testing the activity of Seitz filtered blood. No definite reactions were observed in sheep 37856 and 37806, i.e. those which received filtered material. Sheep 37856, however, died, but the cause of death was obscure. Sheep 37806 was again tested with the same sample of whole blood, and a fatal acute reaction followed. Sheep 37712 and 37880, where the immunity was in the first instance tested with unfiltered blood from the same source, developed mild reactions, and subsequently were immune to a larger dose of the same sample of virus material.

The above results indicate that—

(*a*) the blood of two of the sheep which were recovering from reactions produced by the Welgezegend cattle strain of virus was still slightly infective 28 days after the date of infection, but was definitely inactive in subcutaneous doses of 5 c.c. on the forty-second day;

(*b*) as far as the pathogenicity is concerned, the virus present in the blood of these recovering animals became progressively less active.

(*c*) *Experimental Infection of Animals by means of Intranasal Iniection with Virus-containing Material.*

When experiments were commenced at Welgezegend, five calves were injected intranasally with material consisting of a mixture of blood, urine, milk and emulsified necrotic tissue from three affected cows. This experiment was undertaken with the express purpose of excluding foot and mouth disease. Four out of these five calves developed definite reactions. The infectivity with bluetongue virus in the blood of one of these calves was established in the subsequent experiments [*vide* Experiments 1 (*b*)].

In Experiment 1 (*a*) an attempt was made to confirm this method of intranasal infection in sheep. Two animals were accordingly injected intranasally with 5 c.c. blood from a reacting sheep. No reactions, however, became perceptible. This experiment was repeated at Onderstepoort, with the following results:—

Table 10 (*c*).

To Determine whether it is possible to Infect Sheep with an Intranasal Injection of Virus-containing Material.

No. of Animal.	Date of Infection and Nature of Infective Material.	Result.	Date of Immunity Test and Source of Material.	Result.
Sheep No. 37801	*7.7.33*, intranasal injection of a mixture 25 c.c. blood, bile and emulsified necrotic buccal mucosal scrapings ex sheep No. 33614, i.e. Kromdraai virus	Peracute fatal reaction. I.P.—3 days. Died on 10th day	—	—
Sheep No. 37879	,,	No reaction	*18.7.33*, 2 c.c. saline emulsion of spleen pulp ex sheep No. 37801	Acute reaction.
Sheep No. 37762	*7.7.33*, intranasal injection of 20 c.c. blood ex sheep No. 33614	,,	,,	Fatal peracute reaction. I.P.—2 days. Died on 8th day.
Sheep No. 37760	,,	,,	,,	Fatal acute reaction. I.P.—4 days. In moribund condition on 11th day and destroyed.

Summary of Results.

One sheep (No. 37801) became infected and reacted after an intranasal injection of virus-containing material.

(*d*) *Intramucosal Inoculation of Virus-containing Material.*

The pathological-anatomical changes seen in bluetongue clearly indicates an epitheliotropic nature of the virus. Distinct changes (*vide* pathology) become manifest in the mucous membranes.

It was considered not unlikely that reactions on the buccal mucosa would be provoked at the site of inoculation of virus-containing material. The following experiments were therefore arranged:—

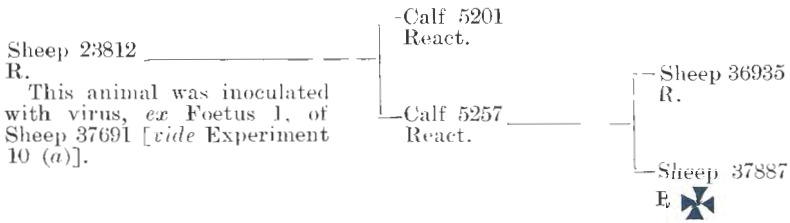


Table 10 (*d*).

To Determine the Result of an Intramucosal Inoculation of Virus Material.

No. of Animal.	Date, Method of inoculation, and Source of Material.	Result.
Calf No. 5201	*8.6.33,* Kromdraai cattle virus ex sheep No. 36812 as follows: (1) Left side of tongue: 0·5 c.c. buccal epithelium emulsion in saline, intramucosally; (2) Right side of tongue: 0·5 c.c. blood	Distinct rise of temperature after an incubation period of 3 days (*vide* Chart X). On the second day slight injection of the mucosa at the sites of inoculation was noticeable, but no lesions developed. On the 15th day small necrotic lesions were seen on the dental pad and inner surface of lower lip.
Calf No. 5257	,, ,,	Distinct rise in temperature on 4th day (*vide* Fig. XI). On the second day after inoculation slight reddening at the sites of inoculations on the tongue. Excoriations appeared on the mucosa of the upper and lower lips and at the angles of the mouth. These lesions appeared on the 6th day and persisted for 12 days. In the later stages they became somewhat ulcerative.
Sheep No. 36935	*13.6.33,* 5 c.c. blood ex calf No. 5257, subcutaneously	Subacute reaction and recovery. *Immunity Test.*—On 6.7.33 1 c.c. blood ex blue-tongue sheep Novo. Only a slight rise in temperature on 7th day was observed and this was apparently of no significance.
Sheep No. 37887	,, ,,	Fatal peracute reaction. Died on 7th day.

Summary of Results.

Contrary to expectations, no distinct local lesions developed at the site of inoculation on the tongues of the calves. However, general reactions followed, and this was similar as observed in calves in other experiments, where virus-containing material was injected intravenously, subcutaneously or intranasally.

The blood of one of the calves (5257) was infective as is illustrated by the reactions which developed in the sheep.

APPENDIX B.

Under this will be included all data of post-mortems and subsequent microscopical examinations of the various tissues collected. In each case reference will be made to the experimental number, about which full particulars will be obtained in Appendix A, the number of the sheep, date of death, number of days after injection of infected material which elapsed before death occurred, the etiological diagnosis with the significance of most important changes, followed by a summary of macroscopical and microscopical findings.

The post-mortems under review will be considered under two headings: (1) natural cattle cases, (2) experimental sheep cases.

1. *Natural Cattle Cases.*

These mainly refer to three Friesland bovines concerned in the outbreak at Welgezegend; these were destroyed for post-mortem examination.

(*a*) Black and white cow, condition rather poor, staring coat, killed for post-mortem.

Slight general anaemia and cachexia; swelling of the tongue fairly extensive, causing partial protrusion from the mouth; on dorso-lateral aspect of the tongue there is localised necrosis about 1½ c.m. in diameter and about ½ c.m. in depth, surrounded by a reddish zone; on the upper lip there are two superficial ulcers on the mucous membrane. The other organs showed no specific changes.

(*b*) Black and white cow, condition poor, coat staring, killed *in extremis*.

General anaemia and cachexia; fairly extensive deep-seated foetid partly gangrenous necrosis of the tongue, involving practically the whole of the left dorso-lateral aspect of the middle third—it is about 3 c.m. in depth in places, extending well into the muscular substance of the tongue; superficial ulcers on the mucous membranes of the lips and the dental pads; the superficial layers of the skin in the interdigital space show a shreaded appearance due to partial desquamation, leaving a reddish moist surface after removal; multiple circumscribed necrotic nodules in the lungs, varying in size from ½-1 c.m., with no evidence of encapsulation; localised sero-fibrinous pleuritis; linear fairly deep-seated ulcers on the pylorus, about 3 c.m. × ¼ c.m. × ¼ c.m., edges clean and sharply defined with a dark, reddish base and periphery; hyperaemia and a slight superficial dermatitis of the skin of the teats extending on to the udder.

Microscopical Examination (Specimen No. 13637).

Tongue.—In places some of the epithelial cells show "ballooning" and a loose infiltration with neutrophiles in others. The localised necrosis involves the whole of the epithelial layers, which has become disorganised and in many respects lost. The whole has become infiltrated with neutrophiles, which show necrobiosis. The cells underlying the necrotic material still show evidence of extensive cellular infiltration extending into the musculature of the tongue. The process is of the nature of an acute localised necrotic stomatitis characterised by the absence of any extensive proliferation of connective tissue.

Lip.—Similar lesions of necrosis and ulceration with infiltration of the deeper layers of the mucous membrane.

Pyloris.—Ditto.

Lung.—Shows multiple, fairly extensive localised necrotic areas without encapsulation at the periphery of these lesions, numerous bacteria in the form of filaments can be identified forming an extensive network, probably *B. necrophorus*.

(*c*) Black and white Fries cow, recovering from pseudo foot and mouth disease, killed for post-mortem.

Slight general anaemia and cachexia, superficial necrosis of the dental pad, several ulcers with hyperaemia of the periphery of the pylorus of the stomach, ulceration of the dorsum of the middle third of the tongue about 1 c.m. in diameter in the process of healing, characterised by sharply defined edges as if a circumscribed portion of the mucous membrane had been scooped out. No further pathological changes of a specific character was seen in this case.

2. *Experimental Sheep Cases.*

No. of Expt.	No. of Sheep.	Death.		No. of Days of Reaction.	Specimen No.	Etiology.	Macroscopical.	Microscopical.
		Date.	No. of Days after Injection.					
1 (*a*)	37420	9.5.33	13	8	—	Killed *in extremis*, bluetongue (characterised by necrotic lesions in mucous membranes in stage of healing)	Excoriations nostrils; superficial ulcers, lower lip; coronitis; haemorrhagic cystitis; sub-endocardial haemorrhages; healed-out ulcer tip of tongue; hyperaemia oesophageal groove and petechiae along fold; oesophagostomum nodules, oedema peri-tracheal tissues and inter-mandibular space	No material.
1 (*a*)	37365	9.5.33	14	7	—	Bluetongue (characterised by multiple haemorrhages)	Slight oedema lungs; aspiration of food; acute fibrinous peritonitis sequel perforation of rectum; slight tumor splenis; hyperaemia abomasum and intestine; hydro-thorax; sub-pleural ecchymoses; acute coronitis; perforation rectum	,,
1 (*a*)	37077	1.5.33	12	10	13785	Bluetongue (characterised by multiple necrotic areas and hyperaemia of mucous membranes)	Small necrotic areas lips; localised hyperaemia lips; hyperaemia of papilae anterior portion tongue; hyperaemia pharynx and larynx, tumor splenis; acute haemorrhagic gastro-enteritis	,,
1 (*a*)	37411	9.5.33	12	10	13810	Killed *in extremis*, bluetongue (characterised by haemorrhages and necrosis in stage of healing)	Oedema peri-tracheal tissues and intermandibular space; sub-epicardial haemorrhages; tumor splenis; sub-mucous haemorrhages tongue; coronitis; excoriations skin; hyperaemia oesophageal grooves; petechiae small intestine and abomasum	,,
1 (*a*)	37331	1.5.33	6	4	—	Bluetongue (characterised by necrosis in m.m. of mouth and nose, haemorrhages heart, and oedema lungs)	Petechiae epicardium and endocardium; hyperaemia and oedema lungs; petechiae and ecchymosesm ucosa of upper and lower lips, and upper and lower gums and tongue; acute catarrhal enteritis	,,

2. *Experimental Sheep Cases*—(contd.).

No. of Expt.	No. of Sheep.	Death.		No. of Days of Reaction.	Specimen No.	Etiology.	Macroscopical.	Microscopical.
		Date.	No. of Days after Injection.					
1 (*a*)	37421	12.5.33	15	12	—	Bluetongue (characterised by necrosis in mouth and nose, haemorrhages heart, and oedema lungs)	Post-mortem changes fairly advanced; necrosis external nares; cyanosis mucosa mouth and skin; necrosis ventral aspect of tongue and along borders of tip; subendocardial, epicardial, and myocardial extravasations; ecchymoses mucosa conjunctiva; fairly marked oedema lungs; localised necrosis of hard palate; petechiae and ecchymoses mucosa bladder	No material.
1 (*b*)	37265	4.5.33	9	4	13795	Bluetongue (characterised by by multiple petechiae mucous membranes and oedema subcutis)	Swelling and cyanosis at margins of lips, tongue and around hoofs; petechiae and hyperaemia small intestine and abomasum; hyperaemia large intestine; petechiae mucosa bladder; ecchymoses and extravasations epicardium; few ecchymoses both endocardia; slight hydropericardium; extensive oedema subcutis of intermandibular space and ventral aspect cervical region; haemorrhages in mycocardium; fairly well marked hyperaemia liver, kidneys; slight hyperaemia and oedema lungs	*Lip* (skin): In places slight "ballooning" of epithelial cells; in the other places lesion more advanced, i.e. infiltration with neutrophiles, necrobiosis, and ulceration with infiltration of neutrophiles into the corium in places haemorrhages alone appears, also seen in the hair papilla around the root. *Lip* (papillae of mucous membrane): Haemorrhages in the corium and here and there deeper layers of the stratified epithelium show irregular vacuolation; at the apex some of the papillae show space filled with a granular or stringy material; badly stained with eosin. *Myocardium*: Well marked haemorrhages in epicardium and in the substance of the myocardium. *Lung*: Subpleural and interstitial haemorrhages, and oedema and hyperaemia. No specific changes in liver, kidneys, and spleen.
1 (*b*)	37298	15.4.33	20	15	—	Killed *in extremis*, bluetongue (characterised by oedema of subcutis)	Slight general anaemia; oedema subcutis of intermandibular space, cervical region, and surrounding tissue of trachea; degeneration of liver and kidneys; ascites, few parasitic nodules	No material.

1 (*c*)	37328	11.5.33	16	13	13861	Bluetongue and sequelae of verminosis (characterised by necrotic lesions in mouth and coronitis)	General anaemia; localised necrosis skin (pressure of mosquito cage); localised hyperaemia gums and external nares; hyperaemia of coronets; marked haemonchosis; numerous parasitic nodules in intestines; impaction forestomachs; constipation; slight tumor splenis	No specific changes in spleen, liver, and myocardium.
1 (*c*)	37293	2.5.33	7	5	13790	Killed *in extremis*, bluetongue (characterised by haemorrhages and hyperaemia in mucous membranes)	Cyanosis lips and tongue; multiple petechiae and ecchymoses epicard, endocard, lips, tongue, small intestine and trachea; slight extravasations serosa of rumen; hyperaemia kidneys; slight hyperaemia myocardium; slight diffuse hyperaemia nasal mucosa; marked swelling lips and tongue; very slight oedema lungs	*Tongue:* Hyperaemia and haemorrhages in corium extending into the deeper layers; a number of the papillae of corium infiltrated with neutrophiles; epithelial layers in places show "ballooning"; some of the epithelial layers show slight changes in the staining intensity, infiltration with neutrophiles and loss of the superficial epithelial cells in places. *Lips:* Few haemorrhages into the papilae with slight infiltration with neutrophiles. *Myocardium:* Small irregular haemorrhages. No specific changes in lymph glands, spleen, brain, thyroid, and kidneys.
1 (*c*)	37267	22.5.33	12	7	13905	Bluetongue (characterised by oedema and necrosis buccal cavity)	Slight hyperaemia coronets; extensive oedema subcutis; ascites; oedema tongue; degeneration liver; degeneration kidneys; localised necrotic areas lateral, ventral, and dorsal aspects of tongue (not extensive); oedema lungs; degeneration myocardium	*Liver:* Few haemorrhages in places associated with infiltration with neutrophiles and in places with necrobiosis; also slight hyperaemia. No specific changes in *myocardium* and *kidneys.*
1 (*c*)	37207	9.5.33	12	6	13809	Bluetongue (characterised by cyanosis and early stages necrosis lips and tongue)	Swelling, cyanosis and early necrotic foci tongue, lips, soft palate; wellmarked hyperaemia and oedema lungs; hyperaemia nasal mucosa; localised hyperaemia rumen, recticulum and omasum; multiple ulcers pyloris; few ecchymoses small intestine; hyperaemia large intestine; numerous parasitic nodules in intestines; hyperaemia larynx and trachea; haemorrhages myocardium	*Lips:* Around root of hairs haemorrhagic zone. *Lip* (i) *Skin:* "ballooning" of epithelial cells in stratum spinosum with extensive infiltration of neutrophiles; earlier lesions not seen; later lesions show extensive infiltration of corium with blood and desquamation of necrotic parts, involving almost complete loss of the epithelial layers. (ii) *Mucous Membrane:* haemorrhages in the corium without and with neutrophilic infiltrations, extending into the epithelial layers. No specific changes in kidneys, myocardium and lungs.

2. *Experimental Sheep Cases*—(contd.).

No. of Expt.	No. of Sheep.	Death.		No. of Days of Reaction.	Specimen No.	Etiology.	Macroscopical.	Microscopical.
		Date.	No. of Days after Injection.					
1 (*c*)	37297	11.5.33	14	8	13860	Bluetongue (characterised by hydropericard, marked hyperaemia and oedema lungs, extravasations epicard and endocard)	Hydropericard; marked hyperaemia and oedema lungs; extravasations epicard and endocard; general cyanosis; venous hyperaemia liver, kidneys and spleen; hyperaemia upper extremities hoofs; hyperaemia margin lower lip; slight acute catarrhal enteritis; hyperaemia pharyngeal and parapharyngeal lymph glands and papillae rumen; localised slight hyperaemia pyloris	In sections from myocardium and tongue no specific changes except hyperaemia and haemorrhages.
1 (*c*)	37280	23.5.33	27	20	—	Pneumonia.....	Advanced post-mortem changes; marked extravasations conjunctiva (right eye); oedema of lungs; acute bronchopneumonia; localised fibrinous pleuritis	No material.
2	37452	10.5.33	14	11	—	Bluetongue (oedema of the glottis) (characterised by extensive transudation into connective tissues)	General anaemia and emaciation; slight post-mortem changes; oedema of subcutis of cervical region; healing out ulcers inside of cheek; severe oedema of glottis; multiple haemorrhages on pharyngeal muscles; hyperaemia and oedema lungs (marked); hydrothorax; few *Haemonchus contortus* and *Oesophagostomum columbianum*, *Cysticercus tenuicollis* in abdominal and pelvic cavity; slight hydropericardium; *Oestrus ovis* larvae	,,
2	37302	27.5.33	22	13	13928	Bluetongue (characterised by hydropericard, oedema and atelectasis lungs)	Well-marked hydropericard, haemorrhages myocard; well-marked oedema and slight hyperaemia lungs; atelectasis both lungs resulting from bronchitis; hyperaemia and degeneration liver; hyperaemia kidneys; slight hyperaemia spleen and intestines	*Lung:* Oedema and hyperaemia. *Myocardium:* Slight hyperaemia and haemorrhages endocardium.

2. *Experimental Sheep Cases*—(contd.).

No. of Expt.	No. of Sheep.	Death.		No. of Days of Reaction.	Specimen No.	Etiology.	Macroscopical.	Microscopical.
		Date.	No. of Days after Injection.					
1 (*c*)	37297	11.5.33	14	8	13860	Bluetongue (characterised by hydropericard, marked hyperaemia and oedema lungs, extravasations epicard and endocard)	Hydropericard; marked hyperaemia and oedema lungs; extravasations epicard and endocard; general cyanosis; venous hyperaemia liver, kidneys and spleen; hyperaemia upper extremities hoofs; hyperaemia margin lower lip; slight acute catarrhal enteritis; hyperaemia pharyngeal and parapharyngeal lymph glands and papillae rumen; localised slight hyperaemia pyloris	In sections from myocardium and tongue no specific changes except hyperaemia and haemorrhages.
1 (*c*)	37280	23.5.33	27	20	—	Pneumonia.....	Advanced post-mortem changes; marked extravasations conjunctiva (right eye); oedema of lungs; acute bronchopneumonia; localised fibrinous pleuritis	No material.
2	37452	10.5.33	14	11	—	Bluetongue (oedema of the glottis) (characterised by extensive transudation into connective tissues)	General anaemia and emaciation; slight post-mortem changes; oedema of subcutis of cervical region; healing out ulcers inside of cheek; severe oedema of glottis; multiple haemorrhages on pharyngeal muscles; hyperaemia and oedema lungs (marked); hydrothorax; few *Haemonchus contortus* and *Oesophagostomum columbianum*, *Cysticercus tenuicollis* in abdominal and pelvic cavity; slight hydropericardium; *Oestrus ovis* larvae	,,
2	37302	27.5.33	22	13	13928	Bluetongue (characterised by hydropericard, oedema and atelectasis lungs)	Well-marked hydropericard, haemorrhages myocard; well-marked oedema and slight hyperaemia lungs; atelectasis both lungs resulting from bronchitis; hyperaemia and degeneration liver; hyperaemia kidneys; slight hyperaemia spleen and intestines	*Lung:* Oedema and hyperaemia. *Myocardium:* Slight hyperaemia and haemorrhages endocardium.

2	37454	15.5.33	9	5	13872	Bluetongue (characterised by oedema lungs, necrosis tongue and haemorrhages mouth, heart, etc.)	Hyperaemia coronets; slight ecchymoses skin (under tail); hyperaemia and necrosis lips; subepicard, endocard, and myocardial petechiae and ecchymoses; very marked oedema lungs; necrosis angle of mouth; localised necrosis hard palate; necrosis ventral and lateral aspect of tongue; hyperaemia pharynx and larynx; hyperaemia and necrosis rumen and oesophageal groove; haemorrhagic gastritis and enteritis	*Lip* (i) *Skin:* Haemorrhages in the form of a zone around the root of the hair in its follicle; here and there necrosis of epithilium and infiltration of the epithelial layers with neutrophiles, much less changes in the corium; irregular loss of some of these infiltrated areas, involving the greater part of the epithelial layers; the different stages are not well defined; at margin of skin and mucous membrane this loss involves a fairly large area with haemorrhage and slight infiltration of the underlying tissues; rest of the mucous membrane of the lip shows no changes. *Oesophagus:* Haemorrhages into the corium of a few papillae. *Tongue:* Fairly extensive ulceration of mucous membrane; the base of the ulcer being formed by irregular remains of epithelial cells in the stage of necrobiosis, with haemorrhage and infiltration of the underlying corium, but the latter is slight in comparison with the infiltration in the epithelial layers; the process is primarily associated with disturbances in the epithelial layers and of an acute nature without evidence of proliferation of connective tissue. In another section of the tongue there is "ballooning" of a few cells in the stratum granulosum, the cells being swollen, but spherical and their cytoplasm appears homogeneous glassy-looking and of a light brick red colour with eosin; the nuclei appear "ghost-like." *Myocardium:* Shows extensive haemorrhages.
2	37679	24.5.33	17	10	—	Broncho-pneumonia; sequel to aspiration of ingesta during bluetongue reaction	Post-mortem changes; general cyanosis; degenerative changes liver; acute catarrhal broncho-pneumonia; fibrinous pleuritis; degenerative changes kidney; slight chronic catarrhal cholecystitis; slight nodular oesophagostomiasis; dilatation heart; tumor splenis; hyperaemia lymph glands respiratory tract	No material.

2. *Experimental Sheep Cases*—(contd.).

No. of Expt.	No. of Sheep.	Death.		No. of Days of Reaction.	Specimen No.	Etiology.	Macroscopical.	Microscopical.
		Date.	No. of Days after Injection.					
2	37691	26.5.33	12	2	13922	Killed *in extremis*, bluetongue (characterised by necrotic lesions and haemorrhages)	Ulceration of lips and buccal mucosa; haemorrhages lateral border tongue; oedema lips, intermandibular spaces, subcutis neck, larynx and pharynx; ecchymoses small intestines; ulceration pyloris; subepicardial and endocardial haemorrhages; hyperaemia lungs; parasitic nodules intestines; degeneration liver and kidneys	*Lips:* Here and there haemorrhages into the corium of the papillae. *Small Intestines:* haemorrhages here and there between the glands extending into the connective tissue. *Myocardium:* Extensive multiple haemorrhages, with well-defined patches of fatty changes. *Lungs:* Multiple haemorrhages. *Liver:* No specific changes.
2	37810	26.5.33	10	4	13921	Bluetongue (characterised by multiple haemorrhages and oedema of the subcutis)	Very slight post-mortem changes; slight general anaemia; oedema subcutis of intermandibular space and peri-tracheal tissues; multiple haemorrhages buccal nasal mucosa; hyperaemia rumen, recticulum and omasum, small intestines, kidneys, liver, and lung; atelectasis lung; haemonchosis; degenerated parasitic nodule liver; caseous nodule lung; extravasations epicard, and right endocardium and to a lesser extent in left endocardium; cestodes, oesophagastomiasis and *Oestrus ovis* larvae	*Lung:* Hyperaemia and small abscess surrounded by granulation tissue. *Tongue:* Haemorrhages in corium of papillae, and in one place localised infiltration of neutrophiles in the stratified epithelium. *Myocardium:* Few haemorrhages in epicardium. *Lung:* Hyperaemia and oedema. *Liver:* haemotoma (probably traumatic). No specific changes in *kidneys*.
3	37165	22.5.33	13	9	—	Bluetongue, (characteristic lesions in mouth disappeared but changes in coronets still present)	Slight haemonchosis; parasitic nodules in intestines; oedema ventral aspect neck; hyperaemia coronets	No material.
3	37768	27.5.33	11	7	13927	Killed *in extremis*, bluetongue (characterised by well-marked oedema of lungs and subcutis and haemorrhages myocard)	Well-marked oedema lungs and slight hyperaemia; fairly extensive oedema of subcutis of intermandibular space, lower cervical region, surrounding tissue of trachea and pharynx; petechiae epicard; few ecchymoses endocardium and myocardium; hyperaemia and degeneration liver; hyperhaemia kidneys; slight tumor splenis; slight hyperaemia oesophageal groove; ulceration pyloris; slight acute haemorrhagic enteritis; oedema and haemorrhages lips and tongue.	*Lips:* Haemorrhages into corium mainly of the papillae; in one place the stratified epithelium infiltrated with neutrophiles which extends on to the corium. *Heart:* Haemorrhages epicardium extending into the myocardium. No specific lesions in *liver, kidneys, lungs, spleen, adrenals, brain.*

9	37168	8.5.33	11	8	—	Bluetongue (characterised by oedema)	Oedema subcutis head; oedema lungs; marked oedema tongue, glottis and peritracheal tissues; petechiae abomasum and small intestines; subepicardial petechiae; slight tumor splenis	No material.
9	37089	24.5.33	—	—	—	Bluetongue (characterised by necrosis and extravasations epicard, endocard, bladder, and intestines)	Superficial necrosis external nares, mouth, and inside cheeks; marked petechiae and ecchymoses endocard; hydropericard; localised superficial necrosis ventral aspect tongue; acute haemorrhagic enteritis; petechiae mucosa bladder and urethra	,,
9	37079	25.5.33	14	8	—	Bluetongue (characterised by slight necrosis tongue, oedema lungs, glottis, etc.)	Post-mortem changes fairly advanced; marked hydropericardium; hyperaemia and necrosis tip of tongue; oedema glottis and slight oedema intermandibular space; marked oedemia lungs; subendocard and epicard haemorrhages; acute haemorrhagic gastro-enteritis; localised hyperaemia urethra; ecchymoses urinary bladder; hyperaemia coronets	,,
9	37086	22.5.33	11	6	—	Bluetongue (characterised by extensive necrotic changes mouth and slight oedema lungs)	Post-mortem changes advanced; excoriations external nares; hyperaemia mandibular lymphatic gland, necrosis buccal mucosa, especially inside lower lips and tongue; localised urethritis; hyperaemia small intestine; haemonchosis; slight oedema lungs; hydropericardium; cyanosis skin	*Parapharyngeal lymph glands:* Revealed no specific changes.
9	37078	23.5.33	12	7	—	Bluetongue (characterised by oedema, necrosis external nares and angle of mouth and extensive oedema) *Note.*—complicated with peritonitis as result of rectal perforation.	Marked oedema subcutis along ventral aspect neck intermandibular space, head, supra-obited fassae, ears and upper portions of fore limbs; acute purulent peritonitis with ascetis; marked hydrothorax; fairly marked hydropericardium; few endocardial petechiae; necrosis external nares, medial septum of nose and angles of mouth; haemonchosis; fistula rectum (perforation by thermometer)	*Lungs:* Slight hyperaemia. *Myocardium:* Slight hyperaemia and in places fatty changes.

2. *Experimental Sheep Cases*—(contd.).

No. of Expt.	No. of Sheep.	Death.		No. of Days of Reaction.	Specimen No.	Etiology.	Macroscopical.	Microscopical.
		Date.	No. of Days after Injection.					
10 (*a*)	36812	8.6.33	13	6	13961	Killed *in extremis*, bluetongue (characterised by necrotic changes tongue, oedema lungs, etc.)	General oedema; ulcerative glossitis; severe pulmonary oedema; extravasations left endocardium and pulmonary artery; hyperaemia forestomachs and small intestine	*Pulmonary artery:* haemorrhages into media-adventia. *Tongue:* Classical case in which all the lesions occurred in various stages:— 1*st stage:* Hyaline droplet-like formation in swollen epithelial cells in the stratified epithelialium near the basal membrane, some of the epithelial cells show ballooning, but their contour is not lost. 2*nd stage:* the vacuolated spaces in the stratified epithelium infiltrated with neutrophiles, not many neutrophiles in these spaces. 3*rd stage:* Necrobiosis of the epithelial cells and neutrophilic infiltration into the stratified epithelium. The corium bordering on this shows haemorrhages and extensive infiltrations with neutrophiles. 4*th stage:* Partial desquamation of the necrotic areas with the whole contour of the mucous membrane disorganised as a result of necrotic material and infiltrated cells.
10 (*a*)	36779	12.7.33	6	4	14065	Killed in early stages of bluetongue for collection of material (characterised by multiple haemorrhages of mucous membrane of tongue and extensive oedema of subcutis)	Well-marked oedema in intermandibular space, extending on to the masseters and ears; multiple haemorrhages of mucous membranes of lips, tongue epicardium, right endocardium, larynx, subcutis, skin, omasum and abomasum; slight degenerative changes kidney and liver; haemorrhage pulmonary artery above the semilunar valves	*Tongue:* Extensive circumscribed haemorrhages into epithelial layers extending from basal membrane to the flattened superficial layers, with atrophy of adjoining epithelial cells; the underlying corium shows practically no changes. *Pulmonary artery:* extensive haemorrhage into the media and adventitia. *Epicardium (at the apex):* Fairly extensive haemorrhage extending into the myocardium. *Spleen, liver, and kidneys:* No specific lesions. *Vulva:* Fairly Extensive ulceration of the mucous membrane, the base of the ulcer being formed by the corium which is very extensively infiltrated with neutrophiles, these extend into the depth of the corium to a considerable extent, the cells involved show necrobiosis in places.
10 (*b*)	37806	—	12	8	14104	Bluetongue (characterised by subcutis oedema and localised necrotic lesions in various organs in process of healing out)	Fairly marked oedema of subcutis, peritracheal periosophageal connective tissues, oedema of the lungs, hyperaemia of corium of hoofs, subepicardial and subendocardial haemorrhages, erosions and swelling tongue and lips, hyperaemia and superficial erosions mucous membrane of rumen, reticulum and omasum; excoriations skin and vagina	

10 (*b*)	36976	4.7.33	15	10	14051	Killed *in extremis*, bluetongue (characterised by marked prostration)	Emaciation, discharge of ingesta through the nose; subadocardial haemorrhages and haemorrhages under capsule of the spleen	No material.
10 (*c*)	37801	17.7.33	10	7	14078	Bluetongue (characterised by multiple haemorrhages)	Petechiae and ecchymoses mucous membranes tongue, cheeks and lips; subpicardial and endocardial haemorrhages; slight oedema of the lungs; swelling and petechiae of vulva; petechiae mucosa of reticulum and oesophageal groove; acute haemorrhagic enteritis with numerous small petechia mucous membrane intestines; petechia bladder and skin in vicinity of mammae and joints; oedema of subcutis of ventral aspect cervical region	*Tongue:* Here and there haemorrhages into the corium of the papillae *Myocardium:* Multiple haemorrhages not frequent and not extensive, in places associated with infiltration with neutrophiles. All other organs examined show no specific changes.
10 (*c*)	37760	29.7.33	11	7	14105	Killed *in extremis*, bluetongue (characterised by extensive oedema of subcutis and petechiae and ecchymoses in various organs)	Extensive oedema subcutis, peritracheal and perioesophageal connective tissues; oedema of lungs and tongue; subepicardial and endocardial haemorrhages; exceptions vagina and nostrils; localised hyperaemia rumen, reticulum and omasum, petechiae abomasum and small intestines	*Rumen:* Musculature shows multiple haemorrhages. Other organs show no specific changes.
10 (*c*)	37762	25.7.33	8	6	14096	Bluetongue (characterised by oedematous and petechiae)	Oedema of the subcutis, subepicardial and subendocardial haemorrhages; slight oedema of the lungs, oedema of peritracheal, tissues, larynx and tongue; petechiae ventral aspect of tongue; oedema of lips with petechiae on the mucous membrane; haemorrhages papillae of rumen, reticulum and omasum; localised hyperaemia pylorus	*Spleen, kidneys, liver, myocardium* show no specific changes. *Rumen:* Some of the papillae show fairly *characteristic changes*, viz., "ballooning" of the stratified epithelial cells, corresponding more or less with stratum granulosum; this "ballooning" is characterised by large spherical appearance of the epithelial cells, some of them showing the presence of a blauenotous-like material of a light pink colour with eosin; in others this material is more compact and homogenous; in the majority of affected cells there is loss of nuclei, in places these enlarged cells show infiltration with neutrophiles, in some the contour of the cells still well defined. Except for haemorrhages in the papillae of the corium it is remarkable how free it is of any infiltrative changes.

APPENDIX C.

(1) Extracts from Reports by Veterinary Officers on the Occurrence of this Bluetongue in Cattle.

Note: That the veterinary officers were dealing with bluetongue in cattle, is based upon the descriptions given in field reports. No aetiological diagnosis is given in these reports, and apparently the disease was no recognised as bluetongue. In some instances the descriptions are not sufficiently detailed, and the conclusion of the existence of bluetongue is not definite. It should be remembered that an investigation of these outbreaks was primarily undertaken to exclude foot and mouth disease and not to ascertain the nature of the disease.

Date and Locality.	Report by.	Extract in Field Reports.
24.2.33. Vlakfontein, Nigel, Tvl.	T. Adelaar.....	"1 *ox*. Necrosis on the dental pad."
23.2.33, Paardefontein, Heidelberg, Tvl.	D. G. Steyn.....	"1 *ox*. Animal listless. Mucopurulent discharge from the nose. Ulceration of interdigital space. Extensive ulceration of mucous membrane of upper and lower lips, gums and dental pad."
27.2.33, Klipriver, Ladysmith, Natal	J. R. Frean.....	"1 *calf*. Salivation and stiff gait. Small ulcers on upper gum. Diptheritic deposit ventral surface of the tongue."
28.2.33. Trumpeters Post, Mafeking	J. J. Keppel.....	"*Calves* (the number affected not stated). The calves show peculiar lesions on the dental pad. These lesions are ephemeral, and as rapidly as they appear they disappear, leaving a small circular lesion without ulceration. These small lesions are multiple and close together."
3.3.33, Townlands, Standerton, Tvl.	J. G. Bekker.....	"1 *cow*. Superficial diffuse necrosis on muzzle, inside of nostrils, dental pad and gingiva. Hyperaemia of the tongue. Teats all sore. Calf of cow normal. Temperature varied at different examinations 106° to 101°. Later marked skin lesions developed."
16.3.33, 5.3.33, 9.3.33, different farms in Mafeking and Marico districts	N. C. Starke.....	"*Number of calves*" the condition noted in these calves is referred to as a "diphtheritic stomatitis."
5.3.33, Oudehoutsdraai, Volksrust	J. Dickson and J. G. Williams	"2 *cattle*" (sex not given). "Two animals showed necrotic lesions in the mouths. In one animal the tongue was protruding about 8 inches. The organ was bluish discoloured and was swollen and firm. Small necrotic foci were also evident on the under surface of the tongue. There were also other cattle on the farm affected with stiffsickness, but apart from the stiffness nothing abnormal and no mouth lesions were present."

Date and Locality.	Report by.	Extract in Field Reports.
12.3.33, Blinkpoort, Heidelberg	J. B. Quinlan.....	"*One cow.* Animal *in extremis.* Necrosis ventral aspect of tongue and on the dental pad."
14.3.33, Vlakplaas, Germiston, Tvl.	J. B. Quinlan.....	"*One heifer.* Superficial ulceration of the upper and lower lips and superficial ulceration on the ventral aspect of the tongue. In the region of the fetlocks the skin felt hot and was very red. The interdigital space showed epithelial excoriation."
14.3.33, Hartlam, Reitz, O.F.S.	C. C. Wessels.....	"*One ox.* Profuse salivation and mucopurulent discharge from nostrils. Several abrasions on the mucosa of the dental pad, lips and underface of the tongue. The lower lip was also slightly swollen. Some of the papillae also showed hyperaemia and were swollen. On examination of the nasal cavities there were two small ulcers on the septum nasi."
17.3.33, Poortjiesfontein, Standerton, Tvl.	J. G. Bekker.....	"*Two milch cows.* Temperatures 103·5 and 104·5°. Necrosis on the dental pad, upper and lower lips and underneath the tongue. Distinct swelling of the lower portions of the limbs and redness on the plantar aspect of the digits. The teats were sore and an exudative inflamation of the skin of the flanks noted."
18.3.33, Kromdraai, Standerton, Tvl.	J. G. Bekker.....	"*One milch cow.* This animal was frequently examined and showed necrosis of lips, gums and ventral aspect of tongue. Teats sore. Later extensive skin lesions developed."
14.3.33, Welgezegend, Standerton, Tvl.	J. B. Quinlan and J. G. Bekker	"3 *cows.* Temperatures 103, 104, and 104·5 Necrosis dental pad, upper and lower lips, muzzle and behind incisor teeth. In one case the tongue was protruding and swollen. On the ventral aspect of apex the mucosa appears raw and very red. The tongue of another beast also severely affected and a large deep seated necrotic lesion on lateral aspect in the region of the body of this organ. The lower portions of the limbs in all cases appeared swollen and the surface of the skin in the interdigital spaces appeared moist and excoriated. All the udders were affected, especially the teats, which were red and covered with thin crusts." *Note.*—A fuller description of these cases is given in Appendix "A."

Date and Locality.	Report by.	Extracts in Field Reports.
19.3.33, Rooikop, Germiston, Tvl.	P. S. Snyman.....	"1 *ox*. Necrosis lips, dental pad, etc."
20.3.33, Ascent, Vrede, O.F.S.	J. B. Quinlan and J. G. Bekker	"1 *ox*. Swelling in the region of fetlocks. Necrosis of anterior aspect of dental pad and borders of lips."
27.3.33, Verblyden, Standerton, Tvl.	J. G. Bekker.....	"1 *heifer*. Temperature 106°. Necrosis dental pad and lips. The papillae on lips swollen and tips yellow in colour (necrosis), bases red. Feet swollen and an anterior aspect of interdigital spaces triangular areas, which are covered with dark brown scabs and underneath a raw granulating surface. Distinct 'break' at the coronets."
29.3.33, Mietjiesfontein and Rietvlei, in the Koedoesrand, N.Tvl.	G. de Kock.....	Describes a condition seen in cattle and he refers to it in the following way: "Cattle were seen showing a disease condition resembling three-day stiffsickness. In two cases I was struck with the swelling and redness of the tongues."
1.4.33, Swartland, N.Tvl.....	P. S. Snyman.....	Describes a cattle disease on this farm as follows: "The lesions in the mouth begin as a small swelling in the form of a pimple. Necrosis of the mucosa in the region of the swelling soon takes place and enlarges rapidly. This is seen especially on the ventral aspect of the tongue. No lesions were observed in the interdigital spaces, but lesions were present on the anterior aspects of the coronets. These showed a tendency to spread to the plantar aspects. One case was encountered with lesions of the skin of the udder and flanks. The epidermis was red and could easily be removed leaving a moist surface."

(2) General Reports on this Disease.

The following interesting and valuable information on this disease of cattle has come to our notice:—

Mr. F. A. Verney, Principal Veterinary Officer, Basutoland, in his annual report of the year 1932, states:—

> "In the autumn a cattle disease occurred that simulated very closely all the symptoms of foot and mouth disease, and had I not observed this disease 16 years ago, I should have been genuinely alarmed. The disease is indicated by an ulcerative stomatitis, loss of appetite, rise in body temperature, usually associated with a stiff gait and swollen fetlocks, occasionally with necrotic sores in the interdigital space. The disease usually breaks out in individuals in a herd, and shows no evidence of being infective and all my efforts to infect other cattle with saliva proved futile, and it is this factor that makes one definitely to decide against the dreaded contagious foot and mouth disease."

Mr. B. J. Brummer, Government Veterinary Officer, O.F.S., in a report in March, 1933, states:—

> "I have seen sporadic cases of this disease in various parts of the Free State. Generally only one or two cases occur on a farm . . . . The most common lesions seen are: an acute dermatitis of the skin around the mouth. The skin is just inflamed, then gets dry and hard and forms

cracks all along the borders of the lips. The muzzle becomes dry and painful, and the animal will often lick this part with the tongue. A burning sensation must be present, as the animal often shakes its head and even becomes vicious in the acute stages. Later the superficial layers of the skin peel off. In severe cases, the mucous membrane of the mouth is also inflamed and red. This may pass off without any further lesions, but usually lesions resembling that of *bluetongue in sheep* develop. These are of a diffuse nature and are mostly formed on the dental pad, along the borders of the lips and sometimes under the tongue. The mucosa of the nostrils is also generally inflamed, very sensitive, and easily bleeds.

"In most cases an acute laminitis is present in all four feet, accompanied by a redness of the skin along the coronets and a swelling of the lower parts of the legs. The swelling is most noticeable around the fetlock joint and may extend up to the knees and hocks, but I have never seen any sores formed (unless of a traumatic nature) along the coronets and between the claws.

"In fatal cases death occurs early in the acute stages before the lesions become properly developed. Once the skin lesions are noticeable, the animal is usually past the danger point. Generally a slight gastro-enteritis is also present. The disease occurs very sporadically and leaves little opportunity for further investigation."

Mr. Brummer suspected a poisonous plant as a possible cause of this disease.

Mr. C. C. Wessels, Government Veterinary Officer, Bloemfontein, in a general report on this disease, states that during April and March, 1933, numerous outbreaks of this disease occurred in various parts of the Free State. He mentions that when one of these cases occurred, all the neighbouring farmers were greatly perturbed since they suspected foot and mouth disease.

Mr. S. Reynolds (farmer). Zandbaken, Val, Standerton, in a letter dated 19th March, 1933, to the Director of Veterinary Services, referred to the disease as follows:—

"I find that the disease is to a certain extent seasonal, and mostly, if not always, only noticed during March and April. It bears many similarities to bluetongue of sheep and being most acute—as with most other South African diseases—in cattle imported from Europe. The affected cattle run a high temperature with complete or partial loss of use of the tongue. The tongue often going dark blue in colour with inflammation and eruption of skin around and under the tongue and lips. The feet are tender and sore and the animals move stiffly; in other cases, no feet disturbances are noted. In more acute cases as it varies, of course, in intensity—new hoofs would grow through and replace the old ones. The disease lasts a few days and then recovery would be rapid."

In a letter, dated 19th March, 1933, to the Director of Veterinary Services, *Mr. Armitage* (farmer), of Vaalbank, Standerton, describes a condition encountered in 1931 in two of his cattle (a year-old-bull and a two-year-old heifer) in the following way:—

"Both cases were very similar and started with high temperatures within a day of each other. The animals were very stiff and lame; in fact, a few days later they could hardly stand. The lower portions of the limbs were sore and swollen, but no open sores were seen. Two or three days later the tongues became very swollen and pinkish blue in colour. They seemed quite paralysed and hung out of the mouths. A hard scale formed over the upper lips and nostrils. This scale gradually became loose and fell off in one piece as the animals got better.

"The affected cattle could not eat for some time, but appeared to be hungry and were fed with slices of mangels and pumpkins, which were placed on the back of the tongues.

"As the condition improved the animals began feeding again, but were stiff for some considerable time.

"The heifer was turned out to graze as soon as she could walk. The young bull was left in with my other bulls, and I noticed sometime afterwards that all his hoofs were very long and found that new ones were growing. Some time later the old hoofs fell off."

APPENDIX D.

Temperature Charts of Experimentally Infected Sheep and Calves.

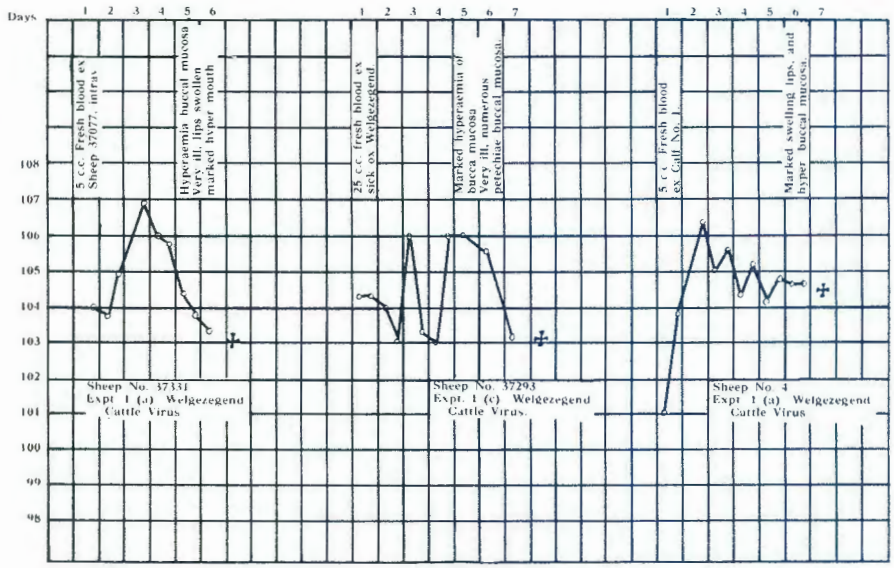


Chart I.

Peracute reactions.

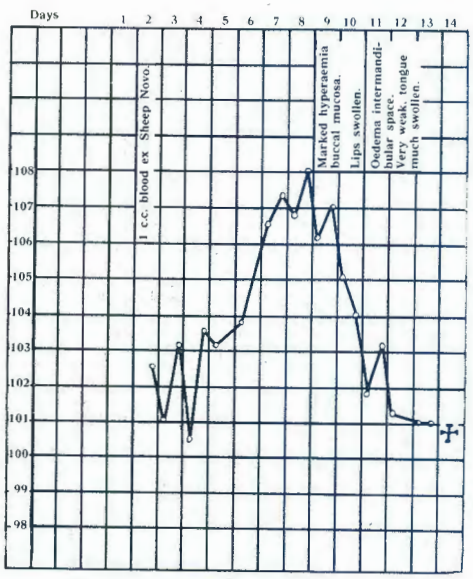


Chart II.

Sheep 37078, Expt. 9. Acute reaction. Note: Very high temperature and collapse.

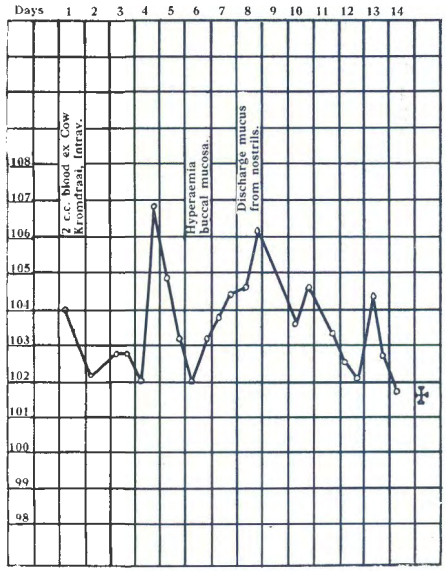


CHART III.

Sheep 37452, Expt. 2. Acute reaction. NOTE: Intermittent nature of temperature.

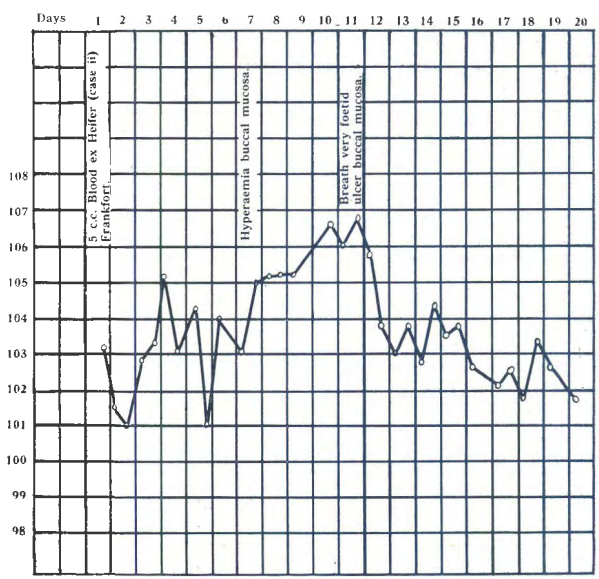


CHART IV.

Sheep 37678, Expt. 7 (*b*). Acute reaction. NOTE: Long duration of temperature.

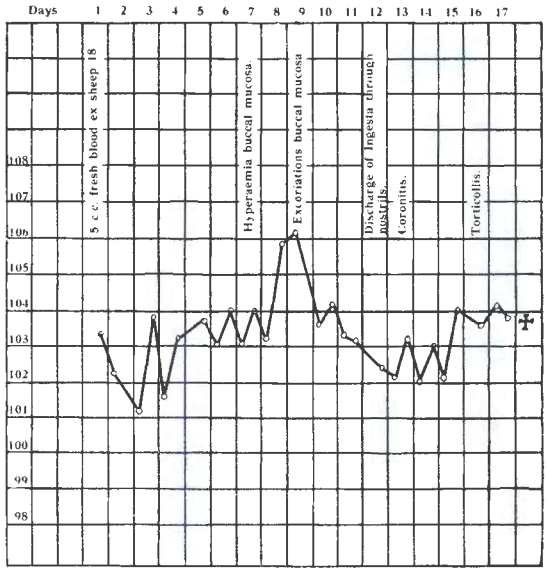


CHART V.

Sheep 37679, Expt. 2. Subacute reaction. NOTE: Short duration of temperature reaction (ephemeral).

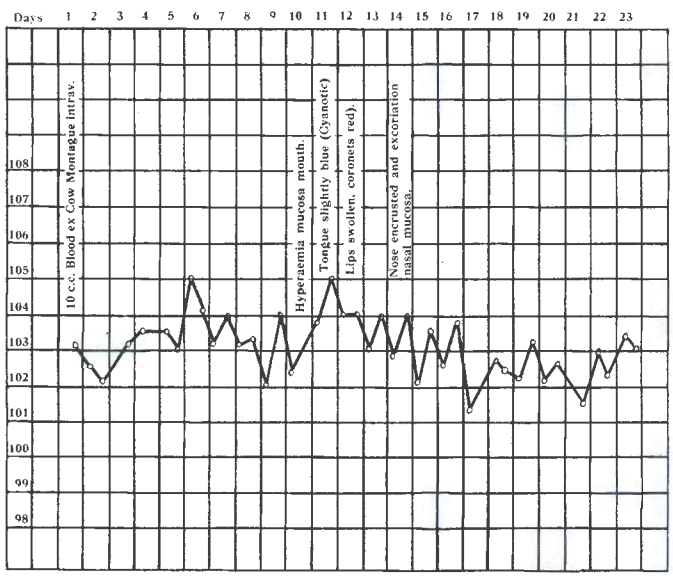


CHART VI.

Sheep 37174, Expt. 6. NOTE: Slight elevation temperature (a febrile reaction), but distinct development of lesions.

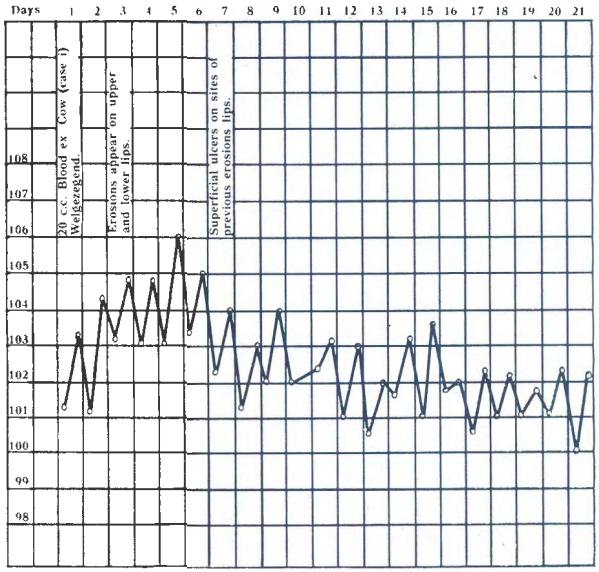


CHART VII.
Calf 1, Expt. 1 (*a*).

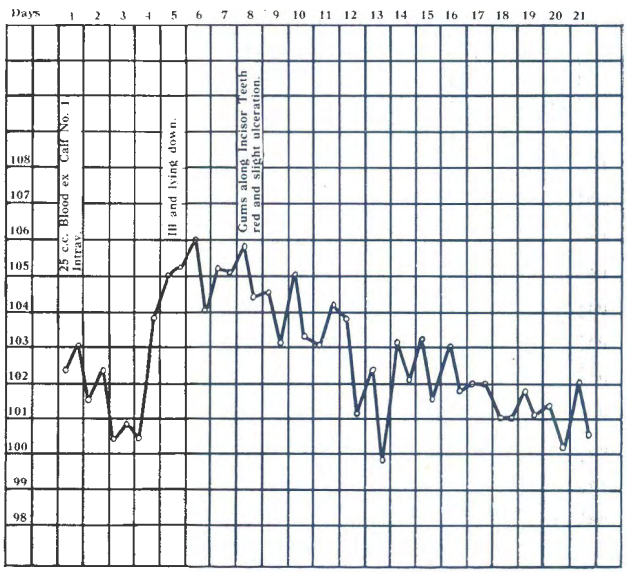


CHART VIII.
Calf 3, Expt. 1 (*a*).

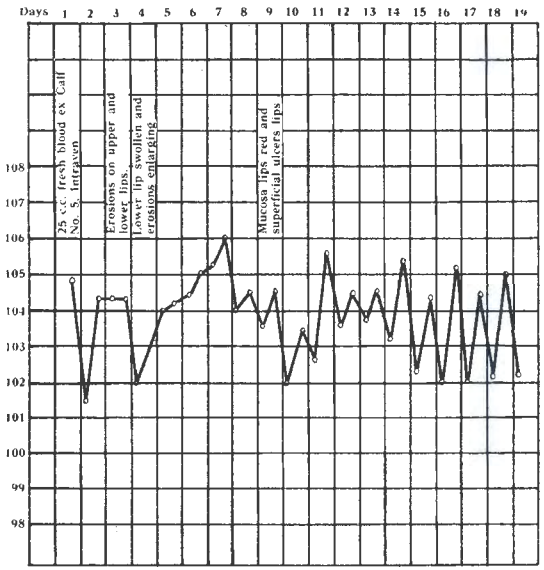


CHART IX.
Calf 10, Expt. 1 (*b*).

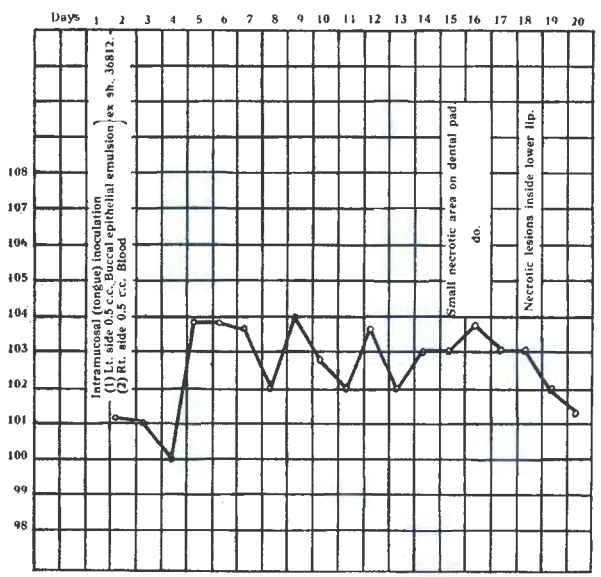


CHART X.
Calf 5201, Expt. 10 (*d*). NOTE: Temperature recorded once daily, i.e. at 9 a.m.

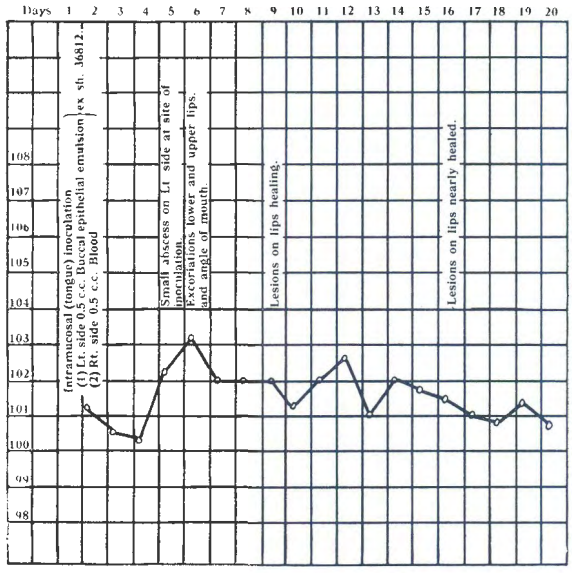


CHART XI.

Calf 5257, Expt. 10 (*d*). NOTE: Temperature recorded once daily, i.e. 9 a.m.