

TRYPANOSOMIASES OF DOMESTIC ANIMALS IN  
THE UNION OF SOUTH AFRICA.

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CHAPTER I.

SCOPE OF THESIS AND GENERAL INTRODUCTORY REMARKS.

The major portion of this thesis will be devoted to the consideration of the chemotherapy of those trypanosomiases which are conveniently grouped under the term "Nagana". In addition to the recording of the drugs which have been tested by the writer reference will also be made to drugs which have been used by other workers in the Union of South Africa even though the tests gave unsatisfactory or negative results. Many of these tests have not been published and the reason for their introduction in this work is to place on record, for sake of completeness, the drugs employed and the results obtained. Quite striking is the large number of drugs which have been given trials since 1910. Details of experiments by other workers are provided only when successful or promising results have been obtained. The position now is that satisfactory methods of treatment, some highly efficacious, have been evolved for all of the trypanosomiasis of domestic animals due to *Glossina* transmitted pathogenic trypanosomes.

Chapters on Symptomatology, Diagnosis etc. are also included. These record mainly the observations made by the writer on various species of animals since the commencement of this work at the beginning of 1929. Special interest is attached to the observations on the anaemia of *Trypanosoma congolense* infection of bovines and of sheep and the variation of the nature of this infection from peracute to chronic according to the influence of environmental conditions.

The endeavour is made to restrict as much as possible the subject matter to observations made by the writer. This procedure is only occasionally departed from and then only when it becomes necessary to introduce observations by other workers

for the sake of completeness.

The non-pathogenic trypanosomes and T. equiperdum, the trypanosome of Dourine, are not dealt with in this work. The omission of reference to T. equiperdum infection of horses is not because it is a disease which is not of great economic importance to the Union of South Africa, but because it is a trypanosomiasis in a class by itself, the glossinae not being associated with its transmission. Furthermore, Dourine is a disease which has received and will receive a considerable amount of attention from research workers in Europe, Asia and ~~the~~ ~~Americans~~, being a major problem in many parts of the world. The glossina transmitted trypanosomes are particularly the problem of the African continent and, as far as the Union is concerned, a problem of a fairly well defined and restricted area of the north-east.

The importance of the Nagana group of diseases has, in the past, resulted in the expenditure of considerable sums of money in research work and will, in the future, undoubtedly call for further considerable expenditure. These diseases, probably to a greater extent than any other disease or group of diseases, have interfered with the progress and development of areas of country comparatively near to centres of civilization and suitable for agricultural settlements. They present therefore a problem of great importance and of some urgency and any advancement in knowledge which, even to minor extent, assists in their control cannot but have a considerable influence on the opening up and wealth of the infected parts and on the type of life lead by the inhabitants.

It, however, is freely admitted that any means of control which are introduced for any other purpose than the destruction of the glossinae are only palliative. The ultimately complete and final solution is undoubtedly the destruction of the glossinae. Even if a method of immunization or rather a method of producing resistance to the deleterious effects of the trypano-

somes were to be devised, yet the production of this or its maintenance would be burden of considerable moment in a new country which, of a necessity, would have to bear in addition heavy charges in connection with marketing and the combating of other diseases usually found associated with the trypanosomiases.

The elimination of the tsetse fly from the sphere of operations is a problem which has in recent years received a considerable amount of attention. Whether this will be brought about by some special system of clearance, capture or other direct method or whether, as is very likely, it will remain a problem until such time that it will be automatically solved when, with increased population resulting from increased world demand for foodstuffs, the advancement of settlements with extensive agricultural developments will bring about a state of unsuitability for the continued existence of the tsetse fly.

In the meantime restriction of the further extension of the disease and, when it is present, its control would appear to be the main immediate indications. Under specially favourable conditions the elimination of the glossinae in certain areas may be possible and may serve as a stimulus to the attainment of the final goal.

Failing the destruction of the fly there remains two other links of the chain open to attack, namely, the control of the reservoir of the infection and the control of the disease when it appears in the domestic animals. The control of the reservoir hinges essentially on the often uncontrollable factor of the game (and the often unrealised reservoir the pre-munished domesticated animal). It is not proposed to refer further to the rôle of game as reservoirs of infection and to the effective control, as this matter is one which arises from time to time for further, often bitter, controversy. It is sufficient to state here that the game are reservoirs. The

matter of the domestic animal reservoirs is somewhat different. Probably the chief danger is on account of these animals often not being known to be reservoirs. If they are detected as such their control is simple either by destruction or by the application of efficacious therapeutic measures. The control of the disease in domestic animals is dependent on the application of efficient, practical and economical therapeutics. The rôle of therapeutics will probably be enhanced when the time comes to eliminate entirely reservoirs from among the domestic animals, reservoirs which are likely to arise during the treatment of animals for trypanosomiasis. Thus the chemotherapeutic measures would in the first place be utilised to control the ravages of the disease in the animals and in the second place to bring about the destruction of the parasites in the domestic reservoir by sterilisation. The elimination of the wild game reservoir would require the elimination of the domestic reservoir.

The importance of a highly efficacious therapeutics under the present conditions can be readily appreciated. It, in the primary stages of the attack of the disease, would be of inestimable value in controlling the disease in the domestic animals which are, in the type of country where trypanosomes are found, essential for its development and in the final offensive would be required for the elimination of the domestic animal reservoirs.

In the Union of South Africa the problem is of restricted importance on account of the area of the Union at present infected being comparatively small. But this was not always the case for, up to quite a recent date, tsetse fly occurred in other parts. Curson (1932) reviews the evidence of its presence in the Transvaal and Bechuanaland in a recent article. The distribution of the tsetse flies in Zululand has been fully dealt with by Curson (1928) and Pappert (1930).

## CHAPTER II.

The three trypanosomes of Nagana, namely T. congolense, T. brucei and T. vivax vary considerably as to their effect on the different domestic animals. In undeveloped sections the animal which is first introduced for the purpose of settlement and agricultural pursuits is usually the bovine. Consequently it is in the bovine that variation of susceptibility to the different trypanosomes and the pathogenicity is in most cases first observed. Sheep on the other hand are often the last to be introduced and, until such introduction takes place, the sheep as a consequence may not be regarded as being particularly susceptible.

For bovines the trypanosome which is of most importance is undoubtedly T. congolense. Death from T. congolense infection, however, is dependent to a considerable extent on the environmental conditions. If a bovine is kept under good conditions of temperature, protection and food, it is exceptional for it to die. In the large number of cases which were produced with three strains of T. congolense not a single death was recorded in the <sup>a</sup>stabled animals even though the effects on the animals of the infection were always severe, the anaemia and loss of condition being marked. If, however, such animals were exposed to inclement weather, even though the food supplied remained the same, there was a definite exacerbation of the condition and deaths resulted. This question of the influence of environmental conditions on T. congolense infection of bovines will be further dealt with under the heading of symptomatology. T. vivax infection of bovines does not appear to exert as detrimental effects as T. congolense infection. Exposure of animals to unfavourable conditions was not carried out. There is loss of condition and anaemia appears when the bovines are kept under stable conditions, but without treatment recovery of condition results. In no case could death be ascribed to the infection with T. vivax. T. brucei infection of bovines was not experi-

mented with. Curson (1928) regarded T. brucei infection of bovines as a benign one.

It was determined that, under artificial conditions, the transmission of T. congolense, and T. vivax to bovines by the subcutaneous or intravenous injection of infected blood was invariably successful.

In equines the trypanosome which is of most importance is T. brucei. The strain used in these experiments was obtained from a natural case in a donkey from Zululand. For horses, whether stabled or not, this strain produced an acute condition which resulted in the death of the animal often within one month after infection. There was a rapid loss of condition and an anaemia. After this strain had been kept going in horses for a few years the virulency was decreased. In a donkey this strain of T. brucei produced a subacute disease. Every equine, however, which has been infected has died in the absence of treatment. No endeavour was made by the writer to transmit T. congolense or T. vivax to equines. Curson (1928) records the finding of T. congolense but not T. vivax in equine blood smears in Zululand. Graf (unpublished) carried out chemotherapeutical tests on horses artificially infected with T. congolense. Other works have recorded the occurrence under natural conditions of T. vivax in equines.

In canines the trypanosome which is usually regarded as the one which produces the most severe effects is T. brucei.

Montgomery and Kinghorn (1908) described this parasite as one producing fatalities in dogs. Many cases of trypanomiasis in dogs, however, are undoubtedly due to infection with T. congolense which produces, at times, a peracute rapidly fatal disease. The strain of T. congolense utilized in the work on dogs was obtained from a dog naturally infected in Zululand. The T. brucei infection in dogs was not as severe as that produced by T. congolense. No experimental work was carried out with T. vivax infection of dogs.

In swine the only trypanosome tested out was T. congolense. This infection of pigs has been recorded in the Belgian Congo as a peracute disease of pigs with a high mortality. Two strains of T. congolense were used in these experiments. In neither case was the disease produced of any great severity. Infection was easily produced by the subcutaneous injection of infected blood.

In sheep T. congolense infection was produced by the subcutaneous injection of infected blood of bovines, guinea pigs, sheep and dogs. The onset of the disease is somewhat acute but mortality is low. The sheep were kept under favourable conditions. The usual outcome was the chronic state. T. brucei was transmitted to sheep and goats by Graf and by the writer to sheep. The writer was not successful in his attempts to transmit T. vivax to sheep. Other workers appear to have had little difficulty in carrying out such transmission.

It must be borne in mind that the pathogenicity of the various trypanosomes to the domestic animals will show considerable variations according to the virulency of the particular strain, the state of health and the condition of the animal, the environmental conditions, etc. The findings, therefore, of the writer are not necessary true for all the strains of any one species of trypanosome under all conditions. They represent only his own observations. For example the strain of T. brucei used in his therapeutical tests was invariably fatal to horses in approximately 30 days, whereas the strain formerly used at Onderstepoort for similar work usually resulted in the production of a chronic disease.

In this work the following strains were utilised:

T. congolense.

- (a) Zululand strain collected from a bovine.
- (b) Zululand strain collected from a dog
- (c) Strain obtained from Southern Rhodesia.

T. brucei

One strain which was collected from a donkey in Zululand.





## CHAPTER III.

### Periods of Incubation.

The periods of incubation of the various trypanosomes vary among themselves for the different animals and, as would be expected, also according to the virulency of the particular strain of parasite utilised. As the determination of a period of incubation in these trypanosomiases is unsatisfactory when symptoms other than temperature are utilized, the periods hereunder are judged either from the first temperature elevation or from the first appearance of trypanosomes in stained smears of blood or lymphatic gland juice. In a number of cases of T. Congolense and T. vivax infections of bovines an accurate determination was arrived at by a careful twice daily temperaturing and a daily examination of stained smears. This procedure was carried out particularly in cases of T. vivax infection and the infection produced by the Zululand bovine strain of T. congolense for the purpose of comparison of the two infections in bovines. The details of this series of examinations are tabulated below.

TABLE I.

Periods of Incubation of Bovine Trypanosomiasis.

Number of Bovine	Date of Infection.	Species of Tryp.	Strain of Tryp.	Source of Tryp.	Period of Incubation.		
					Temperature.	Blood Smear.	Gland Smear.
2634	10/1/29	T. congolense	Zulu-	Guinea pig	5 days	7 days	11 days
2639	"	"	"	"	5 "	6 "	9 "
270	"	"	"	"	5 "	6 "	15 "
2709	"	"	"	"	5 "	7 "	11 "
2714	"	"	"	"	5 "	7 "	9 "
2464	20/4/29	"	"	"	6 "	6 "	--
2468	"	"	"	"	6 "	7 "	--
2473	"	"	"	"	6 "	5 "	--
2471	"	"	"	"	7 "	6 "	--
3506	13/9/29	"	"	"	5 "	7 "	--
3525	"	"	"	"	5 "	6 "	--
3527	"	"	"	"	6 "	5 "	--
3542	"	"	"	"	4 "	4 "	--
3627	"	"	"	"	6 "	4 "	--
2994	17/10/29	"	Rhodesia	"	6 "	5 "	--
3626	5/12/29	"	"	"	12 "	5 "	--
3684	20/9/29	"	"	"	7 "	6 "	--
3671	9/12/29	"	Zulu-	"	5 "	4 "	--
2715	10/1/29	T. vivax	Tsetse-land	B.2780	4 "	14 "	8 days
2727	"	"	"	"	8 "	14 "	7 "
2743	"	"	"	"	6 "	16 "	6 "
2765	"	"	"	"	8 "	14 "	8 "
2766	"	"	"	"	9 "	15 "	11 "

The examination of Table I will reveal several points of interest especially when a comparison of T. congolense and T. vivax infections is made. The first temperature elevations of the T. congolense infection show only minor variations the range, being 4 to 7 days with eight of the fourteen animals showing the elevations on the 5th day. The variations in those infected with T. vivax are somewhat greater, the range being from 4th to 9th days.

The appearance of the parasite in the blood smears in the case of T. congolense infection shows great regularity, the range being from 4th to 7th day and in the T. vivax infection the parasites, appearing much later, are found from 14th to 16th day. In T. vivax infection of bovines the trypanosomes are usually difficult to find in blood smears and consequently, notwithstanding the careful examination under-

taken, the possibility of missing the first appearance must be considered.

When the gland smear results are examined it is seen that the converse holds good. In T. congolense infection the appearance of the parasites is comparatively late being from 9th to 15th day (due to the rarity of the parasites in gland smears ?), whereas in T. vivax infection they appear from 6th to 11th day.

When the Rhodesian strain of T. congolense was used, the temperature elevation was occasionally as late as 12th day. The blood smears showed the trypanosome and not later than the 6th day. Only a few cases, however, were recorded.

The Zululand dog strain was used in one case. The disease was the most benign of all the cases of T. congolense infection produced in bovines. The trypanosomes were first found in blood smears on the 6th day, but were always very rare.

In T. brucei infection of horses was obtained with marked regularity the shortest period of incubation of any of the trypanosomiasis. Of the thirteen horses recorded the shortest period, judged from the temperature elevation, was 3 days, the longest 8 days, while eight of the thirteen horses showed the elevation in 4 days. T. brucei was found in stained blood smears in every case not later than the 8th day and in some cases as early as the 4th day.

In sheep with the first generation of the Zululand dog strain of T. congolense the trypanosomes were found on the 12th day and the first temperature elevation appeared on the 15th day. With the second generation in sheep there was a decrease to 10th and 6th day, respectively, whereas in the third generation the first temperature elevation was on the 8th day with the parasites, however appearing later. With T. brucei infection the second generation after the infection from the horse showed a shorter period, when the first

elevation of temperature was utilized, than the first generation being on the 4th day as against the 12th day. In this infection the examination for the parasite is unsatisfactory on account of its great rarity in blood smears of the sheep. As already mentioned the writer was not successful in his attempts to transmit T. vivax to sheep.

In dogs T. congolense of the Zululand dog strain produced an elevation of temperature on the 4th day, the temperature appearing in the earlier generations somewhat later. The trypanosomes were found in blood smears as early as the 6th day. T. brucei, obtained from an infected horse, gave an elevation of temperature on the 20th day, parasites appearing on the 7th day.

In pigs T. congolense infection with the Zululand dog strain shewed an elevation of temperature and presence of trypanosomes on the 11th day. When the Rhodesian strain was used the temperature elevation and the trypanosomes appeared on the 13th day.

Table II gives the periods of incubation judged solely from the first elevation of temperature in T. brucei and T. congolense infections of horses, sheep and goats arrived at during the experiments of Graf (unpublished). The periods of incubation obtained by the writer were in almost every case shorter than those of Graf due, probably, to the greater virulency of the trypanosomes used.

TABLE II.

Periods of incubation of Trypanosomiasis (Graf).

Species of Animal.	Number.	Date of Infection.	Species of Tryp.	Source of Tryp.	First temperature elevation.
Sheep	9567	22/7/26	T. congolense	Guinea pig	4th day.
"	13468	"	"	"	5th "
"	13817	21/9/26	"	sheep	6th "
Goat	14593	"	"	"	7th "
"	14460	31/9/26	"	"	13th "
"	14456	"	"	"	12th "
"	14455	"	"	"	11th "
"	14402	"	"	"	14th "
"	13999	"	"	"	13th "
Sheep	11651	"	T. brucei	Goat	9th "
"	12532	7/9/26	"	"	7th "
"	13068	21/9/26	"	"	5th "
"	13663	31/9/26	"	"	8th "
"	13004	"	"	"	8th "
Goat	14411	21/9/26	"	"	8th "
"	14365	22/7/26	"	Guinea pig	12th "
"	14042	"	"	"	11th "
"	14017	"	"	"	12th "
"	14400	"	"	"	15th "
"	14373	"	"	"	8th "
Horse	17792	21/9/26	T. cong.	Sheep	21st "
"	18022	"	"	"	19th "
"	18096	14/10/26	T. brucei	"	8th "
"	18081	21/9/26	"	Goat	9th "
"	18224	14/10/26	"	sheep	7th "
"	18085	"	"	"	8th "
"	18102	21/9/26	"	Goat	11th "

## SYMPTOMATOLOGY.

### (a) Trypanosoma congolense Infection of bovines, ovines, canines and swine.

The symptoms in the various animals mentioned are those which have been observed by the writer in animals which have been infected by inoculation and which have been kept under environmental conditions subject to control. The symptoms observed under these laboratory conditions agree very well with those recorded by workers who were able to keep cases of natural infection under observation in the field. All the symptoms observed in the field have been reproduced under controlled laboratory conditions by means of variations in the environmental conditions. Under similar conditions at the laboratory the symptoms in the various species of animals have presented a marked uniformity.

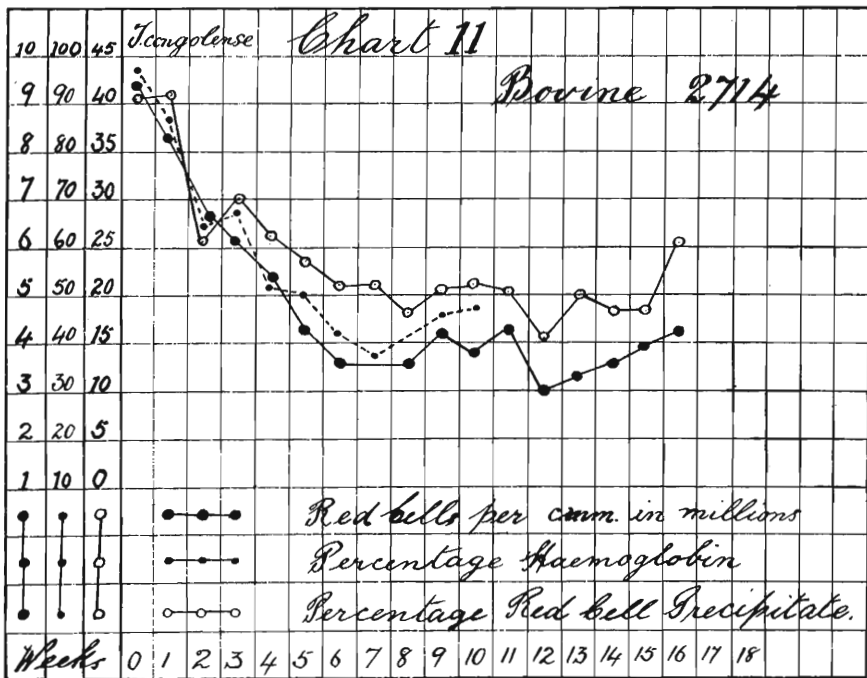
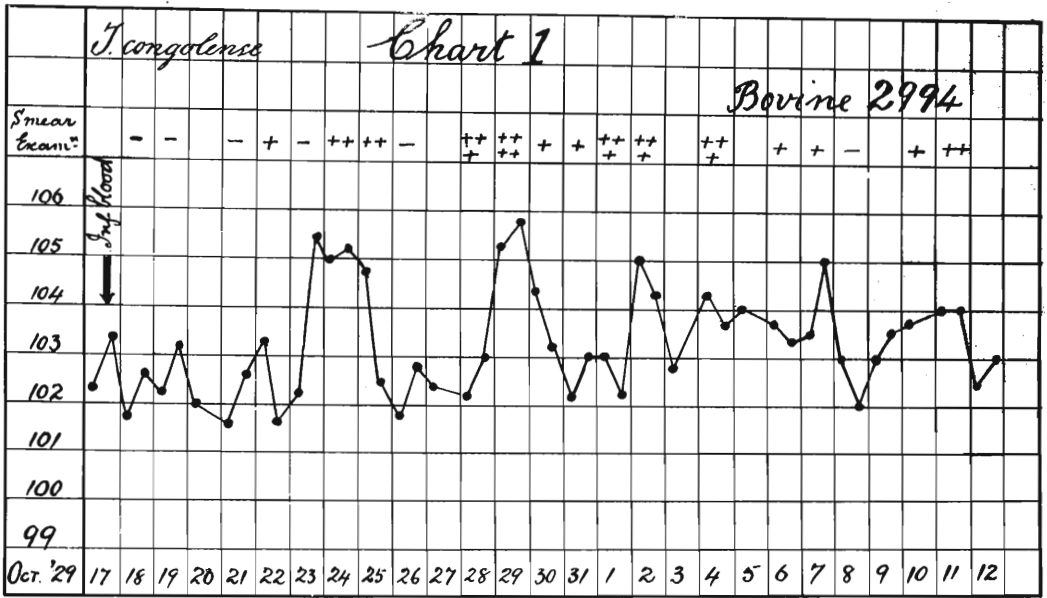
The symptoms in the different species of animals are, hereunder recorded separately, special emphasis being placed on the symptomatology in the ox on account of the importance of the disease in this animal.

(1) Symptomatology in bovines. The disease (T. congolense infection) can conveniently be described as occurring in the peracute, acute and chronic forms. The acute form occurs during the primary stages of the infection but under favourable conditions passed into the chronic form and at times even into the premunised state. Both the acute and the chronic forms, if the environmental conditions are unfavourable, pass rapidly into the peracute form which is the precursor of death. It would appear, therefore, that the chief factor in the determination of the type or form the infection takes is the one associated with the condition the animal lives under. The more severe these conditions are the more acute is the disease. These determinations correspond to what is known happens under field conditions. Good climatic and hygienic conditions plus a good food supply postpone, under field conditions

the onset of the recognized acute nagana symptoms.

Acute T.congolense infections were produced as the result of the injection of T.congolense infected blood obtained from infected guinea pigs or bovines. The disease is issued in by an elevation of the temperature, at times higher than 105°F after an interval which varies but which may be as short as four days. The parasites may be found in blood smears as early as the 4th day, being somewhat later in the gland smears. Chart I of temperature and of smear examination is submitted. During the initial part of the infection there is dullness and decreased appetite. At intervals the appetite is more or less normal and this capricious nature of the appetite persists until the form becomes either chronic or peracute. The coat is rough and dry. The constitutional disturbances, never very marked, are more in evidence during the exacerbations of temperature improving during the remissions. The visible mucous membranes are paler than normal, but icteric discoloration was not observed in any of the large number of bovines experimented with. The pulse is accelerated and the respirations, which are shallow, show increased frequency. Oedema and eye-lesions have not been observed in the acute cases. An examination of the blood establishes definitely the presence of an anaemia and furthermore determines the most marked changes that occur in this disease. There is a rapid decrease in the haemoglobin, in the red precipitate (red cell volume), and the number of red cells. The condition thus is essentially one of a rapidly produced anaemia with a loss of condition notwithstanding a fair but capricious appetite associated with an intermittent fever. Charts II illustrates the changes determined in the blood constituents. The haemoglobin determinations in this case are incomplete but sufficient are available to indicate that the haemoglobin decrease corresponds fairly accurately with the decrease in the number of red cells and the red precipitate.

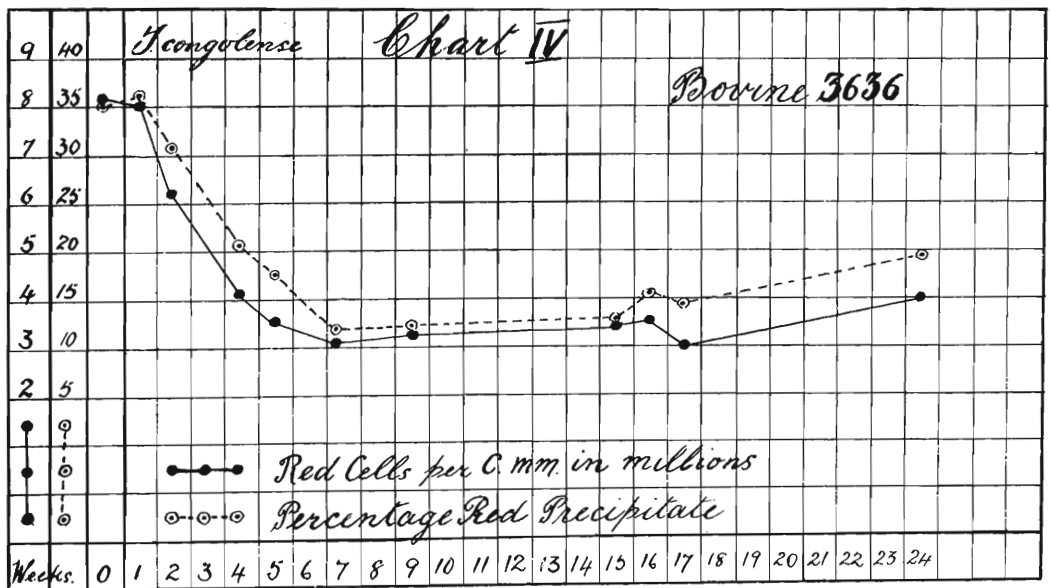
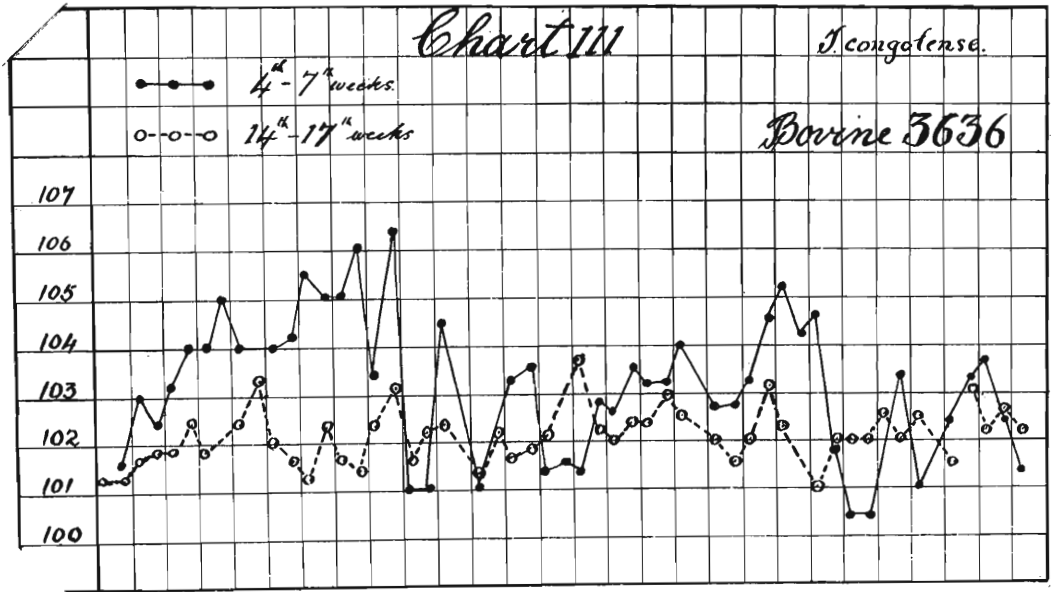
As already stated, such acute cases under favourable conditions pass gradually into the chronic form of the disease,





with at times an improvement in the condition and the anaemia.

The chronic form of T.congolense infection is characterized chiefly by the evidence of the anaemia and the absence of the more acute symptoms noted in the previous form. There is apparently an equilibrium between the body resistance and the parasites but the equilibrium is usually at a low red cell count not, as occurs in premunition, at a high red cell count. This chronic form under favourable conditions may, on account of the upset of the equilibrium in favour of the parasites, pass into the peracute form or under very favourable conditions approach the state of premunition, e.g. when tonics which have apparently no effect on the parasites bring about an improvement in condition and result in an equilibrium on a higher plane. Superficially the most marked symptoms of the chronic form are the loss of condition, the dry scurfy skin, the accelerated pulse, the shallow rapid respirations, the distress produced by even slight exertion and the tendency for the marked exacerbations and remissions of the acute form to disappear. As in the acute form oedema and eye-lesions were not observed. The number of red cells and the red precipitate usually remain practically stationary at a low level. Chart IV illustrates the primary fall in the number of red cells and the red precipitate during the acute stage and the attaining and the maintaining of the equilibrium during the chronic stage. Photograph I of this bovine 3636 is added to illustrate the appearance of a chronic case of T.congolense disease 19 weeks after infection. Chart III represents the temperature curves of bovine 3636 during the acute and chronic states, the former curve being about ten weeks prior to the latter. The comparison of the two curves illustrates well the changes in the temperatures which take place when the disease passes into the chronic state. In sheep, on the other hand, the exacerbations and remissions of temperature are remarkably persistent. The peracute form which is described last on account of the appearance of symptoms which have not been noted in the



acute and chronic has been produced by the exposure, during inclement weather, of bovines in the chronic or acute states of the infection. The change from these states to the peracute is very rapid for within a week the condition may pass from the more or less non-varying chronic state or the previously described acute state, to the peracute form showing a marked exacerbation of the condition with the development of additional symptoms. In this peracute form may be observed symptoms such as salivation, lachrymation and photophobia associated with oedema and acute keratitis. Photograph 2 of bovine 2727 illustrates the appearance clearly. The eye-lesions in this case improved rapidly on the institution of a trypanocidal treatment, although no local treatment of the eyes was carried out. Recovery, however, was not complete on account of the persistence of corneal opacities. If suitable treatment of a bovine suffering from a peracute attack is not instituted the animal dies. For example, death occurred in a bovine which, when in a chronic state of the disease was exposed to inclement weather. This animal had not previously been treated. It died one week after being exposed. The trypanosomes which previous to exposure were always difficult to find, became very numerous within a few days. Abnormal forms were frequent especially so in the muscle smears. Later three further bovines were exposed. They however, were not in the chronic state for they were placed out immediately after being infected. These bovines whose numbers were 416, 3508 and 3520 died during the 10th, 5th and 9th weeks after the date of infection which was the day of commencement of exposure. Before and after death trypanosomes were very frequent in the blood smears. Curson, who conducted many of his observations in the field, records oedema and corneal opacities in both the artificial and natural cases of T. congolense infection in bovines. Hornby (1929) surprisingly has not observed either oedema or eye-lesions in this disease. He states that "the disease (T. brucei infection) to which it gives rise is associated with oedema keratitis, sleeping sickness, in

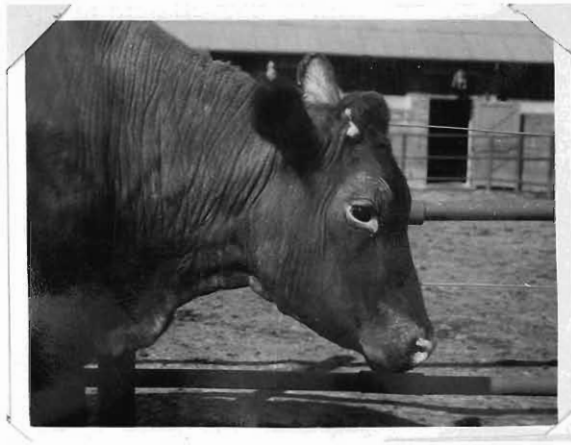
utero infection etc. This is not the case with T.congolense disease". He then formulates the theory that "T.congolense is essentially a blood parasite and T.congolense disease is essentially an anaemia". In the peracute cases at this Institution there were no complicating diseases and in those cases treated rapid improvement set in. Similar and even more advanced eye-lesions have been observed together with local and generalised oedema in T.congolense infection of dogs. Furthermore, the condition in T.brucei infection of horses is in many cases characterized by the anaemia with the absence of oedema and eye-lesions.

From the descriptions given above of the three states of T.congolense infection of bovines it will be seen that the major common symptom is the anaemia which is always present in the infected bovines provided that the bovine has not attained the state of premunition. The bovine regularly shows a low red cell count, red precipitate and haemoglobin content. These changes were noted by the writer in all the cases examined whether peracute, acute or chronic. Hornby after his visit to Onderstepoort repeated this work and has published his results in a recent article (1931). It is gratifying to note that his findings are almost identical to those of the writer. Common also<sup>to</sup> the three types of T.congolense infection is the negative finding of absence of marked changes in the red cells. It was early determined by the writer that except for a slight anisocytosis there were no other changes in the red cells such as are usually associated with the presence of anaemia in bovines. Polychromasia, basophilia and normoblasts were not found in a single case. These points have been recorded by Parkin and Hornby (1930). Since then the writer has had no reason to change this observation as far as T.congolense infection of bovines is concerned.

Of interest when the symptoms of the disease are under consideration is the rapid improvement of the anaemia as a result

of the institution of treatment with antimosan. It is not even necessary that the treatment be sufficiently efficient to produce sterilization to bring about complete recovery from the anaemia. There might, for example, result a return to the original red cell count and the original red cell precipitate and the haemoglobin might return to normal notwithstanding that the trypanosome can still be found in blood smears. And furthermore, the bovine can retain this state of blood normality notwithstanding exposure to weather sufficiently inclement to cause death in, for example, chronic cases. It is, in other words, in a state of premunition, the commonly understood immunity as applied to protozoal diseases.

In calves T.congolense infection produces as severe ill-effects as in adult bovines. Photograph 3 is submitted herewith as an illustrating of the infection in a calf which was born of a cow which was not affected with the disease. This photograph was taken 11 weeks after the injection of T.congolense. In another calf, which was born of a cow in a premunished state, the infection with C.congolense of the same strain as that with which the cow was infected did not produce as severe ill-effects as in the previous case. Photograph 4 of this calf is submitted. Further work would be necessary to determine whether calves born of premunished bovines have or receive through the milk some slight resistance to infection with the parasite. The behaviour, in addition to the symptoms, of the two calves was different for the calf of the premunished cow was lively, while the other showed marked depression. Although only two calves were used for this comparison, the results are somewhat suggestive and afford a possible explanation of why, in some parts, certain herds can be maintained in areas where they are constantly exposed to infection with trypanosomes. The presence of some slight resistance in calves born of infected cows might increase their chances of survival.



Photograph 1. B. 3636. Chronic case of T. congolense infection.



Photograph 2. B. 2727. Peracute case of T. congolense infection.



Photograph <sup>3</sup>~~4~~. B. <sup>3671</sup>~~3698~~. T. congolense infection of calf.



Photograph <sup>4</sup>~~3~~. B. <sup>3698</sup>~~3671~~. T. congolense infection of calf.

(ii) Symptomatology in ovines. The effects of T.congolense infection on sheep were, when concomitant diseases were eliminated, seldom as striking as on bovines. Consequently classification into peracute, acute and chronic states was not attempted. The apparently peracute cases, i.e. the cases which progressed rapidly to a fatal termination with the appearance of numerous trypanosomes in the blood were, in most cases, associated with a concomitant infection of heartwater and the peracute state might not have arisen if it were not on account of the presence of this disease. The symptoms in these cases are thus unreliable. Trypanosomes, however, were numerous an unusual finding in T.congolense infection of sheep when kept under favourable conditions. The common course the disease in sheep takes is a primary acute form followed by a chronic. Notwithstanding the frequently high temperature the life of the sheep in many cases does not appear to be in danger. An examination of the sheep shows pale mucosae, accelerated pulse and respiration, some loss of condition which loss, however, is soon recovered and an interference, not marked, with appetite. The temperatures show striking persistent variations with periodic high and low temperatures. The difference in temperatures taken at 10 hours' intervals may be as much as 5-6°F. The blood examination reveals also as in cattle an anaemia which is at a fairly low level early in the disease. Chart XIII illustrates the red cell precipitate of a sheep infected with T.congolense in comparison with that of one infected with T.brucei.

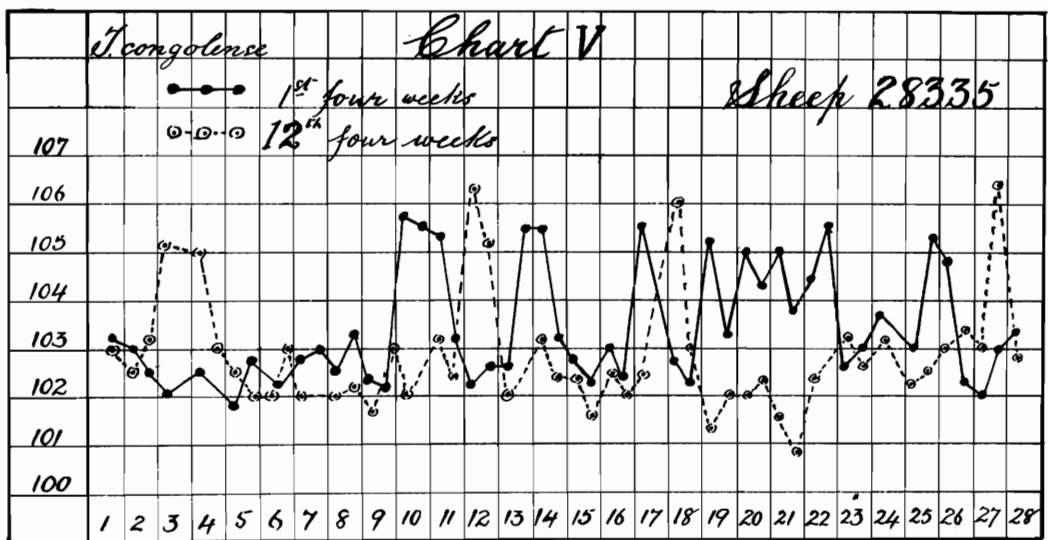
Contrary to what was determined in cattle, the blood in some sheep showed anisocytosis, polychromasia, basophilia and normoblasts. Such changes did not occur in all the sheep under observation and may perhaps be in part due to a concurrent verminosis. No endeavour was made to ascertain the effect of adverse environmental conditions on infected sheep. The symptoms of T.congolense infection of sheep are thus somewhat meagre, the

striking features being the temperature curve and the anaemia as determined by blood examination. As an illustration of the persistence of the marked irregularities of temperatures is submitted Chart V, which represents of the same sheep the temperature curve of the first four weeks and that of the 12th four weeks some ten months later. This is contrary to what occurs in cattle for in these the temperature curve of chronic cases becomes ultimately normal under conditions somewhat similar to those under which the sheep are kept.

(iii) Symptomatology in canines. The dog probably shows best of all the animals the effect of T.congolense infection. The cases on which observations were carried out were one case of natural infection and several cases produced by the inoculation of this strain of trypanosome from dog to dog or from sheep to dog, the sheep having been infected from the original natural case. In every case the disease in the dogs could be classified as peracute except when the course was interfered with intentionally by the use of drugs.

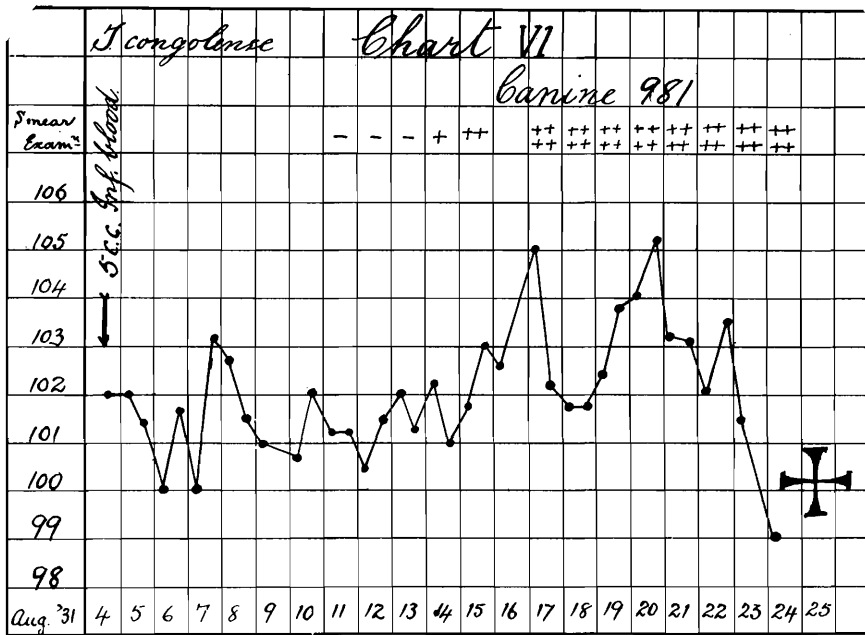
The incubation period when judged by the first elevation of temperature, was as early as 6 days, and by the appearance of the parasites in the blood smears also 6 days. Depression which comes on suddenly is marked, the dog passing from a state of vigour and liveliness to one of depression within a day. This change is particularly noticeable in vicious dogs which, on the onset of depression, permit free and safe handling. Inappetence appears simultaneously. Salivation is present in most cases. About the same time the faeces show changes in consistency and colour, becoming softer and reddish or blackish. Changes in the faeces were more marked in those cases in which the course was longer, i.e. in the more chronic cases. In the peracute cases in which the course from the time of infection to death did not at times exceed 16 days, the faecal changes were not conspicuous. It would appear that the establishment of haemorrhagic changes of the alimentary canal to which the variation of



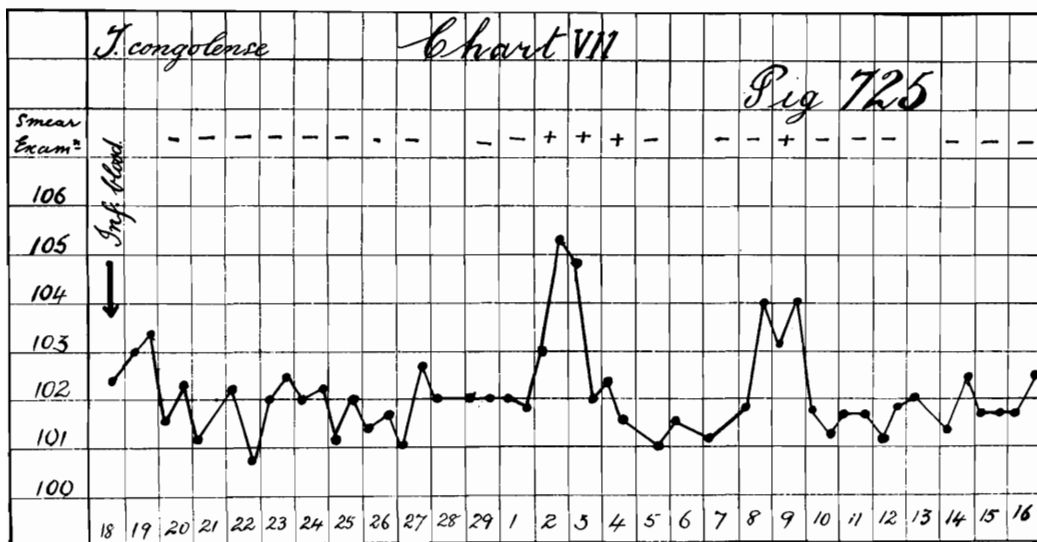


colour of the faeces is due, depends on the occurrence of the less acute condition. In the acute cases ulcerative stomatitis is present, the lesions of which are particularly evident on the floor of the mouth and along the borders of the tongue. These lesions bleed easily. Definite eye-lesions are also present in some cases. These were in the form of conjunctivitis and keratitis with symptoms of photophobia, lachrymation and oedema of the peri-orbital and even lower facial regions. In such cases blindness is present but, if suitable trypanocidal treatment be carried out, there results a complete recovery with no discernable residue of the eye-lesions even though no local treatment be undertaken. The rapid and complete recovery which results from the administration of trypanocidal drugs indicates, without any doubt, that the cause of the eye-lesions is the trypanosome. In one somewhat chronic case an anasarca<sup>ARCA</sup> was present, the entire body presenting a swollen appearance and pitting on pressure. This condition disappeared with suitable treatment. The temperatures do not show the exacerbations and remissions to the same extent as in the ruminants. Chart VI, which is of an acute case, is submitted. The most conspicuous features of T. congolense infection of dogs are the haemorrhagic gastro-enteritis, the ulcerative and at times gangrenous stomatitis and pharyngitis, the oedema and the eye-lesions. The trypanosomes were always easy to find in blood smears.

(iv) Symptomatology in swine. In the pigs which were infected with the Rhodesian and the Zululand dog strain, the period of incubation corresponded fairly closely. The shortest period when judged from the first appearance of T. congolense was 11 days and from the first elevation of temperature also 11 days. In every case with one exception, the parasites were found on the day of elevation of temperature. Blood smears were utilized for this examination and trypanosomes were always difficult to find never being so numerous that they could be described as being fairly frequent. In the examinations made on 140 days, only 45



were found to be positive. Influencing factors might have been the good condition the pigs were in at the commencement of the experiment, and the good housing and feeding. The infection did not interfere with growth and no changes in normality of defaecation, respiration and appetite were noted. Blood examination for anaemia was not carried out. The temperature curves in all the five pigs experimented with showed the exacerbations and remissions commonly found in T.congolense infection of other animals, but the variations were not as marked as frequent, or as persistent as, for example, in the sheep. The variations became less accentuated very soon after the passing of the first acuteness of the disease. A temperature curve covering the first four weeks of the infection is represented on Chart VII, together with the blood smear examination. The T.congolense infection produced in these pigs was of a subacute type. Other observers, especially in the Congo, have reported the disease as being peracute. Probably environmental conditions are the deciding factors.



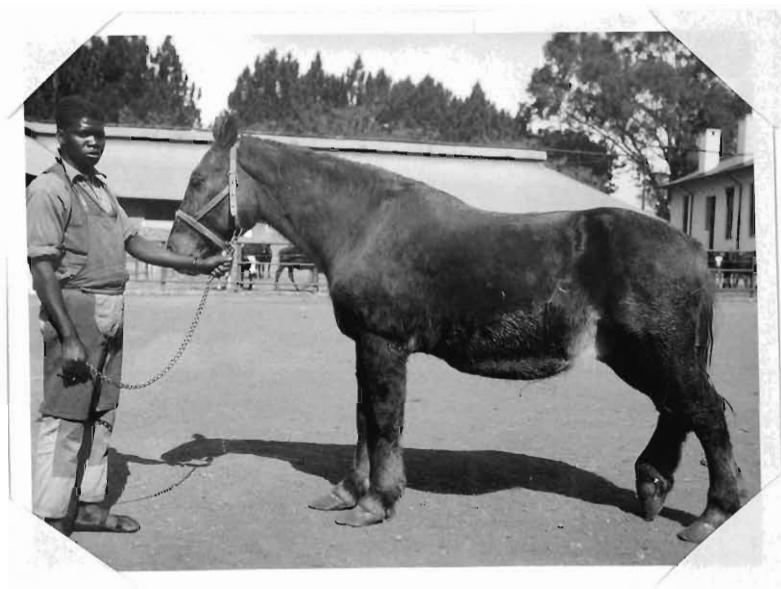
(b) TRYPANOSOMA BRUCEI INFECTION OF EQUINES, OVINES AND CANINES.

T.brucei produces in horses an acute disease whereas in bovines and ovines the disease is of more chronic a nature often without definite clinical symptoms. T.brucei was the earliest trypanosome described in the dog but there is the possibility that T.congolense plays a more important rôle in these animals than was previously thought. Many observers consider that T.brucei is of comparatively little importance for bovines, these animals merely acting as reservoirs for the parasites.

(i) Symptomatology in equines. The infection was produced in only one donkey. This animal showed a gradually progressing wasting disease without marked oscillations of temperature. The trypanosomes were easily found in stained blood smears occasionally becoming frequent. The loss of condition and the weakness of the animal were obvious. The donkey ultimately died after a course of 20 weeks. In horses, however, the same strain which was used to infect the donkey produced an acute disease with a comparatively short course at times less than or not much in excess of one month. The period of incubation in the horse may be as short as 4 days whether judged from elevation of temperature or appearance of trypanosomes in stained blood smears. Gland smears were difficult to make. In those examined no parasites were found. Anaemia as determined by blood examinations develops and its clinical signs are soon evident. Weakness and swaying gait, inability to move at a fast trot, rapid loss of condition, pale mucous membranes which are occasionally icteric, capricious appetite, weak pulse which, when the animal is exercised, becomes markedly accelerated, impaction of the heart against the chest wall determinable by palpation and by sight, hide bound condition of the skin, all appear early in the disease. An observer is particularly struck by the loss of condition and the weakness. Anaemia can be definitely demonstrated by the blood examinations. The number of red cells decrease as does the

percentage of red cell precipitate. Chart IX represents the changes in the red cell precipitate of horse 20417. The infection in this horse is not as acute as in some other case, and furthermore, there is some slight interference towards the end with the anaemia by the introduction of a treatment which resulted in the disappearance for short periods of the trypanosomes. The effect of the latter is probably a decrease in the rate of decline of the precipitate. Notwithstanding it can be seen that the anaemia progresses fairly rapidly. Oedema and eye-lesions do not appear in every case. Photograph 5 illustrates the oedema in one case while photograph 6 illustrates the appearance of a case of T. brucei infection of a horse in which oedema and eye-lesions did not appear. This photograph was taken on the day of death. The horse of photograph 5 showed slight opacities of the cornea. The temperature curve of T. brucei infection of the horse is very striking and of all the trypanosomiases worked with this disease gives probably the most characteristic curve. Chart X is submitted as an illustration. Of interest in this disease, on account of statements already referred to, is the progress, at times, of the disease in the horse to a fatal issue without the development of oedema or the appearance of eye-lesions. The trypanosomes are often difficult to find in blood smears but occasionally they become extremely numerous. By appropriate manipulation with drugs the parasites can be controlled to such an extent that they horse may live for years without further treatment. In such cases the parasites is extremely difficult to detect in blood smears and sub-inoculation of a small quantity of blood into a susceptible horse may fail to transmit the disease. Yet the state of the horse is not entirely comparable to that of a bovine prone to T. congolense for the horse does not approach as near to normality as does the bovine. The horses used were old ones, whereas the bovines were young. Possibly better results would have been obtained if young horses had been used.

(ii) Symptomatology in canines. Only a few dogs were placed under observation. In every case the infection was



Photograph 5. H. 19431. T.brucei infection.



Photograph 6. H.17974. T.brucei infection. Day of Death.



