

Symptomatology of some Trypanosomiases of Domestic Animals.

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THE symptoms in bovines, ovines and swine 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.

(a) **TRYPANOSOMA CONGOLENSIS INFECTION IN BOVINES, OVINES AND SWINE.**

(i) 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 passes into the chronic form and at times even into the premunished 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 conditions the animal lives under. The more severe these conditions are the more acute is the disease. These determinations correspond to what is known to happen under field conditions. Good climatic and hygienic conditions plus a good food supply postpone, under field conditions the onset of the recognised 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 ushered 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 found 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 are never very marked, but 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. Chart 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 characterised 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 pre-munition, 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 pre-munition, 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. Photographs 1 (*a*) and (*b*) of bovine 3636 illustrate the appearance of a chronic case of *T. congolense* disease 19 weeks after infection. Chart III represents the temperature curves of this bovine during the acute and chronic states, the former curves 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 forms 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 symptoms such as salivation, lachrymation and photophobia associated with oedema and acute keratitis may be observed. Photographs 2 (*a*) and (*b*) of bovine 2727 illustrate the appearance clearly. Although no local treatment of the eyes was carried out, the eye-lesions in this case improved rapidly on the institution of a trypanocidal treatment. 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 3416, 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 (1928), 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 generalised oedema in *T. congolense* infection of dogs. Furthermore, the condition in *T. brucei* infection of horses is in many cases characterised 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 pre-munition. 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. Common also to the three types of *T. congolense* infection is the negative finding or 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, punctate 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 pre-munition, 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 illustration 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 pre-munited state, the infection with *T. 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 pre-munited 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 pre-munited 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.

(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 form. 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. There is an albuminuria. The blood examination reveals also as in cattle, an anaemia which is at a fairly low level early in the disease. Chart XII 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 Chart V is submitted, which represents the temperature curve of the same sheep 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 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 utilised 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 VI, 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 a more chronic nature, often without definite clinical symptoms. *T. brucei* was the earliest trypanosome described in dogs 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 VIII 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 trypanosomiasis worked with this disease gives probably the most characteristic curve. Chart IX 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 the horse may live for years without further treatment. In such cases the parasite is extremely difficult to detect in blood smears and subinoculation 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 immune 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 produced by the subcutaneous injection of blood of a horse infected with *T. brucei*. The shortest period of incubation in these dogs was, when judged from the first appearance of the parasite in blood smears, seven days and from first elevation of temperature sixteen days. If further subinoculation had been carried out possibly shorter periods would have been obtained, for the strain of *T. brucei* had been maintained in horses for two-and-a-half years. The trypanosomes were in most cases difficult to find in the blood smears. The course compared with *T. congolense* infection in the same animal was long and even though death resulted ultimately in all the cases there was not the same acuteness associated with the infection as with that of *T. congolense*. There were no symptoms of note other than the fever symptoms. The absence of oedema and of eye-lesions as compared with the definite development of these in *T. congolense* infection is of interest. (See Chart X.)

(iii) SYMPTOMATOLOGY IN SHEEP.

Of all the trypanosomiasis observed *T. brucei* infection of sheep gave the most meagre symptoms. Other than mild fever symptoms,

no abnormality was determined. The temperatures at the commencement of the infection are somewhat irregular but they soon settle down to a comparatively non-oscillating type (see Chart XI). The parasites were extremely difficult to find in the blood smears.

As an illustration of the difficulty of diagnosing the infection by this means may be instanced the blood smear examination of three sheep, the first, second and third generation of the trypanosome after leaving the reservoir, a horse. In the first generation one trypanosome was found in 22 blood smear examinations, and in the second and third no trypanosomes were found in 60 examinations. The complement fixation test was positive. In addition gland smears were examined with negative results. There are no indications of anaemia when judged from the determination of red cell precipitate. Chart XII gives the determinations in a sheep infected with *T. brucei* and in one infected with *T. congolense*. In another sheep the red cell precipitate showed practically no variation during the period of observation which extended from the 24th June to 26th August, 1932.

(c) SYMPTOMATOLOGY OF *T. vivax* INFECTION.

SYMPTOMATOLOGY IN BOVINES.

This infection was produced in all cases except one by the injection of the blood of an infected bovine. As these carriers of the infection had at some previous time been infected with *Piroplasma bigeminum* and, or, *Anaplasma marginale* the *T. vivax* infection was complicated with these diseases. Consequently the temperature curve did not give a true index of the *T. vivax* infection. In the exception noted above the *T. vivax* was transmitted to a bovine by the bite of a tsetse fly. This temperature curve on Chart VII is thus the only true curve of *T. vivax* infection available. The temperatures subsequent to the initial stage do not show marked exacerbations and remissions. Constitutional disturbances are not conspicuous. There is at first some inappetence and a loss of condition, the latter of which might not be fully recovered for a few months. During this period of bad condition the coat is dry and poor in appearance. The superficial lymphatic glands are enlarged. The parasites are difficult to find in the blood smears. In one case, bovine 2727, the animal was not treated and regular examination of both blood and gland smears was carried out over a period of 44 weeks. During the 33rd week *T. vivax* was found in a gland smear, but no trypanosomes were found either in blood and gland smears for 15 weeks before and 11 weeks after this finding, representing in all an examination of 108 smears. *T. vivax* infection in bovines under the conditions prevailing at Onderstepoort thus is a disease which does not produce effects of any great severity. The majority of animals recover, i.e. they regain their normal condition and appearance without the institution of treatment. The possibility of a spontaneous sterilisation must also be considered. (For further information on this matter, see the report by the writer which is shortly to be published in the *Onderstepoort Journal*).

LITERATURE.

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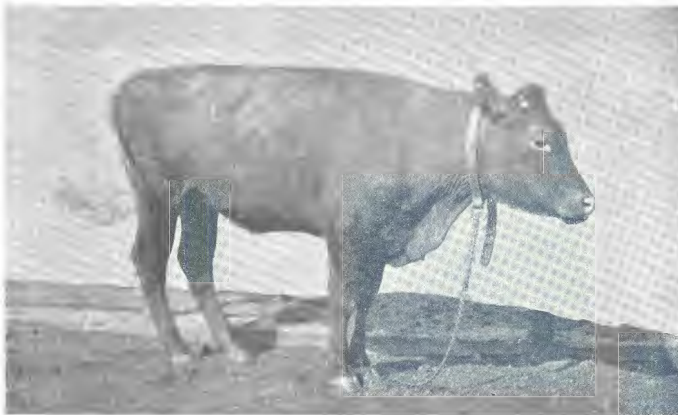
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I (a).



I (b).

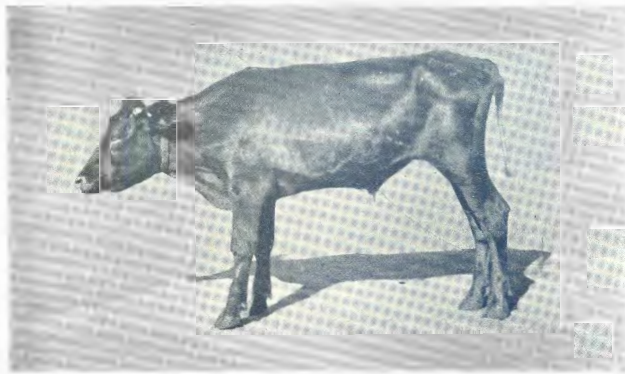


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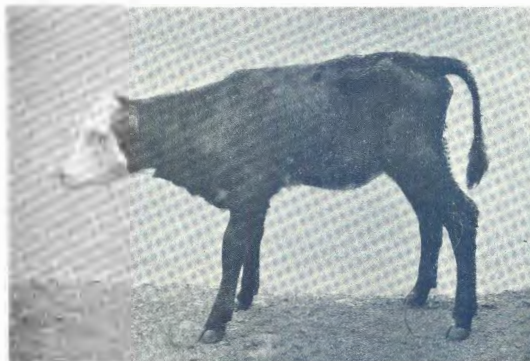
II (a).



II (b).



III.



IV.

