

Paper No. 2.

## CAMEL TRYPANOSOMIASIS IN THE SUDAN.

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### INTRODUCTION.

THE commonest form of trypanosomiasis in camels in the Sudan is caused by *Tryp. soudanense*, an organism of the *Tryp. evansi* type. The immunity reactions of this local trypanosome have never been tested and the name *Tryp. soudanense* is retained for general convenience. Infections due to *Tryp. brucei* and *Tryp. congolense* have been found in nature, and experimentally infection with *Tryp. rhodesiense* and *Tryp. vivax* have been found possible.

*Tryp. soudanense* infection is the only one that has been extensively studied, and is the only one that will be discussed in detail. It may, however, be mentioned that infections with other species appear to be very similar, with the exception that *Tryp. congolense* infection probably runs in general a more acute course and is not quite so easy to cure.

With the great advances recently made in the control of this disease, or group of diseases, whereby it is possible to diagnose obscure cases and cure all cases with nearly absolute certainty, it might be imagined that camel trypanosomiasis could be laid aside as a solved problem. This, however, appears not to be so. In the first place, it is not certain that the present methods of control, although adequate, are the best; further, it seems possible that in the camel, an animal in which all phases of trypanosome infection can be induced, diagnosed, and checked at will, one has a subject the study of which may enable further light to be thrown on the problem of trypanosomiasis as a whole.

The following is a brief summary of present knowledge in the Sudan.

### A. TRYPANOSOMA SOUDANENSE INFECTION.

#### 1. THE TRYPANOSOME.

As mentioned in the introductory notes, the name *Tryp. soudanense* is retained for general convenience. In every way it seems to conform to the *Tryp. evansi* type.

#### 2. TRANSMISSION.

As with other varieties of *Tryp. evansi*, the transmission appears to be entirely mechanical. The infection occurs in the non-tsetse areas, increasing at the end of the rainy season when tabanid flies are plentiful. No special transmission experiments have been attempted, but as *Tabanus taeniola* is the commonest fly, it is supposed to be the usual transmitter. Other species of *Tabanus* and many *Pangonia* and *Stomoxys* are associated and probably assume some share in transmission. In any case, the identity of the actual transmitter seems to be a matter of minor importance, as it is unlikely that any attempt will be made to eradicate the disease by eliminating the flies.

## 3. SYMPTOMS.

It has been generally accepted that the typical form of the disease is that of a subacute or chronic infection, and as this type of infection is so generally known, it is not necessary to discuss it further. The possible occurrence of hyperacute or relatively fulminant cases appears never to have been considered, largely no doubt because research has hitherto been directed almost entirely towards evolving a successful method of treatment, the subjects for such researches having mainly been so called "natural" or "normal" cases collected in the field.

Infection of batches of camels in the laboratory—lots of half a dozen or a dozen—for various experiments have shown extreme variability in the course of infection. As had been anticipated, most cases varied between an initial acute stage, sometimes fatal but usually becoming chronic, and cases subacute or chronic throughout. Quite frequently, however, extremely acute cases were observed, violent symptoms appearing within a day or two of, or on the same day as, the first appearance of trypanosomes in the blood-stream. The first symptom, if noticed, seems always to have been inco-ordinated movement of the hind legs, almost immediately followed by collapse and rapid death in convulsions, with trypanosomes swarming in the blood. The total duration of symptoms in some cases has been less than two hours.

The general train of symptoms would in the field probably lead to the opinion that some kind of poisoning was at issue, but in the laboratory such a diagnosis was almost entirely negatived, since of many camels fed and maintained in exactly similar circumstances only those with intense trypanosomiasis developed the symptoms. A particular case set the issue beyond doubt. The camel was one of a batch of twelve under observation in an experiment where all camels were kept at work. In regard to the remaining eleven, there was nothing unusual, but this one camel, after doing a morning's work, returned to the lines, collapsed, and became comatose within a few minutes—in fact, a report was sent to the laboratory that the camel was dead. On examination, the blood was found to be swarming with trypanosomes, a dose of Naganol was given, and the camel rapidly recovered.

The next point of interest was to decide whether such cases were common in natural circumstances in the field. Hitherto they had only been observed in experimentally infected camels, and it was not beyond doubt that the strain of trypanosome employed had not in some way become exalted. Exaltation was not probable, since the strain had been maintained in camels for many generations without appearing to gain in virulence, and in addition numbers of camels infected simultaneously with those developing fulminant symptoms had not been so affected.

Appeals were therefore made to veterinary officers in the field for closer observation of camels showing violent symptoms of any kind, and recently corroborative evidence has been received from two sources that such cases occur. The first evidence is from an officer stationed in a district noted for camel trypanosomiasis, who states that throughout one autumn he was repeatedly asked to see camels reported to be dying of some kind of poisoning. On examination, the camels were found to be suffering from trypanosomiasis. In this particular district

this officer now treats all so-called "poisoning" cases with Naganol, without troubling to confirm the diagnosis of trypanosomiasis, and the camels recover.

The second is an individual case of an Army camel that was noticed to be lame in one hind leg. It was assumed that the animal had slipped up on the march and sprained its back, although there was no direct evidence of such accident having occurred. Blood examinations showed the presence of trypanosomes, the camel was given Naganol, and the symptoms of "sprained back" disappeared.

The question of hyperacute trypanosomiasis in camels has arisen so recently that little evidence is available for discussion. There appears, however, to be no doubt that it occurs in nature, but cases are probably missed because the symptoms are not those that have hitherto been commonly associated with this infection.

#### 4. DIAGNOSIS.

Little discussion is necessary regarding microscopic examination of the blood as a method of diagnosis. It may be dismissed by stating that it is of moderate use in the acute stages of the disease in such animals as pass through an acute stage. Even so, a single examination is of little use, and in the Sudan repeated examinations are often impracticable.

Small-animal inoculation is the most certain method, but under field conditions it is not practicable.

The adaptation of the formol-gel test, already used successfully for the diagnosis of human kala-azar, constituted a great advance, and by treating all subjects giving a positive reaction to this test it may be claimed that for the first time camel trypanosomiasis was brought under adequate control. In regard to this test, however, it was soon noticed that its accuracy was not so great as had been hoped; in the main the results were reliable, but many non-infected camels gave positive reactions and some infected ones failed to do so, even several weeks or months after the date of infection. The former inaccuracy was known at the time the test was generally adopted in this country, but the latter has been increasingly brought to notice during the two years that the test has been used as the standard diagnostic measure.

A possible reason for the inconsistent results is that the test as applied to camel trypanosomiasis was necessarily different from that employed in the diagnosis of human kala-azar. In the latter disease the essential diagnostic phenomenon is the development of opacity in a formolized serum, whereas in camel trypanosomiasis gelation was found to run much more closely parallel with infection and was of necessity adopted as the more reliable reaction. There was no reason why gelation should not be characteristic of trypanosome infection, but since in practice too many errors were noticed, attempts had to be made to devise some test in which precipitation should be the basis. The precipitate in the formol-gel, or more correctly the serum-aldehyde, reaction has been found to consist of euglobulin, a large excess of which is found in kala-azar patients. It seemed likely that an excess of this serum fraction might exist in camels suffering from trypanosomiasis, and, recognizing its instability in solution, it seemed that the number of agents that might precipitate an excess of it was practically unlimited. Many compounds have been tried in the Sudan, most of them with promising results, but the most consistently useful up to the present has been mercuric chloride. Parallel estimations of

the serum fractions of infected camels have shown that, as in kala-azar, an excess of euglobulin is present, although not so great an excess as in the human disease. This lower excess probably explains the irregularity with which opacity develops in formolized infected camel serum.

The technique at present adopted in carrying out the mercuric chloride test is to draw serum from the suspected camel, allow the blood to clot and stand overnight, and to add one drop of the serum to one cubic centimetre of fairly freshly prepared 1/25,000 aqueous mercuric chloride solution. A positive reaction is indicated by the development of opacity within a few minutes. In early cases only a faint white haze is recorded, but in older cases a heavy white precipitate forms; higher dilutions of the salt also give precipitate in older cases.

Up to the present time about 250 camels under laboratory observation have been submitted to this test, and in no case has an infected camel failed to react, while no normal camel has yet done so. A further great advantage is that the test is of sufficient delicacy to detect the disease within about a fortnight of infection, and will thus detect it in the early stages in camels which do not experience a primary acute phase.

A few observations have shown that after cure the euglobulin excess and the mercuric chloride reaction disappear in about two months.

#### 5. TREATMENT.

The treatment of camel trypanosomiasis can be summed up in one word—Naganol (Bayer 205). The curative value of this compound appears to be in the region of 100 per cent. provided it is administered before a camel is at the point of death.

It has been found that the lowest single dose that will cure all cases with certainty is 10 grammes, although a considerable portion of camels can be cured with single doses of 5 or 6 grammes. At the present time all camels in the Sudan diagnosed as having trypanosomiasis are given a single intravenous injection of 10 grammes, and no relapse has hitherto been noticed.

At one time certain circumstantial evidence was interpreted as indicating that immunity in camels cured with Naganol was of long duration. *A priori*, this claim was opposed to the general experience in cured protozoan infections, and deliberate experiments have shown that immunity probably does not last much longer than the time necessary for the Naganol to be eliminated from the body. Experience with a similar if not identical disease in Russia has shown that Naganol given as a prophylactic is useful for at least three months, while reinfection experiments in the Sudan have shown that cured camels are not resistant for much more than four months. It seems, therefore, that a "relapse" should not be diagnosed at any longer interval than four months after cure; a reinfection is almost certainly at issue, and in this sense reinfections have been observed in the Sudan.

A possible objection to Naganol is the cost; a single dose costs nearly ten shillings. It would seem that if a camel is worth treating, the sum of ten shillings is not too much to pay for the certainty of a cure, but in any case a considerable saving could be effected on large-scale operations if the dose could be reduced. As a single drug it has

been shown that 10 grammes is the lowest certainly curative dose, but by combining it with tartar emetic there is promise of instituting a cheaper routine treatment.

Small numbers of camels have been treated with Naganol, 4 grammes, and tartar emetic, 2 grammes, simultaneously. The two drugs mix well in solution and these doses seem to effect a cure. There is, however, always the objection that if trypanosomes are present in the blood-stream tartar emetic is dangerous. This objection is not removed by the use of sodium antimonyl tartarate. More deliberate experimental work is necessary, but it seems probable that the ultimate routine treatment may be to give Naganol alone to camels showing blood-stream infection and Naganol combined with tartar emetic to those in which a diagnosis is established by the mercuric chloride test.

#### B. TRYPANOSOMES OTHER THAN *TRYP. SOUDANENSE*.

The tsetse-borne trypanosomes are not commonly found in camels, mainly because camel transport is rarely employed in the tsetse areas. Outbreaks of *Tryp. brucei* and *Tryp. congolense* infection have, however, occasionally occurred in camels, and some small study has on this account been devoted to the cyclically transmitted trypanosomes. The following are brief records of observations:—

1. *Tryp. brucei*.—Only one camel observed. Infected with a fatal mule strain, trypanosomes appeared in the blood within a week and were almost continuously present for over a month. A positive reaction developed to the formol-gel test in seven weeks. A single dose of 10 grammes of Naganol effected a complete cure.

2. *Tryp. congolense*.—Strain that had appeared in camels in the field and had been responsible for a very acute course and rapid mortality in nature. Two camels were infected, the one with the milder infection being retained as control. The control camel showed trypanosomes on the 19th day, showed the first other sign (off feed) on the 27th day, and died on the 30th day. The history of the second camel was as follows:—

|           |   |
|-----------|---|
| Zero day: | Inoculated.   |
| 13th day: | Tryps. appeared.  |
| 15th ,,   | Off feed.   |
| 16th ,,   | Tryps. swarming, collapsed and became comatose.<br>10 grammes Naganol given. Camel recovered and appeared to be normal. |
| 26th ,,   | Tryps. reappeared.  |
| 27th ,,   | Off feed, swaying gait, 20 gm. Naganol given and camel again became normal.   |
| 37th ,,   | Tryps. reappeared.  |
| 38th ,,   | 10 gm. Naganol + 2 gm. sodium emetic.   |

From this point the camel seemed to be quite normal in every way for three and a half weeks, when it suddenly died from some undetermined cause, the only post-mortem symptom of which was enteritis.

3. *Tryp. vivax*.—Bovine strain, one camel infected. Trypanosomes appeared in the blood-stream on the 17th day and remained until the 25th day. From this point trypanosomes were not seen, but the camel lost condition and developed a positive reaction to the formol-gel test in six weeks. The mercuric chloride reaction became positive in a week and the titre continued to rise until the day of

treatment. At the end of six weeks a single 10-gramme dose of Naganol was given and the camel recovered.

4. *Tryp. rhodesiense*.—Human strain from the Southern Sudan. One camel infected. Trypanosomes appeared in the blood on the 7th day and the infection ran a fairly acute course. Circumstances did not permit of longer observation and the camel was given 10 grammes of Naganol on the 18th day. A complete cure resulted.

The number of cases recorded under this head is small and on that account it is not desirable to draw any general conclusions. *Tryp. brucei* in the host from which this strain was obtained—a mule—produces a fatal incurable infection. It is not absolutely certain that it would have killed the camel, but, judging from the earlier stages of the disease, it seems highly probable. Regarding *Tryp. vivax*, the natural virulence is not always high, but the strain employed here had killed cattle and, again judging from earlier symptoms, it gave promise of killing the camel failing treatment. The *Tryp. congolense* strain had been found to kill camels very rapidly in nature; and regarding the *Tryp. rhodesiense* strain, nothing can be said except that it also produced an infection that before treatment showed every sign of progressing to the usual termination.

The question of complete cure in the case of the *Tryp. congolense* infection is possibly open to doubt, but in none of the other instances is this so; in fact, from the few cases studied, it seems that in the camel infection with any species of trypanosome is probably curable by Naganol, either alone or in combination, whereas infection with these same trypanosomes in other hosts is not.

There has hitherto been no opportunity to carry out further work on these lines in the Sudan, also there seems to be no probability of doing so in the near future. The significance may be small; the camel may by mere chance behave in a similar manner to, say, mice or guinea-pigs. It may, however, be that there is some factor in the camel which in combination with moderately efficient trypanocidal substances—in this case Naganol—renders them more efficient. In any case the wide range of susceptibility and the actual size of the animal suggest it as a useful experimental subject.

#### SUMMARY.

1. Camels are probably susceptible to all species of trypanosomes pathogenic to various mammals. In nature, owing to their peculiar habitat, the commonest infecting species is *Tryp. soudanense*, and infection with this species has received most attention.
2. In addition to the generally recognized trains of symptoms, the camel not infrequently develops an atypical fulminant type of infection, the existence of which seems not to have been suspected in the past.
3. By the use of the formol-gel test, and later the mercuric chloride test, diagnosis has been improved to the point of almost absolute efficiency.
4. A single dose of 10 grammes of Naganol (Bayer 205) has never failed to cure a camel of *Tryp. soudanense* infection, and it shows great promise with other species of trypanosomes. It seems probable that a combination of Naganol and tartar emetic is at least as useful, and possibly even better—subject always to the objection that in certain types of infection tartar emetic is dangerous.
5. A tentative point is raised as to the possibility of utilizing camels in the study of trypanosomiasis generally.