A FURTHER NOTE ON FILARIÆ IN THE BLOOD OF CAMELS IN EGYPT.

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IN February 1906 I reported having found filarial embryos in the blood of a camel which showed clinical symptoms closely resembling trypanosomiasis, with the addition of an abscess on the off quarter. The embryos were somewhat smaller in size but similar in shape to those found in Algerian camels by E. and E. Sergeant.¹

A few months later I succeeded in obtaining from the Cairo abattoir the male genitalia of a camel containing adult filariæ in the blood-vessels and vas deferens. The females were up to 20 cm. in length by .75 mm. in breadth. The males measured from 8 to 12 cm. in length by .5 mm. in breadth. I thought these were possibly the parents of the embryos found in the circulating blood, and expressed that opinion in my note on the subject.²

Subsequently other specimens of the adult parasites were found in the male genitalia of camels, sometimes causing aneurisms of the spermatic artery, and always more or less cirrhosis of the epididymis.

It was not until December 1909, when systematic examinations of the blood were made of all camels showing symptoms of a general disease, that the filarial embryos were again found.

Symptoms.—These resemble trypanosomiasis, and vary as much according to the severity of the parasitic invasion, the amount of work the subject has been required to perform, and the food supplied. Without the aid of the microscope filariasis cannot be with certainty distinguished from trypanosomiasis, and not infrequently the two diseases are co-existent in the same camel.

In severe cases there is emaciation, extreme weakness, pallor of the mucous membrane, harshness of the coat, watery discharge from the eyes, constipation, dark colour of the urine, disinclination to eat, and sometimes œdema of the sheath, belly, etc., and particularly the hind limbs. The temperature, taken at 9 A.M., registers up to 39.8° C., and it will rise to 41° C. in the evening. The fever lasts for several days—five, six, or seven—according to the severity of the attack, during which period the embryos are easily found in the peripheral blood. The temperature then falls to the normal for a few days, and the embryos are, as a rule, no longer found by ordinary examinations of blood films. In this manner recrudescences follow each other, as in trypanosomiasis, with intervals free from fever.

In my former report I made the statement that apparently the presence of embryos in the peripheral blood was affected by night and day; this I am now able to contradict. The presence of embryos in the blood, in sufficient numbers to make their discovery in films an easy matter, is entirely periodic, and the periods are synchronic with those of fever.

In the milder cases, which outnumber the severe ones, the condition is poor but not emaciated, the appetite good except during the periods of fever, which may occur at intervals of from fifteen to

¹ Ed. and Et. Sergeant: "C.R. Soc. Biol., LVIII., 1905, p. 672, quoted in abstract in "Jour. Trop. Vet. Science," II., 1907, p. 150.

² "Jour. of Comp. Pathology and Therapeutics," Vol. XIX., 1906, p. 120.

thirty days and last from one to three days. Most of the symptoms seen in the more severe type are reproduced in the mild type in a less degree.

The subjects are able to do a little light work, but are not fit for heavy work or a forced march, under which the symptoms become aggravated, and they collapse.

In both the severe and chronic cases there is marked enlargement of certain groups of lymphatic glands, with a tendency to suppuration and induration. A gland or glands may suppurate repeatedly at intervals, and inflammatory tumours up to the size of a cocoanut may be formed. Gravitation abscesses are sometimes formed

FIG. 1.

Showing the two extremities and part of the middle of the body of an adult female. ($\times 35$.)

secondarily to suppuration of lymphatic glands. These are most frequently seen in the region of the shoulders and breast, following suppuration of the prepectoral glands. I have also seen them on the sheath and inside the thigh, secondary to a lesion of the inguinal glands.

Purulent peritonitis is a common cause of death among camels, and though up to the present I have not definitely traced its source to filariasis, I suspect that in the course of the disease a mesenteric gland sometimes suppurates into the peritoneal cavity, with the usual consequences. On *post-mortem* examination of an ordinary case of filariasis it is not uncommon to find some of the mesenteric glands enlarged and hæmorrhagic.

In addition to enlargement and not infrequent suppuration of the superficial groups of glands, with or without secondary or gravitation abscesses, there may occur subcutaneous abscesses which are not obviously dependent upon a gland lesion. The seats in the order of frequency are: shoulder, quarter, sternal pad, root of tail, stifle pad.

The most serious of these is the suppuration of the tissues beneath the sternal pad or callosity, as it prevents the animal from taking proper rest and is persistently recurrent. The lesion may take the form of an acute abscess, or of a sinus with chronic suppuration. In

FIG. 2.

Showing the two extremities and part of the middle of the body of a mature male worm. ($\times 375$.)

either case, with operation and subsequent careful dressing, complete healing may be obtained; the abscess or sinus reforms a few weeks or months later, and this may recur several times. The Bedouins call this condition of the sternal callosity "surrar."

Examination of the pus from any of the abscesses reveals a mixed bacterial infection, but no trace of filaria; if the latter be the cause, their bodies when they die are probably disintegrated by the time the abscess is ripe. The contents of the scrotum are often obviously enlarged.

The Bedouins have no hesitation in designating what I have

described as acute and chronic filariasis as "madroub," meaning stricken (by the fly), a term which really applies to El Debab, and is used synonymously.

Losses and Duration.—The disease is less fatal than trypanosomiasis. In the great majority of cases, if the subjects are placed in good hygienic conditions, clothed, and fed on green food for the first month, improvement takes place. The periods of fever become less frequent, of shorter duration, and the temperature does not rise so high, often not exceeding 38.5°C . at 9 A.M., but rising to 39°C . or 39.5°C . towards evening. Even bad cases may become fat in three months of rest and good feeding. However, return to work

FIG. 3.

Showing development of embryos *in utero*. ($\times 450$.)

will in a short time 'cause the periods of fever to return with their old severity and with all the accompanying symptoms.

The percentage of mortality has yet to be determined; that the disease incapacitates considerable numbers of camels totally or partially from work for long periods is established. In March 1910 twenty-two sick camels from the Suez Canal district were examined, and smears were taken whenever the temperature rose above normal; twelve of the camels had trypanosomiasis, eight had filariasis, and two had a mixed infection of both diseases.

Regarding the latter, it is perhaps worthy of note that on each occasion both parasites were present on the same slide; the periods

of fever were not unusually frequent for either disease; the paroxysms appeared to be synchronous. (See temperature tables, camels Nos. 153, 159.)

The eight subjects of filariasis were under observation, with good food and entire rest, from the beginning of March until June. Seven of them were then returned to duty, and the eighth remained under treatment for fistula of the pad and an inflammatory growth on the shoulder until 2nd November.

Subsequent inspections show that of the eight camels: One was slaughtered 24th January 1911, as being quite useless for work though in fair condition; one appeared well; one was unfit for work, and was recommended for casting; five were able to do a little work, with periods of rest in between. It is hoped that they will live longer than the parasites they harbour.

FIG. 4.

Drawings of embryos as seen in blood, stained by Leishman's method. (1, $\times 450$; 2, $\times 250$.)

Of the total number at the present time, three have sinuses of the sternal pad and one has an abscess in connection with the stifle pad.

The Distribution of the disease in Egypt appears, in the present state of our knowledge, to coincide with the distribution of El Debab. Possibly the *tabanus tæniola* and *tabanus ditæniatus*, which are credited with transmitting El Debab, are also capable of transmitting filariasis by direct inoculation of blood containing the embryos from the diseased to the healthy.

A more recent systematic examination of twelve old camels returned as unfit for duty showed that ten had a mixed infection of filariasis with trypanosomiasis, one had filariasis only, and one trypanosomiasis only.

The following tables show the temperatures of eight camels with filariasis during approximately three months, and the temperatures

MARCH 1910.

<i>Camel.</i>	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	16th	17th	18th	19th	20th	21st	22nd	23rd	24th	25th	26th	27th	28th	29th	30th	31st
991 F.	—	—	—	—	39.3	35.1	38.0	35.6	35.6	35.3	35.9	35.8	35.8	38.0	38.2	38.0	38.3	38.0	35.2	35.8	35.8	35.5	—	37.0	37.0	38.3	36.3	38.2	38.0	37.0	36.0
998 F.	—	—	—	—	38.2	35.1	35.1	35.8	35.8	35.6	35.0	35.8	35.8	38.0	38.0	38.0	38.4	38.0	38.0	38.3	35.8	35.4	—	37.0	36.0	37.3	37.0	37.1	37.2	37.2	37.8
926 F.	—	—	—	—	38.0	38.2	38.5	38.1	35.8	38.0	38.0	35.8	38.0	38.0	38.0	38.0	38.0	38.4	38.6	35.8	35.8	—	—	—	—	—	—	—	—	—	—
716 F.	—	—	—	—	—	—	—	35.4	35.7	38.0	35.9	35.8	35.9	38.0	38.0	38.2	38.0	38.0	35.5	35.8	35.6	35.8	—	39.0	37.8	37.0	39.0	38.2	37.0	37.0	36.6
747 F.	—	—	—	—	—	—	—	35.5	35.8	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.4	38.0	35.6	35.6	38.4	35.6	—	37.0	37.1	37.0	36.0	37.7	37.2	37.0	37.0
248 F.	—	—	—	—	—	—	—	35.6	35.6	35.4	35.0	38.3	38.4	38.0	35.9	38.0	38.0	38.0	35.6	38.0	38.4	35.4	—	36.4	37.2	37.0	36.0	38.0	37.4	38.0	38.0
818 F.	—	—	—	—	—	—	—	35.3	35.7	35.6	38.1	38.0	38.3	38.5	38.0	38.0	38.0	38.0	35.4	35.8	35.8	35.4	—	37.0	37.6	37.0	37.1	37.0	38.2	37.9	37.0
824 F.	—	—	—	—	—	—	—	—	—	—	38.1	38.0	35.9	38.0	38.0	38.0	38.0	38.0	35.8	38.0	38.3	38.8	—	39.4	38.0	37.0	36.2	37.1	37.0	37.2	37.0
150 F. & T.	—	—	—	—	—	—	—	35.5	38.0	38.3	35.9	35.8	35.9	38.0	38.0	38.0	38.0	38.0	35.8	35.6	35.4	35.8	—	36.3	37.0	37.0	37.1	89.0	38.0	38.0	37.6

Note.—Temperatures until 22nd March inclusive were taken at 6 A.M., which accounts for the low normal temperatures.

After that date they were taken between 9 and 10 A.M.

APRIL 1910.

<i>Camel.</i>	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	16th	17th	18th	19th	20th	21st	22nd	23rd	24th	25th	26th	27th	28th	29th	30th	31st
991 F.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
998 F.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
716 F.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
747 F.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
248 F.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
818 F.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
824 F.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
150 F. & T.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

F. Filariasis.

F. & T. Filariasis and trypanosomiasis.

MAY 1910.

<i>Camel.</i>	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	16th	17th	18th	19th	20th	21st	22nd	23rd	24th	25th	26th	27th	28th	29th	30th	31st
	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
991 F.		36.3	37.0	36.8	37.1	37.2	37.0	36.6	37.0	37.0	37.3	37.4	37.4	37.5	37.0	37.6	37.3	37.4	37.0	37.2	38.2	37.0	—	—	—	—	—	—	—	—	—
998 F.		38.0	39.0	37.0	37.0	36.8	37.0	37.0	36.5	37.5	37.3	37.0	37.4	37.5	37.2	37.6	37.4	37.2	37.0	37.0	38.0	37.1	—	—	—	—	—	—	—	—	—
716 F.		36.8	39.0	38.0	37.0	38.2	38.0	37.0	37.0	36.2	37.0	37.6	37.0	37.2	38.0	37.6	37.0	37.2	37.5	37.0	37.6	37.4	37.0	37.4	—	—	—	—	—	—	—
747 F.		37.0	36.8	37.1	36.6	36.7	37.0	37.2	37.0	37.0	37.1	37.0	37.2	36.9	37.1	36.6	37.2	37.0	36.5	37.1	37.4	37.0	36.8	—	—	—	—	—	—	—	—
248 F.		38.3	37.0	37.2	37.0	36.8	37.0	36.6	37.0	37.6	39.0	38.0	39.4	38.0	37.7	37.0	37.3	37.0	37.2	37.6	38.0	37.4	—	—	—	—	—	—	—	—	—
818 F.		37.1	36.8	37.0	37.1	36.6	37.3	37.0	37.5	37.0	36.8	37.0	37.1	37.4	37.0	37.5	37.6	37.2	37.0	37.2	37.0	—	—	—	—	—	—	—	—	—	—
824 F.		37.0	37.0	36.7	37.1	37.5	38.0	37.0	37.6	37.4	37.0	38.0	37.0	37.2	37.0	38.0	38.0	39.0	37.2	37.0	37.2	—	—	—	—	—	—	—	—	—	—
150 F. & T.	37.3	37.0	37.4	37.0	37.2	37.0	36.8	37.6	37.0	37.1	37.0	37.3	37.0	38.0	36.8	37.2	37.4	37.0	37.5	37.2	37.0	37.7	—	—	—	—	—	—	—	—	—

JUNE 1910.

<i>Camel.</i>	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	16th	17th	18th	19th	20th	21st	22nd	23rd	24th	25th	26th	27th	28th	29th	30th	31st
	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
153 F. & T.	—	—	—	—	—	—	—	—	—	38.3	37.0	38.0	39.0	38.5	38.0	36.4	37.5	37.2	36.5	37.0	37.5	37.0	37.0	37.6	38.5	38.5	38.4	39.5	38.0	37.3	—

JULY 1910.

<i>Camel.</i>	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	16th	17th	18th	19th	20th	21st	22nd	23rd	24th	25th	26th	27th	28th	29th	30th	31st
	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
153 F. & T.	37.0	36.4	36.8	36.7	37.0	37.5	36.6	37.0	37.5	37.0	37.4	37.2	37.1	38.0	37.2	36.1	37.8	37.4	36.0	38.0	37.2	36.9	37.4	37.6	37.5	37.6	36.6	37.4	37.6	37.0	37.1

AUGUST 1910.

<i>Camel.</i>	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	16th	17th	18th	19th	20th	21st	22nd	23rd	24th	25th	26th	27th	28th	29th	30th	31st
	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
153 F. & T.	37.3	38.9	36.3	37.5	36.1	37.3	38.0	37.7	36.8	37.5	36.8	37.9	37.8	36.8	36.3	36.5	37.0	38.0	39.0	38.2	37.0	—	—	—	—	—	—	—	—	—	—

F. Filariasis.

F. & T. Filariasis and trypanosomiasis.

of two camels with a mixed infection of filariasis and trypanosomiasis.

Etiology.—The causal agent of this disease is a nematode worm found in the blood-vessels of the lungs, particularly the branches of the pulmonary artery, in the blood-vessels of the testicle, and in the vas deferens.

The adult worms may be found singly, in small numbers, or literally in masses in the positions above indicated. This agrees in part with Lewis's account of *filaria evansi*,¹ which were found in tangled masses plugging the pulmonary arteries, and also in the

FIG. 5.

Showing nodules in lung and on pleura in extreme case of filariasis. The mature parasites were very numerous in the branches of the pulmonary artery.

mesentery. Here his description ceases, and no clinical symptoms are recorded as being connected with the presence of the parasites.

On *post-mortem* examination of camels known to have been subjects of filariasis (*i.e.*, which have shown the symptoms previously described, with filarial embryos in the peripheral blood during the periods of fever), mature filariæ, presumably *filaria evansi*, have repeatedly been found in the positions already indicated. Sometimes they are most numerous in the branches of the pulmonary artery, with few or none in the testicle, or they may be numerous in both situations, or again, may be numerous in the testicle with but few in the lungs. They are never entirely absent from the latter.

¹ Lewis, "Proceedings of the Asiatic Society of Bengal," March 1882, quoted in "Jour. Trop. Vet. Science," Vol. II., 1907, p. 151.

The adult females (fig. 1) measure up to 20 cm. in length by 7.5 mm. in breadth; the external covering is thick and shows a fine striation in longitudinal parallel lines; there is no cross striation. The mouth is terminal and the labia are small.

The vulva is placed about .6 mm. from the anterior extremity.

FIG. 6.
Testicle and epididymis, showing aneurismal dilatations (A and A'), mature worms in position (B), and cirrhosis of epididymis. The testicle is smaller than normal.

The males (fig. 2) measure up to 12 cm. in length by .5 mm. in width; the tail is spirally curved three turns on itself.

The parasite is viviparous, and the various stages of development have been seen in the preparations made from the uterus of the adult female (fig. 3). The egg is at first somewhat comma-shaped (fig. 3, No. 1), then ovoid (fig. 3, No. 2). In both these stages the proto-
y

plasm is clear. The contents become granular (fig. 3, No. 3), then segmented into cells (fig. 3, No. 4). Growth takes place and the cells arrange themselves into the form of a coiled up worm (fig. 3, No. 5); the worm grows and the shell is ruptured and cast off, liberating a still coiled up embryo (fig. 3, No. 6). The embryo uncoils or, rather, unfolds by stages.

If living adult females are placed in normal saline solution for a few hours a white sediment will be seen at the bottom of the vessel; on examination this sediment will be found to consist of embryos.

As seen in stained preparations in the peripheral blood, the embryos have an average measurement of $\cdot 172$ mm. in length by

FIG. 7.

Testicle showing incised aneurism and the causal parasites bulging from the incision.

$\cdot 005$ mm. in breadth. The anterior extremity is somewhat globular and the tail pointed (fig. 4).

Embryos obtained from the uterus are similar in appearance to those found in the circulation, but are apt to be larger than in stained blood films. Forms up to $\cdot 276$ mm. in length by $\cdot 006$ mm. in width are found in normal saline preparations.

Lesions Caused.—When the adults are in considerable numbers in the branches of the pulmonary artery they may produce nodules or tubercles resembling miliary tubercles, or multiple foci of inflammation without nodule formation. The number of nodules varies from a few to a great many. In one case the appearance presented to the naked eye was similar to that of miliary tuberculosis (fig. 5). The bronchial glands were enlarged and hæmorrhagic but showed no signs of tuberculous disease; repeated examinations for tubercle

bacilli both in glands and nodules gave negative results. As a rule the glands are normal or only slightly œdematous.

The histology of the nodules is similar to that of miliary tubercles, with the exception that occasionally portions of embryos can be distinguished within them. Embryos are numerous in the small arteries, and some are seen in the interstitial tissue of the lung, and occasionally in an alveolus. The pleura has nodules projecting from its surface. The bronchi are normal.

The lesions are not to be confounded with those of strongylosis.

In addition to the nodular lesions, aneurisms of the small arteries are met with, particularly along the lower borders of the lung. The aneurismal dilatations are in size up to that of a broad bean; the blood clot within contains coiled masses of adult worms. In some cases nodules are entirely absent.

Frequently dead adults are found attached to the intima of the pulmonary arteries, yellow and necrosed.

When the adult parasites are numerous in the male genitalia there is enlargement of the epididymis up to three or four times its normal size owing to the formation of connective tissue (fig. 6). The testicle is correspondingly atrophied. Aneurisms of the spermatic artery are common up to the size of a bantam's egg. There may be several aneurisms along the course of one artery. The aneurisms contain clots and masses of mature parasites. The vas deferens also contains the parasites and is much thickened. The inguinal glands in such cases are enlarged and hæmorrhagic. The lymph vessels leading from the inguinal glands forwards along the abdominal wall are corded and present a knotted appearance.

Treatment.—Up to the present no treatment, beyond placing the subjects in the best possible hygienic conditions with perfect rest and good food, has been tried. The inadvisability of killing large numbers of parasites of such dimensions in the pulmonary arteries, were it possible without incidentally killing the host, is obvious.

It has several times been noticed that in the course of treatment of camels for trypanosomiasis, in subjects weighing about 400 kilogrammes, and in which the disease was complicated with filariasis, salvarsan being given in doses up to 7·2 grammes intravenously, the appearance of filarial embryos in the circulation was unaffected. In certain other parallel cases the filarial embryos have not reappeared, nor has there been any rise of temperature above the normal for several months in camels at rest with good food. As previously stated, this effect can be produced by rest and good feeding alone, the disease reappearing with hard work on short rations. Seeing that embryos have been found in the circulation shortly after a dose of 7·2 grammes of salvarsan in some cases, and not in others of approximately the same body weight, it seems probable that the disappearance in the latter cases is due more to the great general improvement of condition consequent on the action of the drug on the trypanosomes, combined with rest and good food, than to any specific action the drug may have on the filaria. The particular subjects in question have not yet resumed work, and I therefore have not had the opportunity of judging whether they are free from filariasis.