

*Trypanosome Diseases of Domestic Animals in Uganda.\**III.—*Trypanosoma vivax* (Ziemann).

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[PLATES 3–5.]

Synonyms. { *Trypanosome* of Pordage's ox, 1903 (Sleeping Sickness Commission of the Royal Society, 1903).  
*Trypanosoma cazalbouii* (souma). Laveran.

## INTRODUCTION.

This interesting species of trypanosome appears to be widely distributed in Uganda. It was first discovered by the Commission in two cattle which came from Kavirondo, the district lying to the north-east of Victoria Nyanza. These oxen were driven to Kampala round the north end of the Lake, and probably became infected on the way.

Then the Government Transport Department lost many of their oxen from this trypanosome. They were worked between Kampala, the native capital, and Luzira, the port on the Lake-shore, which lies about seven miles to the south-east. When the epidemic broke out these cattle were kraaled near the Lake-shore, along which they were allowed to graze, and where tsetse-flies are numerous. Afterwards, at the suggestion of the Commission, they were kraaled at Kampala, when the epidemic stopped, and no more deaths from *Trypanosoma vivax* occurred among them.

Cases also occurred among the transport cattle belonging to the German Company, "Victoria Nyanza Agentur." These cattle were employed carrying goods between Lake Victoria and Lake Albert.

Lastly, the *Glossina palpalis* on the Lake-shore near Mpumu, where the Sleeping Sickness Commission laboratory was placed, were found to be naturally infected with *Trypanosoma vivax*, and this trypanosome was found in the blood of a bush-buck, shot at the same place at which the flies were collected.

\* Continued from preceding article.

The evidence, therefore, at present points to the *Glossina palpalis* being the carrier of this disease, and that the wild animals living in the fly area act as a reservoir of the virus.

This species of trypanosome is similar to *Trypanosoma nanum*, in that it is only pathogenic to equines and bovines, and has no effect on the smaller laboratory animals. There was no opportunity in Uganda of inoculating it into horses, mules, or donkeys.

Nine cattle came under observation suffering from a natural infection of the disease. Seven of these died after being at Mpumu, on an average, 103 days. Five cattle were successfully inoculated, and these died, on an average, in 69 days. The disease is, therefore, a fairly rapid and fatal one in cattle. It may be noted that two of the cattle (Experiments 493 and 583), after living for 268 and 237 days respectively, died at last from an accidental infection of *Trypanosoma pecorum*. It is possible that these two oxen had recovered, and if not, it is certain that trypanosomes were either absent or very scanty in their blood, as inoculations from them failed to infect goats and sheep. It may also be noted that none of the four sheep which were inoculated ever showed signs of the disease. This is probably due to the scarcity or absence of the trypanosomes in the blood used in the experiment for inoculation, and not to any natural immunity.

#### MORPHOLOGY OF *TRYPANOSOMA VIVAX*.

This species of pathogenic trypanosome can at once be recognised among all the others by its shape alone. There is no tendency to dimorphism, as in *Trypanosoma brucei* and *Trypanosoma gambiense*. On the contrary, the individuals tend to run persistently to one type. This type has an average length of 24 microns. The body posterior to the nucleus is swollen, and contains clear protoplasm, in which an alveolar structure can be made out; the posterior end is rounded, as a rule, and close to it is the large round micronucleus; the anterior part of the body rapidly narrows and terminates in a free flagellum; the nucleus is elongated and situated in the narrowed part, is often broken up and diffused, and seems to fill up the part of the body in which it lies; the undulating membrane is narrow and simple, and can, as a rule, only be made out by the deeply-stained flagellum running along its border. An examination of the plates which illustrate this paper will, however, give a clearer idea of the general appearance of this species than any written description.

*A. Living, Unstained.*

This species of trypanosome is extremely active in its movements. It dashes across the field of the microscope with such rapidity that it is impossible to follow its movements, cyclone-like leaving a clear path, the corpuscles in its track having been flung on either side. If it remains at the same spot for a time, as it sometimes does, it has an appearance of great energy and power, throwing the surrounding red blood corpuscles about in wild confusion.

*B. Fixed and Stained.*

The blood-films were fixed, stained and measured as described in the 'Proceedings.'\*

*Length.*—The following table gives the average length of this trypanosome in the ox and goat. Twenty trypanosomes are drawn and measured from each preparation, the average length reckoned, and the length of the longest and shortest given.

Table I.—*Trypanosoma vivax*, Uganda, 1909.

No. of experiment.	Animal.	Method of fixing.	Method of staining.	In microns.		
				Average length.	Maximum length.	Minimum length.
290	Ox	Osmic acid	Giemsa	23·7	28·0	21·0
445	"	"	"	23·8	26·0	20·0
450	"	"	"	23·0	25·0	21·0
450	"	"	"	23·4	25·0	22·0
493	"	"	"	23·7	25·0	21·0
597	"	"	"	25·1	28·0	22·0
598	"	"	"	25·8	28·0	24·0
779	"	"	"	24·6	27·0	21·0
982	"	"	"	23·5	25·0	22·0
1267	"	"	"	24·2	27·0	20·0
1462	"	"	"	23·8	28·0	16·0
864	Goat	"	"	24·2	25·0	23·0
864	"	"	"	24·7	26·0	19·0
1036	"	"	"	23·5	29·0	19·0
				24·1	29·0	16·0

As is shown by the above table, this trypanosome varies in length between 16 and 29 microns. Individuals only 16 microns long are rare, and only occur immediately after division. The following table represents the distribution of length among 180 trypanosomes, and it will be seen by it that only three are found to measure less than 19 microns.

\* B, 1909, vol. 81, pp. 16, 17.

Table II.—Represents the Distribution in respect to Length of *Trypanosoma vivax*, Uganda strain, 1909.

Expt. No.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.	32.	33.	34.	35.	Average, in microns.
445								•	•••••	••	••••	•••••	•••••	•										23.8
450							••	•••••	•••••	•••••	•		•••••											23.0
597										•		••••	•••••	•••••	••	•								25.1
598												•••••		•••••	•••••	•••••								25.8



*Breadth*.—Varies between 2 and 3 microns.

*Shape*.—This species can be recognised with certainty by its shape alone. The body of the creature lies mostly posterior to the nucleus, and this part is broad and swollen and filled with beautifully clear protoplasm, in which a delicate alveolar structure can be made out. The body narrows at the nucleus and tapers off rapidly to the anterior extremity (Plates 3 and 4).

*Contents of Cell*.—Clear, with a delicate alveolar structure, and now and then a chromatin-staining granule, especially in the narrow anterior part.

*Nucleus*.—Long and oval, often diffuse, situated towards the anterior extremity, and in a narrowed or waist-like part of the trypanosome.

*Micronucleus*.—Large, round and terminal, or sub-terminal.

*Undulating Membrane*.—Narrow, simple, straight, and little in evidence.

*Flagellum*.—There is a well-marked flagellum, the free part varying from 3 to 6 microns in length (Plates 3 and 4).

#### COMPARISON OF *TRYPANOSOMA VIVAX*, UGANDA, 1909, WITH *TRYPANOSOMA VIVAX*, TOGOLAND, 1903.

Thanks to the courtesy of the Director of the Hamburg Institute of Tropical Medicine, through Dr. Fülleborn, the Commission are enabled to compare the Uganda strain with the original preparations made by Ziemann in 1903.

Table III.—Measurements of the Original Strain of *Trypanosoma vivax* (Ziemann), 1903.

Animal.	Method of fixing and staining.	In microns.		
		Average length.	Maximum length.	Minimum length.
Ox	?	24·8	26·0	23·0
"	?	26·5	31·0	23·0
Sheep	?	21·4	23·0	18·0
"	?	22·1	25·0	20·0
Average.....		23·7	31·0	18·0

The trypanosomes found in the blood of this sheep were shorter, narrower, and have a more pointed posterior extremity than in the type described. Whether this is the rule or only exceptional it is impossible with our scanty material to say.

Table IV.—Represents the Distribution in respect to Length of *Trypanosoma vivax*, Togoland strain, 1903.

Expt. No.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.	32.	33.	34.	35.	Average, in microns.
Ox											•	•	•	•	•	•	•							24.8
Ox												•	•	•	•	•	•		•					26.5
Sheep							•	•	•	•	•	•	•											21.4
Sheep								•	•	•	•	•	•											22.1
Totals .....	—	—	—	—	—	1	2	5	8	10	14	8	11	9	9	2	—	—	1	—	—	—	—	—
Percentage .....	—	—	—	—	—	1.2	2.5	6.3	10	12.5	17.5	10	13.7	11.3	11.3	2.5	—	—	1.2	—	—	—	—	—

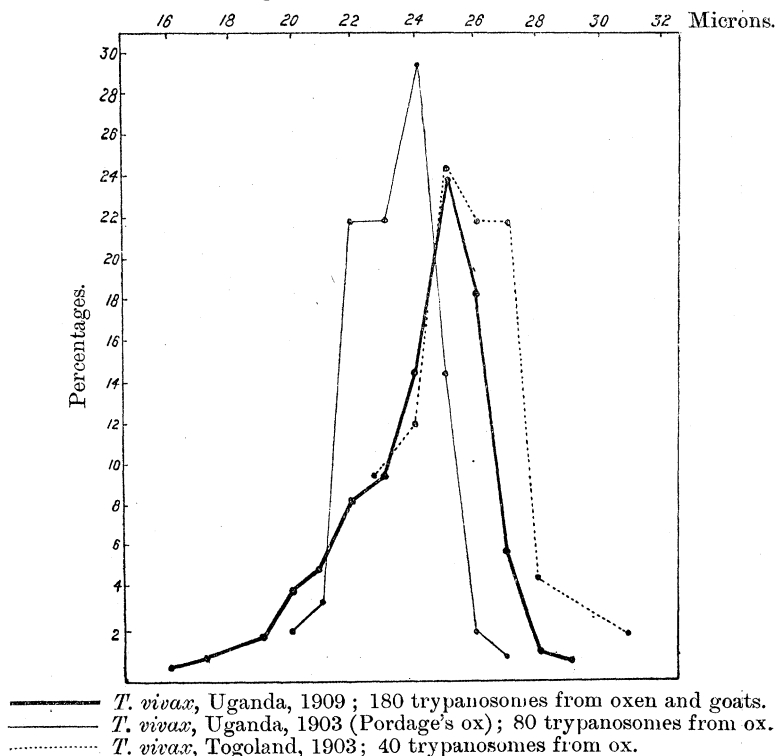
COMPARISON OF *TRYPANOSOMA VIVAX*, UGANDA, 1909, WITH *TRYPANOSOMA VIVAX*, 1903 (PORDAGE'S OX).

On examining the preparations made in 1903 from two oxen belonging to the Uganda Transport, the trypanosomes in them were at once recognised as belonging to this species (Plate 3).

Table V.—Measurements of *Trypanosoma vivax*, Uganda, 1903 (Pordage's Ox).

No. of experiment.	Animal.	Method of fixing.	Method of staining.	In microns.		
				Average length.	Maximum length.	Minimum length.
1	Ox	Osmic acid	Leishman	23·3	25·0	21·0
1	"	"	"	23·1	26·0	20·0
2	"	"	"	23·3	25·0	22·0
2	"	"	"	23·5	27·0	20·0
Average...				23·3	27·0	20·0

CHART giving curves representing the distribution, by percentages, in respect of length of *Trypanosoma vivax*, Uganda, 1909, *Trypanosoma vivax*, Uganda, 1903 (Pordage's ox), and *Trypanosoma vivax*, Togoland, 1903.







From a comparison of these tables and the figures on Plate 3, there can be little doubt that the trypanosome found in the blood of cattle in Uganda in 1909 is identical with that seen in 1903, and also with that discovered by Ziemann in Togoland, and named by him *Trypanosoma vivax*.

As Dr. Laveran kindly examined the Uganda specimens and pronounced them to be *Trypanosoma cazalbovi*, it is probable that *Trypanosoma vivax* and *Trypanosoma cazalbovi* are the same species.

#### ANIMALS SUSCEPTIBLE TO *TRYPANOSOMA VIVAX*.

Date.	No. of expt.	Source of virus.	Period of incubation, in days.	Duration of disease, in days.	Remarks.
Cattle.					
1909.					
July 12	431	Nat. infec.	?	—	Alive after 38 days.
Jan. 14	450	"	?	48	Died of <i>T. vivax</i> .
Feb. 2	493	"	?	268	Also infected by <i>T. pecorum</i> .
Mar. 6	583	"	?	237	"
" 14	597	"	?	49	Died of <i>T. vivax</i> .
" 14	598	"	?	79	" "
May 16	779	"	?	6	" "
July 12	1309	"	?	40	" "
" 12	1318	"	?	—	Alive after 30 days.
Sept. 29	290	Ox 1465	30	32	Died of <i>T. vivax</i> .
Mar. 3	467	Ox 450	—	—	Experiment stopped after 77 days.
May 19	869	Oxen 493, 583, & 598	—	—	" " 101 "
" 19	870	"	—	—	" " 101 "
July 27	737	Goat 864	15	60	Died of <i>T. vivax</i> .
June 21	1030	"	10	83	" "
July 6	1267	"	22	55	" "
" 6	1268	"	15	114	Killed.
		Average ...	18	89	
Goat.					
Mar. 31	623	Ox 598	—	—	Experiment stopped after 48 days.
Apr. 2	636	Ox 494	—	—	" " 46 "
" 3	639	Ox 583	—	—	" " 45 "
May 19	864	Ox 779	15	148	Died of <i>T. vivax</i> .
Aug. 4	1419	Ox 1309	22	—	Still alive after 30 days.
Sept. 10	1652	Ox 1318	21	31	Died of <i>T. vivax</i> .
June 22	1036	Goat 864	27	29	" "
—	1037	"	—	—	Never showed trypanosomes; under observation 66 days.
June 25	1079	"	21	—	Experiment stopped after 21 days.
July 19	1344	"	36	—	" " 36 "
" 26	1383	"	24	—	" " 24 "
Aug. 6	1433	"	12	17	Died of <i>T. vivax</i> .
		Average ...	22	56	

ANIMALS SUSCEPTIBLE TO *TRYPANOSOMA VIVAX*—*continued.*

Date.	No. of expt.	Source of virus.	Period of incubation, in days.	Duration of disease, in days.	Remarks.
Sheep.					
1909.					
Mar. 23	610	Ox 598	—	—	Experiment stopped after 56 days.
Apr. 2	637	Ox 493	—	—	" " 46 "
May 19	863	Ox 779	—	—	Died 124 days after inoculation.
June 17	1013	Ox 583	—	—	Experiment stopped after 72 days.
Monkey.					
Feb. 4	487	Ox 450	—	—	Experiment stopped after 57 days.
" 4	488	"	—	—	" " 57 "
Apr. 3	640	Ox 583	—	—	" " 45 "
" 3	643	Ox 493	—	—	" " 45 "
May 19	859	Ox 779	—	—	" " 40 "
July 9	1304	Ox 1030	—	—	Died 30 days after inoculation.
" 26	1384	Goat 864	—	—	Experiment stopped after 33 days.
Dog.					
Feb. 4	489	Ox 450	—	—	Died 30 days after inoculation.
Mar. 3	576	"	—	—	" 31 " "
June 18	1021	Ox 583	—	—	" 28 " "
" 30	1197	Goat 864	—	—	Experiment stopped after 43 days.
July 16	1343	Dog 1021	—	—	" " 31 "
Guinea-pig.					
Mar. 27	617	Ox 598	—	—	Experiment stopped after 52 days.
Apr. 3	642	Ox 583	—	—	" " 45 "
" 3	645	Ox 493	—	—	" " 45 "
May 19	862	Ox 779	—	—	" " 40 "
Rat.					
Mar. 23	609	Ox 598	—	—	Experiment stopped after 56 days.
Apr. 3	641	Ox 583	—	—	" " 45 "
" 3	644	Ox 493	—	—	" " 45 "
May 19	860	Ox 779	—	—	" " 40 "
Mouse.					
Mar. 27	616	Ox 598	—	—	Experiment stopped after 52 "
Apr. 3	646	Ox 583	—	—	" " 45 "
" 3	647	Ox 493	—	—	" " 45 "
May 19	861	Ox 779	—	—	" " 40 "

CULTIVATION OF *TRYPANOSOMA VIVAX*.*A. Living, unstained.*

This species grew readily on blood-agar, the blood used in the preparation of the medium being that of the goat. The history of a tube which had been

inoculated with a drop of blood from the heart of an ox, Experiment 450, dead of *Trypanosoma vivax* disease, is as follows :—

March 3, 1909.—Inoculated six tubes. The trypanosomes are very scarce in the blood.

March 6.—Tube No. 1 has been examined daily for signs of growth. Nothing living has been seen. The tube remains sterile.

March 8.—To-day many very active trypanosomes are seen. They are single or in small groups of ten or twenty or so. The cell-contents are granular. The cells possess flagella, but no obvious undulating membranes. There are many dividing forms to be seen, and division is evidently going on rapidly, as many individual trypanosomes appear to be undergoing fission into three or more at the same time.

March 9.—Since yesterday an immense multiplication has taken place. The trypanosomes are still very active. They appear to have free flagella and long-pointed, finely granular posterior extremities.

March 11.—Many highly active trypanosomes seen. They are elongated, thin, and have a long free flagellum, sometimes as long as the body itself.

The trypanosomes remained alive and active up to 20 or 30 days, when the tubes became contaminated, or dried up, and were thrown away.

*Size.*—Cultural forms of *Trypanosoma vivax* vary much in size. At first, when they begin to multiply, on or about the sixth day, the individuals forming groups are about 15 microns in length. Next day they are longer and thinner, and later many are seen 50, 60, or more, microns in length.

*Shape.*—At first, the young forms are oval or elliptical in shape; afterwards they become more attenuated; and later still may be seen as huge trypanosomes with undulating membranes and long free flagella.

*Contents of Cell.*—In the living unstained condition this appears to be finely granular.

*Undulating Membrane.*—In the smaller forms composing the groups no obvious undulating membrane can be made out.

*Flagellum.*—This is free and well developed.

*Motion.*—The single forms are extremely active.

#### B. *Fixed and Stained* (Plate 5).

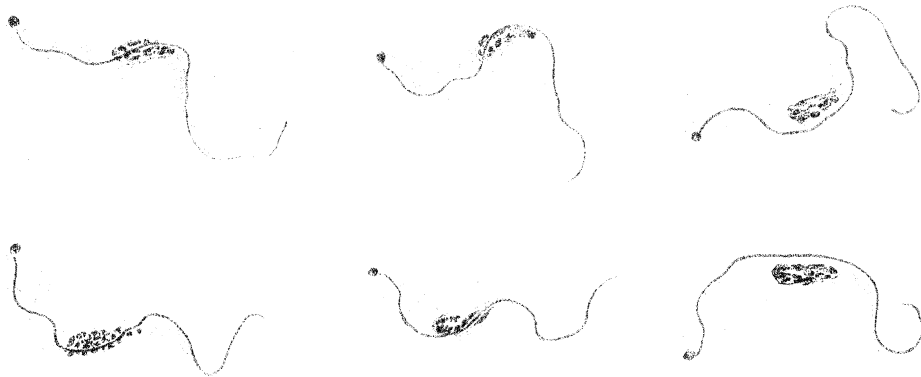
*Protoplasm.*—Is homogeneous, but contains many irregular granules and vacuoles.

*Nucleus.*—Is usually broken up and diffuse.

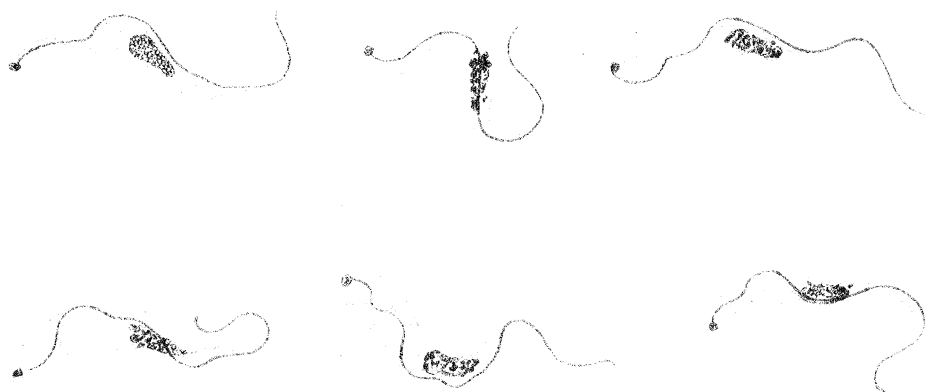
*Micronucleus.*—Often difficult to distinguish. Sometimes placed anterior, at the side of, or posterior to, the nucleus.

*Flagellum.*—Well developed free flagellum.

*Undulating Membrane.*—Present in the older free forms.



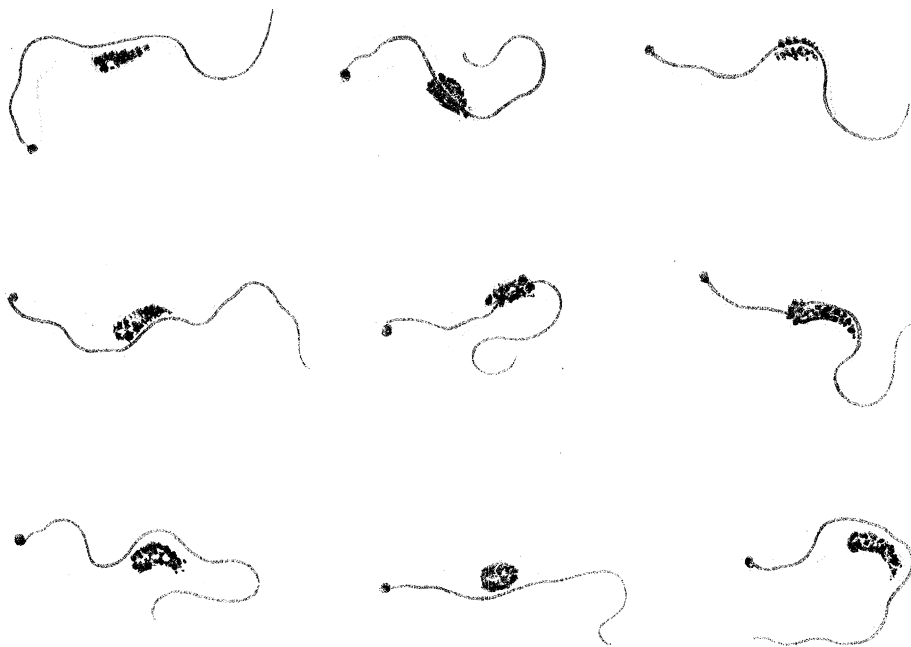
*T. vivax*, Uganda 1909.



*T. vivax*, Fordage's Or 1903.



*T. vivax*, Zaemanni Togoaland, 1903.



*T. Vivax. Ox.*



*T. Vivax. Goat.*



THE CARRIER OF *Trypanosoma vivax*.

It was pointed out in a previous paper that, in laboratory experiments, *Trypanosoma vivax* readily develops in *Glossina palpalis*, and that this tsetse fly can convey the infection to healthy animals after a period of from 20 to 30 days.\* It was also found that this fly is naturally infected with this trypanosome, and several animals became ill and died of this disease when freshly-caught Lake-shore flies were fed upon them.† The epidemic among the Government Transport oxen at Kampala also points to this fly being the carrier. As stated above, as long as the cattle were kraaled at the Lake-shore and exposed to the bites of *Glossina palpalis*, so long did they suffer from *Trypanosoma vivax* infection. Afterwards, when stabled at Kampala, the fatality from this disease ceased.

Although it must be confessed the evidence is rather scanty, what there is points to the *Glossina palpalis* as being a carrier, if not the chief carrier, of *Trypanosoma vivax*; and there is no evidence at present to incriminate the *Tabanids* or *Stomoxys*.

## CONCLUSIONS.

1. *Trypanosoma vivax*, an easily recognisable species, gives rise to a fatal disease of cattle in Uganda.
2. The carrier of *Trypanosoma vivax* is probably *Glossina palpalis*, which is found naturally infected on the Lake-shore.
3. The reservoir of the virus is possibly the antelope which frequent the *Glossina palpalis* area.

## DESCRIPTION OF PLATES.

## PLATE 3.

Figures for the comparison of *Trypanosoma vivax*, Uganda, 1909, *Trypanosoma vivax*, Uganda, 1903 (Pordage's ox), and *Trypanosoma vivax*, Togoland, 1903.

## PLATE 4.

*Trypanosoma vivax*, fixed osmic acid, stained Giemsa. ×2000. Note the large round terminal micronucleus; the broad, swollen anterior part filled with clear protoplasm, in which a hint of the alveolar structure is given; the nucleus situated in the narrowed part of the body; the slightly developed undulating membrane; and the free flagellum.

## PLATE 5.

Fig. 1.—A group of *Trypanosoma vivax* after 5 days' growth in blood-agar. Stained Giemsa. ×2000.

Fig. 2.—*Trypanosoma vivax* after 6 days' growth. Stained Giemsa. ×2000.

Figs. 3 and 4.—After 7 days' growth. Stained Giemsa. ×2000.

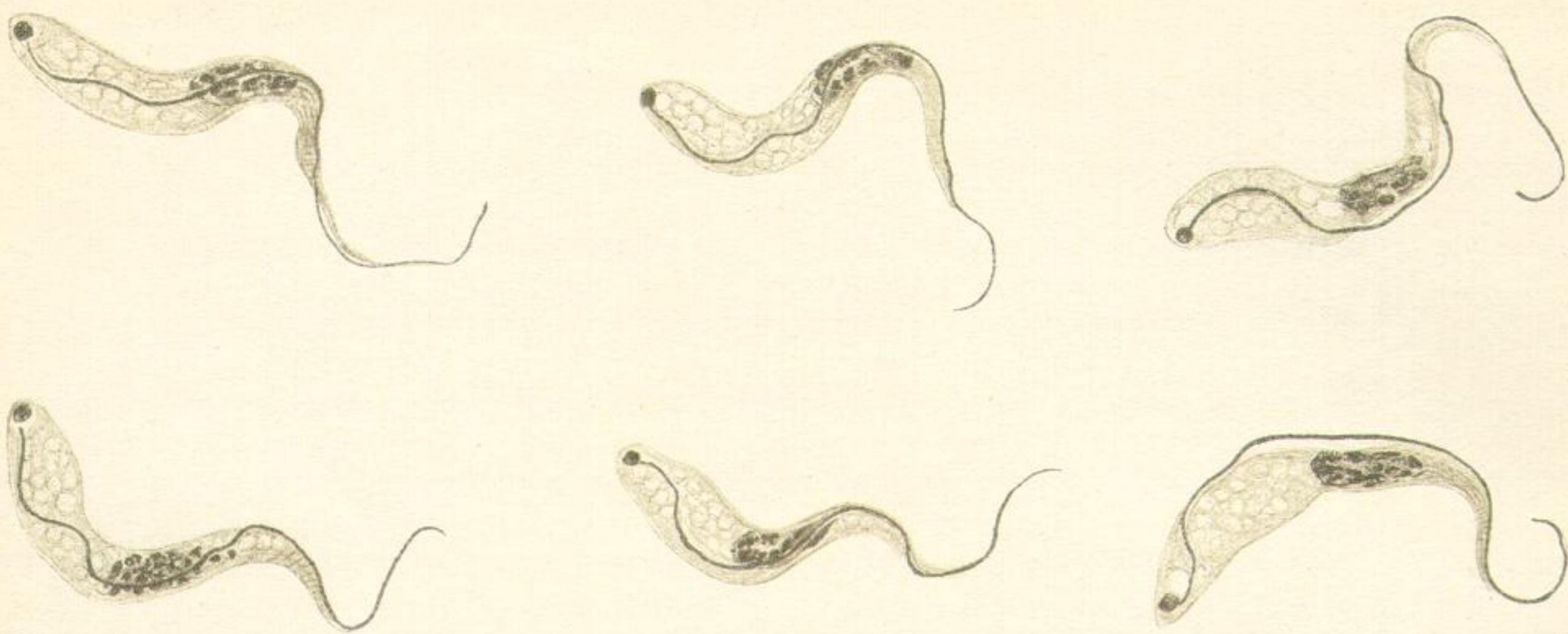
Figs. 5-9.—After 8 days' growth. Stained Giemsa. ×2000.

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\* 'Roy. Soc. Proc.,' 1910, B, vol. 82, p. 381.

† 'Roy. Soc. Proc.,' 1910, B, vol. 82, p. 63.





*T. Vivax. Uganda 1909.*



*T. Vivax. Pordage's Ox 1903.*



*T. Vivax. Ziemann Togoland. 1903.*





*T. Vivax. Ox.*



*T. Vivax. Goat.*



