lower fragment rotated through about 40 degrees and secured in position by means of a plate and screws. The arm was put up supinated and kept in splints for a month, and the result at the date of writing has quite justified the procedure adopted. Supination can now be easily accomplished, and though the movement is somewhat cramped, it should improve greatly as the muscles strengthen and adhesions still further disappear. Massage, passive and active movements, are being continued, together with such exercises as screw-driving, digging in the garden, and piano playing. It is probable that the right arm will be treated in due course, when, in view of the experience gained in operating on the left, the time of treatment will be considerably shortened, the first and fourth operations will be done together, the third and fifth together and the second only done at the last if the result demands it. One lesson to be learnt is to do too much, rather than too little, since the parts contract up, just as in ordinary joint excisions.

ON THE INFLUENCE OF METEOROLOGICAL CONDITIONS ON THE DEVELOPMENT OF TRYPANOSOMA RHODESIENSE IN GLOSSINA MORSITANS.

BY

ALLAN KINGHORN AND WARRINGTON YORKE,

NGOA, NORTHERN RHODESIA.

(Fifth Interim Report of the Luangwa Sleeping Sickness Commission of the British South Africa Company.)

In a former report¹ attention was drawn to certain points which seemed to indicate that meteorological conditions in the Luangwa Valley had a considerable influence on the development of *Trypanosoma rhodesiense* in *Glossina morsitans*. As, however, the experiments were few in number, and were carried out during only a single dry and wet season, no definite conclusions could be drawn. Since the Commission established its head quarters on the Congo-Zambesi watershed, evidence has accumulated which indicates decisively that such conditions, more particularly the temperature, exert a very pronounced influence on the development of the trypanosome in *Glossina morsitans*.

At Nawalia eight transmission experiments were made—four with laboratory-bred and four with "wild" *Glossina morsitans*. At Ngoa five experiments have been carried out to date—four with "wild" and one with bred flies. It is unfortunate that the bred flies are not more numerous, but owing to the low temperature the majority of the flies did not emerge from the puparia, and many of those which did were malformed and quickly died. In all the experiments in which "wild" flies were used, however, the possibility that they were already infected with the

trypanosome was excluded by first feeding them on healthy monkeys.

TABLE I.—*Meteorological Observations at Nawalia, N. Rhodesia, 12° 25' S., 32° 2' E., Altitude 2,100 ft. (approximately).*

1911-12.	External Shade Temperature: Mean.	Absolute Maximum.	Absolute Minimum.	Laboratory Temperature: Mean.	Relative Humidity: Per Cent.	Rainfall in Inches.	Days on which Rain Fell.
June ...	67.2	89.0	44.3	—	48.6	0	
July ...	68.7	91.0	44.6	67.4	45.7	0	
August ...	73.3	96.8	51.2	71.2	35.8	0	
September ...	77.5	103.3	54.0	71.5	31.5	0	
October ...	85.1	107.6	62.3	81.5	31.8	0.26	2
November ...	87.1	107.8	67.9	84.6	41.1	1.61	8
December ...	82.3	101.7	67.8	79.6	69.1	8.54	20
January ...	80.6	101.1	67.0	78.4	77.7	14.97	16
February ...	79.2	96.0	65.1	77.1	73.8	5.55	16
March ...	79.0	97.6	61.0	72.0	52.5	5.42	6
April (to 9th)	79.5	97.9	59.8	77.2	58.0	0.01	1
					56.04		63

TABLE II.—*Meteorological Observations at Ngoa, N. Rhodesia, 11° 40' S., 31° 30' E., Altitude 4,400 ft. (approximately).*

1912.	External Shade Temperature: Mean.	Absolute Maximum.	Absolute Minimum.	Laboratory Temperature: Mean.	Relative Humidity: Per Cent.	Rainfall in Inches.	Days on which Rain Fell.
April (20-30) ...	72.0	89.7	54.1	68.0	53.7	0	
May ...	63.0	90.5	45.1	66.2	51.3	0	
June ...	61.5	85.5	34.3	60.5	53.0	0.01	1
July ...	62.4	83.0	42.3	60.9	53.0	0	
					0.01		1

The details of the Nawalia experiments have already been published,² while those of the Ngoa series will appear in a later report. For the purposes of the present paper synopses of the two series will suffice, and will be found in Tables III and IV.

TABLE III.—*Synopsis of Transmission Experiments with Trypanosoma rhodesiense and Glossina morsitans, carried out at Nawalia, Northern Rhodesia.*

No.	Date on which Started.	Season.	Number of Flies Used.	Variety of Flies Used.	Result.	Duration of Developmental Cycle: Days.	Mean Temperature during Developmental Cycle.*	Absolute Maximum during Developmental Cycle.	Absolute Minimum during Developmental Cycle.	Relative Humidity* per Cent.
1	Aug. 20, 1911	Dry	26	Bred	Infection	13	75.1	90.0	60.5	35.0
2	Nov. 14, 1911	Commencement of rains	16	"	"	15	83.5	93.5	74.5	44.8
3	Nov. 14, 1911	"	57	Wild	"	11	83.8	93.5	74.5	44.8
4	Dec. 29, 1911	Rainy	20	Bred	Negative	—	78.2	87.1	72.8	74.5
5	Jan. 12, 1912	"	42	Wild	"	—	78.0	85.7	72.8	74.2
6	Jan. 12, 1912	"	42	"	"	—	78.0	85.7	72.8	74.2
7	Jan. 12, 1912	"	23	Bred	Infection	19	77.9	85.7	72.8	75.4
8	Feb. 13, 1912	"	104	Wild	"	25	77.3	86.0	71.0	66.5

*In the case of the unsuccessful experiments the mean temperature and the relative humidity have been calculated for the first thirty days only.

TABLE IV.—Synopsis of Transmission Experiments with *Trypanosoma rhodesiense* and *Glossina morsitans* carried out at Ngao, Northern Rhodesia.

No.	Date on which Started.	Season.	Number of Flies Used.	Variety of Flies Used.	Result.	Duration of Developmental Cycle: Days.	Mean Temperature during Developmental Cycle.	Absolute Maximum during Developmental Cycle.	Absolute Minimum during Developmental Cycle.	Relative Humidity, per Cent.
1	May 18, 1912	Dry	116	Wild	Negative	—	° F. 62.7	° F. 74.5	° F. 50.5	52.0
2	June 13, 1912	"	90	"	"	—	59.1	72.4	42.0	52.0
3	June 14, 1912	"	119	"	"	—	59.1	72.4	42.0	52.0
4	June 26, 1912	"	19	Bred	"	—	60.2	71.8	42.0	52.0
5	July 11, 1912	"	176	Wild	"	—	62.0	72.0	49.1	50.0

It will be seen from these tables that whereas, in the Luangwa Valley, *Trypanosoma rhodesiense* was successfully transmitted by *Glossina morsitans*, all efforts in this direction on the Congo-Zambesi watershed have so far been in vain. Of 330 flies used in the valley experiments, 6 and probably 10 became infective. The larger figure is based on the number of salivary gland infections found in the flies. Our experience indicates that the implication of these structures is intimately connected with the ability of *Glossina morsitans* to transmit *Trypanosoma rhodesiense*, and that until they are invaded by the organisms the flies are non infective. Salivary gland infections have been found in all the flies which were capable of transmitting the parasite. In experiment No. 3 (Table III) six flies were found to harbour trypanosomes in the glands, but of these only two were actually proved to transmit *Trypanosoma rhodesiense*. As in all other instances it was shown conclusively that those flies in which trypanosomes were found in the salivary glands were infective, it may be concluded that the remaining four flies in this experiment were also capable of transmitting the parasite. Invasion of the salivary glands has not been observed, except in those flies which were known to transmit *Trypanosoma rhodesiense*. In the five plateau experiments, 520 *Glossina morsitans* were employed without a single fly becoming infective.

The explanation of these apparently contradictory results is at first sight not very obvious, more particularly in view of the fact that even on the plateau "wild" *Glossina morsitans* capable of infecting healthy monkeys with *Trypanosoma rhodesiense* were occasionally encountered. If the climatic conditions under which the valley experiments were carried out be compared with those obtaining during the plateau experiments, it will be seen at once that the most striking difference is one of temperature. As a rule, the temperature during the former series of experiments was roughly from 15° to 20° F. higher than during the latter series.

With a view to ascertaining the influence, if any, exerted by temperature on the developmental cycle of *Trypanosoma rhodesiense* in the tsetse fly, a further series of experiments were performed on the plateau, in which, by means of an incubator, the flies were kept at a temperature approximating to that of the valley at the most favourable season.

TABLE V.—Synopsis of Experiments to Transmit *Trypanosoma rhodesiense* by Means of *Glossina morsitans* kept in Incubator.

No.	Date on which Started.	Season.	Number of Flies Used.	Variety of Flies Used.	Result.	Duration of Developmental Cycle: Days.	Mean Temperature during Developmental Cycle.	Absolute Maximum during Developmental Cycle.	Absolute Minimum during Developmental Cycle.	Relative Humidity, per Cent.
1	June 30, 1912	Dry	61	Wild	Infection	14	° F. 80.6	° F. 87.8	° F. 74.5	36.0*
2	July 1, 1912	"	72	"	"	13	80.6	87.8	74.5	36.0*

* Approximate.

No water was placed in the incubator, and the warm, dry air was found to have a very deleterious effect on the insects. Within the first seven days 25 of the 61 flies with which experiment No. 1 was commenced, and 53 of the 72 in experiment No. 2 had died. Notwithstanding the small number alive at the end of the second week at least one infective fly was obtained in each experiment.

It seems obvious, therefore, that a high temperature favours the development of the trypanosome in *Glossina*

morsitans, and that the comparatively low temperatures obtaining during May, June, and July, on the Congo-Zambesi watershed are very unfavourable to the completion of the developmental cycle of *Trypanosoma rhodesiense* in this fly, and would account for the unsuccessful experiments at laboratory temperatures.

Other observations afford corroborative evidence in support of this contention. An analysis of the valley transmission experiments shows that the largest number of infective flies was obtained at the hottest season of the year.

TABLE VI.—Showing Number of Infective Flies Obtained, and Meteorological Observations at Nawalia (Luangwa Valley).

Number.	Date on which Started.	Season.	Duration of Developmental Cycle: Days.	Number of Infective Flies Found	Mean Temperature during Developmental Cycle.	Absolute Maximum during Developmental Cycle.	Absolute Minimum during Developmental Cycle.	Relative Humidity, per Cent.
1	Aug. 20th, 1911	Dry	13	1	° F. 75.1	° F. 90.0	° F. 60.5	35.0
2	Nov. 14th, 1911	Commencement of rains	15	1	83.5	93.5	74.5	41.8
3	" "	"	11	6	83.8	93.5	74.5	44.8
4	Dec. 29th, 1911	Rainy	—	0	78.2	87.1	72.8	74.5
5	Jan. 12th, 1912	"	—	0	78.0	85.7	72.8	74.2
6	" "	"	—	0	78.0	85.7	72.8	74.2
7	" "	"	19	1	77.9	85.7	72.8	75.4
8	Feb. 13th, 1912	"	25	1	77.3	85.0	71.0	66.5

The fact that an occasional infective "wild" fly was encountered on the plateau during a period (May, June, and July) when attempts to transmit in the laboratory were invariably unsuccessful requires some explanation. A possible solution may be that the flies in question were infected during the warmer season of the year and had survived into the cold season.

If the results obtained by feeding freshly caught flies on

healthy monkeys in the valley are compared with those from flies caught on the plateau, a marked difference in the number of infections resulting is apparent. In the Luangwa Valley 3,202 flies were fed in 29 batches, and *Trypanosoma rhodesiense* was isolated in six of the experiments, giving a ratio of 1 infective fly to 534, whereas on the Congo-Zambesi watershed 5,041 freshly caught *Glossina morsitans* were fed in groups on 39 monkeys, with

4 positive results—1 infective fly to 1,260. As tsetse flies and game are about equally numerous at Nawalia and Ngoa, and as the disease was presumably introduced into the two localities, which are less than 70 miles apart, about the same time, it appears to us that the only essential difference which can account for the fact that the percentage of infective "wild" flies at Nawalia is two and a half times as great as at Ngoa is the difference in the climatic conditions. It will be seen from Tables I and II that the temperatures experienced on the Congo-Zambesi watershed during May, June, and July are very much lower than those at Nawalia from September to March. It was during the months named that our experiments were carried out at the two places.

Finally, it might be mentioned that the percentage of infective "wild" flies caught in the valley was greater in the hot than in the cold season. This point is illustrated in Table VII.

TABLE VII.—Percentage of *Glossina morsitans* found Infected with *Trypanosoma rhodesiense* at Nawalia at Different Seasons of the Year.

1911-1912.	Mean External Shade Temperature.	Number of Flies Fed.	Number Infectious with <i>T. rhodesiense</i> .	Ratio Infective to Non-Infective Flies.
June... ..	67.2°	18	0	0:790
July... ..	68.7°	385	0	
August... ..	73.3°	193	0	
September... ..	77.5°	194	0	
October... ..	86.1°	—	—	1:338
November... ..	87.1°	270	1	
December... ..	82.3°	205	0	
January... ..	80.6°	538	2	
February... ..	79.2°	104	0	1:466
March... ..	79.0°	823	2	
April (to 9th)	79.5°	472	1	

In addition to temperature, there is one other factor in the climatic conditions which may possibly influence the developmental cycle of the trypanosome in *Glossina morsitans*. We refer to the relative humidity of the atmosphere. At the most favourable season of the year in the Luangwa Valley for transmission experiments, and also in the case of those carried out in the incubator, the relative humidity was extremely low. Whether this is a mere coincidence we are, at present, unable to form an opinion, but hope to be able to write more definitely on the subject in a later communication.

SUMMARY.

The developmental cycle of *Trypanosoma rhodesiense* in *Glossina morsitans* is, to a marked degree, influenced by the temperature to which the flies are subjected. High temperatures (75–85° F.) favour the development of the parasite, whilst low temperatures (60–70° F.) are unfavourable.

REFERENCES.

- ¹ Kinghorn and Yorke, *Annals Trop. Med. and Parasit.*, vol. vi, 1912. ² *Ibid.*, vol. vi, No. 1 A, 1912.

THE ninth International Physiological Congress will be held at Groningen in September (2nd to 6th), 1913.

UNDER the title, Vienna Roentgen Courses, an association of all the best known radiologists in Vienna, has been formed on the initiative of Herr Keinz Bauer (Engineer), Docent Dr. Holzknacht, and Docent Dr. Kienböck. It is proposed to organize every year a course extending over ten to twelve days, and covering the whole ground of radiology, theoretical and practical. Among the lecturers who have so far consented to take part in the courses are Messrs. Bauer (Berlin), Freund, Haudek, Holzknacht, Kienböck, Robinsohn, Schüller, and Schwartz (Vienna). The first course will be given in the spring of 1913.

THE ETIOLOGY AND TREATMENT OF MINER'S NYSTAGMUS.

WITH A REVIEW OF 100 CASES.

BY

F. J. BROWNE, M.B., AND J. ROSS MACKENZIE, M.D.,
ABERTILLERY, MON.

THE subject of miner's nystagmus as an industrial affection touches the interests of both employer and employee.

The conclusions formed by us as to the causes, predisposing or otherwise, and the treatment, prophylactic as well as curative, have been arrived at by an unbiased and independent consideration of 100 consecutive cases as they presented themselves to us.

The factors contributing to the production of nystagmus in miners are not numerous, and, arranged in order of relative frequency and importance, are: (1) Inadequate light, (2) errors of refraction, (3) straining of ocular muscles, (4) neurotic temperament.

1. *Inadequate Light*.—That this is an important cause of miner's nystagmus is conclusively proved by the fact that 99 per cent. of our cases had been using the lock-lamp for a number of years. Only one case was found where the naked light was allowed, and here the nystagmus was accounted for by hypermetropia, much straining of the ocular muscles in narrow seams, and a markedly neurotic temperament with much physical debility.

The lock-lamp must be 9 ft. from the farthest point of the mandril, and so the workman is staring into comparative darkness, whereas the naked light is attached to the workman's cap or to a post close beside. Therefore, the naked light not only gives a much brighter and stronger light because it is exposed, but also because the workman has its full benefit. We have also had experience of miners in various parts of Scotland, where the naked light is used, and in these districts miner's nystagmus is practically unknown.

2. *Errors of Refraction*.—An examination of the summary of cases of miner's nystagmus seen by us will show that 90 per cent. had errors of refraction, excluding the three cases in which there was evidence of error, but owing to marked photophobia no exact estimate could be made; while 7 per cent. had normal refraction. Of the 90 per cent., 48 per cent. had either myopic, hypermetropic, or mixed astigmatism; 27 per cent. had simple hypermetropia; and 15 per cent. had simple myopia. It is interesting to note that a large number of the cases of hypermetropia were those of comparatively young men who had worked only a few years at coal-cutting.

3. *Straining of the Extrinsic Muscles of the Eyeball*.—This is the result of the two foregoing factors. In all our cases the workman had his eyes fixed in a staring, strained position for long periods, either downwards and laterally, as in narrow seams, or upwards, as in wide seams; 90 per cent. of our cases were engaged cutting coal, while 10 per cent. were hauliers and timbermen, and one a colliery examiner.

4. *Neurotic Temperament*.—The inability, on the part of a very large number of men with nystagmus, to concentrate their physical or mental powers in any particular line of action guides us to the conclusion that such instability is probably much more the cause than the effect of nystagmus. It most certainly appears to be a weak point in the miner's armour, and would repay careful examination long before the stage of inability to work.

The severe headaches and aching eyes of which these men complain are accounted for by errors of refraction and straining of the eyes; the vertigo, by inco-ordination of the ocular muscles; the conjunctivitis and photophobia by the sudden frequent change from darkness into dazzling light.

Prevention.

This resolves itself into medical examination of all men engaged to work underground, and the periodical examination of all underground workers, for (a) the presence of refraction errors, (b) any signs of incipient nystagmus, (c) physical or nervous debility.

To this must be added the importance of adequate light.