

## THE EPIDEMIOLOGY OF SLEEPING SICKNESS IN EAST AFRICA

### PART I. A SLEEPING SICKNESS OUTBREAK IN UGANDA IN 1957.

BY

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Gambian sleeping sickness in Uganda has been in general at a low endemic level since the last serious outbreaks, in West Nile in 1936 and in the Lake Edward area in 1942. In 1957, however, a sharp outbreak occurred in the Northern Province, on the Aswa River just where the Districts of Lango and Acholi adjoin. An investigation of this epidemic and of the events which led up to it provided a most interesting study in the epidemiology of Gambian trypanosomiasis, which form the subject of this paper.

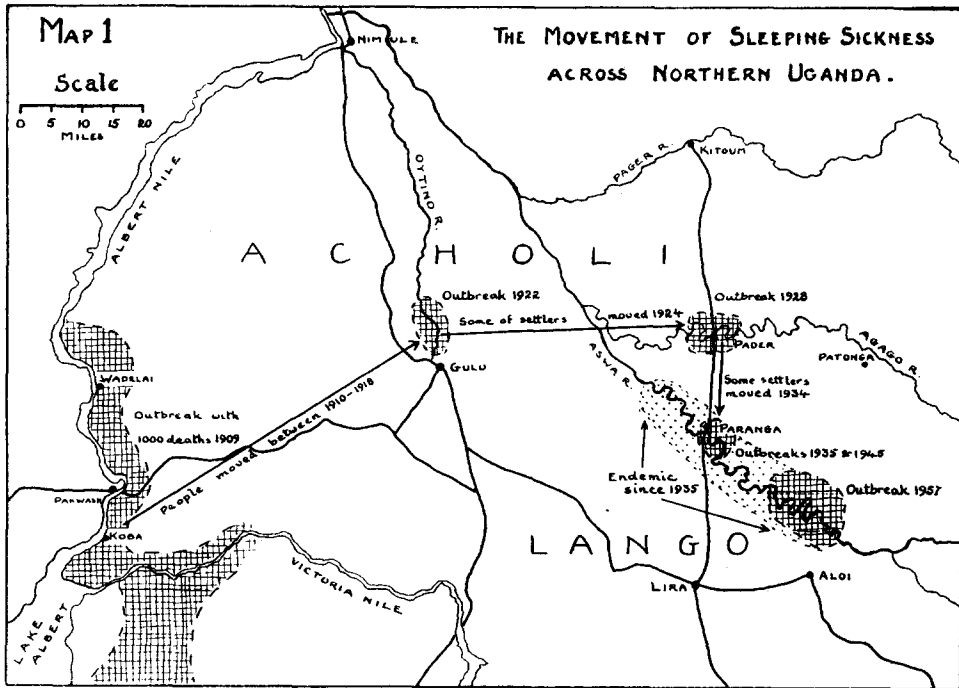
#### HISTORY AND ORIGINS OF THE OUTBREAK

Sleeping sickness in those parts of Lango and Acholi Districts lying in the basin of the Aswa River (R. Moroto, locally in Lango) immediately north of Lira is a comparatively new disease, its earliest appearance here being only 20 years ago. The introduction of infection into this part of Uganda, from a source on the Albert Nile existing in 1909, can be traced with completeness and makes an instructive story, the spread and resulting outbreaks having been almost entirely man-made (Map 1).

Infection is by *Trypanosoma gambiense* with *Glossina palpalis* as the vector. In 1909, outbreaks were reported from a long stretch of the east banks of the Albert Nile below its outfall from Lake Albert and were of such severity that 1,000 deaths were known to have occurred in that year (Provincial Commissioner's & Health Officers' Reports in Gulu). Considering the isolated nature of this region and difficulties of communication at that time this figure can be taken as a minimum, and represents an extensive epidemic. The whole population from a six-mile-wide strip along the east banks of the Nile was moved to areas immediately northwest of Gulu, the District Headquarters. People from the area of Koba, opposite Pakwach, were settled on the river Oytino, a few miles northwest of Gulu, a river heavily infested with *G. palpalis*. As infected persons in these evacuated populations had been neither treated nor segregated the result was inevitable, a severe outbreak on the Oytino in 1922 (Health, 1951). The people were again evacuated, to the area of Koro, just south of Gulu, which was fortunately fly-free. Some of the Oytino settlers however were taken to fill up a new settlement and development scheme on the Agago River in Eastern Acholi, at Pader, where the river crosses the Lira-Kitgum road. This area presented ideal conditions for the development of epidemic trypanosomiasis, the settlements being made on both banks

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of a river whose winding course and many tributaries were all heavily infested with *G. palpalis*. The inevitable epidemic developed 4 years later, in 1928, with over 200 cases in the next 2 years and a quite heavy mortality (Uganda, 1928-30). Again the only means of dealing with this outbreak was by moving the people out of the epidemic area, to Pajule and Lira Palwo where there was no longer a close contact with tsetse and the disease died out. But one group of settlers with allegiance to the Chief of Paranga, 20 miles south, were moved back to that town, and among them were cases of trypanosomiasis. Paranga, with a big cotton ginnery, is situated on the banks of the Aswa River, which holds dense *G. palpalis* fly-belt along its very winding course. Once more the conditions were ideal for starting up an epidemic. Many of the houses and the ginnery itself were within 200-300 hundred yards of the river banks; the people spend many hours of each day drawing water, washing and bathing at places which are typical *G. palpalis* feeding grounds, in the small openings in the dense riparian vegetation caused by rocky stretches of river bank. The move to Paranga was in 1934 and the people remember a man dying of sleeping sickness at the end of that year. By the end of 1935 an epidemic had started which attained alarming proportions locally, with infections occurring mostly on the north bank of the river, in Acholi, at and around the ginnery, and at a lower rate in nearby villages. Five cases however were definitely recorded from the Lango country south of the Aswa. This was the first appearance of the disease in Lango.

A Dispenser was placed at Paranga and, with the treatment of cases and the making of a clearing at the road bridge, the number of cases declined rapidly and ceased to be noticeable after about two years. But the disease did not disappear, from 10 to 30 cases a year were recorded from Acholi District during the next 10 years and then, in 1945, an epidemic flared up once more at Paranga, with at least 100 cases, located mainly around the ginnery

and on the Akidi River, two miles to the east. In Lango District 29 cases were recorded, all from close to the Aswa River in the parish of Abala, immediately opposite Paranga. (GILLET, 1945, Pers. commun.).

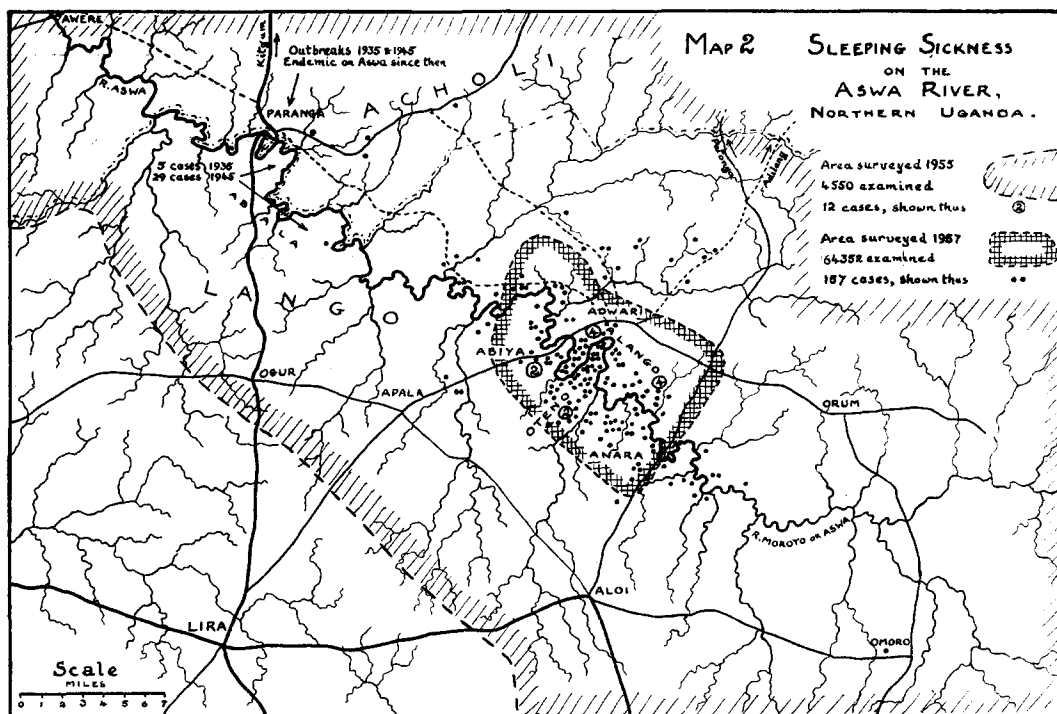
Now this is the first in this series of epidemics that was not man-made. The dry season of 1944-45 was exceptionally severe, a fact recorded in reports and remembered by natives all along the Aswa, both Acholis and Langos. By October, 1944, the level of the river was very low and the water restricted to pools. By December practically all sources of water away from the main river, such as waterholes, tributaries and marshes, had dried up and the river itself was a series of discontinuous restricted pools. So severe was the drought that game animals from eastern Acholi and Karamoja came in numbers down to the Aswa valley for water, appearing frequently among the farms and houses, where a great many were killed. *G. palpalis* retreated also, from a normally extended distribution along the river and tributaries to the close neighbourhood of the remaining pools of water. These pools also became the venue for the local people from miles around, for water, washing, bathing and the watering of livestock. Thus an exceptionally close contact was established between man and tsetse, far closer and more prolonged than occurred in normal years. It was in January, 1945, with these conditions at their most extreme, that sleeping sickness was reported by the Chief of Paranga to be becoming suddenly noticeable, for the first time since 1935.

Treatment and segregation of the cases brought the outbreak rapidly under control, as was shown by the examination of the population at risk in the country around Paranga during the next few years. South of the Aswa, in Lango District, 3,000 - 4,000 examinations in 1946 and 1947 gave 12 and 5 trypanosome infections only, and in Acholi the examination of 1,266 people in 1948 and 1,231 in 1950 gave 1 and 2 positives respectively. These inspections were not maintained regularly, however, the last in Lango being in 1950 along the border with Acholi, and giving 6 cases. This number was the District total for the year. Thus the incidence of 2 - 10 cases a year in each District from 1950 to 1955, mostly along the Aswa River, although it showed the existence of a persistent low endemic must be taken as a minimum, possibly a rather wide underestimate (Uganda, 1951-52).

In 1955 a queried infection in a patient sent in from Adwari was found positive by the D.M.O. Lira, Dr. Blaikie, who, suspecting a greater incidence in this part of the Aswa River, went out and examined 4,450 people in a 70-square-mile block of country of Adware, Apala and Anara divisions. He found 12 infected, none of whom had bothered to come in to the Dispensary, only 15 miles distant. On following up these cases a year later he found more to be present, so, in December, 1956, he repeated the survey, including Anara and a neighbouring division but not covering Apala and Adware. Twenty-nine cases were found, 19 of which came from Anara with a population of only 734 people. Obviously an epidemic was developing, so the whole of Moroto County, which contained these infected locations, was surveyed in February and March, 1957, and showed the presence of 157 infected persons. Seventy per cent. of these infections came from Adware, Apala and Anara, the areas which had shown 12 cases only 18 months previously. The surveys on both occasions were identical in method, so the figures are strictly comparable. This epidemic of *T. gambiense* had developed with great rapidity, increasing tenfold in 18 months.

#### THE PRESENT EPIDEMIC

The distribution of cases found up to May, 1957, is shown on Map 2.



The survey was conducted by the D.M.O.'s. Lira and Gulu, by choosing a number of convenient centres to which people from within a radius of six-seven miles could be called for examination. A census for each division was supplied by the local chief, and absentees on the day of examination were noted and followed up on subsequent visits. Everybody was palpated for enlarged glands but it appears that other clinical symptoms were sought only in the Acholi surveys. Those with enlarged glands had gland fluid examined on the spot as a fresh preparation, and, if negative, a thick blood film was taken and stained, and examined in the hospital. A treatment team followed the survey team, touring the same centres and giving infected persons a course of 5 grammes of suramin and 5 grammes of tryparsamide. At first there was a lag of a few weeks between survey and treatment, but later those found positive by gland examination were given an immediate suramin injection by the Survey Team. Co-operation with the Chiefs was very good and ensured that few cases of short treatment occurred.

The Uganda Tsetse Control Department undertook the work of controlling *G. palpalis* with a spraying technique recently developed by Mr. K. C. Woodcock. He found that a single application of 5 per cent. w/v concentration of Dieldrin to the waterside fringes of the vegetation forming the fly's habitat gave it a toxic coating lasting for over 100 days, and this, because of the habit of *G. palpalis* of frequenting and resting on this waterside evergreen fringe, gave virtually a 100 per cent. kill of the adult tsetse population on the rivers treated. On the Aswa River 76 miles of the main river were sprayed from an aluminium dinghy and 230 miles of tributary streams by knapsack sprayer, the work taking 10 weeks. It was unavoidable that, with the discovery of the extent of this epidemic rather late in the dry season, the tsetse control units were working at a great disadvantage, their

operations had to be rushed ahead with only a couple of months of favourable low water conditions in hand. Nevertheless an almost complete disappearance of old flies resulted on the main river and most of its tributaries, but inevitably some pockets of fly on side streams were missed and served as foci for local reinfestations during subsequent months. Also the main river spraying did not extend upstream, i.e. eastwards, from the bridge immediately north of Aloï, because of old clearings on this stretch of the Aswa. But these clearings were regrown and full of tsetse. Consequently tsetse control ceased at the edge of, instead of well beyond, the area of the heavy epidemic. Another point of importance is that fly-control followed after the treatment of patients by about a month. The effect of this time lag will be discussed later in this paper.

The epidemic was found to lie in the Moroto County of Lango District. The examination of 64,352 people here in the first survey of February-March and May, 1957, showed 157 infected with *T. gambiense*. To make the picture of the epidemic complete the 29 cases found in December, 1956, should be added in, making a total of 186 cases found by May, 1957. In Acholi District the examination of 15,696 people in May showed 1 case only, but 3 more from the area surveyed had already reported to the Awere Dispensary and been found positive. All occurred along a road to Paranga from the centre of the Lango infected area. I visited the area in April, before the follow-up after the first survey was finished, and in June, when survey figures, including those for an additional area in Ogur Division, opposite Paranga, had been completed. The area containing the epidemic was traversed on foot or by bicycle with local chiefs and headmen so that the houses of infected people could be spotted-in on the Uganda Survey Department's 1 : 250,000 map. The water supplies for the villages and infected groups of houses were examined, and information was obtained on the people's activities, movements, the weather as affecting water and farming, and other factors which might contribute in forming the pattern of the epidemic.

As can be seen from Map 2, infections are concentrated along a few miles of the Aswa (Moroto) river in the parishes of Oteno, Alango and Anara, the incidence being as follows :

Oteno, 1,508 people, 37 cases = 2.5 per cent. infected.

Alango, 918 people, 32 cases = 3.5 per cent. infected.

Anara, 972 people, 34 cases = 3.5 per cent. infected.

By far the greatest concentration of infections occurred in Oteno, although, with its higher population, this does not show up in the infection rate. In fact 24 of the 37 cases were located in the narrow tongue of land, less than a square mile in area, contained within the hairpin bend of the main river. Several houses here had 2, 3 and 4 cases coming from the same family. The only other parish with an infection rate over 1 per cent. was Abiya, adjoining Oteno and Alango, with 1.2 per cent. of its 1,448 inhabitants infected. The other parishes containing infections all had rates well below 1 per cent. A tendency is observable for the cases north of the main river to be strung out along the paths, especially the two routes leading to Paranga, radiating out from Adware, i.e. from the main concentration of infection.

Up to the time of writing, a second and third trypanosomiasis survey had been made ; the second, in August, 1957, showing 104 new cases and the third, in January, 1958, showing 70 cases. The area has not been visited by me since these surveys were made, and a full interpretation of this type of data cannot be given without having traced the distribution of these cases on the spot. As far as can be judged from the reports, it appears that the main reduction in incidence has taken place in the focus of the epidemic where infections were

most numerous in the first survey, and that reductions are less evident in the peripheral infected areas. There is a slight outward spread north-westward, towards Paranga, and a small but definite increase in the area eastward of the Alooi-Patonga road, that is to say, neighbouring the unsprayed reach of the Aswa river. But at least the alarmingly rapid initial rate of increase has been checked and any major spread of the epidemic averted.

#### EPIDEMIOLOGY

The country is of the savannah woodland vegetation type, with *Butyrospermum parkii* conspicuous in association of *Combretum*, *Terminalia*, *Vitex* and *Ficus*, and areas of open grassland with occasional *Pseudocedrela*, *Bauhinia* and *Entada* on the river flats. The annual rainfall of 54 inches falls mostly in the seven months April to September. There is heavy cultivation which with annual grass fires reduce the woodland to an open association with well spaced, gnarled and stunted trees forming a marked contrast to the narrow but dense bands of evergreen vegetation fringing the rivers and streams. This riparian vegetation forms the habitat of *G. palpalis*. The population, averaging rather over 50 persons per square mile in Moroto County, is densest along the main river, with the result that game is very scarce, even crocodiles were rarely seen. There are two consequences. The food of *G. palpalis* consists largely of man and his livestock, and there is a shortage of animal protein, domestic stock being only occasionally killed, which is compensated by the amount of fish in the main river, which brings the people down to the Aswa from miles around for their annual fishing foray. This river is the water supply for the people and their stock from the villages all along its course, and villages more than two miles away get their water from one or other of the numerous tributaries, most of which hold *G. palpalis* wherever they hold permanent water, in other words, where they are visited regularly by the people. It is only on headwaters and watersheds well away from the main river that marshes, dams and boreholes provide fly-free sources of water. In brief, the general features of the region are such as confine the vector tsetse to a habitat which is narrowly linear but widely distributed throughout the country, an average of nearly three-quarters of a mile of *G. palpalis* fly-belt per square mile of country in the river basin, and bring certain sections of the community into close and constant contact with tsetse and many into occasional contact.

Of the social habits of the people, two are particularly relevant in the epidemiology of trypanosomiasis. The first is the amount of time spent at the riverside each day, not only filling their pots and watering their livestock but washing their clothes and their bicycles, bathing, or just sitting in the shade of the riverside vegetation and gossiping. The second is the amount of movement which takes place among the Langi of this part. A constant local movement of the people goes on and is not even interrupted by the swollen rivers during the rains, people wishing to cross then either swimming themselves or being swum across while clinging to calabash floats. Most of the families are interrelated and take any excuse for paying one another visits, great occasions being made of marriages, funerals, etc. A number of Langi are settled in the southern bit of Acholi around Acolpi, just east of Paranga, which leads to a great deal of traffic along the routes between this part and Adware. Many cultivate farms at a distance from their homes, which means a three or four mile walk daily, usually crossing a stream, and help in farming is given between families. Markets are a regular draw, especially the big monthly markets which may involve journeys of 15 or 20 miles. Again the Paranga routes are involved, that market is popular because of the demand for farm produce and the presence of shops. And there are special attractions

which draw people from all over the county. The Medical Assistant at Orum has such a good reputation that his medicine is considered better than that in any other Dispensary. Adilang is famous for groundnuts and spears. The Mission at Kalongo with its maternity clinic has gained a reputation for the restoration of fertility and draws people from all over the two Districts. Most of this long-distance traffic is northward from the Aswa, and its effect in causing an outward spread of infection from the main focus is apparent from the map.

The most striking feature in the distribution of infections is the concentration of the majority of the cases into a compact and relatively small focus, not more than 50 square miles in area. It is instructive to study this area, which contained also the 12 cases found in 1955, in order to determine the factors responsible for the remarkably rapid development of an outbreak, the tenfold increase in incidence in 18 months. It can be seen from the map that this concentration of infections lies in a section of the Aswa River where its bends and its tributaries, all holding *G. palpalis*, give the greatest length of fly-belt per unit area of country for anywhere on this part of the river, the average length of fly-belt per square mile of country being 0.8 miles in the epidemic focus against 0.65 miles on adjoining stretches of the river. Houses situated within the loops of the river here are never more than 800 yards from fly-belt, usually within 200 - 300 yards, often with fly-belt on three sides of them. Paths cross and re-cross the river or tributaries, and the people living on these parts can hardly move half a mile without coming into contact with *G. palpalis*. Indeed their proximity to the river is such that tsetse could be found in and around the houses, introduced by people or cattle, at almost any time of the year. Oteno parish also holds the highest density of population, 152 persons per square mile, with the neighbouring section holding from 40 to 96 per square mile. Moreover Oteno has, for several reasons, been attracting an increasing number of people for many years, so it has only now reached its present density, much in excess of that of neighbouring areas. Thus we find two factors vital in the development of any arthropod-borne disease, the density of the vector and the density of the human host, are greatest on this particular spot on the Aswa River, where the epidemic started and from which it has spread. Consequent on the density of the human population is the rarity of wild animals, forcing flies to feed mainly on man and domestic animals, which brings concentrations of hungry flies to the points where man and cattle go down to water. Yet another cause of close man-fly contact arises from the annual fishing which brings people from miles around down to the Aswa, in the height of the dry season, where they spend a week or two in the most intimate contact with *G. palpalis*. Then there is the factor of movement just described, which promotes the rapid dissemination of infection. Finally the dry season of 1956-57 was severe, not so exceptional as that of 1944-45, but enough to restrict surface water, and thus bring about an unusually close contact between man and fly, both among those normally using the Aswa and its fly-infested tributaries for their water and among villages whose sources of water in fly-free marshes and headwaters had failed with the unusual drought. The dangers of the close juxtaposition of village communities and the vector tsetse in a restricted habitat were brought out in the studies by MORRIS (1949) in West Africa. In particular it was shown that high infection rates, 3 per cent. and over at a single survey, arose when the people were living a mile or less from fly-belt of *G. palpalis*. It is interesting to note that infection rates of this magnitude occurred in the three parishes in the focus of the Aswa River epidemic. It is probable that rates above 3 per cent. would have been found here had blood examinations of all the people been made.

The integration of these factors suggests the following interpretation. An increasing

population along the Aswa River, and particularly the comparatively recent concentration of people in Oteno parish, just where the greatest linear distribution of *G. palpalis* occurs, has resulted in conditions promoting the transmission of *T. gambiense* becoming exceptionally favourable on this part of the river during recent years. The infection has been present for the past 10 years ; there is the traffic to spread it ; it only required the increased degree of man-fly contact which arose with the abnormally dry season at the end of 1956 to spark off a situation already dangerous. The main focus of the epidemic was not spotted at once, this area was missed in the December, 1956, survey, yet the December, 1956, and March, 1957, surveys in Anara showed such similar indices of infection that it can be assumed that there must have been a large number of infections in the unsurveyed Apala and Adware divisions at the end of 1956. Although most of the subjects seen in April, 1957, were in the early stages yet there was a proportion in which infection was well advanced and who may have had trypanosomes in the blood for at least a year. These people were still ambulant, so there had been ample opportunity, before they were diagnosed and treated in March and April, 1957, for a wide dissemination of the disease to have been going on.

#### DISCUSSION ON CONTROL

The first lesson arising from this study is the danger of the spread of a disease with a prolonged symptomless stage, such as Gambian trypanosomiasis, a danger which has long been recognized as being associated particularly with lines of communication as well as with big movements of people (WILCOCKS et al., 1946). In the present instance each of the three big jumps across the Northern Province of Uganda was the result of one movement of a large number of people, but the same effect can arise from a large amount of movement going on but involving fewer people at a time, such as takes place on trade and caravan routes (MORRIS, 1951). Although the first type of spread, by a mass movement of people unchecked for infections, is hardly likely to be repeated, yet the pace of developments and trade and the ease and abundance of transport render the second type of spread a very real danger today.

A further type of movement of infection, which was also described in West Africa, can be detected in the Aswa River epidemic. This is the less obvious and more gradual outward spread of infection from the location of its first appearance, usually on a main river, up side streams and along paths and market routes, caused by the journeyings, more limited in length but continuously going on, of the local population.

An advantage of applied biology is that interference with a natural event in an attempt at control can be treated as an experiment and may lead to a further understanding of the event itself. In the present instance the appearance of 104 new cases, two-thirds of the original number found, within 5 months, and of 70 more cases another 5 months later, invites a closer study of the data of the epidemic and of the mechanism of its control. Control operations were based on the elimination of the trypanosome by diagnosis and treatment of cases, and of the tsetse by a method which was effective and rapid but not permanent. For such a combined attack to be successful the following conditions should be fulfilled :

- i. As nearly as possible all cases in the area must be found, which means not only efficient diagnosis but that every infected person must be sought out, whether remote, or too sick to be moved, or even concealed.
- ii. Every case must be rendered permanently sterile to the vector.



- iii. Regular man-fly contact must be broken throughout the epidemic area, even at low densities of tsetse.

Furthermore these operations should be carried out as nearly as possible simultaneously. Since absolute synchronization is rarely attainable in practice, tsetse control should always precede trypanosome control and there should be as short an interval as possible between diagnosis and the first injection. In the case of an epidemic timing becomes of critical importance, a lag of a few weeks, especially if diagnosis precedes tsetse control and so leaves infected flies to give rise to new cases, may mean letting through quite a number of infections.

There are three principal reasons for the first combined attack in Lango apparently not having exerted a greater controlling effect. They are, the difficulty of diagnosing *T. gambiense* infections in the early stages, the interval which elapsed between trypanosomiasis survey and tsetse control, and the fact that some fly-belt was missed during the first tsetse spraying operations, particularly on the main river east of the epidemic focus. The epidemic was at its height at the time of the first operation, in March and April, 1957. The two surveys of Anara at a 2-month interval make it possible to estimate that at least 30 infections a month were being incurred at this time. The method of diagnosis used, the selection of only those showing enlarged glands for further examination, would miss cases in the early stages of infection, possibly the majority of those infected for 6-8 weeks. This lets a number of cases, as many as 40 to 60, past the first treatment, which in their turn give rise to more infected flies. Then, with the month's delay between survey and tsetse control, there will be the continued infection of new cases until the last infected tsetse disappears. There is also the possibility that all infected persons in the area may not have been seen, through absenteeism, deliberate concealment, or their being too sick to come into the examination point. Thus the total leakage of infections past the treatment team can be quite big, and with the pockets of tsetse which were missed in the first spraying, and newly emerging tsetse since, the epidemic was maintained at a somewhat lower level.

In the dry season of 1957-58, however, a rigorous spraying campaign has been continued by the Tsetse Control Department, to deal with those stretches of fly-belt missed a year ago and to deal at once with any foci for reinfestation shown up by tsetse survey. It is improbable that any new trypanosomiasis infections are being incurred in the area of the epidemic at present. As long as diagnosis depends on examination of gland fluid only, or of suspects with obvious clinical symptoms, it is to be expected that cases will continue to turn up, although at decreasing incidence, for a further year or two. A speed-up in achieving complete control could be gained by making a more complete survey, with blood examination of every person present, at least once in the area of the epidemic.

A very important point would appear from the second and third surveys, however, as far as can be judged by examining the data without having yet had the chance of studying the distribution of cases in the field. It would appear that the epidemic had not spread much beyond its former limits. Even if the degree of control attained has not been very high, at least the epidemic has been halted and what would most certainly have been a serious and wide-spread outbreak has been averted. Conditions favourable for the spread of epidemic trypanosomiasis are present throughout the Aswa valley from its headwaters to at least beyond Awere, and widely in neighbouring parts of Lango and Acholi. The whole history of sleeping sickness in these two Districts is a warning of the dangers of its introduction into new localities. Had infections in numbers reached Paranga and straddled the much used Lira-Kitgum road a most dangerous situation could have arisen. Such a position still merits continued vigilance, with surveys repeated at about 6-month intervals in the area

containing the epidemic, to ensure that any changes, geographical as well as numerical, can be spotted at once and the appropriate measures taken.

#### SUMMARY

1) In 1957 an epidemic of Gambian sleeping sickness carried by *Glossina palpalis* broke out on the Aswa River, draining the Lango and Acholi Districts of Northern Uganda.

2) The first appearance of the disease on this river was only 20 years ago, and followed a series of epidemics, each one caused by a big movement of people including infected persons, which had traversed Acholi from west to east, originating in an outbreak on the Albert Nile in 1909.

3) Two previous outbreaks had occurred on the Aswa River close to the site of the present epidemic ; one, in 1935, resulted from the first introduction of the disease, and one, in 1945, followed an abnormal increase in man-fly contact during an exceptionally dry season.

4) Data are given showing the remarkably rapid development of the 1957 epidemic, in which a tenfold increase in the number of cases took place in 18 months.

5) The causes of the outbreak are discussed. A dense human population was occupying a part of the tsetse-infested river where the contact with *G. palpalis* was so close as to be almost inescapable. The absence of other food for the fly, and the people's habits of fishing and travelling, tended to increase the intensity and amount of their contact with the tsetse. Finally a very dry season in 1956-57 aggravated still further this close man-fly contact and caused an existing low endemic of *T. gambiense* to flare up at the alarmingly rapid rate recorded.

6) Control, by mass survey and treatment of cases plus a temporary and local elimination of *G. palpalis* by Dieldrin spraying, kept the epidemic from developing into what might have been a dangerously wide outbreak, but the actual rate of reduction in the epidemic centre was slow. The underlying reasons are discussed.

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