The Control of Tsetse Fly in Southern Rhodesia.

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In the year 1900 when I first arrived in Southern Rhodesia to fill the post of Government Entomologist, tsetse fly was giving trouble on some newly occupied farms between Hartley and Gatoona in the Hartley District, and I was informed that one of my more important duties would be the study of the tsetse fly problem in the Colony.

Up to that time practically no research had been carried out with the most widely distributed tsetse fly of all, namely, Glossina morsitans, the only species with which we are concerned in the northern part of Southern Rhodesia. Even its immature stages were unknown and its natural breeding places had not yet been discovered.

Since then a great deal of water has run under the bridge, and at the present day we probably know more about the life economy, behaviour and habits of morsitans than of any other species of tsetse fly, with the possible exception of G. palpalis.

Apart from work in this Colony which, for lack of proper facilities for uninterrupted research, has perforce been of an intermittent nature, a great deal of attention has been paid to this species in Northern Rhodesia, Nyasaland, Tanganyika, Uganda, the Belgian Congo, Nigeria and elsewhere.

The biggest organisation for the study of tsetse flies is the Department of Tsetse Research in Tanganyika, of which Mr. C. F. M. Swynnerton is the Director. The next largest is the “Tsetse Fly Investigation” in Northern Nigeria, which...
Cutting down the bushes would merely have the effect of pruning them. Something considerably more drastic would need to be employed for lasting results.

This is one of the questions which might repay detailed investigation in reference to conditions in this Colony.

5. Production of Thicket.—The measure which is regarded as most promising against moritana in Tanganyika at the present time is the exact opposite of the suggestion last considered, namely, to increase the undergrowth to such an extent that it forms extensive thicket.

It is the opinion of the Department of Tsetse Research that the open woodling which covers the greater part of that territory, as well as the Rhodesia and other States, is not really the natural climax vegetation of the country, but is a sub-climax, the vegetational succession being held at this point by the effect of grass fires. It is contended that, if grass fires are excluded, the succession will go forward to the climax, which is regarded as deciduous scrub, in the form of thicket. Experiments in excluding grass fires in certain localities have had the effect of greatly thickening scrub growth, and it would appear that, in regard to these localities at any rate, the reasoning has been correct.

I would state plainly that in my opinion this line of reasoning cannot be given general application, at least in Southern Rhodesia. There are no doubt places where thicket would occur but for the grass fires; in fact, I should have little hesitation in indicating certain areas of this nature. There are other places where exclusion of fire could not result in the production of thicket. I refer in the latter case to tracts of clean stemmed mopane forest, which bear no grass at all, and are, therefore, never traversed by grass fires even at the present time.

Thicket production is very dependent upon edaphic, that is soil conditions, and although certain types of thicket occur in poorly grassed areas, there are certain soil conditions which have the dual tendency to produce both thicket and long thick grass. Under such conditions the thicket growth is generally hampered and largely kept suppressed by the grass fires. Exclusion of fires in such localities would certainly result in the spread of thicket.
The Division of Forestry has certain limited tracts of forest in this Colony which have been protected from fire for up to twelve years, and I am informed that although the stand of trees is improving, there is as yet no indication of thicket formation.

By far the greater part of our *Morus* area is dominated by either mfuki (*Brachystegia woodiana*) or mopane. The greater part of this forest is poorly grassed and contains few shrubs to constitute incipient thicket.

If after twelve years of fire exclusion we have not even got an obvious start towards a thicket, this measure cannot be said to be very promising for general application.

Whilst, however, I do not think that mere release of the supposed succession by fire exclusion will result in a general solution of the problem, the question calls for careful investigation under our conditions.

There is the possibility of distributing the seeds of thicket forming shrubs in the selected belt of forest, and several other lines of investigation are worth exploring in this connection.

6. European Settlement.—Under this head, I need only say that European settlement, as it exists in this Colony, can only be effective as a barrier to tsetse in proportion to the distance to which the settlers keep game suppressed beyond the farms. Normally it does not protect itself and cannot persist in the face of advancing fly. In fact, the protection of such settlement constitutes our chief problem.

Apart from modification of the environment, the only alternative appears to be direct attack on the fly itself, under which head we may consider:

1. Biological Control.—Control of insect pests by means of their natural enemies is a measure which appeals to entomologists and laymen alike. I have no time to go deeply into the question of utilising this method against tsetse fly, but would point out briefly that:

   (a) Biological control can never result in total elimination of an insect pest, and

   (b) that tsetse flies are confined to Africa and have been in contact with their natural enemies for countless ages.
It is obvious that all these enemies working together are unable to control the fly.

It is just conceivable that a method might be discovered of modifying the environment in a way which would be imimical to the fly and favour its enemies, but this line of investigation is not regarded as very promising in itself. Modification of environment will, however, always have to be considered from the point of view of the fly’s enemies as well as the fly.

2. Traps.—Traps may be directed either against the puparia (young stage of the fly) or against the adult flies.

Artificial traps for puparia have been experimented with most particularly in reference to *palpalis*, but have also received attention in reference to *morsitans*. They consist of suitable shade to entice the female flies to drop the larvae. The puparia may be collected and destroyed at intervals, or a simpler method of destroying them may be used. The attraction exercised by prostrate tree trunks has been utilised in Tanganyika, trap trunks being laid on logs and at fixed intervals rolled from one side to the other so as to expose the puparia beneath to the sun, which tends to kill them. This measure necessitates removal of as many natural breeding sites in the locality as possible. Whilst such traps might be helpful in combination with other measures in suitable localities, there are obviously in general too many irremovable breeding sites available for more than partial success to attend this form of trapping.

As far as trapping the adult flies is concerned, Mr. Harris in Zululand was the pioneer of serious work along these lines, and has undoubtedly produced a trap which is very useful against *pallidipes* under Zululand conditions.

Unfortunately this trap, and every conceivable modification of it, has been tested against *morsitans* in most parts of Africa, including this Colony, and the verdict is everywhere the same, namely, that it does not catch this species in sufficient numbers to be of practical utility. Moreover, it is found that even against *pallidipes* its efficacy varies greatly with meteorological conditions, and it would appear that the Zululand climate is particularly favourable to its operation.
It is reported, however, to be very effective against *palpalis* in Tanganyika.

The actual fact of the matter, in my opinion at least, is that a trap operating on the principle used, can only be effective against species of tsetse flies which are active during the daytime, and are very dependent upon shade. It is useless against *morsitans* in Southern Rhodesia, both in the wet season and in the cooler parts of the dry season. It is more effective in late August and September, and to a lesser extent in October, but even at best the traps tested did not average in 24 hours more than about the same number of flies which could be caught off man in the same locality with one net in one hour. In the wet season the average catch of the traps in a month did not exceed what could be caught off man with one net in one hour.

The question of trapping *morsitans* has received a great amount of attention in Tanganyika and many ingenious designs have been tried, but as yet we are without an effective trap for this species.

I am personally very anxious to continue experiments with traps, under suitable conditions for uninterrupted research in this Colony, although it is uncertain as to what extent even effective traps could be used to advantage on the edge of our vast fly area.

In Zululand tsetse fly constitutes a sort of pocket problem compared with ours. I doubt if there are more than 500 sq. miles of fly infested forest concerned. The actual infested area may be larger, but the distribution of the forest itself is patchy. Even so, over a thousand traps have been concentrated in and around the Umfolozi Game Reserve, which is itself less than 100 sq. miles in extent.

It is to be realised that one cannot "trap out" limited portions of large *morsitans* areas and then proceed to the next limited area, without isolating these areas. The flies move about far too much for attempts along these lines to have any success. It would be necessary to attack a very large area at one time, which would mean a very large number of traps. To achieve what has been achieved by game reduction, namely, to arrest the spread of fly, by this means would obviously involve interminable and highly expensive trapping.
Any kind of traps would need protection from fire, and this, of course, is a considerable undertaking over large areas in this Colony.

I mentioned these points to illustrate some of the difficulties, not necessarily to condemn the possibility to making use of some effective type of trap against *morsitans* under certain circumstances, particularly in combination with other measures.

3. Poison Gas.—Calls for brief reference. Entomologists are so accustomed to using poisonous gases for the destruction of insects, that the possibility of using such gases against tsetse fly has, of course, been considered. It is not, however, considered that this measure holds out serious promise of feasibility, and no actual experiments have, to my knowledge, been carried out in the field.

One of the reasons is, of course, the danger to human life in releasing such gases in large quantities in the open. Another reason in some quarters is no doubt the fact that use of poison gas on a large scale would probably entail large-scale destruction of animal life, and cannot therefore be regarded as a substitute for game destruction.

Actually, however, the idea is ruled out on the basis of impracticibility.

It is to be realised that in order to kill insects a definite minimum concentration of poisonous gas needs to be maintained for a definite period. Gas released into the atmosphere immediately becomes diluted with air, and even a heavy gas, such as chlorine, tends to diffuse comparatively rapidly. *Chlorine* has been tested against locust hoppers and grasshoppers in Russia and America respectively. It was found that, even working with such a heavy gas very close to the surface of the soil, and, of course, in a very limited area, the cost was too high for practical adoption of this method.

Tsetse flies do not live as close to the surface of the soil as locust hoppers, and the distribution of the gas would need to be correspondingly higher above the surface. Adult locusts will withstand an exposure of several minutes to chlorine at a concentration of 1:1000 in air, which is three times the concentration needed to destroy human beings. Flies, not tsetse flies, which we have tested, proved more resistant than locusts.
The figures with which one is confronted when considering use of poison gas against insects in the open air may be illustrated if we consider a concentration of chlorine of 1:1000 over one square mile to a height of ten feet.

From available information the cost of chlorine at, say, Salisbury would certainly not be less than 1s. per kilogramme. The cost in England is from 6d. to 1s. 2d. per kilo, apart from the cost of the cylinders containing it. Now, a kilo of chlorine makes about 12 cub. feet of gas at average temperatures. To cover one sq. mile, ten feet high at a concentration of 1:1000 of air, would require 278,780 cub. feet of chlorine, that is 28,392 kilos at 1s., amounting to £1,161 12s. 0d. To treat a small area of, say, 100 sq. miles, in this way would therefore cost over £116,000 for gas alone. It is to be admitted that at certain times of year it might not seem necessary to flood the whole area with gas, but complete results could hardly be anticipated from anything less.

What the effect of the procedure indicated would be I cannot say. I have used more or less arbitrary figures to illustrate in a general way the costliness of such attempt.

There are, of course, other gases more poisonous and suitable than chlorine—chloropercin, the well known “tear gas,” for instance—but increasing the poisonous nature of the gas means increasing the danger.

One must bear in mind also the fact that a limited treated area would not remain free from tsetse, even if the gas gave the desired effect. It would quickly be overrun by the fly again and all the work would need to be repeated.

In conclusion, I would express the hope that enough has been said to show that the Government in this Colony has had to take what may be regarded as emergency measures against the advancing fly, and that no alternative measure to game reduction has been feasible in the circumstances.

Now that we have reason to hope that effective control of the fly has been obtained, we are, however, in a position to consider the application of other measures with a view to maintaining this control and of reclaiming country from the fly, should this be considered feasible and necessary. In the meantime, however, we must not relax our grip of the situation.
The application of other measures must inevitably be gradual, and it would be no use to start developing a line of defence, which would take some years to become effective, if in the meantime the fly were allowed to continue to spread. Our line of defence would obviously soon be far behind the enemy's lines.

In the face of a position demanding urgent action, it is no use depending on research, which is unlikely to yield concrete results for a number of years.

Our present control of the situation makes the position particularly favourable for the prosecution of research with a view to finding feasible alternative measures applicable to this Colony, and free from the objections attending game destruction. For this purpose a properly equipped and staffed field research station is required.

Research should obviously go forward at the same time along two main lines, namely, in reference to (1) controlling the fly itself, that is, the entomological aspect, and (2) to immunising or otherwise enabling livestock to live in or on the margins of the fly areas, that is the veterinary aspect.

We are, of course, confronted with the difficulty that the financial resources of the Colony are limited, and that the maintenance of control by present measures is already costing an appreciable sum annually. The cost of research would need to be added to this if disastrous advances of fly were to be avoided in the meantime.

Furthermore, it cannot be said that the prospect of discovery of alternative measures of fly control of general applicability is particularly bright in the present stage of development of the Colony.

In this connection it may, however, be pointed out that promising lines of research have a tendency to appear unexpectedly as one gains additional knowledge of any problem.

If such destruction of game as is being carried out is considered to be too obnoxious, then the Colony must be prepared to finance study with the object of finding an alternative. If a feasible alternative were discovered, we should all, I need hardly say, be only too glad to see the hunters' rifles exchanged for something else, capable of achieving the same end without destroying any wild animals.
My estimate is that once certain objectives have been obtained such control can be maintained at an expenditure of about £5,000 per annum.

Now, the destruction of game is a measure which is abhorrent to all of us, and it certainly would not have been undertaken if any feasible alternative were available to deal with our particular problem. It is the nature of the problem which determines the feasibility or otherwise of various control measures.

In this connection let us turn our eyes for a moment to the eastern border of the Southern Melsetter District, the Chipinga area in fact.

This is a populous part of the country from the agricultural point of view, and is considerably developed. It is adjacent, however, to altogether primitive African conditions in Portuguese territory, the border being not only a political, but also a natural one in that it follows more or less closely the edge of the high veld.

Two species of tsetse fly occur near this portion of the border in Portuguese territory, namely, Glossina pallidipes and G. brevipalpis. These, at least pallidipes, apparently receded in 1896-7, but have gradually spread until at the present time they are permanently established very close to the border, and possibly even within this Colony in one or two deep river valleys.

From 1914 onwards farmers on the border farms began to lose cattle from fly disease, due to incursions by occasional flies, and these losses have continued until at least last year. Farms have been evacuated on this account, and cattle have been evacuated from farms, otherwise occupied. Only two tsetse flies have so far been actually taken within our borders, both pallidipes, which is the species probably responsible for the losses.

Now, until comparatively recent years, very little was known concerning the specific habits of pallidipes, and even to-day, apart from Mr. Harris' fly traps in Zululand, little experience in control of this species seems to be available.
Study of this species has, however, revealed the fact that it differs considerably from *morsitans*, both in regard to environmental requirements and behaviour.

Two important differences are (1) that *pallidipes* is markedly more shade loving than *morsitans*, and (2) that *pallidipes* does not attach himself to man and "follow" for miles as does *morsitans*.

In connection with the situation in the Chipinga sub-district, various proposals had been made by local farmers, including (1) the shooting out of the game near the border in Portuguese territory—an impossible task on account of the nature of the country and the fact that it is foreign territory; (2) the erection of a game fence along the border. The latter was considered in some detail and abandoned on account of the nature of much of the country and the depth of the grass, which produces exceedingly fierce grass fires in some places.

The last suggestion was a border clearing.

Now, I do not think the game was responsible for bringing the fly across the border, and in my opinion the game fence would have been useless for the purpose intended, except in so far as it kept cattle from straying over the border. The investigators in Zululand could not induce *pallidipes* to follow cattle for any distance, and there is no reason to think that it would follow game any more persistently. The border clearing was another matter but, having only the experience with *morsitans* as a guide, it did not seem that any feasible clearing would serve as a safeguard, in view of the facts (1) that this species follows man for up to ten miles or more, (2) that there is abundant foot traffic to and fro across the border, and (3) that even in the absence of traffic, this fly will cross quite a wide strip of open country. The discovery that *pallidipes* does not follow man, however, coupled with the fact that it is more shade loving than *morsitans*, put a different complexion on the matter, so that in 1932 I was in a position to advise the Government that a comparatively narrow clearing presented a reasonable prospect of success.

This clearing was rendered feasible by the fact that open grassland predominates along the portion of the border concerned, and that the forest requiring removal covered probably
less than 10 per cent. of the ground. Also, that by utilising certain high ridges, the clearing could be made very narrow along certain sections.

A clearing has now been created along some thirty odd miles of the border at a cost of about £1,500, extended over three years. It is too early to state with certainty what permanent effect this will have, but the indications up to the present are very encouraging, so much so that cattle have been moved back in large numbers to previously evacuated farms. The main difficulty with which we are now confronted is maintenance of the clearing.

This will serve to illustrate the value of a close knowledge of the life economy of insects in reference to control measures, and the fact that different species of tsetse flies may create quite different problems under different circumstances.

Let us now revert to *morsitans* in the northern part of the Colony and consider the problem presented.

The actually infested country is on the whole of very poor quality and is mostly unsuited to European settlement. There is really no serious demand at present for intensive measures to reclaim considerable portions of this country from the fly for the use of either Europeans or natives. Whilst it is necessary to drive the fly back further from settlement in the Hartley and Wankie Districts, we are mainly concerned, in the present stage of development of the Colony, with preventing the fly from spreading into occupied areas or overrunning country of real agricultural value.

To achieve this, it is necessary to oppose a barrier to the fly's advance along practically the whole fly front. In the absence of such a barrier, it is of no use to spend money attempting to reclaim 100 sq. miles or so here and there. The fly would simply continue to spread elsewhere and would certainly overrun more country each year than was reclaimed.

The public generally fail to realise this essential point and there is a tendency to imagine that the Government is trying to drive the fly out of the Colony by destroying the game. This is far from the truth. No attempt has as yet been made to reclaim one sq. yard of new country for settle-
has been at work for a number of years. These organisations are concerned, not only with a study of the biology of the flies, but also with experiments with control measures.

Before proceeding further there are certain facts which it is necessary to state.

In the first place it must be realised that there are some twenty different species of tsetse flies, all confined to the Ethiopian region, and all, except one, to the continent of Africa and adjacent small islands. One species, namely, Glossina tachinoides, occurs also in the southern point of Arabia. These different species exhibit considerable variation in regard to habitat, habits, behaviour, etc., and statements applicable to one species are not necessarily applicable to another. This has led to considerable confusion in the public mind. People are apt to think that the term “tsetse fly” applies only to one insect, and that there is only one Tsetse Fly Problem. On the contrary, there are a number of different problems created by tsetse flies. Some species are of most importance in reference to transmission of Human Trypanosomiasis or Sleeping Sickness. This is the case with the notorious G. palpalis, which was the cause of the death of at least 200,000 natives in Uganda in the period 1901 to 1906. Most of the species are only known to be of importance in regard to the transmission of Animal Trypanosomiasis, but G. morsitans is capable of transmitting disease to both man and animal.

In the course of this lecture, unless otherwise stated, the term “tsetse fly” will refer to G. morsitans.

Now a few points concerning the life economy of tsetse flies and G. morsitans in particular:

All tsetse flies are bloodsucking insects and differ from some other species of bloodsucking flies, such as mosquitoes, horse flies, blind flies, etc., in that both sexes suck blood. Furthermore, there is no reliable evidence at all that they take any food except blood. They are, in fact, independent parasites on red bleded animals, and are no more capable of sustaining themselves in the absence of such animals than a louse or a tick. In this connection it should be mentioned that the term “animal” in the zoological sense includes the whole animal kingdom and is not confined to mammals.
ment. Any eviction of fly which has occurred in the course of the operations, has been incidental to protection of existing settlement. All that is being attempted is to establish and maintain a zone varying from ten to twenty miles wide, approximately free from game, between the fly and the farms, or other localities it is desired to protect. It is not the 20,000 sq. miles of infested country we are concerned with so much as the 30,000 sq. miles of much more valuable country which the fly threatens to overrun in the northern part of the country. The effect of the operations cannot be judged on the basis of the area actually cleared of fly, although this is considerable.

In spite of assertions to the contrary, the game of the Colony as a whole, is not being menaced by these measures.

The 20,000 animals destroyed annually at the present time consists, to the extent of about 60%, of small buck, pig, carnivora and animals other than large game. Game does not figure in the Census returns, of course, but in my judgment the annual number destroyed probably does not equal the natural increase of the game in the northern part of the Colony as a whole. Apart from the tsetse fly cordon, the game in the uninhabited parts is protected, either completely or in a very considerable degree, and there is undoubtedly far less poaching than there was before the cordon was completed and control established.

It must not be overlooked that European settlement, and even a moderately dense native population, are in themselves incompatible with the presence of large numbers of game animals. The portions of the Colony containing least game at the present day are not the areas of the Government's anti-fly operations but the areas which have been in closest occupation for the greatest length of time.

In regard to reclamation measures, with which research work in tsetse fly has been mostly concerned, it is therefore to be realised that whatever measures were adopted to banish tsetse and to open up more and more country to occupation, they would inevitably have a repercussion adverse to the game.

Game feeds the tsetse, but in return the presence of tsetse to a large extent protects the game.
The ideal, with the object of reducing the necessity for slaughter as much as possible, would be to have the fly cordon enclosed throughout with 100% effective game fences, but I am afraid that the Colony would have to face a very heavy bill if this were attempted.

The desire is, of course, to obtain some feasible alternative to game destruction for controlling tsetse.

With this idea in mind, we may turn hopefully to some of the latest publications of, say, the Department of Tsetse Research in Tanganyika. The following is an extract from a contribution to the Tanganyika Standard by the officers of that Department last year:—

"Our fullest investigation of habits has been on G. morsitans, and we know it exceedingly thoroughly; but our field experiments on this species, in which the suggestions from our observations on it will be tested out, are only commencing now—and that haltingly—as a result of shortage of staff and money. We are very hopeful as to the ultimate result, but this important fly holds us at a disadvantage in the meantime." . . . "As regards the vexed question of the game animals, it is not considered likely that they will be called upon to contribute heavily to the destruction of G. palpalis and G. swynnertoni, and it is hoped that the same may prove true of the end as regards G. morsitans."

There is obviously not much help in the direction of immediate alternative action against morsitans in this extract.

Now, as I have already stated, the three fundamental requirements of tsetse flies are (1) suitable climate, (2) suitable vegetation and (3) sufficient food. Apart from direct attack on the fly itself, it would be necessary to alter one of these requirements to the fly's disadvantage in order to get rid of it. Obviously we cannot alter the climate as a whole, and we are at present attacking the fly through its food supply.

The alternative is, therefore, to attempt to modify its vegetational shelter. Possibilities in this direction may be considered under various headings as follows:—

1. Total Removal of Forest.—This is a definitely effective method of reclaiming country from tsetse and has, in fact, been utilised to some extent in Tanganyika with unpaid
tribal labour. It is far too expensive with paid labour, as a reclamation measure, and is in many respects objectionable.

For our purposes, we may, however, consider it from the point of view of a barrier clearing to arrest the fly's advance.

One of the first difficulties to contend with is that in spite of considerable experiment with widths of clearings in Tanganyika, we do not yet know for certain what width of open country would definitely stop morsitans. It is a very difficult matter to determine by experiment. We are informed that in Nyasaland morsitans a few years ago advanced across a clearing a mile wide apparently without a check. The present opinion is that two miles is the absolute minimum for morsitans and that the clearing must be settled with natives for maintenance and to stop game crossing.

Clearings of a permanent nature are very expensive to create in country which is at least 90% forested, like the margin of our present fly area. Neither stumping or burning the stumps produces a permanent clearing in the dominant Brachystegia (Mesa, Mtuli, etc.) forest. Poisoning is more hopeful, but is apparently more expensive than burning the stumps. Ring-barking is only partially effective and takes a long time to produce a clearing.

If we were to attempt forthwith to create a two mile wide really permanent clearing all along our fly front, it would undoubtedly cost a very large sum of money indeed, and, as it could not be relied upon to effect its object, such an undertaking has obviously been out of the question, as far as meeting the emergency is concerned.

It does not follow that something of this nature could not be developed gradually once we were sure of results, but the expenditure would undoubtedly have to be spread over a large number of years. It would, however, be necessary to hold the fly in check by other measures in the meantime.

Unless clearings can be settled closely with natives they will inevitably demand recurrent expenditure in maintenance which, in the case of really extensive clearings, would be very considerable.

It is in this respect that Southern Rhodesia is very heavily handicapped. Tanganyika is short of fly free land for native occupation with cattle, as some of their tribes will
not continue to inhabit country in which cattle cannot be kept. The Makorekore, Chikunda, Bashankwe, Batonka, etc., living in our fly areas do not fall into this category. They have apparently lived for many generations in fly infested country, and whilst they have a tendency to acquire cattle in fly free areas, they do not evacuate their ancestral homes when fly returns.

The native population of our fly areas is comparatively small, and there are not nearly enough natives close to settle a clearing all along the fly limit. It is obvious that natives cannot be moved wholesale from fly free parts and settled along the fly limit, at least until shortage of land elsewhere enforces such action. At best they would be exposed to the risk of loss of livestock, and at worst might contract sleeping sickness in some areas by wandering into the fly area, which, if game were protected, would certainly become very densely infested. Advance in medical and veterinary science might, of course, modify the position somewhat.

Another apparently insurmountable difficulty is the nature of the country along the fly limit which in many parts is of exceedingly poor fertility and unsuited to support a large native population.

It is to be realised that, if game is to be protected, the tendency of the fly to pass any barrier will become very strong indeed, and it is quite obvious that the barrier would need to have no weak sections if the fly was to be held back indefinitely by this means.

I may say that a barrier of combined European and native settlement has been created in Nyasaland across a wide valley with natural mountain barriers on either side. The area is particularly suitable for growing the class of tobacco in which Nyasaland specialises. According to available information, this barrier is not settled sufficiently closely to keep down the forest, but it is included in an open shooting area which extends for a considerable distance in the direction of the fly. Apparently, in this case, settlement is being used as an aid to game reduction and not as a substitute for it.

2. Selective Forest Clearing.—Experiments in reference to removing essential elements of the forest, as opposed to total clearing, have been carried out in various parts of Africa,
particularly in Nigeria, where the results obtained against *morsitans* have been only partial. They are, I understand, being prosecuted at present in Tanganyika against *morsitans*. They are usually based upon the need of the fly for shade during the late dry season when the dominant savannah forest of the locality may become entirely leafless. The feasibility of the measure depends greatly upon the nature and habit of the dominant forest, which is determined by climate and soil.

An experiment of this nature was commenced on the Gwai River in 1928, but was discontinued before any considerable area had been treated.

There are possibilities in this measure in certain areas, particularly those dominated by mopane forest, but it is certainly not applicable over the whole fly front. It is a measure calling for careful experimental investigation in each piece of country concerned. It is on the whole a distasteful measure, as it commonly involves the destruction of the finest evergreen trees in the locality, the object being to make the whole country shadeless in the hottest period of the year. It would best be applied to the creation of a barrier in the form of a zone of country unsuited to permanent occupation by the fly.

3. *Controlled Grass Burning.*—One of the first measures tested in Tanganyika was the protection of the grass until late in the dry season, followed by an organised burn on a large scale with a high wind.

This can be utilised for a direct attack on the fly or for modifying its vegetational environment.

In thickly grassed areas, the result is to burn out the thickets and generally to suppress the undergrowth. In this way it has proved effective to a considerable extent against the tsetse fly *G. suymnertoni*, which is largely dependent upon thicket and lives in thickly grassed country.

Another effect is to drive the flies into areas which will not burn, and here they can be caught. It also destroys a proportion of the puparia but, as the grass can only be burnt once a year, in this Colony at any rate, and the fire takes place during the period when the pupal period is shortest, the destruction of a portion of the puparia present at the time cannot have much effect on the fly as a whole.
The life cycle of tsetse flies is extremely simple. The maggots or larvae are produced one at a time and attain full growth within the mother fly. After birth, they need no nourishment, but simply wriggle into the soil, if sufficiently soft, or under other available shelter if not, and within a few hours change into black puparia (chrysalis stage of butterflies and moths). From these the perfect flies emerge within a period ranging from about three weeks to several months, according to the temperature.

The rate of breeding is very slow for an insect, as, even in the height of the breeding season, the maggots are produced at the rate of only about one in a fortnight. Twelve offspring is probably a large family for a tsetse fly, compared with, say, six hundred in the case of a house fly.

Study of the breeding of *morsitans* in its natural habitat has led to the discovery that the maggots are dropped in almost any spot affording the necessary shade. A favourite site is under the prostrate trunks of fallen trees, but hollow trees are utilised largely, especially at certain times of year, whilst the banks of dry water courses, overhanging rocks, the division between the exposed roots of large trees, hollows in the soil, etc., have yielded an abundance of puparia. It is clear, in fact, that all that is needed for the young stages is a small patch of shade. Too much exposure to the sun will kill the puparia.

All tsetse flies are forest insects, and are unable to persist in extensive tracts of open country. Shade is a necessity to them. They tend to desert forest which becomes leafless in the latter part of the dry season, and to confine their movements to forest still in leaf. This is particularly apparent in areas which include large tracts of mopane forest, which is markedly and consistently deciduous. It is less apparent where the dominant forest is irregularly deciduous, as the tracts of leafless forest are then limited in extent and flies may pass through them comparatively freely.

Finally, the distribution of tsetse flies is limited by climatic factors. In Southern Rhodesia *morsitans* has never been recorded as occurring above an altitude of about 4,000 feet; in fact, over a considerable distance on the north-west
side of the main watershed, the former limit follows approximately the 4,000 foot contour. Where the ground has an aspect with an easterly element the former limit tends to follow a considerably lower altitude, in some places not exceeding 2,500 feet. This may be due to the occurrence of "mist belts" along bold rises in the ground with an easterly aspect. Excessive humidity is unfavourable to *morsitans*.

There is no evidence that any part of Southern Rhodesia is too hot or too dry for *morsitans*, but a considerable portion of the Colony is either too cool or too humid for this species.

The three fundamental requirements of a tsetse fly are, therefore: (1) a suitable climate; (2) suitable shelter in the form of vegetation and (3) a sufficient and suitable food supply.

In order to make the present tsetse fly position in this Colony clear, it is necessary to go back to the past century.

At the time when David Livingstone and subsequent explorers were travelling about this part of the world, Southern Rhodesia from all accounts was infested with tsetse fly to the extent of about half its area (see map). There is evidence, however, that in the south and extreme west the fly areas had broken up considerably by 1890 coincident with the activities of the hunting fraternity, who attributed the disappearance of fly in various parts to their own inroads into the game, more especially buffalo. The Matabili, who came to Bulawayo about 1836, took a considerable and continuous part in this destruction. The explorer Karl Manch had the very good sense to leave a map of the fly limits in 1865-1869, which is embodied in the present-day maps. It figured only the part of the Colony from the longitude of the eastern boundary of the present Hartley District westwards. Selous and other hunters left many records of tsetse fly in the Colony, and there are natives and Europeans living to-day who have been able to supply information from personal experience concerning the former distribution of the fly. As a matter of fact, information in this connection has been gathered from a large number of different sources.

By 1896 there is no record of any considerable change in the fly position on the north-west side of the main watershed.
except the extreme west, but the fly infested areas in the Limpopo, Lundi and Sabi Valleys had apparently become patchy.

The year 1896 was a critical one in the history of the Colony in more ways than one, but we are only concerned with the Rinderpest epizootic.

This apparent misfortune was followed by the total disappearance of tsetse from the southern part of the Colony and the shrinkage of the great infested area in the north to a few isolated spots in the districts of Sebungwe, Hartley and Lomagundi. We have direct evidence as to the location of practically all of these survival localities.

Experience in the Transvaal for half a century had led to tsetse fly being regarded as an ephemeral scourge, and the general impression after 1896 in Southern Rhodesia appears to have been that the fly had disappeared or was on the point of disappearing.

Such optimism was destined to be short-lived. Fly began to make its presence felt again from about 1901, especially in the Hartley District, where there was much mining activity.

It soon became evident that the fly was increasing again, and in 1905 a large portion of the Hartley District was thrown open to free shooting with a view to checking this menace. It was closed for one year in 1908, but was opened again in 1909, shortly before I came to Salisbury.

Although cattle were contracting trypanosomiasis on the occupied farms in the Hartley District, between Hartley and Gatoona and on the Umfuli River, fly in 1909 was present only in very small numbers. The fly area was small and surrounded on all sides by mines and farms. The game was, of course, greatly depleted and the fly was evanescent. The coup de grâce appears to have been administered by temporary clearance of the heart of the fly area in connection with a wood contract for the Cam and Motor mines, commencing in 1912. The Department stipulated that the concession was not to be exploited on the basis of selective cutting, but that the whole forest must be levelled. There was, however, very little
fly in the area when the cutting commenced, and there is veterinary evidence to the effect that trypanosomiasis had greatly decreased by 1912.

That the fly in other parts was still spreading was abundantly clear, both from my own journeys and from reports of Native Commissioners, Police, etc., in the districts concerned. Apart from Suri-Suri belt in the Hartley District, with which we have just dealt, the fly was still, however, remote from settlement and the position was not acute.

In 1918, however, the fly, spreading in a south-westerly direction from the great Sebungwe fly area, began to infect cattle along the Gwaai River, one isolated European farmer being involved.

The first suggestion to deal with the situation was to clear a mile width of forest across the front of the advancing fly. In 1918 some three hundred natives were assembled for this purpose. The influenza epidemic, however, interfered with the work and the operations were terminated after only about one and three-quarter sq. miles of forest had been levelled. Subsequent experience has, in any case, shown that a mile wide clearing would be ineffective against *morsitans*. Early in 1919 a conference was held at Salisbury, presided over by the Administrator, and it was decided to attempt to drive back the fly in this salient by destroying the game. These operations commenced in June, 1919, and were terminated in 1922, by which time the fly had receded far enough to clear the Gwaai River of trypanosomiasis. The native herds remained healthy and increased during the next five years, and cattle were brought back again to the farm mentioned, where they remained without loss.

Unfortunately the operations were discontinued after 1922 and game began to increase again with the result that the fly showed a renewed tendency to advance. In 1927 cattle began to die again from fly disease on the Gwaai River, and as nothing effective was done for several years the fly increased enormously between the Gwaai and Shangani Rivers, and spread much further afield than in the first instance. When intensive operations were again renewed in 1931, the position was very bad indeed and, whilst fly is
decreasing in intensity in this region, we can as yet record no definite retrogression as a result of the present operations.

In the Lomagundi District in 1922 fly commenced to spread south-east from what had been known as the Tchetchewini fly area, destroying native cattle, and in 1923 cattle began to die on occupied farms on the east side of the Hunyani River. By 1924 cattle were also dying on various farms between the Hunyani and Angwa Rivers. Native cattle in the Sipolilo Reserve were also affected. In short, a very serious position had developed.

Operations against game in the Sipolilo sub-district were commenced under the direction of the Assistant Native Commissioner in 1924, and have continued to this day, with the result that the whole sub-district south of the escarpment has been practically cleared of fly.

Similar operations were commenced the same year west of the Hunyani.

In May, 1925, in view of strong representations from the local farmers, a conference, presided over by the Minister of Agriculture and Lands, with representatives of farmers concerned, was held in Salisbury. This conference was in favour of an intensive policy of game reduction. This led to the erection of game fences, ten miles apart, between the Hunyani and Angwa Rivers, which distance was later increased to twenty miles. This measure has been highly successful. The position began to improve from 1927 onward. The fly has now receded some twenty miles or more, and no cases of trypanosomiasis have occurred in the farming area for something approaching two years. Only two farms have had a few cases since 1930. It is estimated that about 1,100 sq. miles of country have been virtually cleared of tsetse from the Sipolilo sub-district to the Umungwe sub-district in the course of these operations.

In 1925 settlement, extending from the east in the Hartley District, encountered tsetse fly extending from the west and another very acute position developed. This was dealt with on the same principle as the Lomagundi section just mentioned, operations commencing in 1927 with two game fences, completed in 1928. These operations have been extended north and south to meet the tendency of the spread-
ing fly to outflank the barrier. Progress has been slower than in Lomagundi, due to the facts that fly was really dense close up to the settlement, that the operations were hampered by scarcity of permanent water, and that a good deal of thick country was included in the area.

In September, 1932, an additional zone of ten miles was taken over, as the original ten mile zone was judged to be too narrow. Trypanosomiasis has not yet disappeared altogether from the farming area, but the number of cases has decreased very greatly. The fly has receded and in no part of the original ten mile zone is more than an occasional fly seen at the present time. It is estimated that about 500 sq. miles have been virtually cleared of fly in this section. The original high densities show unmistakable signs of breaking up in the new zone on the western side.

In 1930 similar operations were undertaken to protect the farms in Lomagundi West as fly was found to be spreading from the Umfuli River northward. These have had a fully satisfactory effect, and some three hundred square miles of country have been cleared of the pest in this part.

In 1929 a conference of Native Commissioners was held at Salisbury to consider native interests in relation to the spread of tsetse fly, and it was decided to endeavour to complete a game reduction cordon around the whole fly area. This was given effect in 1930.

By this means the fly in general appears now to be held in check, although a small advance has occurred in the neighbourhood of the Urungiwe Native Reserve during the past few years. This was anticipated and is due to the very broken and waterless nature of the country in the western half of the reserve, making effective hunting almost impossible, and possibly the reluctance on the part of the Department to permit elephant and rhinoceros, which occur there in considerable numbers, to be destroyed. There is little doubt that the fly in this locality can be held successfully where the terrain is more suitable.

At the present time Southern Rhodesia is the only country known to me which is menaced with spreading tsetse fly (moresotes) where there is reason to judge that the position as a whole is under artificial control.
Apparently the measure has been found useful in parts of Uganda against *morsitans*, but it has been tried for four years and abandoned in Nigeria. We tried it out for three years in the Lomagundi district in this Colony, and the results were very discouraging. As a matter of fact, Mr. Sweeneyton, who is responsible for this measure, admits that much of the country included in the *morsitans* areas which he has seen in this Colony is not suited to its adoption and apparently much of the Tanganyika fly area is similarly unsuited.

4. *Clearing Undergrowth.*—A suggestion has recently been put forward to the effect that the fly is dependent upon undergrowth, and that natives should therefore be armed with sickles, cane knives, etc., and set to clear out the shrubs.

The association of any species of tsetse fly with particular types of vegetation is largely influenced by the optimum humidity for that particular species of fly. Thick vegetation tends to increase the humidity, and in the case of such a fly as *palpalis*, which needs a very high humidity, clearing the undergrowth has had a beneficial effect, presumably by reducing the humidity. *Morsitans* is not generally regarded as being dependent upon undergrowth. It is essentially an open forest tsetse fly, favouring particularly such clean stemmed forest as mopane.

One must not, however, be didactic on a question of this nature. As already stated, there is an optimum humidity for each species of tsetse, and information is available to show that, although the optimum humidity for *morsitans* is undoubtedly considerably lower than for *palpalis*, the humidity in very hot dry weather at low altitudes may be considerably below the optimum, leading to a decrease in the numbers of the fly at this period.

Whilst, therefore, in the wet and cool seasons thick vegetation is definitely avoided by *morsitans*, it does not follow that it may not afford a welcome and even necessary refuge under the very hot and dry conditions, which occur seasonally at low altitudes.

It is clear, however, that, even granting such a dependence, the permanent elimination of undergrowth is not an undertaking which can be put rapidly into effect over an extended fly front.