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## The Tsetse Fly Problem and its Control in South Africa

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### INTRODUCTION

So far as the Union of South Africa is concerned tsetse flies may be considered to constitute but a minor problem because they are confined to parts of Zululand only. The area involved, however, comprises some 7,000 square miles of extremely valuable country particularly suited to the raising of cattle.

For Africa as a whole, particularly equatorial Africa, the 20-odd described species of tsetse flies constitute by far the major problem with which this continent has to contend. This may sound a rather sweeping statement to make in the face of such a disease as malaria, but it must be borne in mind that in the presence of tsetse flies it is not possible for a large community of human beings to exist. In the first place man may be directly affected by the fatal disease, sleeping sickness, as a result of which human beings shun vast tracts of tropical Africa. Secondly, where this human infection does not exist in the tsetse fly-infested areas, animal trypanosomiasis or, as we know it, "nagana," makes it impossible to keep stock, and man and his domesticated animals are inseparable.

Tsetse flies are highly specialized insects which live exclusively on blood, in most cases that of warm-blooded animals. Their life histories are exceptional in the insect world and their habits are such as to make their control a problem which has taxed human ingenuity to its limit with, to date, comparatively little to show for the effort expended.

From time immemorial communities of these flies have existed in Africa, the continent to which they are confined, with the exception of one species which is alleged to occur to a very limited extent in the southern tip of Arabia, undisturbed in most instances by the advent of European civilization. The distribution of the different species of tsetse flies is dependent upon environmental requirements that are special to each and, although they have one requirement common to all, namely, an assured regular food supply in the form of blood of the host animals, there is considerable variation in respect of their other requirements. Thus at one end of the scale there is the dreaded *Glossina palpalis*, notorious for the role it plays in the transmission of human sleeping sickness: it requires a high degree of shade and humidity and for this reason is confined to the banks of lakes and streams. At the other end are species such as *Glossina morsitans*, which is a typical savannah type requiring more open park land and is found frequently a long way from any open water. Between these limits each other species has its own particular requirements confining it to certain special botanical associations.

### THE LIFE HISTORY OF THE TSETSE FLY

The life history of the genus *Glossina* consists of the formation of a single egg at a time, which hatches within the body of the female. The egg-shell is extruded and the white grub-like larva, provided with a dark posterior end on which the spiracles are situated, remains within the uterus of the female, with its oral aperture attached to a minute teat leading from a special milk gland, until almost ready to pupate. When mature it is deposited on the ground and immediately burrows its way for a short distance under the surface. Here it metamorphoses within about an hour to form a characteristic dark brown barrel-shaped pupa having two distinct knob-like projections at one end. From this pupa the fully formed adult fly emerges. There are variations within the genera in the duration of the different stages and as to the site for deposition of the larvae.

### THE FOOD HABITS OF THE TSETSE FLY

The food habits of the different species also vary. *G. palpalis* will frequently feed upon cold-blooded animals such as crocodiles

and monitor lizards (iguanas), although in common with other species like *G. morsitans* and *G. tachinoides*, it may be looked upon as largely homophilic. *G. palpalis* and *G. brevipalpis*, on the other hand, do not appear to be so readily attracted to human beings and may be regarded as more zoophilic in their food preferences. These differences in habits may possibly account for the relative importance of *G. palpalis*, *G. tachinoides* and *G. morsitans* as transmitters of human sleeping sickness. *G. pallidipes* is not normally associated with the transmission of human sleeping sickness, but recent evidence obtained in Uganda indicates that it can do so. This appears to support the contention that all species of tsetse flies are capable of transmitting the trypanosomes responsible for either animal or human trypanosomiasis, but their importance in this respect depends upon their food habits.

All species of tsetse flies are basically dependent upon wild antelopes for food, but the different species show individual preferences. *G. morsitans* appears to feed principally upon the large game species such as buffalo, koodoo, etc., and apparently cannot maintain itself upon the smaller species only. On the other hand, *G. pallidipes* is apparently able to adapt itself to the smaller species such as the warthog, bushbuck, etc., without access to the larger species.

### Methods of Controlling the Tsetse Fly

#### GENERAL METHODS

The very intensive studies which have been made upon the life histories and habits of the different species of *Glossina* have indicated that great importance must be attached to seemingly insignificant differences in habits such as those detailed above and in certain instances control measures based upon utilization of factors related to such habits have yielded spectacular success.

In general the methods of control which can be applied successfully to this genus may be summarized under the following heads:—

1. Those designed to affect adversely the environmental requirements of the fly. These consist of the elimination of shade, particularly by the removal of certain types of thicket bush, and have yielded most success with *G. palpalis*—a species confined to the banks of lakes and rivers by virtue of its dependence upon high degrees of shade and humidity.

With other species which are not confined to such narrow limits the application of the method is more difficult as much larger areas have to be cleared and clearing requires the elimination of more species of plants. In these cases maintenance of the clearings is very costly.

2. Those designed to eliminate or reduce the food supply of the fly to a level at which it can no longer maintain itself—the destruction or removal of game animals. These measures have been very successfully applied in Southern Rhodesia, where it is claimed that approximately 6,000 square miles of country have been freed of *G. morsitans*.

With certain species this method has not been so successful, presumably because the flies concerned can adapt themselves to feeding and maintaining themselves upon smaller animal species that evade the measures used.

3. The direct attack upon the fly itself without disturbing either its environmental or food requirements. Apart from the question of biological control by means of hyperparasites or predators two methods appear to be possible, the use of a trap capable of catching the fly in sufficient numbers to lead ultimately to its complete extinction, and the application of an insecticide in a manner capable of achieving eradication.

#### THE TSETSE FLY IN SOUTH AFRICA

Before going into this question of the application of insecticides for tsetse fly control a brief description of the problems presented by tsetse flies in the Union should prove of interest.

There appear to be four areas in Zululand which may be regarded as the primary foci of tsetse flies and from which occasional extensions into the surrounding country may occur.

From south to north these areas consist of the Umfolozi Game

Reserve (*G. pallidipes*); some 30 miles to the north the Hluhluwe Game Reserve (*G. pallidipes* together with *G. brevipalpis*); about 40 miles further north is the Mkuzi Game Reserve (*G. pallidipes* and in addition a small species, *G. austeni*); adjacent to the Mozambique border is the Nduma Game Reserve (*G. brevipalpis*).

According to the writings of some of the early colonists, notably the Voortrekker, Louis Trichardt, a fourth species of tsetse fly, probably *G. morsitans*, occurred in the Transvaal prior to 1900. It extended along the Limpopo river and its tributaries eastwards and well down into the eastern low veld areas of the Transvaal. At about the time of the rinderpest epizootic in 1896 it disappeared completely and has never recurred since. There is evidence to show, however, that it was disappearing from the western limits of the area even prior to the advent of the rinderpest.

Differences of opinion exist as to the factors responsible for its disappearance from the Transvaal, but in view of the results achieved in recent years in Southern Rhodesia in freeing large tracts of country from the same species by partial game elimination, it seems obvious that it was due to the depletion of host animals as a result probably of hunting, and later of rinderpest, which decimated many of the game species, the larger ones particularly. *G. morsitans* is not now a problem in the Union, but it is present to the north in Portuguese territory, and has shown a tendency to spread during the last ten to 15 years, and a re-invasion might occur.

In Zululand the relative importance of the *Glossina* species is determined by the climatic and vegetational requirements of the three species present. Thus *G. pallidipes*, which is by far the most important, may be called the savannah species which infests typical savannah bush veld and, by virtue of the extent of the type of bush capable of supporting it, occurs over very considerable areas. *G. brevipalpis* may be looked upon as a forest species requiring dense shade as is afforded by the forest bush of the Hluhluwe Game Reserve and the riverine forests along the Pongola river near the Portuguese border. This species is, therefore, very much more confined in its distribution and will never constitute the problem which is presented by *G. pallidipes*. In the case of *G. austeni*, which we may call the riverine and savannah thicket species, more information is required in order that its exact distribution may be plotted, but up to the present it appears to be confined largely to the Mkuzi river and the country adjacent to it.

The conditions governing the continued existence of a community of tsetse flies thus consist of a vegetational association and climate suited to the requirements of the particular species, together with a permanent food supply in the form of host animals which, by virtue of their habits and close association with the fly, assure the latter of a blood meal at intervals of, at the most, three days. This delicately balanced association between the fly and its food supply is one which could presumably exist only under undisturbed natural conditions; should any factor or factors intervene which would upset the normal habits of the game, a disturbance in this balance could occur, as a result of which the fly would be unable to obtain its meal of blood within the three-day period and very heavy mortality, if not extinction of the species, would follow. Such a disturbance in the fly-host balance was successfully applied in Southern Rhodesia in the case of *G. morsitans*, with the result that the species became extinct over very large tracts of country as a consequence of starvation.

Up to the present the method has not been successful in the case of *G. pallidipes*, probably because this fly is (a) provided with senses enabling it to locate its food more easily, (b) adapted to feeding upon the smaller species of game such as warthog, bushpig, bushbuck, etc., which are associated with dense thicket and difficult to eliminate, or (c) capable of ranging over a relatively larger area actively searching for food.

In any campaign designed to eradicate *G. pallidipes* by interference with its food requirements apparently nothing short of total extermination of the host animals would be successful. In the Union we have been committed to a policy whereby it has been necessary to retain certain species of indigenous animals, such as the white rhinoceros, in fly-infested areas and our efforts have perforce been confined largely to the creation of game-free belts, with the object of preventing the spread of tsetse flies from their habitual haunts. This policy has greatly complicated the work of control and frequently confused the picture of the fly-host association because, on account of their wandering habits, it has not been possible to confine the animals to particular localities. In view of such a declared policy of game preservation the obvious alternative has been some direct method of attack upon the fly itself in its natural surroundings.

#### THE HARRIS "FLY" TRAP

The Harris Tsetse "Fly" Trap has been given very exhaustive trials in Zululand over many years. By its use a very useful index of the presence of "fly" can be obtained, but it has not been possible to control or even to bring about a reduction in the numbers of *G. pallidipes* and *G. brevipalpis*.

#### The Spraying of DDT from Aircraft

Various reports, mostly in photostat form, were received from the Union's Scientific Mission to America during the war. These included the apparently successful application, particularly in the Pacific theatre, of DDT from aircraft for the control of malaria and fly-borne dysentery amongst troops. They also contained information on the use of aircraft for its application in the Mediterranean and other areas. This led, early in 1945, to consideration of the possibility of utilizing the method for the eradication or control of tsetse flies in the extensive bush areas of Zululand.

In the case of the malaria vectors the insecticide could be applied from aircraft to destroy effectively large numbers of the adult insects lurking in sylvatic surroundings and also, if well distributed over breeding areas, to control the immature stages as well. It was considered that DDT might be applied in this way from aircraft in certain bush areas in Zululand during the maximum period of leaf drop, when the cover for the tsetse fly would be least. On account of their life history, tsetse flies, however, could be brought into contact with DDT only in the adult stage as the larval and pupal stages would not be affected. It would, therefore, be necessary to make repeated applications at intervals within the gestation period of the female fly, to prevent further depositions of larvae, and to spread them over a period sufficient to allow of the hatching of all pupae present in the ground at the time of the first application. By this means, and provided that 100 per cent. mortality of adult flies resulted at each application, the hope was entertained that complete eradication could be achieved within the experimental area or that the number of flies could be so reduced as to make it possible by further applications at the end of the period to achieve success.

From preliminary experiments at the Field Nagana Research Station in the Umfolozi Game Reserve in Zululand satisfactory evidence was obtained of a high degree of susceptibility of *G. pallidipes* (the species involved) to DDT, and it was found that tall dry grass and bush treated with both emulsions and solutions of DDT showed residual effects over considerable periods.

It was deemed advisable that the area chosen for the trial of the efficiency of DDT should be one representing, as far as was possible, an untouched natural locality containing a high density of fly together with an ample number of host animals in the form of game antelopes. At the same time the area should be isolated in order to obviate the rapid infiltration of new flies from the surroundings. In order to be in a position to assess the value of the DDT applications at the conclusion of the experiment it was necessary to choose an area where fairly accurate observations regarding relative fly density had been conducted for a considerable period prior to the commencement of the experiment. The question of a control area which would be left untouched and which would serve as a basis of comparison with the treated area was considered, but in view of the topography of the country and the dangers of fly infiltrating into the experimental area if such a control area was left in the immediate vicinity, it was decided to dispense with such a control and compare results with conditions existing in more distant fly-infested areas even though, on account of climatic conditions, these areas were not strictly analogous.

The experimental area decided upon was the Mkuzi Game Reserve covering approximately 30 to 35 square miles, lying to the east of the Ubombo Range of mountains and bounded on the north by the Mkuzi river. To the east and south there is comparatively open country, with the exception of small thicket areas which it was the intention to include in the experiment. An accurate record of the fly position existed as revealed by Harris Tsetse "Fly" Trap records over many years. The only species of tsetse flies within the area consisted of *G. pallidipes*, with rare isolated records of *G. austeni*, taken in the immediate vicinity of the Mkuzi river, the banks of which are lined by magnificent wild fig trees amongst which in parts there are dense shrub thickets and extensive patches of reeds.

At the time the Union Defence Force was the only body from which aircraft could be obtained and these consisted of military types with the exception of a few heavy commercial machines which had been taken over from Union Airways. The type of aircraft selected for the initial attempt was a J.U. 52 which was fitted with two fuselage tanks of a combined capacity of 400 gallons.

THE TECHNIQUE OF SPRAYING THE DDT MIXTURE

It was considered that it was necessary to employ a finely atomized spray which would adequately penetrate thickets and make contact with the adult flies. The actual spray delivery apparatus used was adapted from information obtained from American sources and consisted of a venturi slung under the fuselage. The spray fluid was fed by gravity through radially arranged holes at the throat of the apparatus so that jets of fluid impinged on to a central point where the airstream, accelerated by the anterior cone of the venturi, came into contact with it, breaking it up into fine droplets. It was found, however, that a certain amount of reconsolidation of atomized spray took place against the sides of the posterior cone of the venturi and to overcome this difficulty, which was considered a disadvantage, a second metal cone was arranged over the posterior orifice of the venturi in such a way that the impinging columns of air would cut through the partially atomized spray and complete the process of atomization.

Fig. 1 shows the spray delivery apparatus.

In the course of a series of test runs conducted with this apparatus and using a variety of spray fluids it was found that it was necessary to incorporate an oil soluble dye into certain of them in order to observe the actual distribution of the spray on test cards arranged on the ground. Flying at a height of 50 to 60 feet, crosswind at wind speeds of between six to ten miles per hour, gave what was considered to be an effective swathe-width of 70 yards, at the same time allowing a safe margin for overlap of swathes.

The method of testing distribution of spray, and the actual results obtained on test cards, are illustrated in Figs. 2 and 3.

The initial attempt using J.U.52 aircraft fitted as described above was undertaken in July, 1945. The spray used consisted of an oil in water emulsion containing 5 per cent. of the para isomer of DDT dissolved in toluene and containing 10 per cent. of a heavy mineral oil, saponified pine resin being used as the emulsifying agent. Delivery of spray was adjusted to 25 gallons per minute which, at the speed of the aircraft of 120 miles per hour, gave a coverage of one gallon of spray fluid per acre or .5 lb. p.p. DDT per acre.

Great difficulty was experienced during this initial attempt in the actual application of the spray, in that it was not found possible to land the aircraft on the landing strip which had been prepared in the Mkuzi Reserve for this purpose, and use had to be made of an aerodrome over 50 miles away from the scene of operations. The result was that no adequate contact existed between the ground party and the aircraft personnel, and coverage of the area had to be left to the judgment of the pilot. This arrangement proved most unsatisfactory.

Valuable information was gained, however, which pointed the way to various refinements which were incorporated in the later spraying ventures. In the first place it was found that the aircraft used was not well suited for the purpose and, apart from being cumbersome and not easily manoeuvrable at this low altitude, the engines were inclined to overheat. Secondly, the emulsion used although well atomized and giving a fairly satisfactory penetration of thickets, was inclined to be deposited upon foliage in the form of discrete droplets which showed no tendency to spread upon leaves. It was shown, too, that the saponified resin and some unsaponified resin was inclined to harden, thus forming a protective coating and masking the effect of the DDT, so that the residual effect appeared to be adversely affected.

In view of the practical difficulties encountered it was decided to cease operations at this stage and, using the experience gained, to re-organize the entire experiment, utilizing a lighter type of aircraft and substituting an oil solution type of spray for the emulsion.

During the second series of spray tests Avro Anson twin-engined aircraft were employed which were fitted with fuselage tanks of 200-gallon capacity. The same type of spraying apparatus was used, but in this case a 5 per cent. solution of DDT (pp. isomer) in furnace oil and paraffin was substituted for the emulsion. Seven aircraft were used and landed on the specially prepared airstrip in the Mkuzi Reserve which served as base for the operation.

It had been decided prior to the commencement of the work that the experimental area would be sprayed three times, spaced over a period of five weeks. Two weeks would be allowed to elapse between the first and second applications and three weeks between the second and third. This procedure was based upon the assumption that the first two applications would cover the normal gestation period of the flies, but that by the end of the second application a fair amount of DDT would have been deposited over the area, namely, 1 lb. per acre, which should exert a residual effect permitting of slight extension in the time neces-

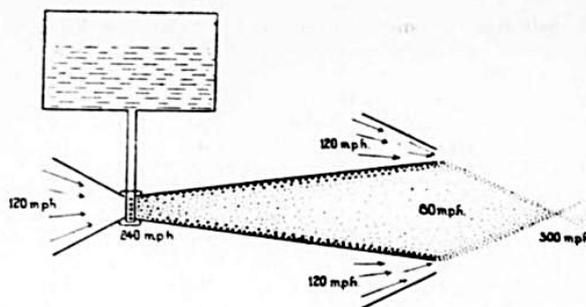


FIG. 1.

Rectangular container represents fuselage tanks of 200 gallons capacity, the contents of which are fed by gravity into the throat of the venturi.

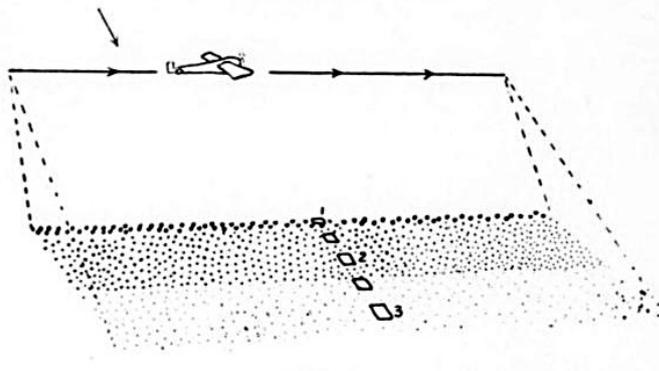


FIG. 2.

Arrow indicates wind direction.

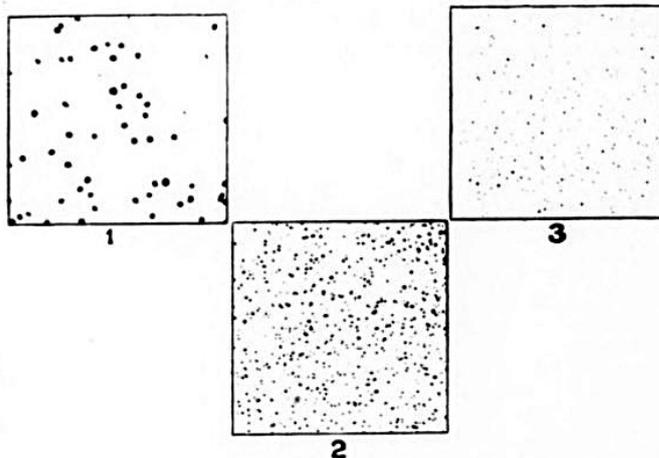


FIG. 3.

Spray droplet distribution on test cards arranged as shown in Fig. 1.

sary for the third application. By the end of the third application sufficient amounts of the insecticide would have been deposited to ensure a residual effect of at least an additional week, so that a period of at least six weeks would elapse during which all adult flies emerging from pupae in the ground would have been destroyed either by direct contact with DDT during the actual spraying operations or by contact with treated surfaces.

THE SPRAYING EXPERIMENT

Spraying operations were commenced on November 30th, 1945, considerable difficulty being experienced to start with in arriving at a method by means of which the aircraft could be made to fly accurate parallel courses at intervals of 70 yards. Flying by means of instruments was soon proved to be too inaccurate to be relied upon, even though the starting points of the runs six to eight miles in length were marked by means of flags attached to tall masts. A procedure was evolved, however, whereby the spraying aircraft commenced its run over a flag, the course being set upon a smoke generator at the end of the run. Having made its turn the aircraft then sprayed in the reverse direction, com-

mencing the run over a flag and ending over a smoke generator. Occasionally it was necessary on account of the topography of the country to use a smoke generator in the centre of the run. The first spraying of the area was completed by December 4th, 1945. The second spraying was carried out between December 15th and 20th, somewhat more bush on the outskirts of the Reserve being covered on this occasion. The third and final spraying of this series was conducted between January 9th and 15th, 1946.

#### RESULTS OF EARLIER SPRAYING EXPERIMENT

The evaluation of the results attained by the three sprays laid down is by no means an easy matter because of the lack of any very effective means of determining the actual density of "fly." A large number of Harris traps had been maintained in the area for a number of years, the catches of which had been recorded on a monthly basis. For a month prior to the commencement of spraying, daily recordings of "fly" were instituted and the weekly totals from the various trapping areas submitted to headquarters. It was noted that the weekly totals showed a steady increase during November to a peak of 7,053 *G. pallidipes* for the week ending December 1st, 1945, in what was known as the high fly density area, in which 230 Harris traps were situated. In what was known as the low fly density area, in which 61 traps were sited, a total of 1,089 flies were recorded for this week.

In the high fly density area the catch at the end of the week during which the first spray was laid down dropped to 37.5 per cent. of the total recorded for the previous week. This decrease in flies was maintained so that the figure reached 19 per cent. after the second spraying and 14 per cent. for the week ending the completion of the third spraying. Thereafter the catches dropped further so that at the end of January a figure of 7 per cent. of the original total was reached. A similar decrease was noted in the low density area. From about the end of March a gradual increase in fly catches was noted in both the high and low fly density areas but even up to the commencement of the 1946 season's operations the pre-treatment level had not been reached. In the bushed areas surrounding the Reserve, which were included in the second and third sprayings, traps were placed shortly after the commencement of spraying and here similar decreases in the fly catches were noted and they have been maintained in all cases.

Observations conducted throughout the area by noting the activity of "fly" around motor vehicles and personnel were equally significant. Whereas at the commencement of spraying *G. pallidipes* was very numerous and annoying to ground parties, it disappeared to such an extent that even after the second spraying it could be found in its favoured haunts only with difficulty, and at the end of the third spraying could not be found at all.

It must be borne in mind, however, that, with the exception of light rains which delayed operations during the second spraying for a matter of two days, extremely dry conditions prevailed throughout the entire period of the three sprayings.

A peak may have been reached at the time of the first spraying as shown by the steadily mounting weekly fly catches during November and it is possible that the decreases in weekly totals thereafter may have been partially due to climatic conditions. In the eastern section of the Reserve which normally contains the highest concentration of game and "fly" the grazing deteriorated rapidly and some movement of game was observed towards the west where more dry grass was to be found. The movement of game could not be attributed to disturbance caused by the spraying operations as it was noted that the game were only very temporarily affected by the aircraft passing overhead and in any case the whole reserve was subjected to identical treatment. This migration of game did not appear to influence materially the incidence of fly, and the gradual increase in catches appeared to run parallel to each other in the high and low density areas, except that from late in June, 1946, until the commencement of the third series of spray tests in August, the highest catches were maintained in the low density area, whereas a decrease occurred in the high density area.

Heavy rains occurred in January, 1946, shortly after the completion of the third spraying and, in view of the rapid increase in leaf cover which followed these rains, it was decided to postpone operations until the winter months as it was feared that insufficient penetration of thicket by spray droplets would result as a consequence of this heavy overhead canopy.

The general conclusions arrived at were that the method of DDT dispersion in atomized spray form from aircraft for tsetse fly control could be regarded as satisfactory in areas not too extensive and where the terrain was such as to make the use of aircraft possible, and provided infiltration of fly from adjacent

untreated areas could be excluded. Certain important conditions impose limitations on the use and manner of operating such a campaign. They are:—

1. In very dense thicket there is a definite danger of insufficient penetration of spray because of spray droplets being caught on the overhead canopy.

2. The method may be best applied only at the time of maximum leaf drop which restricts the time of spraying to the winter months only.

3. The spray must be finely atomized in order to make contact with the adult fly during periods of activity. It may be likened to a space spray which necessitates low flying in order to prevent excessive loss through evaporation, and this in turn restricts effective swathe widths to not more than 70 yards.

4. Spraying must be carried out crosswind, as flying into or downwind still further reduces the swathe width. This frequently complicates the practical application of the method, depending upon the topography of the country to be sprayed.

With these limitations in mind improvements in the mode of application of DDT were sought for in view of the further operations against tsetse flies contemplated for the dry season of 1946.

It was considered that the smoke or aerosol method of dispersion of DDT might be better than that previously used. A series of experimental test runs with aircraft was conducted in order to ascertain whether the introduction of highly concentrated solutions of DDT into the hot exhaust gases of the engines would result in the production of suitable smokes lethal to Diptera. A second consideration was whether aerosols so produced and liberated from a height practicable for flying over bushed areas would reach ground level in a lethal concentration.

The preliminary tests were conducted at Pretoria and excellent results were obtained using blowflies exposed in netting cages as test insects. Flying at heights of from 30 to 50 feet it was noted that in still air towards evening the smoke reached ground level in a matter of seconds after the aircraft had passed.

The results obtained were sufficiently encouraging to warrant a test of the method on tsetse flies in their natural environment in Zululand, and consequently a series of test runs in the Umfolozi Reserve was arranged early in July. Tsetse flies and blowflies were exposed in net cages under a variety of conditions and it was demonstrated that *G. pallidipes* showed a considerably higher degree of susceptibility to DDT in aerosol form than the blowflies. At the same time it was noted that except where thermal conditions prevailed the smoke descended to ground level very satisfactorily. Wind tended to disperse the smoke rather rapidly although even in wind of a velocity of up to four or five miles per hour fairly satisfactory results could be expected.

#### LATER MODIFICATIONS OF SPRAY APPARATUS

The apparatus as finally adopted, fitted to twin-engined Anson aircraft, consists of fuselage tanks of 200-gallon capacity the contents of which are fed by gravity through unmodified tubes of five-eighths of an inch inside diameter directly into the exhaust manifold of each engine about one and a half inches from the confluence of the two arms of the exhaust ring pipe. The stubs of the exhaust manifolds are extended by means of a sheet metal stock of the same diameter as the stub for a distance of approximately eight feet backwards past each engine nacelle. The hot exhaust gases from the seven-cylinder Gypsy IX engines give almost perfect sublimation of the DDT in the form of a dense white smoke although a small quantity of fluid in extremely fine particles may be detected.

The DDT solution used consists of 20 per cent. of the technical product (or 16 per cent. of the para para isomer) dissolved in four parts toluene and seven parts C.I. fuel oil. This is fed at the rate of five gallons per engine per minute and represents an output of ten gallons per aircraft per minute or 16 lb. of p.p. isomer DDT per minute. At a speed of 120 m.p.h. the aircraft covers approximately 50 acres per minute, assuming a swathe width of 70 yards. This represents a theoretical application of .32 lb. p.p. isomer DDT per acre or one gallon of the concentrated solution in smoke form per five acres.

Between August 7th and 14th, 1946, the aerosol method of DDT dispersion from aircraft was tested in the Mkuzi Reserve and the whole area, including all the surrounding bushed areas in which the presence of tsetse flies had been demonstrated, was treated. This represented an area of approximately 40 square miles. Many practical difficulties were encountered, chief amongst which were adverse weather conditions, but the entire area was covered in some ten hours of flying from the afternoon of August 12th to the morning of August 14th, 1946.

Experience soon showed that the very early mornings from dawn until 6.30 or 7 a.m. on bright days, with extensions of one or three hours on overcast days, offered the best spraying conditions.



It will be noted from Table I that following upon the application of the fluid sprays an initial drop in fly catches occurred in the high and low "fly" density areas, reaching lowest point at about the end of March, 1946. Thereafter a slight rise occurred followed again by a decline in catches, but the figures remained fairly constant for the five to seven weeks prior to the commencement of the aerosol applications in August, 1946, when a marked drop occurred.

In the Extension Areas and Western Section the fluctuations were not so apparent and a steady decline in catches had occurred which had almost reached exhaustion point prior to the commencement of the aerosol applications.

TABLE II  
TSETSE FLY CATCHES—HLUHLUWE RESERVE

Catches for month	<i>G. pallidipes</i>	<i>G. brevipalpis</i>	Total
1945—			
November .. ..	70,194	1,042	71,236
December .. ..	72,839	1,172	74,011
1946—			
January .. ..	48,759	487	49,246
February .. ..	28,181	639	28,820
March .. ..	38,927	726	39,653
April .. ..	39,230	782	40,012
May .. ..	78,443	1,643	80,086
June .. ..	65,355	2,170	67,525
July .. ..	61,726	1,210	62,936
August .. ..	84,937	972	85,909
September .. ..	40,728	580	41,308
October .. ..	30,114	361	30,475
November .. ..	28,962	229	29,191
December .. ..	—	—	—

Table II gives the fly catches over the same period for the Hluhluwe Reserve which, as stated previously, was regarded as an untreated control area although not strictly comparable on account of a considerably higher rainfall and more luxuriant vegetation.

The tentative general conclusions which may be drawn from the above figures, which are further supported by visual observation throughout the entire period, are as follows:—

By virtue of suitable vegetational and soil conditions and a large permanent population of host animals the high and low "fly" density areas may be regarded as permanent haunts of *G. pallidipes* in which breeding has taken place actively since time immemorial. This view is supported by the fact that, over four months of applications of DDT applied at intervals designed to prevent further depositions of larvae, were required to exhaust the unhatched pupae assumed to have been present at the commencement of operations in August. (Exposure of freshly formed pupae under natural conditions in Zululand had shown that emergence of adult flies might be delayed in winter up to four and even five months.)

It is likely that comparatively little breeding has taken place in the extension areas. The high incidence of "fly" in some of these areas when trapping was commenced may have been due to infiltration from the breeding areas. As far as can be ascertained these areas do not carry a large permanent game population, but game animals move into them from time to time. The almost complete disappearance of "fly" from these areas encountered at a comparatively early stage may possibly be accounted for by reduction of the "fly" in the breeding areas, which may have served as the source of these dispersing flies, together with a lack of pupae from which new flies could have hatched.

Although total eradication has not yet been achieved, the tsetse fly incidence, as revealed by Harris "Fly" Trap catches, together with careful observations, has been reduced to a level at which it may be hoped that the natural mortality to which the adult and immature stages are exposed may result in total elimination of this slow breeding parasite.

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## Poliomyelitis and Virus Disease of Dogs

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We have witnessed in the last few months an unusual epidemic of poliomyelitis (infantile paralysis) among the human population. It has appeared rather significant to me that during those same months veterinary surgeons have been puzzled by a simultaneous epizootic of unexplained nervous disease among dogs, and particularly among greyhounds. It may be intrepid on my part to make the suggestion that there is any connection between these two outbreaks; indeed, the current medical and veterinary knowledge and opinion seems definitely to negative such a view, as the specific causative virus is said not to attack dogs, although monkeys and rabbits are susceptible.

As a clinician, I have come to the increasing belief that the symptoms in one species are synonymous with many to be observed in the other, and I would need convincing by a pathologist that it was impossible for the ultra-microscopic organism of poliomyelitis to attack the anterior horn cells of the grey matter of the dog's cord.

At the latter part of last year a rather alarming number of valuable racing greyhounds—mostly between nine and 24 months old—were exhibiting unaccountable and unusual derangements of the nervous system. As in the human being, very seldom were all the varied symptoms common to the disease seen in one animal, but if a series of cases was taken it would have been possible to find almost all of the symptoms described as occurring in man. For instance, one dog would show a mild fever, with exaggerated depression, sore throat, stiffness and anorexia, ending with fits; another would show the most severe convulsions, fit following upon fit in rapid succession (in one case every ten minutes until it died). When it was possible to subdue these, paresis or paralysis ensued, and the animals usually succumbed, probably as a result of respiratory paralysis.

In several cases, dogs which had been distemper-immunized early in life and had never contracted distemper, have gone down with so-called chorea which has progressed to the convulsion stage and death. More than one has shown undoubted wasting of the thigh muscles, and one dog (at present in hospital) developed chorea, unassociated with distemper, and a marked atrophy of all the muscles of the off hind leg. This dog is to be destroyed, as so many others have been; and it becomes a very serious matter indeed when one witnesses such decimation among dogs which quite commonly cost anything up to £1,500 or more. Veterinary surgeons have no name for the condition and certainly no reliable treatment. There is, however, a widespread belief among many of them that an unknown virus is taking hold of our canine population. With this thought in mind last autumn I sent two moribund greyhounds to a well-known research laboratory for a diagnosis. The report was, briefly, to the effect that distemper virus was found in one dog and an unknown virus in the other. It is this unknown virus (which I contend may be that of poliomyelitis) which has given rise to the belief in some minds that the biologics used in anti-distemper immunization have been to blame. Possibility of breakdown with the latter cannot, of course, be entirely eliminated, but is there not a strong case for organized investigation into the whole matter? Our knowledge of these intricacies has not yet reached finality and further investigation on these lines might be most illuminating.

May we now, for purposes of comparison, briefly review the disease as affecting the human being:—

1. "Recent evidence has shown that the virus of poliomyelitis appears in the faeces for some days or even weeks after onset of the infection, and that the virus probably reaches the central nervous system from the bowel, since it has been demonstrated in the abdominal sympathetic ganglia. In the pre-paralytic stage of the infection, characterized particularly by fever and irritability,

our disposal and to the technical staff of No. 1 Air Depot for advice and the modification of the aircraft and construction of the spraying equipment; to the Survey Section of the South African Air Force for supplying aerial survey maps of the area which were of great assistance; to the pilots whose enthusiasm and excellent co-operation played an all-important role in the results achieved; to Dr. Orchard of the Division of Chemical Services for valuable assistance in evolving a satisfactory spraying technique and to Klipfontein Organic Products who were responsible for the manufacture and regular supply of the DDT and the spray solutions used.