HANDBOOK FOR THE USE OF

TSETSE FIELD STAFF

DEPARTMENT OF VETERINARY SERVICES

Department of Veterinary Services,

Branch of Tsetse and Trypanosomiasis Control

A Revised Handbook for the use of Tsetse Field Staff.

August 1975

FOREWORD

Successful tsetse control is absolutely dependent upon well trained field staff. With this in mind I asked Dr. G.F. Cockbill, Assistant Director of Veterinary Services, Tsetse and Trypanosomiasis Control, from 1st March 1964 to 17th April 1972 and head of the Branch for that period, whether he would undertake the task of up-dating our training notes on a printed handbook basis. He very kindly agreed to do this and this most admirable book is the product.

We are extremely grateful to Dr. Cockbill for all the work he has put into writing the handbook, which I am certain will be a standard reference book to all field staff for many years to come. It is very detailed, but clearly written and covers all the field work of the Branch. I am certain that it will contribute immensely to our training efforts.

I am also grateful to those senior officers of the Branch who have assisted Dr. Cockbill in his work, particularly Mr. W.P. Boyt, Chief Veterinary Officer (Trypanosomiasis), who advised on the trypanosomiasis section and the Training Officer, Mr. J.L.H. Pasqual, for general assistance.

Special thanks must go to Mr. A.J. Beeson, the Branch's Mapping Officer, whose enthusiasm for the project was endless. He has been responsible for many of the diagrams, maps and illustrations and also for arranging for the production of the very practical cover.

I would also like to thank Mrs. A. Cockbill for typing the various drafts and the manuscript, the Director of Conservation and Extension for permitting his staff to set this handbook on the VariTyper and the Controller of Printing and Stationery for the final production.

Finally, I commend this handbook to all field staff and I trust that they will make full use of it. I feel I cannot stress this too strongly if we are to achieve the efficiency which is required to attain our objectives.

DESMOND F. LOVEMORE
Assistant Director Veterinary Services
Tsetse and Trypanosomiasis Control

ABOUT THE REVISED HANDBOOK

Since the 'Handbook for the use of Field Staff' was issued in 1966 changes in techniques have taken place, particularly in the application of control measures, and new knowledge has been gathered on the behaviour of the tsetse fly which make it necessary to revise certain sections of the text. The opportunity has been taken to bring the entire Handbook up to date.

The Handbook is designed primarily for the use of those who are involved in the control of tsetse flies in Rhodesia, where the only tsetse species of economic importance are *Glossina morsitans morsitans Westw.* and *Glossina pallidipes* Aust., but the principles of control and the organisation of resources might, with modification, have application elsewhere and against other species of tsetse fly.

The Handbook is not a text book. It is offered as an aid in the training of tsetse control personnel. The information it contains has been derived partly from the many publications on tsetse flies and African cattle trypanosomiasis and partly from experience gained from successful, and sometimes unsuccessful operations waged against the tsetse fly in Rhodesia.

A complete knowledge of the contents of the Handbook will not alone ensure that a man will be an effective tsetse control officer. He must, in addition, acquire the skill and experience of applying his knowledge under the arduous, sometimes hazardous, often lonely but always stimulating conditions of life in the Rhodesian tsetse bush.

I am grateful to all those members of staff, professional and technical, who have given me their unstinted help in preparing this Handbook, and to Miss Janet Smith, of the Department of Conservation and Extension for preparing the Ms. for the printers.

Gerald. F. Cockbill.

REVISED HANDBOOK FOR THE USE OF FIELD STAFF

Index

List of illustrations

List of maps

List of tables

1. THE FUNCTION AND STRUCTURE OF THE BRANCH OF TSETSE AND TRYPANOSOMIASIS CONTROL.

1.1 The function of the Branch

The Branch of Tsetse and Trypanosomiasis Control forms part of the Department of Veterinary Services whose function is to administer the Animal Health Act, to devise and implement measures to control epizootic disease and to carry out research on animal diseases. It is the function of this branch to carry out control measures against the tsetse fly and the disease trypanosomiasis which it transmits. To this end, also, investigations are carried out into the behaviour of the tsetse fly, on control methods, on the responses of animals to the trypanosomes causing disease and on their reactions to various drugs; and, in order to monitor the feeding habits of tsetse flies under changing conditions of food availability, the bloodmeals taken by tsetse flies are identified by serological methods.

The headquarters and main research laboratories of the Branch are situated in Salisbury at the Agricultural Research Station, Post Office Box 8283, Causeway, Rhodesia, telephone nos. 27094 and 26196.

Field stations are distributed strategically throughout the areas of control operations, and field research stations have been established at Lusulu, Binga District and at Rekomitjie in Urungwe District where investigations are carried out under field conditions.

1.2 The structure of the Branch

For administrative purposes the areas in which tsetse control operations are carried out are divided into *Regions*, the extent, number and importance of which vary with the changing extent and intensity of infection in stock and with the distribution and abundance of tsetse flies, Map 1.

At present the distribution of the Regions is:-

Western Region

This includes the Zambesi tsetse belt lying to the west of the Sanyati River.

Northern Region

This is that part of the Zambesi tsetse belt lying between the Sanyati River and the Hoya River, Darwin District.

Eastern and South Eastern Region

This region extends from the Hoya River eastwards and south-eastwards to the Inyanga Mountains, and from the Lusitu River where it crosses the international border southwards and south-westwards, to the Limpopo River. Large areas of this front have been cleared of tsetse flies since 1962, and the only tsetse control operations carried out in this area of Rhodesia are confined to the eastern portion of the Sabi Basin. Assistance is given, however, in the international tsetse control operations carried out in the adjacent areas of Mocambique.

The three regions are made up of *Operations Areas*, the number and extent of which are related to the distribution of the tsetse fly. Elimination of tsetse from one area, or invasion into another would call for a redefinition of areas, and a redistribution of personnel and other resources.

The shooting of certain game animals forms one of the tsetse control methods. In order that this operation shall be conducted according to regulation, certain tsetse "areas" have been proclaimed Controlled Hunting Areas, in terms of the Wild Life Conservation Act, in which named officers and their African staff are permitted to shoot specified animals as a tsetse control measure.

The overall conduct of tsetse and trypanosomiasis control operations is the responsibility of the Assistant Director of Veterinary Services (Tsetse and Trypanosomiasis Control), under the Director of Veterinary Services, who, in turn, is directly responsible to the Secretary for Agriculture.

The Chief Glossinologist is responsible for for the organisation and conduct of tsetse control operations, with, as far as staffing problems permit, a Regional Glossinologist responsible for operations on each front. The Regional Glossinologist is assisted by a staff of Glossinologists to plan and co-ordinate control operations in his area and one or more Senior Tsetse Field Officers who supervise and co-ordinate the multifarious duties involved in tsetse operations.

The Regional Glossinologist (Research Stations and Field Investigations) assisted by one or more Glossinologists and ancillary staff, plans, co-ordinates and conducts research into tsetse biology with special reference to improving our control measures.

The Chief Tsetse Field Officer gives assistance to professional staff by acting as a liaison officer between them and the Senior Tsetse Field Officers. He is charged with the responsibility of supervising the general efficiency of the field officers through their respective Senior Field Officers, and, in consultation with the Senior Tsetse Field Officer (Training) for maintaining their standard of competence.

The Senior Tsetse Field Officer organises the appointment and dismissal of labourers, their wages, food and accommodation, simple medication, and transport. His staff of Tsetse Field Officers act as supervisors of labourers and heavy mechanical equipment engaged in construction and maintenance of roads and tracks, fences and camps, and, where necessary, take part in survey, spraying and hunting operations.

In each area, teams of Tsetse Field Assistants under a Senior Field Assistant carry out field surveys to determine the distribution and abundance of tsetse flies, under the direction of the Glossinologist for the area, and take a major part in applying insecticide to tsetse habitat during spraying operations.

The Chief Veterinary Officer (Trypanosomiasis) is responsible for devising and co-ordinating control measures against trypanosomiasis in livestock, operating through the Assistant Director of Veterinary Services (Field) and his Animal Health Inspectorate.

The Chief Veterinary Research Officer (Trypanosomiasis) and his staff conduct research into the utilization of existing and new trypanosomicidal drugs and into the reaction of domestic and wild animals to the presence of trypanosomes in their blood, with the object of devising improved control of the disease.

The Field Investigations Officer collects and collates data on the incidence of trypanosomiasis in stock and on the progress of drug treatments, to maintain up-to-date epizootological intelligence of the trypanosomiasis position. He acts as a liaison officer between the CVO(T) and the Animal Health Inspectorate.

The compilation of working maps, the recording of new data on existing maps, the production of visual aids for training courses and the training of his staff are the responsibility of the Topographer.

The Senior Tsetse Field Officer (Training) is entrusted with the task of devising and organising training courses for field staff, and of providing them with the technical and scientific background necessary for them to become efficient officers. Whenever possible new recruits will be given an introductory course of instruction.

The general administration and accounting functions of the Branch are the responsibility of the Administrative Officer and his staff. The allocation of funds to provide for the various activities in the several operations areas, the purchasing of stores and equipment and the daily accounting for the multifarious transactions involved in running the Branch are controlled from headquarters. Figure 1 displays the structure of the Branch.

1.3 Terms of employment

The general terms of employment for officers and employees are laid down in RGN No. 52 of 1971 and RGN No. 529 of 1971 respectively, and apply throughout the Service. However, because of the specialized nature of tsetse control work, certain departures from these general conditions have become necessary. They relate mainly to hours of duty. Although hours of duty are laid down by regulation for staff in general, these cannot be applied under field conditions. Our work is concerned with controlling tsetse flies and trypanosomiasis wherever and whenever there is the need. Stock must be tended and emergencies dealt with at any time of the day or night. Sundays and Public Holidays have no significance in the field. Work must proceed as required. In case of any misunderstanding, it is necessary to quote Section 38(1) Part III of the Public Services Act (Chapter 90).

"Every officer shall place the whole of his time at the disposal of the Government, and shall not be entitled as a matter of right to any remuneration in respect of any duty or work in the service which he is lawfully required to perform, unless there is special provision to the contrary in the conditions of his employment in the Service."

There is no special provision to the con-

MAP 1

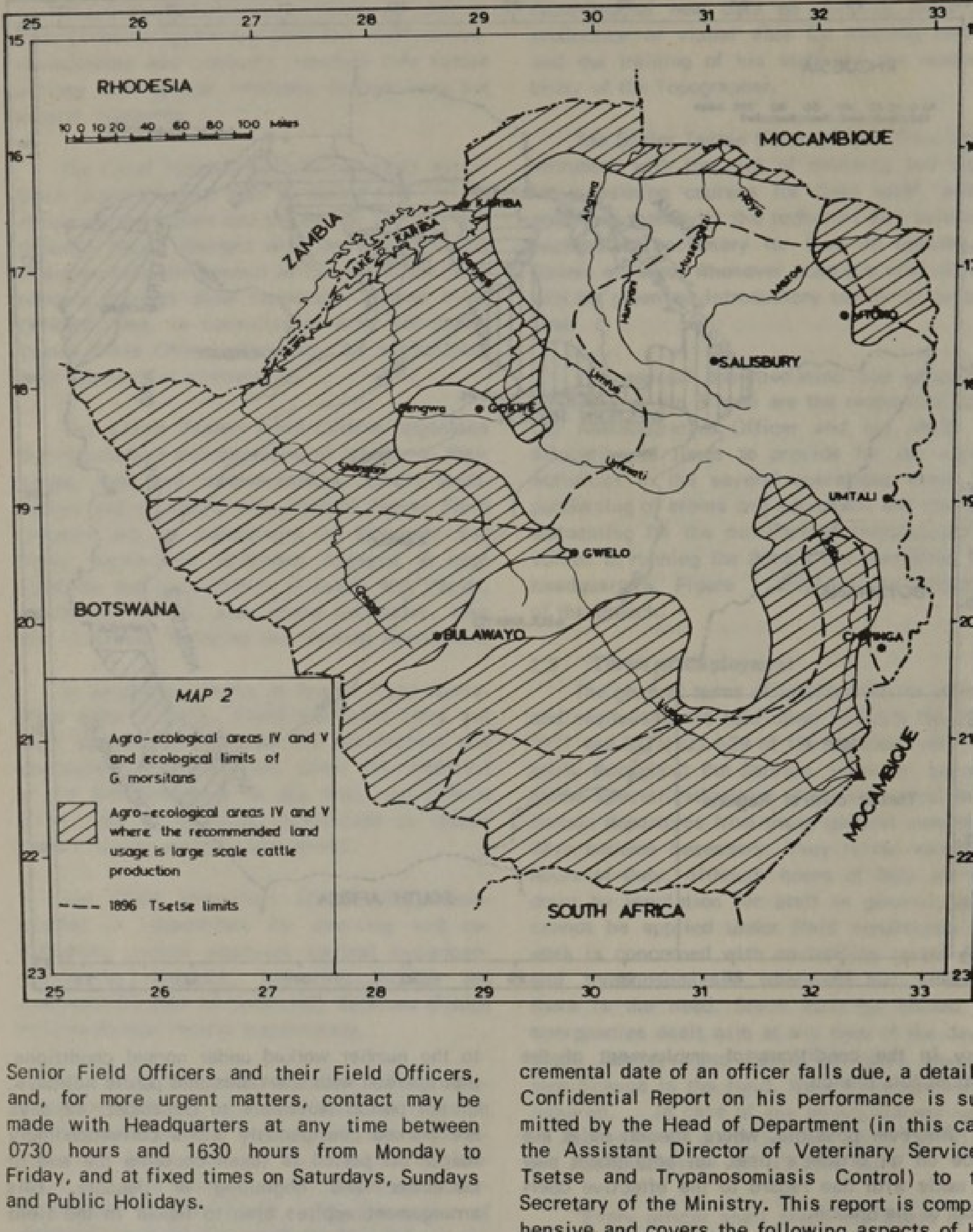
Tsetse control Regions

trary in the conditions of employment of the staff of this Branch.

Wherever possible, where special calls are made on an officer's time, an adjustment may be made with due regard to the effective operation of the Branch.

Thus, in order to maintain operations as uniformly as possible in the field, to avoid needless use of transport and the disruptions involved in weekend and holiday breaks, the system has been adopted of working for 21 days continuously each month, and taking the remaining portion of the month off. The number of days actually worked per year thus corresponds to the number worked under normal conditions, interspersed with weekends and public holidays. In the period November to December, 42 days are worked continuously and a correspondingly longer off period is taken covering the end of December and beginning of January. This arrangement applies also to labour in the field on hunting and spraying operations.

The officer in the field may, at times, feel that he is out of touch with the headquarters staff, and that his activities are unobserved and unrecorded. This is certainly not the case. A comprehensive radio network working on fixed schedules ensures daily contact between Headquarters and Senior Field Officers, and between



Senior Field Officers and their Field Officers, and, for more urgent matters, contact may be made with Headquarters at any time between 0730 hours and 1630 hours from Monday to Friday, and at fixed times on Saturdays, Sundays and Public Holidays.

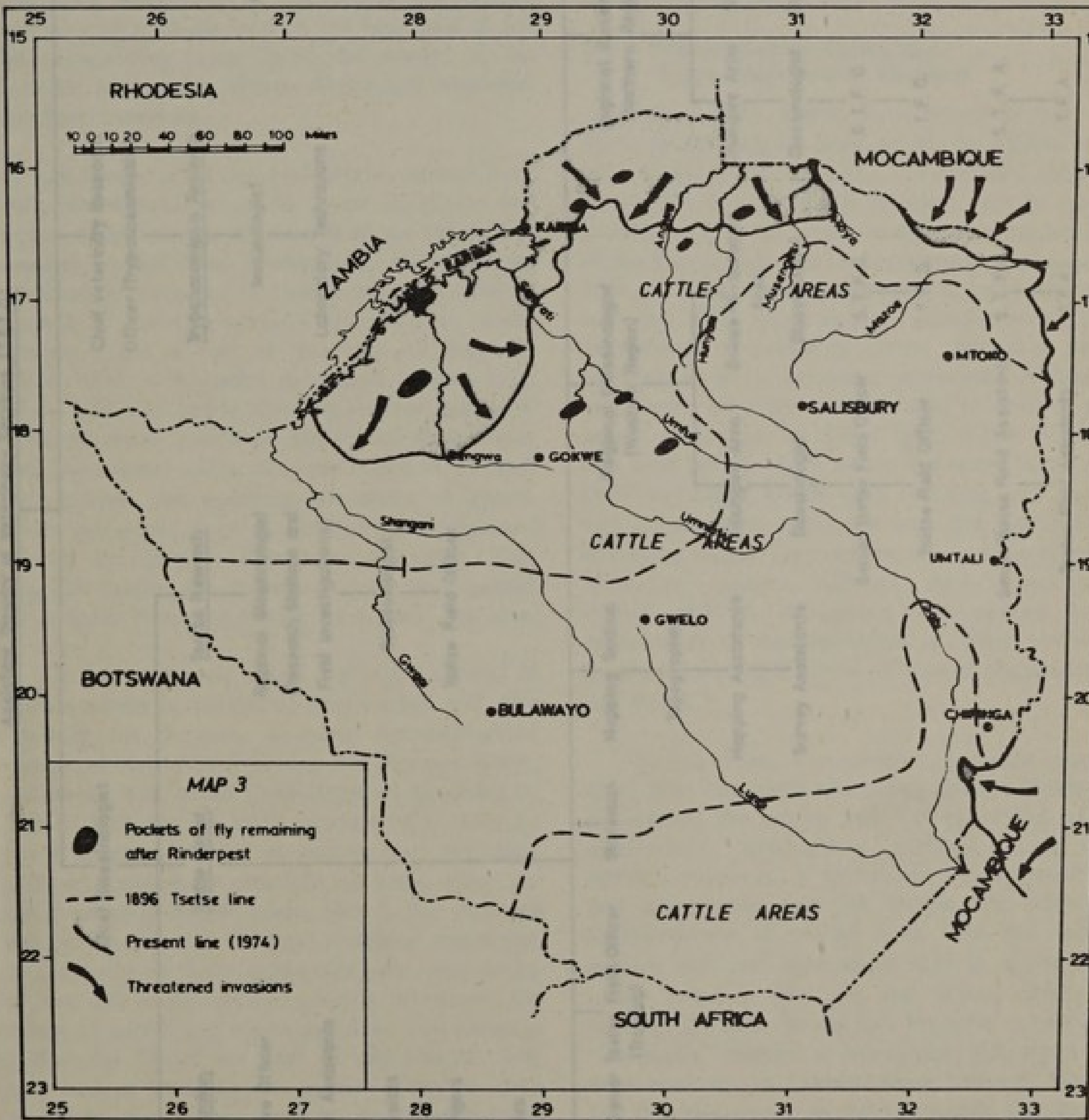
The monthly progress reports on the activities carried out in the area are compared at Headquarters with previous reports from the area and with reports from other areas so that an assessment can be made of relative progress. Both good and unsatisfactory performances are specially noted for future reference.

About two months before the annual incremental date of an officer falls due, a detailed Confidential Report on his performance is submitted by the Head of Department (in this case the Assistant Director of Veterinary Services, Tsetse and Trypanosomiasis Control) to the Secretary of the Ministry. This report is comprehensive and covers the following aspects of his work:-

Industry
Accuracy
Degree of Interest
Reliability
Quickness of Apprehension
Power of Reasoning
Theoretical and Practical knowledge

Reaction to Volume of Work
Method of Tackling Work
Suitability for Promotion
Judgement
Ability of Expression on Paper
Attitude toward Public Expenditure
Ability in reporting
Personality
Ability to Supervise staff
Ability to take Responsibility
Speed of Work
Imagination
Output of Work

If an adverse mark is given to an officer on any of these aspects it may lead to the withholding of the anticipated annual increment. Persistent inefficiency would indicate the unsuitability of the officer for this kind of work, and could result in discharge or transfer.



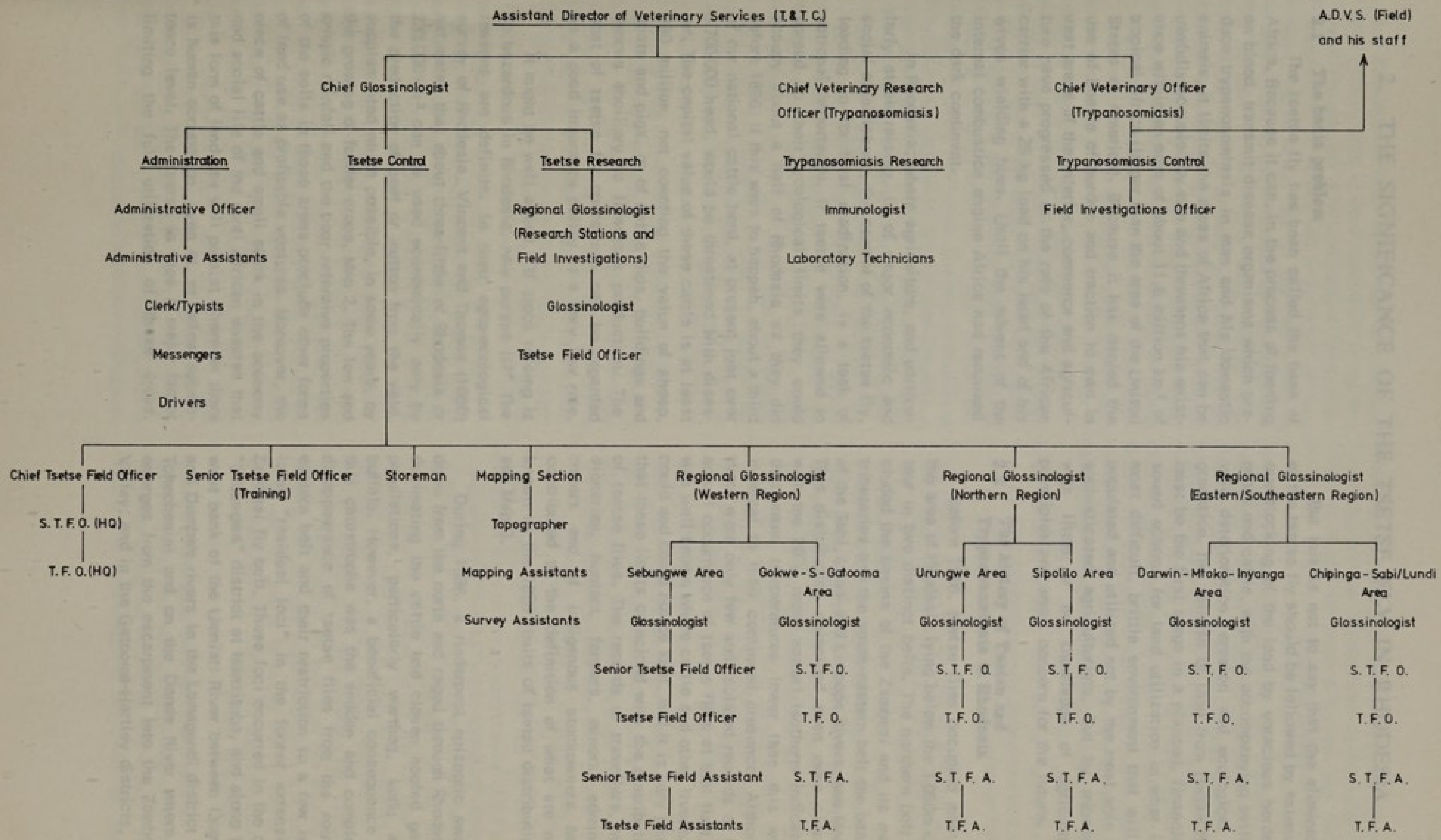


Fig 1 The structure of the Branch of Tsetse and Trypanosomiasis Control

2. THE SIGNIFICANCE OF THE TSETSE FLY IN RHODESIA

2.1 The basic problem

The tsetse fly has been called the bane of Africa. Because it can, in the process of feeding on blood, transmit disease organisms which produce trypanosomiasis in man and his domestic animals, it limits the areas of Africa that can be usefully occupied by man and threatens his existence within an area of about 11,6 million km² of tropical Africa (larger than the area of the United States of America). Because it has denied the use of beasts of burden and traction to man in vast areas of the interior, commerce and agriculture have progressed at the rate of the African carrier with a 25 kg load on his head and of his wives wielding hoes. Until the advent of the internal combustion engine Africa had remained the dark continent.

In Rhodesia, where agriculture, and particularly stock raising, is of major economic and social significance, the control of the tsetse fly, leading to its total eradication, is a task of national importance. If tsetse were allowed to spread to their ecological limits they could occupy about a half of Rhodesia as they did before 1896. If this were to happen, about a third of our national cattle herd, at present just over 5 700 000 head, would be threatened with disaster. The capital value of these cattle is at least $90 million, not counting the value of sheep, goats and pigs, or of cattle dips, buildings and fences ancillary to livestock production. The cost of tsetse fly operations can be regarded as a good insurance policy at a very low rate.

It might be well asked, "If stock raising is so hazardous in Rhodesia, why pursue it?" The reasons are definite. In their agro-ecological survey of Rhodesia, Vincent and Thomas (1960) estimated that about three-fifths of Rhodesia or 233 000 km² can be used economically only by the production of beef or mutton from the veld, supplemented where possible, in some years, by the growing of fodder crops, Map 2. The low and erratic rainfall and the poor retentive properties of the soils in these areas preclude other forms of land use as profitable ventures. Moreover, the place of cattle and small stock in the economy and social life of the rural African ensures that this form of land use will persist wherever there is human occupation, even at, or below subsistence level. The tsetse is thus a major factor limiting the full utilization of these areas.

But this is not to say that the elimination of the tsetse fly should be followed by extensive overstocking of the land by voracious herds of goats and cattle, with the accompanying evils of veld deterioration, erosion and ecological degradation. The release of land from tsetse flies must be the first stage in a planned, financially sound scheme for land utilization in what is a most difficult, brittle environment that will be populated and utilized not by the most able and sophisticated agriculturists, but by tribesmen with little or no knowledge of agricultural principles and small concern for the future.

2.2 The history of Tsetse and Trypanosomiasis in Rhodesia

Before 1896, tsetse flies occupied most of the area of Rhodesia lying below the 1 050m contour in two distinct belts. The northern belt included the basins of the Zambesi and its major tributaries and the south-eastern belt the basins of the Sabi, Lundi and Limpopo Rivers, see Map 3. This distribution coincided even more closely with the 20°C mean annual isotherm indicating that mean temperatures lower than this were inimical to their continued presence. Although there were only few and isolated records of the actual occurrence of tsetse flies at that time, it was well known where cattle and other livestock could and could not be kept, and it is very likely that these limits coincided with the distribution of tsetse flies. The records of travellers, missionaries, hunters, farmers, miners, administrators and of indigenous stockowners have contributed to the definition of what are now known as the 1896 limits of tsetse distribution, see Map 3.

During 1896, a rinderpest epizootic swept down from the north and raged through Rhodesia decimating the cattle and cloven hoofed game populations, particularly warthog, kudu and buffalo. However, a beneficial consequence of this catastrophe was the sudden and complete disappearance of tsetse flies from the south-eastern belt and their restriction to a few isolated "residual foci" in the former extensive Zambesi fly belt. These foci occurred in the old "Sebungwe" district at Manzituba, and along the west bank of the Umniati River between Ongwe and Dumbwe rivers in the Lomagundi district at Tchechenini and on the Dande River where it emerges from the escarpment into the Zambesi Valley; and in the Gatooma-Hartley districts, on the Shuru-Shuru River near Chigwell Siding; near the junction of the Umfuli and Nyabongwe Rivers, and in the vicinity of Gowe on the Umniati, indicated on Map 3.

Gradually the game populations recovered and with them, the fly, but its recovery occurred only in the Zambeṣi fly belt. This recuperative ability of the tsetse fly has been demonstrated repeatedly over the years, and serves to emphasise the fact that control measures cannot be withdrawn with safety until long after an area is apparently free of tsetse. By 1901, the presence of tsetse flies became evident at Gatooma and Hartley, where trek oxen supplying the miners began to die from trypanosomiasis. As agriculture extended, contact with the fly became more frequent.

Little was known at that time about the habits of the tsetse fly, other than that they were woodland creatures and that they fed upon the larger game animals and on livestock when it was available. Using this knowledge in an effort to alleviate the situation, the administering body, the British South Africa Company, suspended the game laws in the Gatooma-Hartley district for three months during 1901. Later, in 1905, they were again suspended (with the exclusion of zebra, elephant, rhinoceros, hippopotamus and ostrich) until 1908. In 1909, owing to heavy losses of stock, the infested areas were reopened to free shooting and remained so until 1928. This action, together with extensive clearing of the neighbouring bush to supply the needs of the local mining activities was accompanied by the local disappearance of the fly by 1916.

The fly did not assume prominence again until 1918, when trypanosomiasis made its appearance on European farms in the Gwaai-Shangani area, where cattle began to die in large numbers. There was no cure available for the disease at that time nor any known means of combatting the fly. However, as long ago as 1914, in London, the Inter-Departmental Committee on Sleeping Sickness had proposed that an experiment should be carried out in a part of Africa where game, tsetse and trypanosomiasis existed, to observe the effect on the tsetse of killing off the game animals on which the fly fed. The opportunity had now presented itself.

Hunting operations were undertaken, starting in 1919, in which game (other than hippopotamus) were killed within an area of the Gwaai-Shangani basin. By 1921, the disappearance of trypanosomiasis in the cattle had demonstrated the efficacy of the method, and, in 1922, hunting was terminated. Trypanosomiasis reappeared, however, in 1927, as it did elsewhere in Rhodesia on farms adjacent to the tsetse belts. Under pressure from the affected stock-owners Government adopted game elimination in 1933 as a general policy for controlling the tsetse fly wherever it was impinging on agriculture. Again these operations were successful against the tsetse fly concerned, *Glossina morsitans*, and by 1945, some 25 000 km^2 of previously fly infested country had been reclaimed.

Between 1945 and 1959, while the tsetse menace had apparently abated over much of the country, great public opposition to the shooting of game had been developed and organised, culminating in 1955 in the appointment of a Commission of Inquiry into human and animal trypanosomiasis in Rhodesia. In its Report, the Commission paid tribute to the greatest success in tsetse control that had been achieved in Africa, but recommended that other means of control should be investigated, particularly discriminative clearing of bush combined with close settlement and the use of modern insecticides. But it emphasised that until the proper methods of application of these new measures had been worked out, a modified form of game control should be continued.

Other methods of tsetse control were applied between 1956 and 1960, including discriminative bush clearing, intensified hunting in certain areas, the application of insecticide from aircraft (which had been tried in Rhodesia in 1953 and 1954 and found to be ineffective) and the application of insecticides from the ground.

The use of game destruction as a means of tsetse control was discontinued on all fronts by 1960, although some shooting was still undertaken for the protection of game fences.

After 1960, with the cessation of hunting, the tsetse situation deteriorated. The tsetse fly was extending its range, and occupation of agricultural areas was expanding, bringing livestock in the marginal areas nearer to tsetse infested country. Not only were the areas of Doma and Sipolilo threatened, (areas where all control measures had been withdrawn), but serious advances of fly were taking place in the Sabi-Lundi, Urungwe, and Sebungwe areas where discriminative bush clearing and the use of insecticides had been practised.

It had become apparent at this time, from identifications made of the blood meals taken by *G.morsitans* in the north western regions of Rhodesia, that this species fed mainly upon warthog and bushpig, kudu and bushbuck. These animals together provided over 70 per cent of their food. It seemed that the fly was so dependent on these animals that if these alone were removed from a tsetse habitat, the tsetse population would come under stress, perhaps sufficient to bring about its collapse.

The opportunity to test this hypothesis arose in October 1962 in the Nagupande area of Binga District, where a dense tsetse population supported by a variety of game animals appeared to provide the focus from which tsetse flies had been transmitting trypanosomiasis to cattle in the Gwaai-Shangani basin, up to 40 kilometres to the south and southwest. In order to rectify this situation, drug treatment of the cattle was intensified, and limited and local tree felling and insecticide spraying operations were carried out along the drainages. But the major effort was directed against the Nagupande focus. An area of 320 km² was enclosed by an 8-strand game fence, and, after the elephant and buffalo had been driven out or killed, the warthog, bushpig, kudu and bushbuck were systematically hunted and killed. In twelve months these animals had been almost completely removed, and, apparently as a consequence, the tsetse population dropped from a monthly catch of about 1 050 per month to less than 50. Moreover, trypanosomiasis had by this time disappeared from the Gwaai-Shangani cattle. We were convinced that this form of game elimination would have a place in future tsetse control operations, if the need arose.

By mid 1963, it had become very evident that the current methods of tsetse control were inadequate and should be replaced or, at least, supplemented by other methods. The situation had deteriorated to such an extent that, in late 1964, it was found necessary, in the light of the Nagupande experience, to reintroduce a modified form of game elimination carried out within zones demarcated by fences, and supported by extensive use of persistent insecticides applied from the ground. These are the methods now in use, and they are showing marked successes in several major areas.

The present situation is that, of the total area of Rhodesia – 388 500 km² – about 45 300 km² are generally infested with *G.morsitans* and, more locally, with *G.pallidipes* along its northern, northeastern and southeastern borders. Along the inner fringes of this distribution about 20 700 km², occupied mainly by tribesmen and their cattle are subject to sporadic, sometimes seasonal, invasions of tsetse that maintain a persistent trypanosomiasis in the stock, which is kept under control only by continuous inspections, diagnoses and drug treatments carried out by the Veterinary Branch of Field Services. Between the fringe areas and the 1 050 m contour, regarded as marking the ecological limit of *G.morsitans*, there are areas totalling 132 100 km² which could be reoccupied by the fly if effective control measures were withdrawn.

2.3 Recapitulation

1. The tsetse fly in feeding, transmits a fatal disease, trypanosomiasis, to man and his stock.
2. The presence of tsetse flies limits the distribution, survival and development of man in tropical Africa.
3. In Rhodesia, tsetse flies occupied about one half of the country before 1896. They could reoccupy this area if control measures were withdrawn.
4. Agriculture, and in particular stock raising, constitutes a major element in the economic and social structure of the country.
5. Control measures carried out since 1919 have recovered large areas from the fly making them available for agricultural development.
6. Their improvement and continued use could eliminate tsetse flies from the country.
7. The utilization of land recovered from tsetse fly must be planned and controlled.

Character	*G.morsitans*	*G.pallidipes*	*G.brevipalpis*	*G.austeni*
1 Size	Medium	Medium	Large	Small
2 Length	8–10mm	8–10mm	10–14mm	7–8mm
3 Colour of dorsal surface of abdomen	Distinct, divided dark brown transverse bands on yellow ground. Each half of each band semi-lunar in shape.	Distinct, divided dark brown transverse bands on yellow ground. Inner posterior angles of half bands are right-angled, appearing as though showing through varnish.	Uniformly brown. Banding absent.	Brown with reddish tinge. Banding indistinct.
4 Width across eyes	Less than width of thorax.	Not less than width across thorax.	–	–
5 Colour of front tarsal segments	Apical segments with dark tips.	All uniformly pale.	–	–
6 Colour of hind tarsal segments	Only two apical segments dark.	Only two apical segments dark.	Only two apical segments dark.	All segments dark.
7 Length of hooked hairs on third antennal segment	One seventh of width of segment	One third of width of segment.	–	–
8 Hypopygium	Large in relation to size of abdomen.	Small in relation to size of abdomen.	–	–
9 Femora	Pigmented	Pale	–	–
10 Apical scutellar bristles (Fig. 14)	Short in female, long in male.	Long in both male and female.	–	–
11 Male genitalia (Fig. 11)	Membrane present. Median lobes well developed. Rudimentary 'tooth'.	Membrane present. Median lobes present, but with post-lateral tooth well developed.	Claspers free. Well developed 'tooth'. Membrane absent.	Membrane present. Median lobes present. 'Tooth' present.

Table 1. Distinguishing external morphological characters of tsetse flies recorded in Rhodesia.

3. THE CLASSIFICATION, ANATOMY AND FUNCTION OF THE TSETSE FLY

3.1 Classification

In order to be able to describe a tsetse fly and to draw distinctions between the sexes and different species of tsetse flies, it is necessary to become familiar with their general structure (morphology) and the way in which they carry out their bodily functions (physiology). As this involves the absorption of ideas that may be new to you, you will have to learn some new words to describe them. These 'technical terms' are simple devices, used to describe briefly what are often quite complicated ideas.

When we discuss a tsetse fly we should be sure that we know what we are talking about. We should know how it differs from all other living things. Let us classify it. Living things can be placed into two main groups:-

(i) those organisms that possess the green colouring matter chlorophyll, by means of which they capture energy from the sun directly, for use in their life processes. These belong to the Plant Kingdom.

(ii) those organisms that do not possess chlorophyll, but obtain the energy for their life processes by consuming plants or by consuming organisms that have themselves consumed plants. These belong to the Animal Kingdom.

There are also groups of plants, the Bacteria and Fungi, and other parasitic plants that do not possess chlorophyll, but they possess other characteristics that place them in the Plant Kingdom.

The tsetse obtains its energy for living not directly from the sun but by feeding on other organisms. It is therefore an *animal*.

Some animals exist as single cells. These are Protozoa. The single cell provides whatever support and locomotion is required; it respires, feeds, digests, excretes and reproduces. The trypanosomes which are transmitted by the tsetse fly are a special group of the *Protozoa*.

Other animals are made up of groups of similar cells forming *tissues*, each performing a special function – the *Metazoa*. The tsetse, like most animals, belong to the *Metazoa*. Different parts of the animal provide for support, for locomotion, for respiration, for digestion, for excretion and for reproduction.

The *Metazoa* are divided into large groups – the members of each group having many features in common, and being quite distinct from members of other groups. Animals with backbones, a jellyfish, a starfish, a snail, an earthworm, the bilharzia parasite, an insect – each belongs to a different major group or Phylum.

The tsetse fly belongs to the Phylum *Arthropoda*, which includes all those animals which possess:-

(i) a body clearly made up of *segments* in at least one stage in their lives.

(ii) a firm, sometimes hard, outside skeleton, the exoskeleton, formed of rigid plates, which serves for attachment for the muscles of locomotion. The exoskeleton contains in its outer layers the substance chitin which is highly impervious to water. Where movements are required between these rigid plates they are joined together by flexible, but chitinised membranes.

(iii) legs composed of tubular segments with flexible membranous joints.

(iv) necessarily, because of the firm outside skeleton, a method of growth in which the exoskeleton is discarded (*ecdysis* or moulting) as the animal grows, to be replaced from below by a new exoskeleton.

(v) a central nervous system which lies ventrally in the body cavity. (In backboned animals the central nervous system lies dorsally in the body cavity).

The group *Arthropoda* includes the following main classes:-

(i) Crustacea. Crabs, lobsters, shrimps etc.

(ii) Arachnida. Scorpions, spiders, mites ticks etc.

(iii) Myriapoda. Centipedes, millipedes

(iv) Insecta. All insects

The *Insecta* differ from other *Arthropoda* by having:

(i) a body clearly divided into three parts; the head, the thorax and the abdomen

(ii) a single pair of antennae

(iii) three pairs of mouth parts (these are greatly modified in the tsetse fly)

(iv) three pairs of legs borne on the thorax

(v) usually one or two pairs of wings borne on the thorax (insects, birds and bats are the only animals that can really fly)

(vi) a system of paired spiracles and branched tracheae through which they breathe air.

As the tsetse fly possesses all of these characteristics it is an *Insect.*

The Class *Insecta* contains about three quarters of all the known species of animal. There are over 700 000 known species of insect, and there are possibly five times as many unknown species. The Class includes such diverse forms as dragonflies, cockroaches, locusts, lice, aphids, ants, bees, beetles, butterflies and flies. It is divided into *Orders.* The tsetse fly belongs to the Order *Diptera* because:

(i) it possesses only one, anterior, pair of functional wings

(ii) it undergoes a full development from egg, to a legless larva, to a pupa, and finally to adult

(iii) it possesses suctorial mouthparts.

The Order *Diptera* includes mosquitoes, midges, horseflies, robber flies, fruit flies and house flies; each group belonging to a different Family.

Tsetse flies belong to the Family *Muscidae* which includes houseflies, bluebottles and stable flies (Stomoxys). Tsetse flies can be distinguished from other Muscidae by having:

(i) a hatchet shaped cell in the wing venation, and

(ii) wings that fold over the abdomen like the blades of a pair of shears, and

(iii) piercing and sucking mouthparts.

All tsetse flies, (and there are 33 species, sub-species and races), belong to the *genus Glossina,* just as all cats, domestic and wild, belong to the genus *Felis.* The various kinds of tsetse are grouped into species, which are regarded as the biological units. The criterion of a species is that its members can interbreed amongst themselves to produce fertile offspring but not with members of other species. It is generally true that knowledge of the structure of a male and female member of a species is knowledge about all members. The tsetse fly which occurs most frequently in Rhodesia is *Glossina morsitans.*

Animals and plants are identified by two names. The first, generic name, is always written with a capital letter and the following specific name with a small letter. In print they are always written in italics, and underlined when type written. The name of the person (or a contraction of it) who first described the organism in print and the date should follow the specific name. This practice serves to distinguish a name from that of a different organism given the same name by another person.

Thus, our common Rhodesian tsetse fly is identified as belonging to the:-

Kingdom	*Animalia*
Phylum	*Arthropoda*
Class	*Insecta*
Order	*Diptera*
Family	*Muscidae*
Genus	*Glossina* Wiedemann 1830
Species	*morsitans* Westwood 1850

The other important Rhodesian species is *G. pallidipes* Austen 1903. (After first mention, the generic name may be contracted to the initial letter, and the authority's name can be omitted.)

Minor differences may occur between members of a species, associated with differences in their geographical distribution or diet. If these differences are constant from generation to generation they may warrant using an extra name to indicate a sub-species. Thus, since our *G. morsitans* differs slightly but consistently from *G. morsitans* found in West Africa, the Rhodesian form was distinguished as *Glossina morsitans orientalis* Vanderplank and the West African sub-species as *Glossina morsitans submorsitans.* The latest publications however, refer to the Rhodesian form as *Glossina morsitans morsitans* since it has been found to resemble the original named specimen now in the British Museum. It is not only of academic interest to know precisely which organism is being dealt with. Not only are there structural differences between sub-species, but behavioural differences can occur. The success or lack of success of control measures could depend upon the slight differences in host preferences or reaction to desiccation that exist between sub-species. Methods of control found to be suitable against one subspecies might be found to be less effective against another, and modifications of the methods might be called for.

Now that we have established that we are dealing mainly with *Glossina morsitans morsitans* let us become more general. Tsetse flies have many distinctive features in common, and a general description will serve to describe all species. Specific differences will be emphasized where they apply.

3.2. General external anatomy and function

Fig.2 and Fig.3

3.2.1 The head Figure 4

The head bears the main sensory organs, the mouth and its associated feeding apparatus, and encloses the brain. On the head are borne:-

The compound eyes

These are large, paired, faceted structures occupying the front and sides of the head. The eyes function as bundles of minute telescopes each contributing to form a mosaic image of the object. *G. morsitans* can react to moving objects at a distance of about 150 metres, and make use of sight in finding their hosts at a distance.

The ocelli

Between the compound eyes on top of the

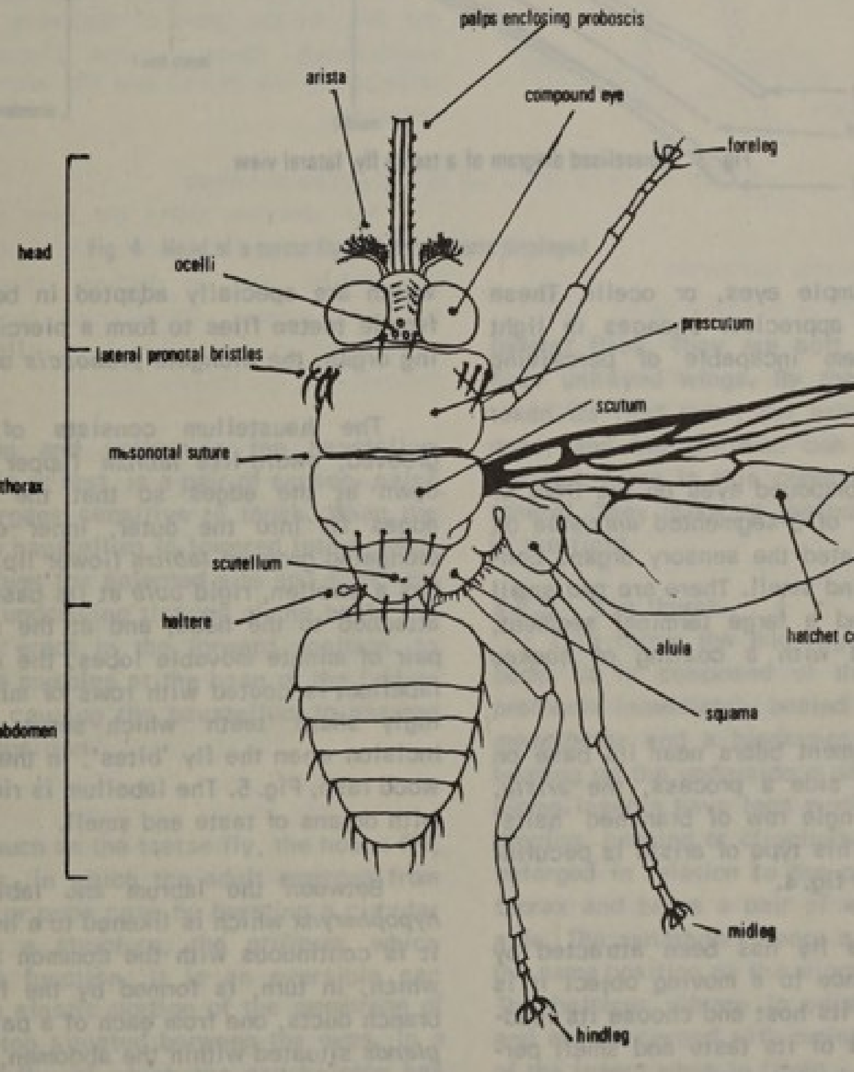


Fig. 2 Generalised diagram of a tsetse fly, dorsal view

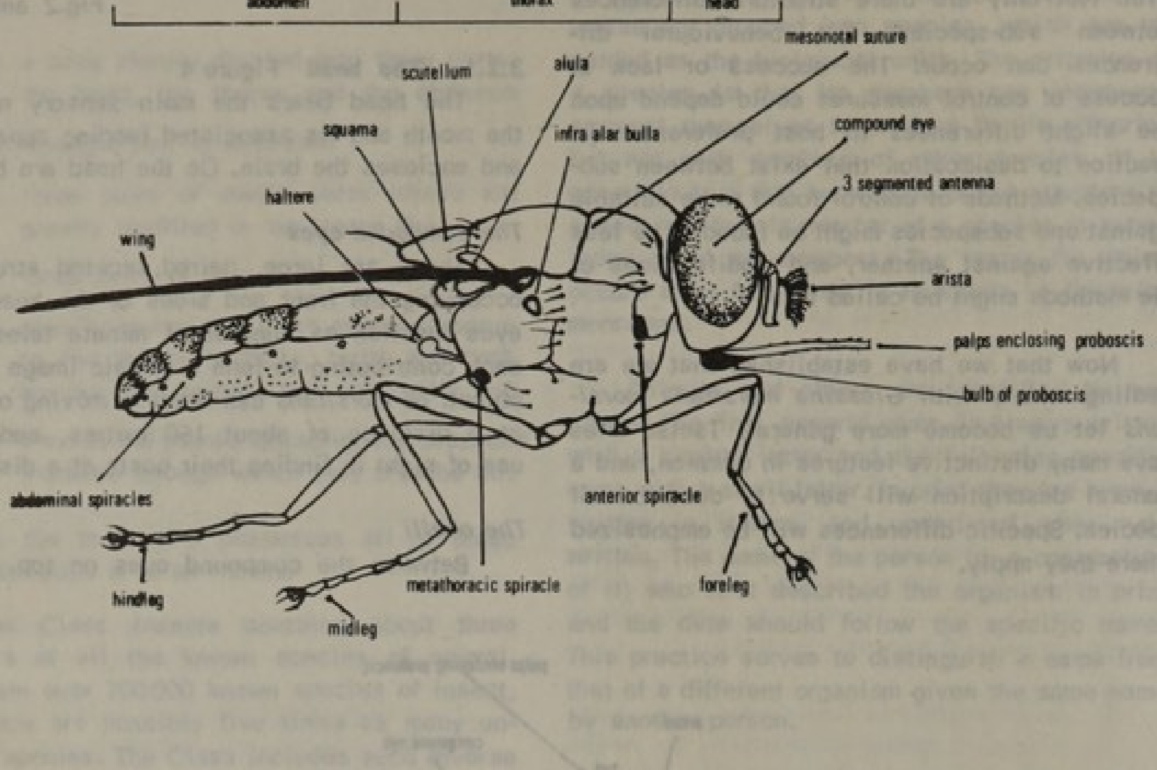


Fig. 3 Generalised diagram of a tsetse fly, lateral view

head are three simple eyes, or ocelli. These enable the fly to appreciate changes in light intensity, but seem incapable of perceiving images.

The antennae

Between the compound eyes on the front of the head is a pair of 3-segmented *antennae* on which are concentrated the sensory organs concerned with taste and smell. There are two small basal segments and a large terminal segment, which is provided with a coating of *hooked bristles*.

This third segment bears near its base on the upper (dorsal) side a process, the *arista*, which carries a single row of branched 'hairs' on one side only. This type of arista is peculiar to tsetse flies, see fig. 4.

When a tsetse fly has been attracted by sight from a distance to a moving object it is able to distinguish its host and choose its feeding sites by means of its taste and smell perceptors located on the antennae.

The mouthparts

Surrounding the mouth are the mouthparts which are specially adapted in both male and female tsetse flies to form a piercing and sucking organ, the elongate *proboscis* or *haustellum.*

The haustellum consists of a slender, grooved, sword-like *labrum* (upper lip), curved down at the edges so that the outer, upper edges fit into the outer, inner edges of the elongated grooved *labium* (lower lip). The labium has a swollen, rigid *bulb* at its base where it is attached to the head, and at the tip carries a pair of minute movable lobes, the *labella.* Each labellum is coated with rows of minute exceedingly sharp 'teeth' which serve to make the incision when the fly 'bites', in the manner of a wood rasp, Fig. 5. The labellum is richly supplied with organs of taste and smell.

Between the labrum and labium lies the *hypopharynx* which is likened to a hollow tongue. It is continuous with the common *salivary duct* which, in turn, is formed by the fusion of two branch ducts, one from each of a pair of *salivary glands* situated within the abdomen, Fig. 6.

The labrum and labium, with the hypopharynx lying in a groove along its floor, form the *food canal,* Fig. 7. which is lined with organs of

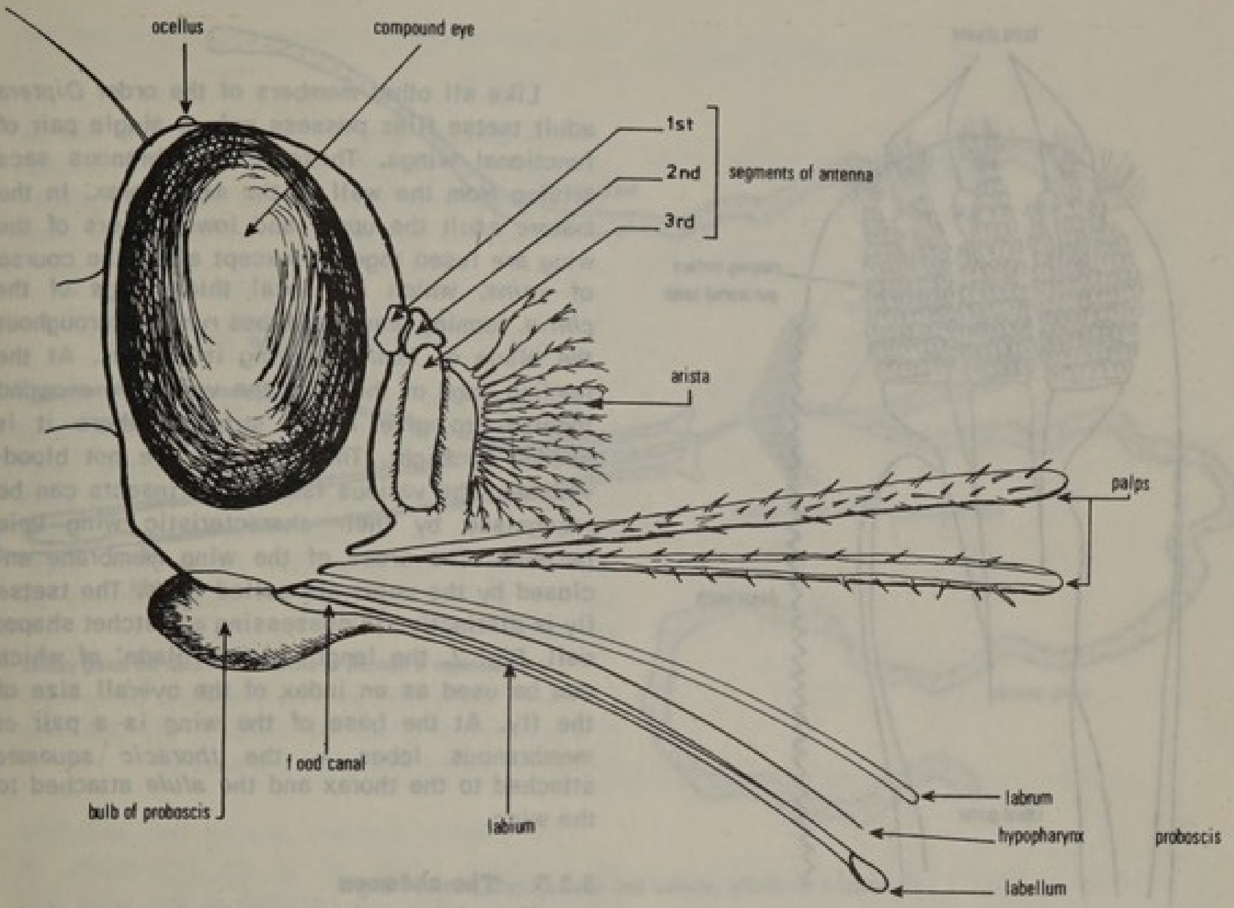


Fig. 4 Head of a tsetse fly with mouthparts displayed

taste and smell.

The palps

Embracing and protecting the haustellum when the fly is at rest, is a pair of sensory *palps* which bear organs sensitive to touch. When the fly feeds, the haustellum is lowered into a vertical position over the selected site and sunk into the skin and underlying tissues of the host. The palps remain erect in the forward position. In dead flies the muscles at the base of the labium shrink, often causing the haustellum to assume the vertical position.

The ptilinum

In flies such as the tsetse fly, the house fly, blowflies, etc. in which the adult emerges from the puparium or pupa case by bursting a circular lid, there is a structure, the *ptilinum,* which performs this function, It is an eversible sac formed by an elastic portion of the membrane of the exoskeleton situated between the eyes. In a young, unfed fly, of which the exoskeleton has not yet hardened, the ptilinum can be expressed by gently squeezing the fly between the thumb and forefinger. Such young flies are termed *teneral* flies. They are soft to the touch, and have unfrayed wings. By the time the fly has taken its first meal, the exoskeleton has hardened, and the ptilinum can no longer be expressed. Flies in this condition are termed *non teneral.* They make up the bulk of those caught in the field.

3.2.2 The thorax

This forms the mid region of the insect's body. It is composed of three segments, the *prothorax* immediately behind the head, a middle *mesothorax* and a hindermost *metathorax,* each bearing on the underside a pair of *walking legs.* (Some insects have legs modified for swimming, digging, jumping or clinging). The mesothorax is enlarged in relation to the prothorax and metathorax and bears a pair of wings, one on each side. The metathorax bears a pair of *halteres* in the same position as the wings of the mesothorax. The halteres vibrate in unison with the wings and are concerned with maintaining the balance of the insect when in flight.

The upper or dorsal portion of the mesothorax is enlarged to form the *dorsum* which provides a

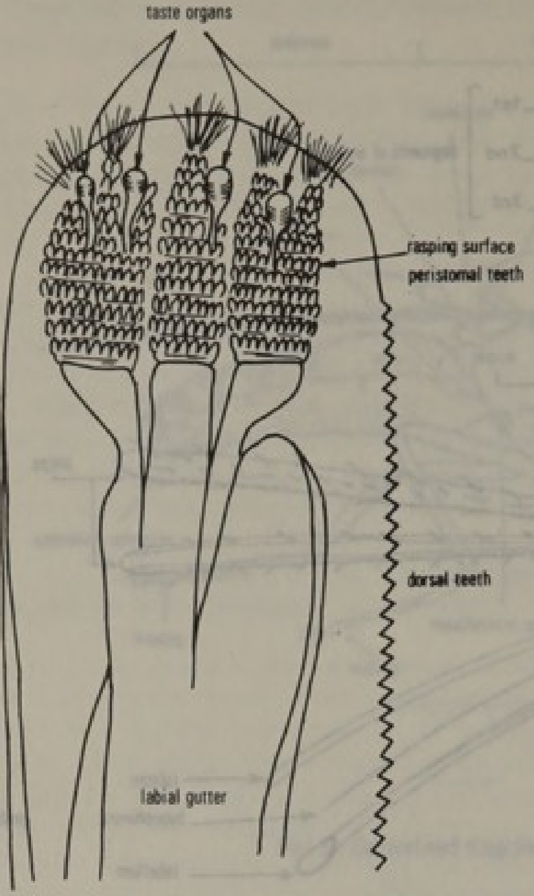


Fig. 5 Right labellum, inner surface

firm base for the wings, and internally, the muscles of flight, The dorsum is divided by lines of junction, or *sutures*, into a *prescutum* immediately behind the prothorax, a large *scutum* and a posterior triangular *scutellum*. The scutum is separated from the scutellum by a transverse *mesonotal suture*. Each of the six legs is composed of a short segment, the *coxa*, by which the leg is attached to the thorax; a shorter bent *trochanter* which serves to direct the rest of the leg outwards from the thorax; a long stout *femur*; a longer, slender *tibia* and a five segmented foot or *tarsus*. The last segment of the tarsus carries a pair of *claws* and a pair of adhesive pads, the *pulvilli*, by means of which the insect is enabled to cling to smooth or inverted surfaces. Between each pair of *pulvilli* a tuft of bristles, the *empodium*, arises from the terminal segment of the tarsus, see Fig. 8.

A tsetse fly spends much of its adult life resting with its tarsi closely applied to the surface of twigs and branches. It is mainly through the surfaces of the tarsi that the insecticide is taken up when tsetse rest on insecticide-coated surfaces.

Like all other members of the order *Diptera* adult tsetse flies possess only a single pair of functional wings. These are membranous sacs arising from the wall of the mesothorax. In the mature adult the upper and lower layers of the wing are fused together except along the course of *veins*, which are local thickenings of the *chitin*, forming branched tubes running throughout the blade or *lamina*, giving it support. At the leading edge of the wing the veins are crowded together to give added strength where it is needed in flight. These 'veins' are not blood-vessels. The various families of insects can be recognised by their characteristic wing vein patterns. The areas of the wing membrane enclosed by the veins are called *cells*. The tsetse fly is distinctive in possessing a 'hatchet shaped' cell, Fig. 2, the length of the 'blade' of which can be used as an index of the overall size of the fly. At the base of the wing is a pair of membranous lobes – the *thoracic squamae* attached to the thorax and the *alula* attached to the wing.

3.2.3 The abdomen

The *abdomen* forms the hind region of the insect body and contains the digestive organs and glands, the fat bodies (storage organs), excretory organs, reproductive organs and the simple heart and main blood vessel, which extend forward into the thorax, Fig. 9.

That the insect is a segmented animal can clearly be seen from an examination of the abdomen. In both male and female tsetse six of the abdominal segments are clearly visible from above. The first segment of the abdomen cannot be readily seen. It is modified as an attachment to the thorax, and the terminal segments are bent under and greatly modified to form the external copulatory organs.

i In the male the terminal segments are held folded underneath the abdomen to form a cushion-like *hypopygium* or male genital armature, Fig. 10. This feature distinguishes the male from the female tsetse, which does not possess a hypopygium. The hypopygium can be unfolded backwards to expose the clasping apparatus by which the male holds the female during copulation. The various species of male tsetse flies can be distinguished by the appearance of the genital armature, Fig. 11.

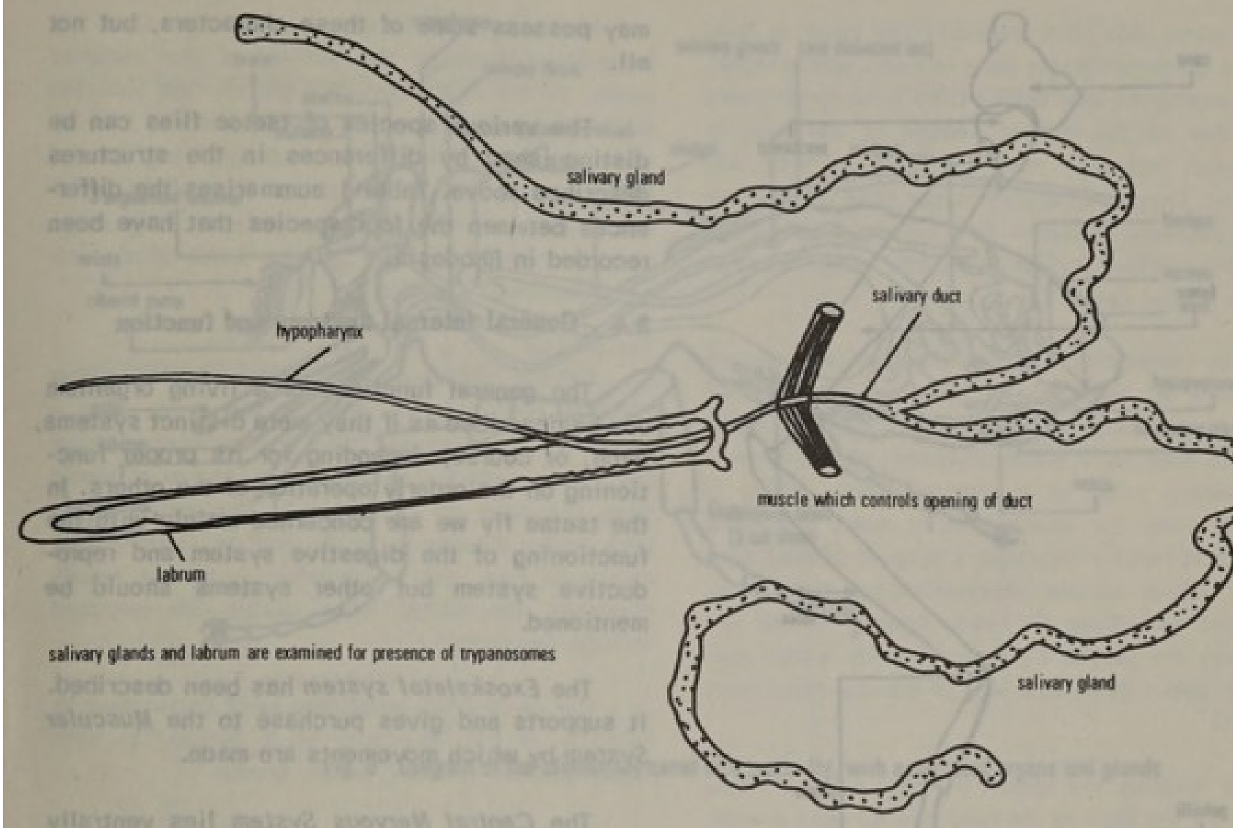


Fig. 6 Labrum, hypopharynx and salivary glands of a tsetse fly

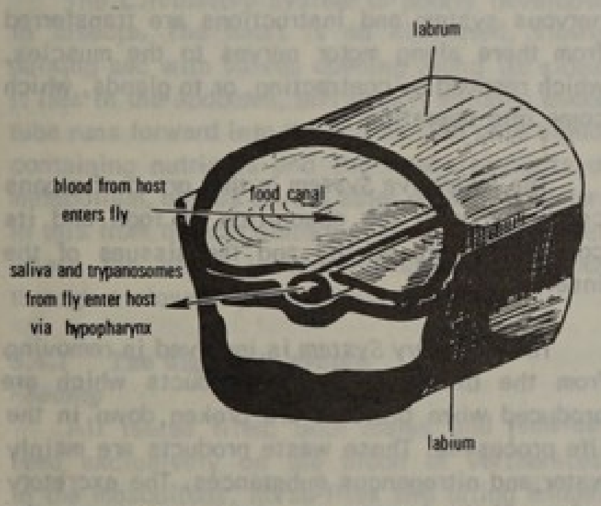


Fig. 7 Transverse section through a proboscis

ii The female genital armature lies telescoped between the upper and lower portions of the seventh segment and is not conspicuous, Fig. 12.

3.2.4 Other features of the exoskeleton

The spiracles

The mesothorax and metathorax and the seven anterior segments of the abdomen are each provided with a pair of breathing pores or *spiracles,* which can be seen, with the aid of a pocket lens, to form a row along each side of the body. The spiracles communicate with a system of branched air tubes *(tracheae)* which conduct atmospheric air to the individual cells of the body and through which carbon dioxide is carried from the cells. Water vapour also escapes from the body through the spiracles, and the insect is able to regulate the flow of gases and water vapour by opening and closing the spiracle openings.

The bristles

Tsetse flies are richly supplied with bristles, or *setae* many of which are related to organs of touch. Some are borne on a flexible base and may serve to detect sound waves.

Certain readily identifiable bristles on the thorax are made use of in measuring the relative sizes of tsetse flies. It has been found that the

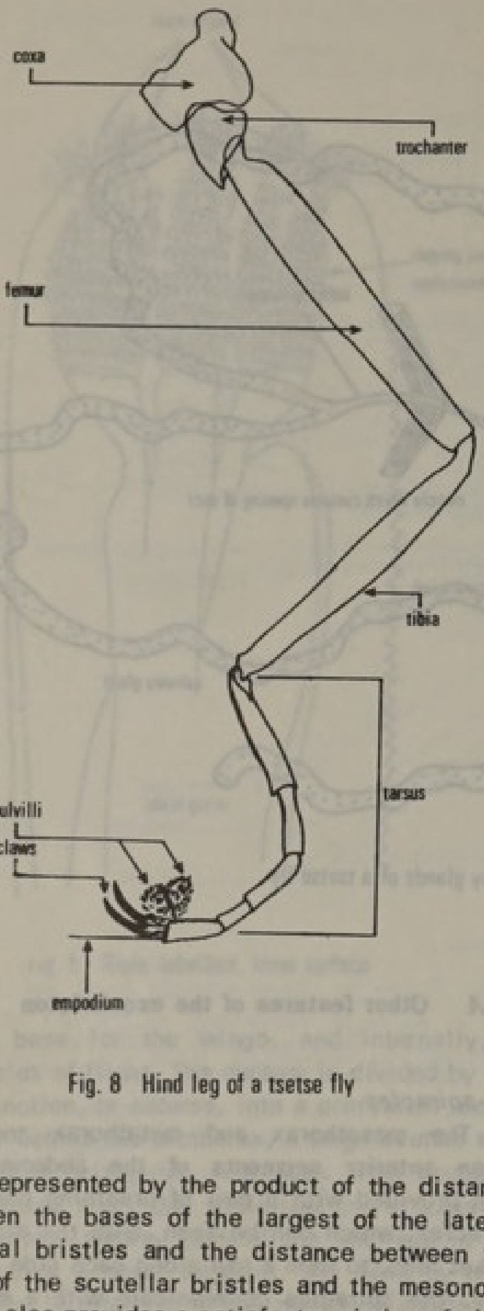


Fig. 8 Hind leg of a tsetse fly

area represented by the product of the distance between the bases of the largest of the lateral pronotal bristles and the distance between the base of the scutellar bristles and the mesonotal suture also provides a satisfactory index of size, Fig. 13. Sexual differences may occur in the lengths of the bristles. Thus, the median pair of *apical* scutellar bristles of female *G. morsitans* is shorter than the outer pair, but in the male they are of approximately equal length. In *G. pallidipes*, by contrast, the bristles are of equal length in both sexes, Fig. 14.

3.3 Identification

Tsetse flies may be distinguished from all other insects by their possession of a single pair of functional wings that overlie the abdomen and overlap like the blades of a pair of shears when the insect is at rest; by the possession, in both male and female adults of a piercing and sucking proboscis, and the possession of a hatchet cell in the wing venation. Other insects may possess some of these characters, but not all.

The various species of tsetse flies can be distinguished by differences in the structures described above. Table 1 summarises the differences between the four species that have been recorded in Rhodesia.

3.4 General internal anatomy and function

The general functions of a living organism can be described as if they were distinct systems, each, of course, depending for its proper functioning on the orderly operation of the others. In the tsetse fly we are concerned mainly with the functioning of the digestive system and reproductive system but other systems should be mentioned.

The *Exoskeletal system* has been described. It supports and gives purchase to the *Muscular System* by which movements are made.

The *Central Nervous System* lies ventrally in the body cavity as in all Arthropods. In insects, the brain is situated in the head and surrounds the gullet. Changes in the environment, internal and external, are detected by the sensory organs, the information is conveyed along sensory nerves to the appropriate portion of the central nervous system and instructions are transferred from there along motor nerves to the muscles, which respond by contracting, or to glands, which come into operation.

The *Digestive System* is that group of organs concerned with the absorption of food and its conversion into energy and the tissues of the insect.

The *Excretory System* is involved in removing from the blood the waste products which are produced when proteins are broken down in the life processes. These waste products are mainly water and nitrogenous substances. The excretory organs of the insects are simple structures, the *Malpighian tubules*, of which in the tsetse fly, there are two pairs, Fig. 9.

The *Respiratory System* consisting of the spiracles and tracheae allows for the intake of oxygen from the air (or from water in the case of aquatic insects) and the elimination of the waste product carbon dioxide formed from the breakdown of the fats and carbohydrates of the body to produce energy.

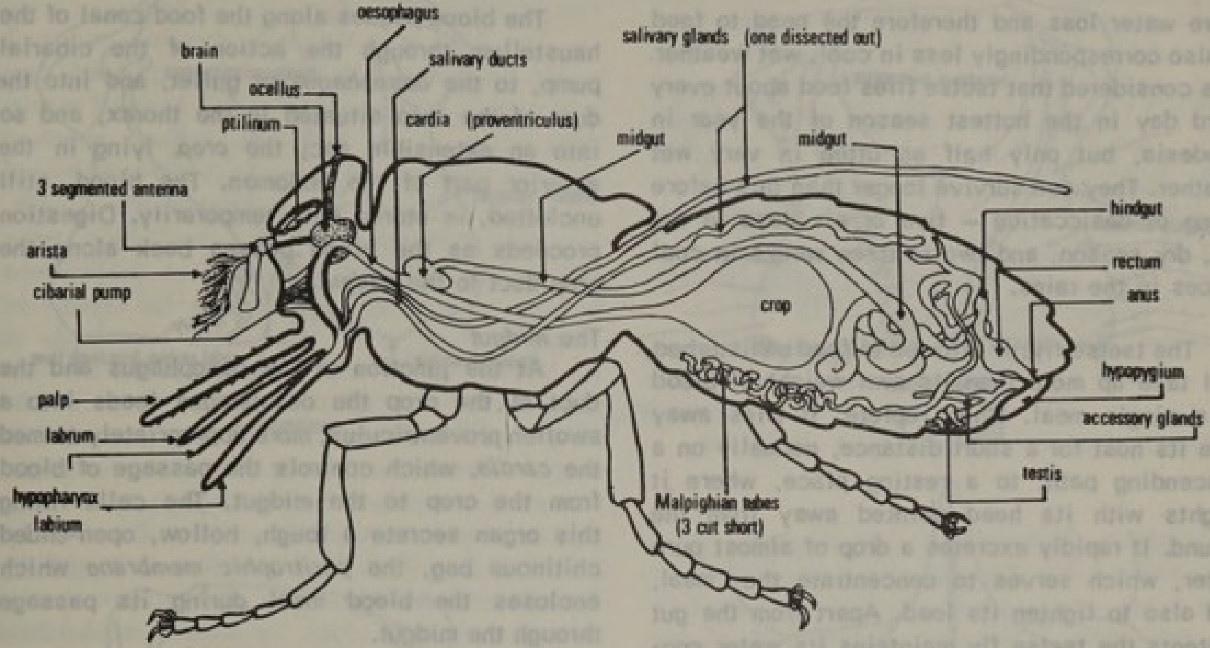


Fig. 9 Diagram of the alimentary canal of a tsetse fly, with associated organs and glands

The *Reproductive System* includes those organs concerned with the production of the male (*spermatozoa* or sperms), and female (*ova* or eggs) germ cells.

The *Circulatory System* is poorly developed in insects. The heart is an elongated, slowly pulsing sac with valves opening along its sides. It lies in the abdomen, and from it an open ended tube runs forward into the thorax. The pale blood, containing nutrients and the waste products of metabolism, bathes all the other organs. It differs in this from the circulatory system of vertebrates where the blood is pumped around the body through a closed system of blood-vessels.

3.4.1 The digestive system

Feeding

All tsetse flies, both males and females, feed exclusively on the blood of vertebrates. In the mosquitoes, horse-flies and biting midges only the females feed on blood. Those tsetse flies like *G.morsitans* and *G.pallidipes* which live in open woodland, the savanna tsetse flies, feed mainly on the blood of the larger game animals and, out of choice, on only certain species of those. Tsetse mouthparts are specially adapted for piercing and sucking blood from their hosts and the digestive organs are capable of dealing only with blood as a food. From the blood meal tsetse obtain the protein part of their diet and from it they synthesize a quantity of fat which provides a store of energy. This store of fat is built up by the young fly over several meals and attains a maximum after about three weeks of adult life.

Fig. 10 Hind end of abdomen of male ventral view

But the blood meal not only supplies the fly with food. It also provides it with water. Water is constantly being lost from the surface of the body and must be replenished at short intervals to prevent the death of the insect from desiccation. The interval between feeding varies a good deal from species to species and still more with season. Evaporation, and therefore water loss from the insect, is less in cool, wet weather than under hot, dry conditions. The need to restore water loss and therefore the need to feed is also correspondingly less in cool, wet weather. It is considered that tsetse flies feed about every third day in the hottest season of the year in Rhodesia, but only half as often in very wet weather. They can survive longer than this before dying of desiccation – five or six days in the hot, dry season, and two to three weeks in cool places in the rains.

The tsetse fly, if allowed to feed undisturbed, will take up more than its own weight of blood in a single meal. When replete, it flies away from its host for a short distance, normally on a descending path, to a resting place, where it alights with its head pointed away from the ground. It rapidly excretes a drop of almost pure water, which serves to concentrate the meal, and also to lighten its load. Apart from the gut contents the tsetse fly maintains its water content at about three quarters of its non-fatty body weight.

In feeding, the tsetse fly first settles itself firmly on the skin of its host and selects a site, lowers its haustellum into the vertical position and rapidly sinks it into the skin. It then partly withdraws it, moves its head a little and sinks the haustellum again, deeply, in a fresh direction. The labella at the tip of the labium cut their way through the tissues of the host by means of the prestomal teeth until a blood vessel is pierced. The fly does not feed directly from the blood vessel, however, but from a pool of blood which forms in the tissues damaged by the repeated probings. The fly, before imbibing blood, ejects saliva produced by the *salivary glands* through the hypopharynx into the wound. Proteins in the saliva prevent the blood from clotting in its passage to the gut of the fly. It is within the saliva that trypanosomes are normally transmitted from an infected fly to the vertebrate host.

The subsequent process of feeding will be described in relation to the organs of the digestive system.

The alimentary canal. Fig. 9.

This is the tube along which the blood passes from its entry at the *mouth* to its exit as *faeces* at the *anus*. It consists of a *fore, mid,* and *hind gut.*

The *foregut*

The tsetse proceeds to suck up the blood from the pool by the action of the muscular *cibarial pump* situated in the head.

The blood passes along the food canal of the haustellum through the action of the cibarial pump, to the *oesophagus* or gullet, and into the duct of the crop situated in the thorax, and so into an extensible sac, the *crop*, lying in the anterior part of the abdomen. The blood, still unclotted, is stored here temporarily. Digestion proceeds as the blood passes back along the crop duct to the *midgut.*

The *midgut*

At the junction of the oesophagus and the duct of the crop the oesophagus leads into a swollen proventriculus, more appropriately termed the *cardia,* which controls the passage of blood from the crop to the midgut. The cells lining this organ secrete a tough, hollow, open-ended chitinous bag, the *peritrophic membrane* which encloses the blood meal during its passage through the midgut.

The peritrophic membrane is of importance in relation to the infection of a tsetse fly with trypanosomes of the *T.brucei* group.

Within the midgut digestion takes place. The blood meal loses much of its liquid content which passes through the peritrophic membrane and gut wall, into the surrounding blood of the fly. Digestive *enzymes,* (which are proteins which bring about profound chemical changes at temperatures which living things can tolerate) are produced by the cells lining the inner wall of the midgut, and pass through the peritrophic membrane and digest the concentrated blood meal. The products of digestion pass towards the terminal end of the midgut where they are absorbed from the interior of the gut, through the peritrophic membrane, through the cells lining the gut and into the blood of the fly.

Certain micro-organisms are present in the giant cells of two longitudinal bands of tissue in the middle region, the *mycetome,* which may assist in the insect's nutrition.

Part of the food is used immediately to maintain the activities of the fly and part is converted to fat and accumulated as an energy reserve in the fat bodies situated in the abdomen. The fat is the source of energy used by the fly in its activity between feeds and by the female in the production and nutrition of the larva. The undigested part of the blood meal is passed on to the hindgut.

The *hindgut*

This is the terminal portion of the alimentary

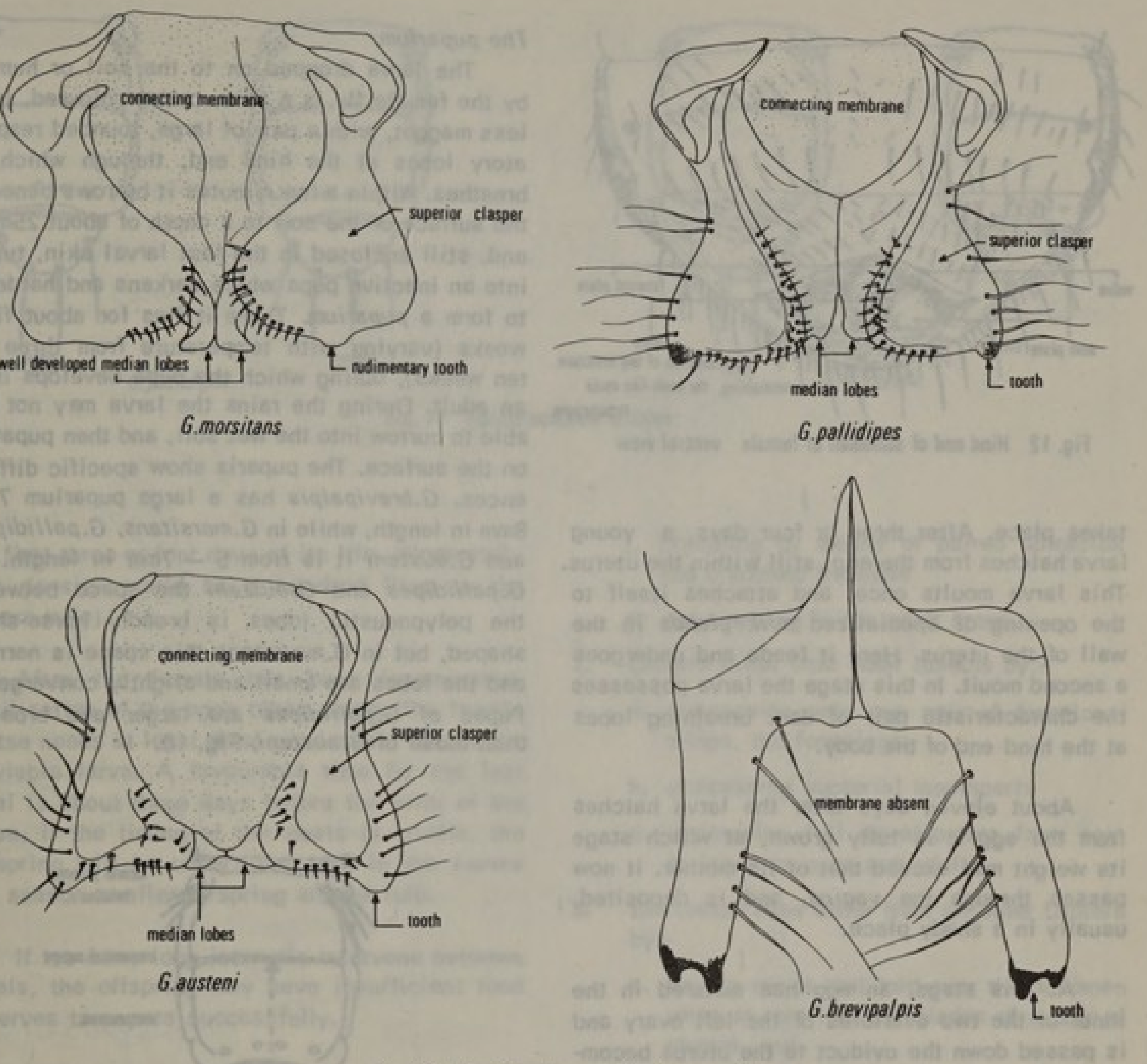


Fig. 11 Superior claspers of male tsetse flies

canal. Here most of the remaining water in the gut contents is absorbed.

At the junction of the mid and hindgut four *malpighian tubules* arise, as blind ended tubes lined with excretory cells. These organs remove excess water and nitrogenous waste materials from the blood of the insect. These, mixed with the undigested remains of the blood meal, are voided as faeces.

3.4.2 Reproduction

The female reproductive organs, Fig. 15

Unlike most female insects, the female tsetse fly does not lay her eggs. The egg is developed, fertilized, incubated and hatched, and the resulting larva is matured within the body of the female. The larva is dropped when it is fully mature, ready to pupate. Although relatively few larvae are produced in a female's lifetime, the survival rate is very high compared with that of an insect like the house fly which produces several hundred eggs, of which few may survive to maturity.

The female reproductive organs are situated within the abdomen. There is a pair of ovaries, unequal in size because the eggs develop alternately in right and left ovary. Each ovary is composed of two egg tubes or *ovarioles* in which the eggs are generated. Soon after a female tsetse fly emerges from the puparium, an egg begins to develop in the inner of the two ovarioles in the right ovary. After about nine days, it is fully developed and passes from the ovary into the *uterus* by way of the common *oviduct*. Normally by this time the female has mated, and the *spermatheca*, her receptacle for the spermatozoa, contains sperms. The egg becomes fertilised in its passage into the uterus where development

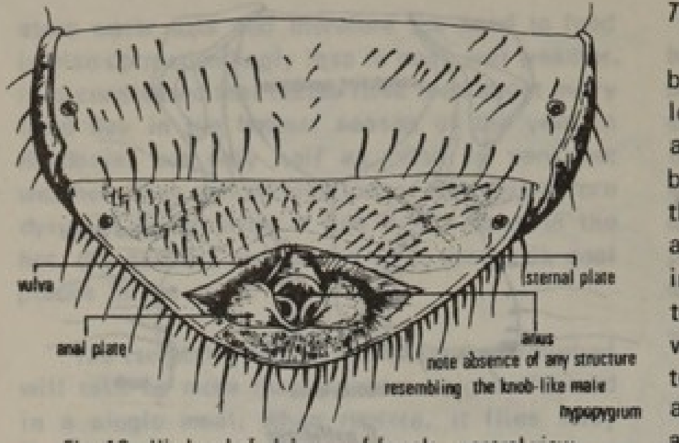


Fig. 12 Hind end of abdomen of female ventral view

takes place. After three or four days, a young larva hatches from the egg, still within the uterus. This larva moults once, and attaches itself to the opening of specialized *"milk" glands* in the wall of the uterus. Here it feeds and undergoes a second moult. In this stage the larva possesses the characteristic pair of dark breathing lobes at the hind end of the body.

About eleven days after the larva hatches from the egg it is fully grown, at which stage its weight may exceed that of its mother. It now passes through the *vagina*, and is deposited, usually in a shady place.

At this stage, an egg has matured in the inner of the two ovarioles of the left ovary and is passed down the oviduct to the uterus becoming fertilised on the way. The process of incubation, hatching and larval development recurs, and a second larva is deposited.

The third matured egg originates from the outer ovariole of the right ovary. and the fourth egg from the outer ovariole of the left ovary. This sequence is continued throughout the breeding life of the fly. Thus, knowing that it takes about nine days for an egg to mature and pass in sequence from the ovarioles it is possible to estimate the physiological age of the female tsetse fly up to about 60 days by dissection and examination of the ovaries, Fig. 16.

The male generative organs, Fig. 17

The male generative organs are situated within the abdomen and consist of a pair of testes, each in the form of a long coiled tubular gland. The lower part of this tube, the *vas deferens*, leads into the median *ejaculatory duct*, which opens to the exterior at the *aedegus*. A pair of large coiled accessory glands is present.

The puparium

The larva dropped on to the soil or humus by the female fly is a pale, cream coloured, legless maggot, with a pair of large, rounded respiratory lobes at the hind end, through which it breathes. Within a few minutes it burrows beneath the surface of the soil to a depth of about 25mm, and, still enclosed in the last larval skin, turns into an inactive pupa which darkens and hardens to form a *puparium*. There it lies for about five weeks (varying with temperature from three to ten weeks), during which the pupa develops into an adult. During the rains the larva may not be able to burrow into the wet soil, and then pupates on the surface. The puparia show specific differences. *G.brevipalpis* has a large puparium 7 – 8mm in length, while in *G.morsitans, G.pallidipes* and *G.austeni* it is from 5 – 7mm in length. In *G.pallidipes* and *G.austeni* the space between the polypneustic lobes is broadly horse-shoe shaped, but in *G.morsitans* this space is narrow and the lobes are small and slightly convergent. Pupae of *G.pallidipes* are larger and broader than those of *G.austeni*, Fig. 18.

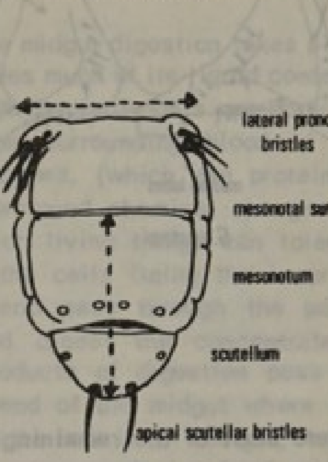


Fig. 13 Dimensions used to measure thoracic area

Mating

Tsetse flies breed throughout the year. The male tsetse fly will attempt to mate with the female whether she is at rest, feeding or flying. The males are not potent for a few days after they emerge but the females are almost invariably inseminated in the first three or four days after emergence. This one mating suffices to fertilise all the eggs produced, the sperms being stored in the spermatheca. The female fly does not tolerate a second mating, but males mate several times. The mating organisation is extremely effective, as even at low fly density one very seldom encounters an unmated female that has taken its first meal, which it usually does within

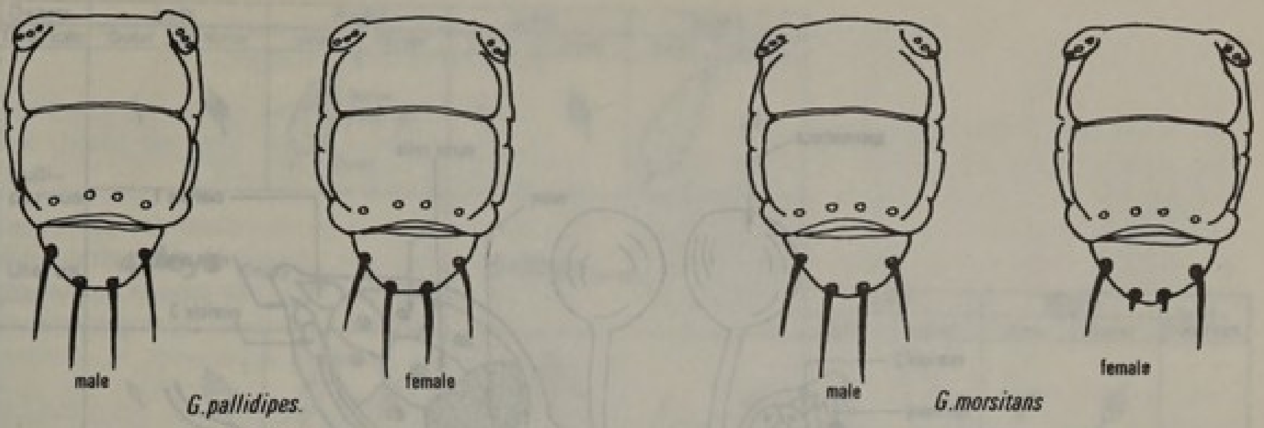


Fig. 14 Apical scutellar bristles

the first three or four days of its life. (Moderately low density would be a hundred flies to the square mile).

After the female has been inseminated, fertilisation of the eggs takes place. The female tsetse needs at least three good meals to produce a viable larva. A favourable time for the last meal is about three days before the birth of the larva. If the timing of the meals is erratic, the offspring will be undersized, and in the severe dry season smaller offspring are the rule.

If too many long intervals intervene between meals, the offspring may have insufficient food reserves to pupate successfully.

Emergence

Males and females emerge from the puparia in equal numbers. When development is complete, the young fly everts its ptilinum which pushes off a circular cap on the puparium. The fly crawls out and, using its ptilinum, forces its way through the soil to the surface where it straightens its crumpled wings. Its exoskeleton soon hardens and it eventually flies off in search of a meal. The whole operation takes less than an hour.

3.5 Recapitulation

1. Insects differ from all other animals by:-
   a. having a firm exoskeleton
   b. having three pairs of segmented legs
   c. having a body clearly divided into a head, thorax and abdomen
   d. having a single pair of antennae
   e. having usually one or two pairs of wings in the adult stage
   f. breathing by means of paired spiracles and branched tracheae
   g. not moulting in the adult stage.
2. Diptera differ from other insects by:-
   a. possessing only one pair of functional wings, the forewings
   b. possessing suctorial mouthparts
   c. undergoing full development from egg, to larva, to pupa and adult.
3. The tsetse flies differ from all other Diptera by:-
   a. having wings that fold over the abdomen when at rest like the blades of a pair of shears, and
   b. having a hatchet shaped cell in the wing venation, and
   c. having piercing and sucking mouthparts in both male and female adult.
4. The head bears the principle sense organs, the compound eyes and ocelli, the antennae and palps; the mouthparts; labrum, hypopharynx and labium; the ptilinum; the brain; and the cibarial pump.
5. The thorax is the mid part of the body. It bears on the mesothorax, a pair of functional wings, and on the metathorax, a pair of halteres. The prothorax, mesothorax and metathorax each bears a pair of walking legs. The thorax contains the flight muscles.
6. The abdomen is the hind portion of the body. It contains the organs of digestion, excretion, reproduction and circulation, and the salivary glands and fat bodies. In the male tsetse the tip of the abdomen is modified

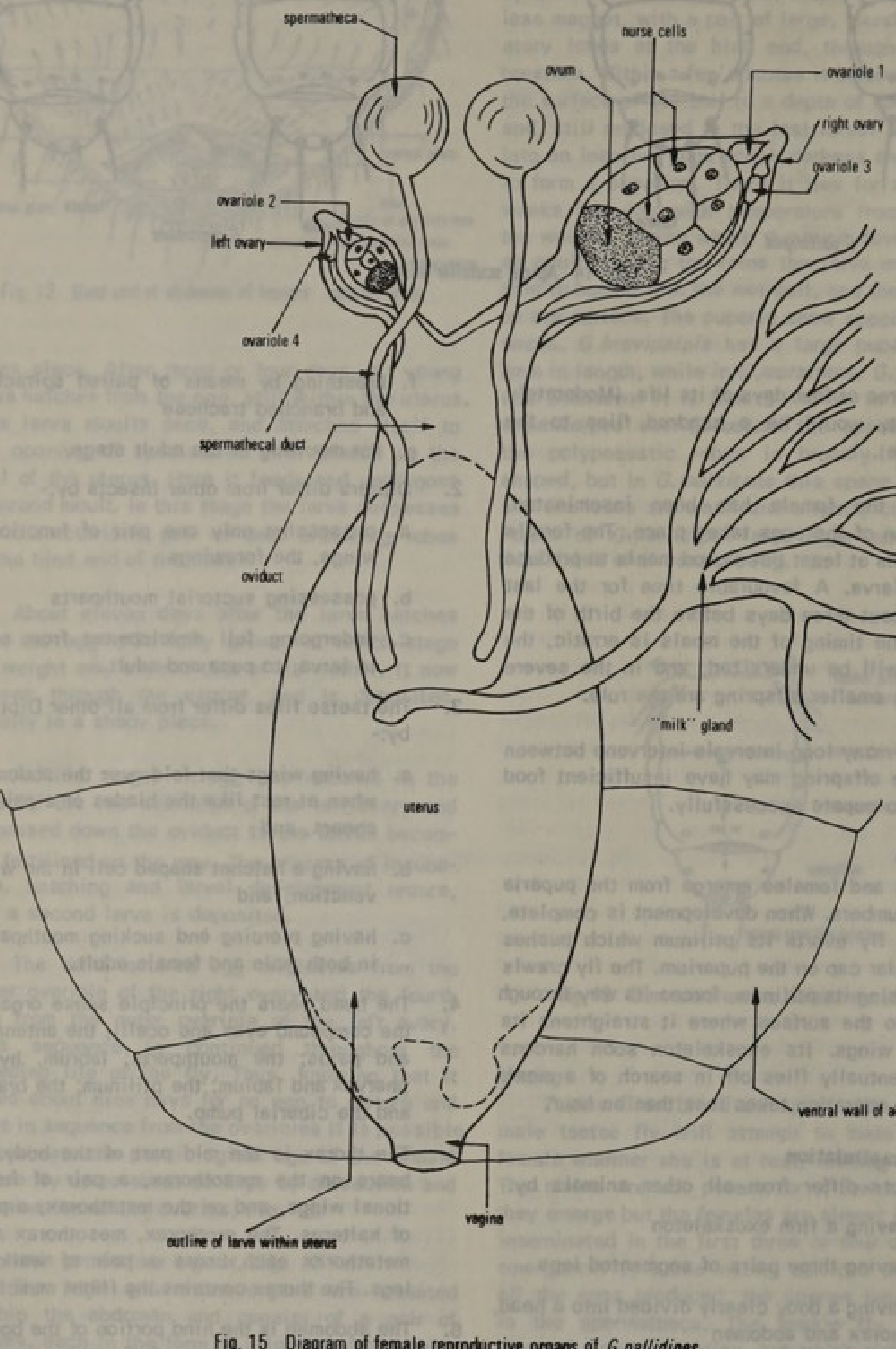


Fig. 15 Diagram of female reproductive organs of *G.pallidipes.*

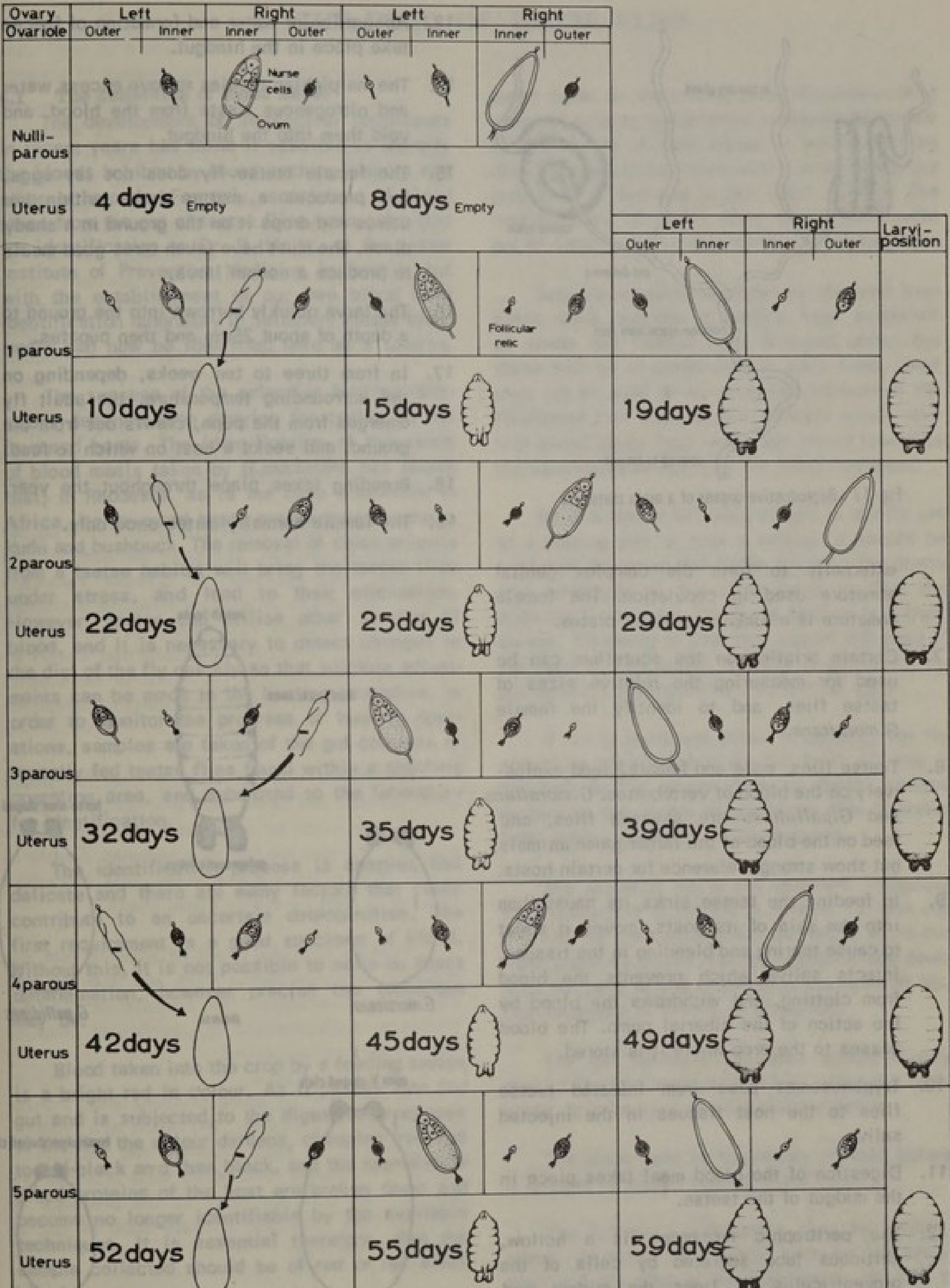


Fig. 16 The ovulation cycle in at 26°C (modified from Saunders, 1962 and Challier, 1965)

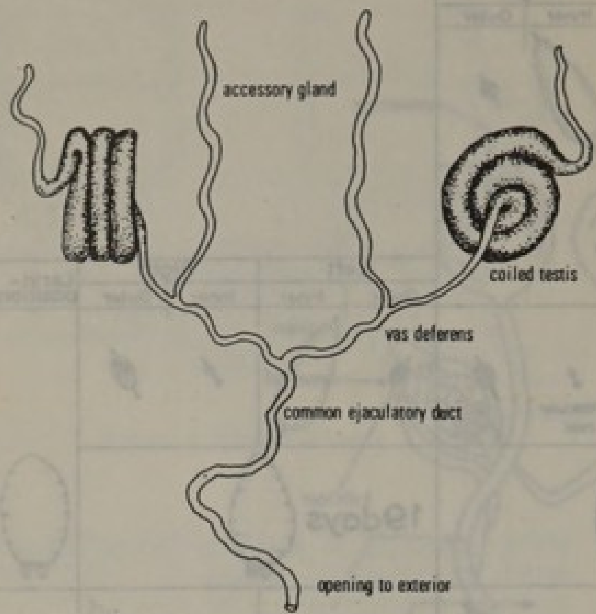


Fig. 17 Reproductive organs of a male tsetse fly

externally to form the complex genital armature used in copulation. The female armature is a simple series of plates.

7. Certain bristles on the scutellum can be used for measuring the relative sizes of tsetse flies, and to identify the female *G.morsitans*.

8. Tsetse flies, male and female, feed exclusively on the blood of vertebrates. *G.morsitans* and *G.pallidipes* are savanna flies, and feed on the blood of the larger game animals, but show strong preference for certain hosts.

9. In feeding the tsetse sinks its haustellum into the skin of its hosts, moves it about to cause tearing and bleeding in the tissues, injects saliva which prevents the blood from clotting, and withdraws the blood by the action of the cibarial pump. The blood passes to the crop where it is stored.

10. Trypanosomes pass from infected tsetse flies to the host tissues in the injected saliva.

11. Digestion of the blood meal takes place in the midgut of the tsetse.

12. The peritrophic membrane is a hollow, chitinous tube secreted by cells of the proventriculus. It lines the midgut and encloses the blood meal during digestion. It plays a part in relation to infection of the fly with trypanosomes of the *T.brucei* group.

13. Absorption of water and formation of faeces take place in the hindgut.

14. The malpighian tubules remove excess water and nitrogenous waste from the blood, and void them into the hindgut.

15. The female tsetse fly does not lay eggs, but produces a mature larva within her uterus and drops it on the ground in a shady place. She must have taken three good meals to produce a normal larva.

16. The larva quickly burrows into the ground to a depth of about 25mm and then pupates.

17. In from three to ten weeks, depending on the surrounding temperature, the adult fly emerges from the pupa, crawls out from the ground, and seeks a host on which to feed.

18. Breeding takes place throughout the year.

19. The female normally mates once only.

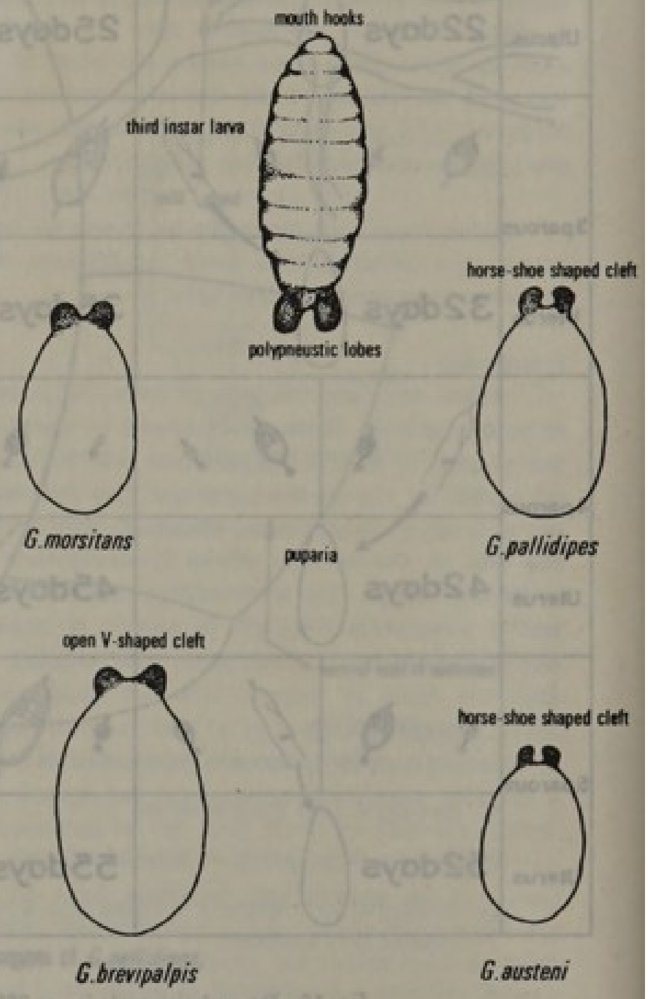


Fig. 18 Tsetse larva and puparia

4. THE FOOD OF TSETSE FLIES

4.1 The collection of blood meals

The development of serological techniques in recent years has made it possible to identify the bloods imbibed by blood sucking insects and other arthropods. Formerly, specimens of blood taken from the gut of tsetse flies were submitted for identification to Dr. B. Weitz, at the Lister Institute of Preventive Medicine in Britain, but with the establishment of our own blood meal identification laboratory in Salisbury tsetse blood meals can now be identified here as a routine.

The success of the selective hunting operations depends upon denying the tsetse fly its favoured hosts. The identification of thousands of blood meals taken by *G.morsitans* has shown that, in Rhodesia, as is the case elsewhere in Africa, its favoured hosts are warthog, bushpig, kudu and bushbuck. The removal of these animals from a tsetse habitat will bring the tsetse flies under stress, and lead to their elimination. However, tsetse can utilise other sources of blood, and it is necessary to detect changes in the diet of the fly quickly so that suitable adjustments can be made to the hunting procedure. In order to monitor the progress of hunting operations, samples are taken of the gut contents of recently fed tsetse flies found within a shooting operation area, and submitted to the laboratory for identification.

The identification process is complex and delicate and there are many factors that could contribute to an uncertain determination. The first requirement is a good specimen of blood. Without this, it is not possible to make an exact determination, however precise the technique may be.

Blood taken into the crop by a feeding tsetse is a bright red in colour. As it passes into the gut and is subjected to the digestive processes of the fly, the colour darkens, changing from red to red-black and then black, and the identifiable blood proteins of the host are broken down and become no longer identifiable by the available techniques. It is essential therefore, that the sample collected should be of *red or red/black* blood.

Immediately after a tsetse fly has fed, it seeks a sheltered place where it rests while it digests its meal. Catches made in these resting sites show a greater proportion of females than those made on the conventional flyrounds. If it were required to demonstrate a sexual difference in the choice of host animal it would best be displayed in catches from such places where the proportion of females in the catch is high. The resting sites of tsetse flies should be sought out as sources of suitable blood meal collections.

Suitable samples may also be obtained from black cloth screens or mealie bags supported on poles and carried by a flyround party, but these will be of predominantly male flies. Oxen must not be used as an attractant because of the likelihood that some of the samples would contain blood taken from them, and would prejudice the conclusion drawn from the identifications.

When a tsetse has been caught in the fly net at a resting site or from a screen, it should be held with the head and thorax between the thumb and forefinger of the right hand so that the abdomen is exposed. The fly is held up to a light source, shielding it with the cupped left hand if the light is very bright, and the condition of the gut contents inspected by transmitted light.

If red or red/black blood is present, the fly should be transferred to the left hand, holding it securely by the thorax with its dorsal surface resting on the centre of one of the 5cm diameter filter papers provided for the purpose.

The posterior tip of the abdomen, including the hypopygium if the fly is a male, is then cut off, and the gut contents are expressed on to the filter paper by gently drawing a knife blade down from the base of the abdomen to its severed tip. The remainder of the fly is discarded.

The gut contents are then spread evenly over as large an area as possible, using the knife blade, to produce a central circular patch.

The blade must be thoroughly cleaned before it is used to spread another blood meal.

The following information must be written, neatly, in black lead pencil between the blood meal and the edge of the filter paper, so that it can be read without having to rotate the filter paper:-

a. The species of fly: G.m. for *G.morsitans*
G.p. for *G.pallidipes*

b. The sex of the fly: O.M. for old male
O.F. for old female

c. The date

d. The locality: Fly round and sector number, or Survey number with grid reference, or Name of area where collection was made.

The filter papers with the blood meals must be kept in a tin, such as a tobacco tin, with a clean blank filter paper inserted between every two blood meal squashes to prevent contamination, and the tin must be kept in a dry place, prior to despatch to headquarters, Salisbury. Collections should be addressed to the officer who gave instructions for their collection, and should be labelled with the locality where the collection was made, the date, and the number of blood meals contained.

On their arrival at Salisbury the blood meal collections are numbered, recorded and the details of the collections entered on blood meal collection sheets. The individual blood meal squashes are grouped according to the condition of the blood, and their size into the following categories:-

Condition: A – fresh blood, red
B – fatty, shiny, red blood
C – pale, red blood
D – red, with black blood
E – black blood, dark
F – pale black blood with yellow fat bodies
G – yellow fat bodies

Size: With the aid of a series of circles drawn on a transparent sheet, ranging from 1 cm^2, by 1 cm^2, to 8 cm^2, the blood meals are classified as 1-8, giving 56 categories.

Bloodmeals in categories A to E are suitable for processing but categories F and G are seldom identifiable and should be discarded. A blood meal squash must be at least 1 cm^2 in area to to give sufficient material for it to be specifically identified. Lesser amounts may be identified only as far as the group to which it belongs, e.g. Bovidae or Suidae.

The origin, serial number, category and size of the blood meal squashes are written on the individual filter papers, and the collection is sent for processing to the blood meal laboratory.

4.2 Identification of the blood meal

When viruses, bacteria or protozoa invade the system of an animal they act as *antigens,* and stimulate an immediate defensive reaction in the animal. Certain proteins, called *antibodies,* appear in the blood and neutralise these foreign substances. This reaction is known as an *immune response.* Several other substances can act as antigens, and each different antigen will cause the body to produce an antibody which will react only with that particular antigen. The antigen-antibody reactions are highly specific. Antibodies can break up red blood cells, (lysis) or cause bacteria to clump together (agglutination) or alter the structure of proteins, (precipitation). By these means, the foreign substances are rendered harmless, and they can be eliminated.

If the antigens cannot be neutralised by the defensive antibodies, the body mechanisms are disturbed, and abnormal or disease symptoms appear. The ability to produce effective antibodies to specific antigens may persist in the body for long periods, producing the condition known as *immunity.* For example, an attack of measles in childhood, if not fatal, produces a persistent immunity.

Antibodies can be removed from the blood of an animal, and under carefully controlled conditions, be made to react with the appropriate antigens, so that the reaction becomes visible in a test tube or on a glass slide. This procedure is used to identify tsetse blood meals.

Proteins from the blood of animals that are possible hosts of tsetse flies are injected into experimental animals. The animals respond by producing antibodies to the particular proteins that have been introduced.

For example, if blood proteins from a kudu are injected into a rabbit, the rabbit will produce antibodies to the kudu proteins, and these antibodies will always react when kudu proteins are present, but will not react to the presence of proteins from unrelated animals such as ox, or monkey or warthog.

The tsetse blood meals as submitted from the field are the gut contents of the fly, and include blood from the various animals on which tsetse flies have fed. These are tested with a series of known antibodies. If a reaction takes place it indicates the origin of the blood meal.

Two main tests are used to identify a blood meal. They both are interpreted according to the presence of absence of a visible reaction.

4.2.1 Group identification

A precipitation test is used to distinguish the blood of family groups of host animals, for example, between blood from Bovidae, Suidae, Primates and Equidae.

4.2.2 Specific identification

To identify species within the family groups, a more delicate technique is used, involving an agglutination reaction. By this means blood meals from, for example, kudu, can be separated from those from eland or buffalo and blood meals from warthog can be distinguished from those from bushpig.

The following scheme summarises the tests as they are actually used:-

Test 1	Test 2
Precipitation Test: for determination of family groups	Agglutination Test: for determination of species
Bovid	kudu bushbuck ox buffalo eland impala sable reedbuck sheep waterbuck goat duiker
Suid	warthog bushpig
Primate	monkey baboon human
Equid Elephant Hippopotamus Rhinoceros Birds Reptiles Dogs Cats	

5. VEGETATION IN RELATION TO TSETSE FLIES

'The Rhodesian Botanical Dictionary of African and English Plant Names by H. Wild (Govt. Printer, Salisbury) would be of invaluable help with this section.

While it is not expected that tsetse field staff should become botanists, they must achieve facility in recognising major patterns of vegetation, and should become familiar with the principal components of the groups of trees and shrubs which form these patterns. They must also be able to recognise these patterns in aerial photographs. Tsetse flies are typically woodland creatures, the various species favouring recognisably different conditions of woodland produced by different groups of tree species. An understanding of the habits of tsetse flies, as an aid to exercising effective control measures, requires some knowledge of the structure and distribution of the major elements which make up the woodland in which tsetse flies live.

5.1 Some definitions of terms

The study of the relationships between living plants and animals, and between these and the climate and soils in or on which they live is known by the general term *Ecology*. The efficient tsetse field worker inevitably becomes a tsetse ecologist. Not only does he learn to appreciate the reactions of tsetse flies to their environment but, by becoming involved with problems of the distribution of man and his livestock in relation to tsetse distribution he also gains experience in human ecology of simple social systems.

The vegetation of the world can be divided into large comprehensive groups, known as *plant formations*, limited by climate or soil or both, described according to the type. The formation types, evergreen woodland, deciduous woodland, grassland and desert are well known and understood generally. The savanna woodland of tropical and subtropical Africa is a formation, composed of smaller groups of plants forming *associations*. Thus, in Rhodesia the savanna woodland formation includes the mopane formation, dominated by *Colophospermum mopane*, and the *Brachystegia* formation, dominated by, but by no means entirely composed of *Brachystegia* species. A plant is described as being *dominant* when it is the most important species in its *community* or group of plants which grow together. 'Most important' does not always mean most numerous, though it often does. In a pure stand of mopane trees, the mopane is obviously the dominant species, although there may be, numerically, more grasses present. In such a situation, the dominant species presents a greater bulk, and impresses its character on other organisms living within its confines. In a pine forest or tropical rain forest, for example, the sunlight which penetrates to the ground is so feeble that few other herbs, trees or shrubs can survive at ground level.

Plant communities are always changing their composition, and over a period of time, will exhibit a *succession*. If a plot of ground is cleared of vegetation for cropping, and, afterwards left uncultivated, it will gradually become covered with vegetation, which will change in composition until it reaches a stable condition determined by the prevailing climate and nature of the soil. This state is known as a *climax*. A tobacco land in *Brachystegia* woodland in Rhodesia, if left derelict, would become sparsely covered with herbaceous weeds and woody shrubs, forming an *open* community, with patches of bare ground. The woody shrubs would increase in number to the exclusion of herbaceous plants. Trees would invade the area, and in the course of time, *Brachystegia* woodland would again dominate, with grass and shrubs covering the intervening ground, forming a closed community, determined by the current climate and soil condition. In Chipinga district the high rainfall and deep soils of Chirindu Forest permit a true climax of a different type with large, very tall, evergreen trees predominating, but on the Kalahari sand soils and in the cool winters and annual fires that occur in the western areas of Rhodesia, a sub climax is reached in which the Rhodesian teak *Baikiaea plurijuga* is dominant. The annual grass fires which the indigenous peoples of Africa impose on much of the vegetation prevent the achievement of a true climax, and lead to the creation of *fire sub climaxes* represented by such as *Brachystegia* and *Baikiaea* (gusu) woodlands. Over periods of geological time luxurious tropical forests that now are represented by coal deposits such as at Wankie, become replaced by very different vegetation formations determined by the prevailing soils and climate.

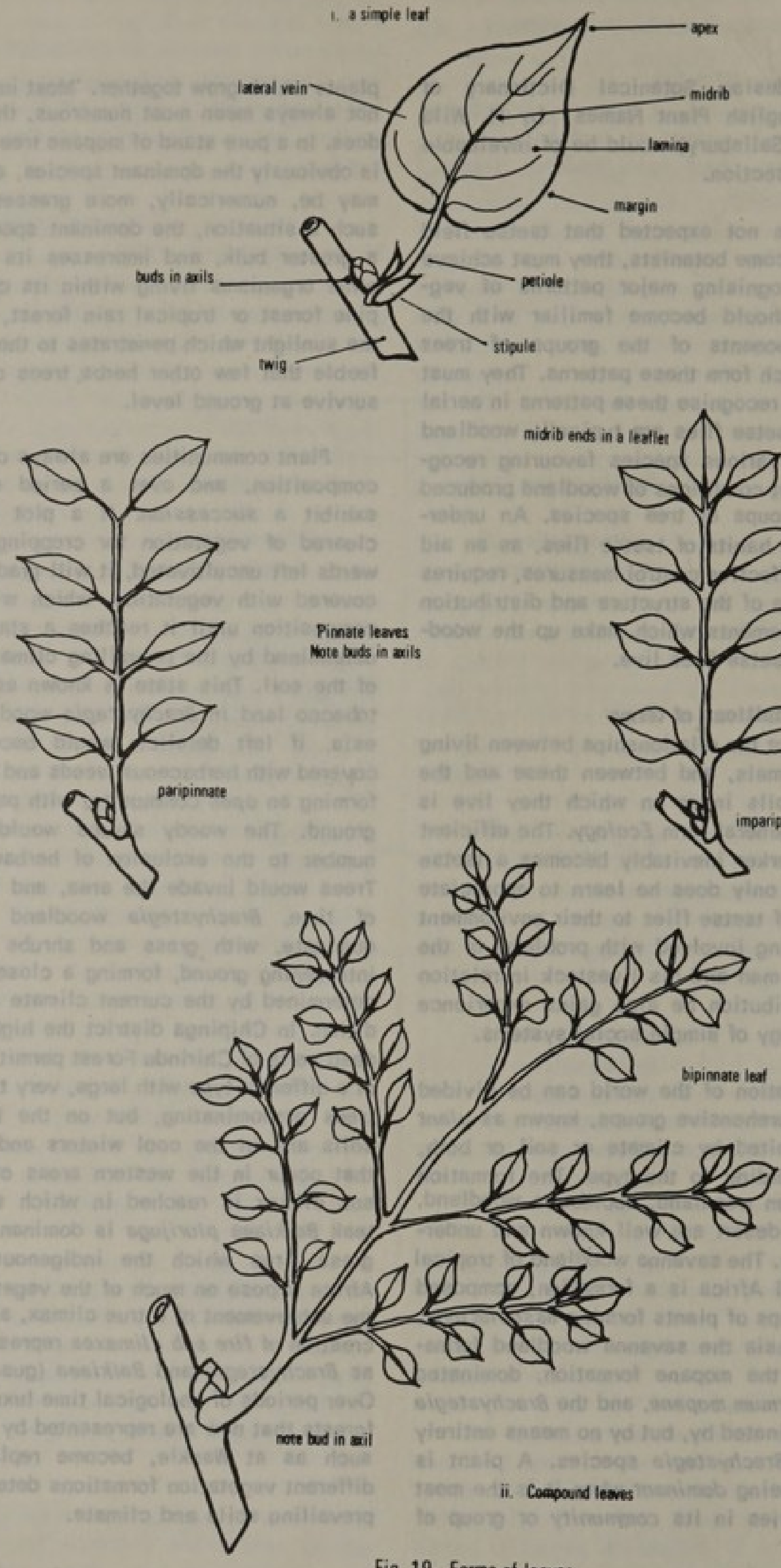


Fig. 19 Forms of leaves

5.2 Identification of vegetation communities

For the purposes of tsetse control, especially for the application of insecticide to tsetse resting sites, it is necessary to be able to recognise and describe a few distinct vegetation communites and the dominant species therein, both in leaf and in leafless conditions. Within a natural Rhodesian woodland inhabited by tsetse flies it is usual to find the vegetation composed of trees, shrubs (low woody plants with several stems arising at ground level) and herbs, (plants without permanent woody stems above ground level). In some woodlands, for example in *Brachystegia* woodland, the larger trees form an upper *canopy* or *topstorey*, below which the smaller trees and taller shrubs form an *understorey*, below which grow the low shrubs and herbs. The wide range of shade conditions found in this type of woodland provides suitable habitat for *G.morsitans* and *G.pallidipes*.

The major tree communities met with in tsetse control operations are:-

Riverine fringe vegetation

Brachystegia spp. woodland (Msasa woodland)

Colophospermum mopane woodland (Mopane woodland)

Baikiaea plurijuga woodland (Gusu)

Acacia spp. woodland

Combretum spp. woodland

Thicket, Sinanga or Jese

Open grassland (vleis or grassland flats)

Riverine fringe vegetation: Semi-evergreen

This type of vegetation lines the alluvial or sandy flood banks of rivers and drainages. The trees are semi-evergreen and provide ample shade and refuge for tsetse flies in the hot dry periods of the year, when the vegetation in the general woodland is leafless. A well defined double canopy is often present.

Special attention is paid to the tsetse refuge and resting sites in this type of vegetation during spraying operations.

The main components of riverine fringe vegetation are listed. Field staff should become familiar with most of these species:-

Trees *Acacia* spp.

A.albida (white thorn, apple-ring, acacia, mutsangu, umpumbu)

A.galpinii (monkey thorn, muchinanga, umkhaya)

A.nigrescens (knobthorn, mkaai, umkhaya)

A.tortilis (umbrella thorn, muunga)

Albizia versicolor (poison pod, mubungata, umnonjwana)

Balanites aegyptiaca (muvambangoma, muongo)

Berchemia discolor (munyi)

Combretum imberbe (leadwood, muchenarota, umchenalota)

Cordyla africana (mutondo)

Croton megalobotrys (mubvuguta, mutonga)

Diospyros mespiliformis (ebony, mushenje, umdhlawuzo)

Drypetes mossambicensis (mururugwi, shakwari)

Ficus capreifolia (wild fig, mutsamvi) on edges of perennial rivers and pools

Garcinia livingstonei (african mangosteen, munhinzwa, mukovonga)

Kigelia africana (sausage tree, mumvee, umvebe)

Lonchocarpus capassa (rain tree, mupandapanda, dungamuzi)

Sapium ellipticum (munyeredzi)

Tamarindus indica (tamarind, musika)

Trichilia emetica (banket mahogany, muchichiri, mutsikiri)

Xanthocercis zambesiaca (nyala tree, muchetuchetu, musharo)

Climbers

Artabotrys brachypetalus (mudavashoko, ipamba)

Capparis tomentosa (mukorongwe)

Combretum microphyllum (burning bush, mupfurura, bambagwena)

Combretum mossambicense (shaving brush combretum, mubondokoroto)

Shrubs

Acacia ataxacantha (mukomborakombora, uthathawu)

Bauhinia tomentosa (mupondopondo)

Boscia spp.

Bridelia spp.

Cassia abbreviata (long pod cassia, murembeerembe, isihaqa)

Combretum spp.

Friesodielsia obovata (formerly *Popowia obovata*, muchinga, umkozombo)

Grewia spp. (donkey berry, mutongoro, mubhubhunu)

Lecaniodiscus fraxinifolius (musando, mutalala)

Herbs

Disperma crenatum perennial

Grasses

Digitaria spp. perennial

Panicum spp. annual

Rottboellia exaltata annual

Urochloa spp. annual

Brachystegia woodland (msasa woodland). Deciduous

The msasa, *B.spiciformis* and mfuti, *B.boehmii* together with the mnondo, *Julbernardia globiflora* form extensive mixed deciduous woodlands at medium to high altitudes, often on gravelly or rocky soil. Soon after the winter, June to August, the trees shed their leaves, and the evergreen riverine vegetation is revealed in sharp contrast. *B.spiciformis* is one of the earliest trees to produce a flush of new leaves. From late July, the red and yellow foliage is, for a few weeks, a brilliant feature of the Rhodesian countryside.

B.glaucescens often becomes the dominant tree on rocky kopjes and well drained rocky hill slopes with locally higher rainfall than the surrounding woodland, as on the Chuhanja Hills in the Sabi-Lundi region.

The common species found in *Brachystegia* woodland are:-

Acacia nigrescens (knobthorn, chianga, umkhaya, umhlopa)

Albizia antunesiana (shaving brush albizia, muriranyenze, umnonjwana)

Brachystegia boehmii (mfuti, itshabela)

Brachystegia spiciformis (msasa, igonde)

Burkea africana (mukarati, umnondo)

Julbernardia globiflora (mnondo, umshonkwe)

Kirkia acuminata (mubvumira, umvumila)

Parinari curatellifolia (muhacha, muchakata, umkhuna)

Pericopsis angolensis (formerly *Afrormosia*, muwanga, umbanga)

Pterocarpus angolensis (mukwa, umbvamaropa, umvagazi)

Sterculia africana (mungoza, mulele)

Uapaca kirkiana (mahobohobo)

Xeroderris stuhlmannii (formerly *Ostryoderris*, mudzungu)

Small trees and shrubs

Albizia anthelmintica (musalati, munanswa)

Combretum fragrans (formerly *C.ternifolium*, mugwabwa, ibaghabagha)

Combretum celastroides, C.erythrophyllum, C.microphyllum

Diospyros kirkii (mushenje)

Diplorhynchus condylocarpon (mtowa, inkamamasane)

Euphorbia ingens, E.cooperi (mukonde)

Ochna spp.

Pseudolachnostylis maprouneifolia (duiker berry, mudyahembwe umqhobampunzi)

Strychnos spp.

Swartzia madagascariensis (mucherekese, umketsheketshe)

Terminalia sericea (mangwe, mukonono)

Xeromphis obovata (chizhuzhu, ingwagela)

Colophospermum mopane woodland. Deciduous

Mopane woodland contains fewer subdominant tree species than *Brachystegia* woodland. Mopane becomes the dominant tree on drainage lines on highly alkaline grey clay (mopane clay) at medium altitudes, and over extensive areas in the northern, western and southern lowveld. On basaltic clays, which crack widely during the dry season, the roots of mopane trees are snapped off by the shrinking, effectively pruning them, to produce the 'scrub' mopane typical of this type of soil.

In deeper alluvial soils adjacent to larger rivers mopane trees may grow to 15m. Stands of such robust trees have been described as 'cathedral mopane'. Mopane woodland may occur as almost pure stands or interspersed with other species such as:-

Trees

Acacia nigrescens (knobthorn, chianga, umkhayaomphlope)

Acacia polyacantha (formerly *A.campylacantha*, mukwaka)

Afzelia quanzensis (pod mahogany, mukamba, umkama)

Combretum imberbe (leadwood, mutsviri, umtswili)

Terminalia spp.; *T.prunioides, T.randii, T.stuhlmannii*

Smaller trees and shrubs

Euclea divinorum (mubhubhunu, umtshekesane)

Flacourtia indica (mutombototo, umthunduluka)

Maerua edulis (katunguru, muswezu)

Strophanthus spp.

Ximenia americana (sour plum, mutengeninyatwa, iholotshane)

Grasses Mainly *Aristida* spp.

Baikiaea plurijuga woodland. Deciduous

B.plurijuga forms extensive, often pure stands on Kalahari sands, sufficiently distinctive to be called by a special name – *gusu.* Sometimes it is found associated with the following species:-

Trees

Baikiaea plurijuga (Rhodesian teak, gusi, umkhusu)

Brachystegia spiciformis (msasa)

Erythrophleum africanum (mushati, umbako)

Guibourtia coleosperma (muchiva, umtshibi)

Julbernardia globiflora (mnondo, umshonkwe)

Pterocarpus angolensis (mukwa, muvamaropa, umvagazi)

Ricinodendron rautanenii (wild almond, muoma, umgoma)

Shrubs

Baphia massaiensis (formerly *B.obovata*, umbondo, musenezuka)

Combretum celastroides (umlalanyathi)

Acacia spp. woodland. Deciduous

Acacia spp. usually occur associated with other dominant species, but may congregate in local situations on drier soils. On Kalahari sands in the western regions of Rhodesia and in the south east, on cretaceous soils, *A.giraffae* (camel thorn, umohlo) may be locally common on the edge of depressions.

A.karroo (mimosa thorn, muunga, isinga) is a common and widespread Acacia occurring on fertile, black, clay soils and along water courses, and in wooded grassland.

A.polyacantha (hook thorn tree, chiungadzi, umohlo) is often gregarious on the edges of depressions and riverine fringes or in woodland.

A.robusta var. clavigera is common along rivers and on alluvial soils at lower altitudes.

A.sieberana (umbrella thorn, mubayamhondoro, muunga) is widespread and common on alluvial plains, on open and wooded grassland or in open woodland.

A.xanthophloea (fever tree, jelenga) occurs gregariously around pans and riverine fringes and flood plains in the southeastern lowveld.

Combretum spp. woodland. Deciduous

Combretum spp. occur commonly throughout wooded areas of medium to low rainfall, sometimes, with *Terminalia* spp. becoming locally the dominant genus. The more common species found in such situations are:-

Trees

C.apiculatum (mugodo, umbondo)

C.celastroides (umlalanyathi)

C.fragrans (mugwabwa, imbhagabhaga)

C.imberbe (leadwood, muchenarota)

C.molle (mubondo)

C.zeyheri (muchenja, umbondo)

Sclerocarya caffra (marula, umganu)

Terminalia sericea (mukonono, mususu, umangwe)

Shrubs

Rhoicissus revoilli, R.tridentata (muchenarota)

Thicket (Sinanga or Jese bush). Deciduous

Thicket is a general name given to the close, often impenetrable growth of small trees and shrubs but often containing large trees. Sinanga or 'Jese' bush is a particular kind of thicket restricted to the northern lowveld and is composed mainly of the following species:-

Trees

Adansonia digitata (muuyu, umkhomo)

Boscia spp.

Combretum elaeagnoides

Commiphora mollis (muchamwa, iminyela)

Diospyros senensis

Excoecaria bussei

Lannea stuhlmannii (musototo, umganunkomo)

Lecaniodiscus fraxinifolius (musando)

Pteleopsis sp. (muchaba)

Pterocarpus antunesii (mudadima, mukambo)

Schrebera trichoclada (mukakata)

Strychnos spp.

Terminalia prunioides (muchanana, shahanzowa)

Triplochiton zambesiacus (mutombugwe, uganso)

Xeroderris stuhlmannii (inodzungu, umthondulu)

Shrubs

Acacia schweinfurthii

Bauhinia tomentosa (mupondopondo)

Canthium frangula (musasate)

Capparis tomentosa (mukorongwe)

Combretum celastroides (umlalanyati)

Combretum mossambicense (mubondorokoto, mutwetwe)

Dalbergia martinii (lombe)

Dichrostachys cinerea (mupangara)

Friesodielsia obovata (muchinga)

Gardenia resiniflua (mutara)

Grewia spp.

Strophanthus kombe (kombe)

Tarenna luteola

Open grassland (vleis or grassland flats)

A vlei is a poorly drained area of illuvial soils. In the dry season the soil often becomes hard and deeply cracked, and supports only grasses and a few stunted trees and shrubs. The edges are usually sharply defined by the growth of deciduous woodland. The components of vlei edge vegetation are determined by the surrounding dominant vegetation types. Thus, if the vlei is surrounded by *Brachystegia* woodland, tree species found in that association will occur at the vlei edge.

Shrubs occurring within open grassland include:-

Cardiogyne africana (mupumbura)

Diospyros lycioides subsp. *sericea* (formerly *Royena sericea)*

Lannea edulis (tsambatsi, intakubomvu)

Syzygium guineense (mukute)

5.3 The transitional zones, or ecotones

The communities listed above provide suitable habitat for at least part of the year for tsetse flies and for the animals on which tsetses feed. As the winter progresses leaf fall occurs in the general woodland, and the savanna tsetse are compelled to find shelter where it occurs. The variety of shade conditions found where one tree community merges into another offers some refuge. In these situations, the tree species of both communities intermingle in what is known as the Ecotone (or more commonly, locally as a 'contact zone'). These ecotones are given special attention in insecticide spraying operations. They can be recognised on aerial photographs as the division between two or more vegetation patterns. Within the ecotones, the boles of the larger trees, and other resting and refuge places of tsetse flies are treated.

The Field Assistants are generally very knowledgeable about the local vegetation. The Field Officer and Field Glossinologist would do well to spend time with Field Assistants traversing the bush on foot noting and memorising the names, appearance and diagnostic features of the more common tree species in the various communities.

5.4 Diagnostic features used in identifying plant species

The appearance of the flowers, fruits, stems and leaves is used in identifying flowering plants. Since the flowers are present for only a short period of the year they are of less use for identification in the field than are the leaves and fruits, although they afford a precise means of identification. As one becomes familiar with the names of trees, one learns to recognise the general forms the trees take, with and without leaves, and the ecological situations in which they occur.

The leaf

The leaf is a special adaptation of vascular plants for absorbing energy from the sun. It is composed of various groups of similar cells, forming tissues, each performing a particular function. The fibres and woody cells provide support; the phloem conducts manufactured food from the leaves to other parts of the plant; the mesophyll and palisade cells within the leaf, containing the chloroplasts which carry the green colouring matter, chlorophyll, are the site of manufacture of sugars and starches from carbon dioxide in the atmosphere and water taken in by the roots, under the action of sunlight; special cells, the stomata, by swelling or contracting regulate the flow of air and water vapour through the epidermis.

The leaf is produced from a stem, and always, between the leaf and the stem, in the *axil,* there is a bud. If there is no evidence of a bud where it might be expected, then the structure under examination is not a leaf, but more likely part of a leaf, or a stem.

Simple leaves

These consist of a single *midrib* from which lateral veins arise, supporting the *blade* or lamina. (Some trees, like palms possess leaves that do not have midribs. The veins are more or less parallel along the length of the leaf), Fig. 19.

Compound leaves, made up of leaflets

In compound leaves the midrib does not bear a lamina, but the lateral veins bear leaflets or *pinnae.* There is no bud between the midrib and a lateral vein. Such leaves are termed *pinnate.*

In some compound leaves, the lateral veins do not produce pinnae but themselves produce sub-lateral veins which support the leaflets. Such leaves are bipinnate.

The *margin* of the lamina may be *entire,* (smooth in outline), or may be indented, (dentate, serrate, sinuate). Figs 20 – 22 show various shapes of leaves, with the appropriate terms.

Leaves may be attached to the stem by a stalk or *petiole,* or may be sessile, without a petiole. At the junction of the leaf or petiole

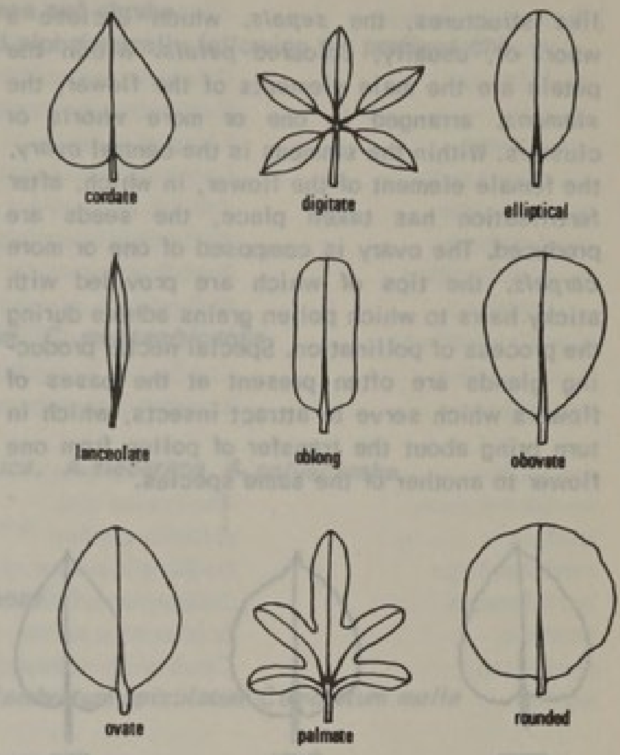


Fig. 20 Shapes of leaves

with the stem small, leaflike appendages, the *stipules* may occur. The leaf may thus be *stipulate* or *exstipulate.*

The arrangement of the leaves on the stem may be alternate, where they arise singly in a spiral fashion ascending the stem. They may be produced in pairs opposite to one another at the same *node* on the stem, or in threes, *ternate* or fours, *quadrate,* or more. The surface may be *glabrous,* without hairs, or covered with small hairs, *pubescent,* or with matted hairs, *tomentose.* If it is rough to the touch, it is *scabrous.*

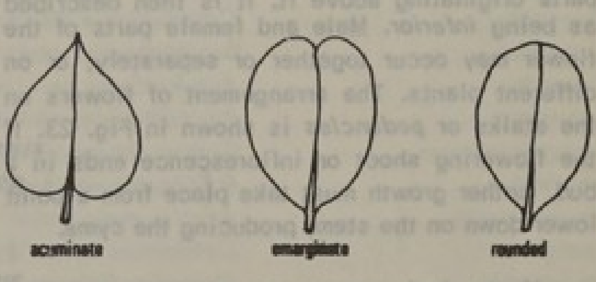


Fig. 21 Apices of leaves

The flowers are made up of a series of modified leaves, arranged around what is really a very short stem. In a flower of simple structure there is a whorl of separate, usually green leaflike structures, the *sepals,* which enclose a whorl of, usually, coloured *petals.* Within the petals are the male elements of the flower, the *stamens,* arranged in one or more whorls or clusters. Within the stamens is the central *ovary,* the female element of the flower, in which, after fertilisation has taken place, the seeds are produced. The ovary is composed of one or more *carpels,* the tips of which are provided with sticky hairs to which pollen grains adhere during the process of pollination. Special nectar producing glands are often present at the bases of flowers which serve to attract insects, which in turn bring about the transfer of pollen from one flower to another of the same species.

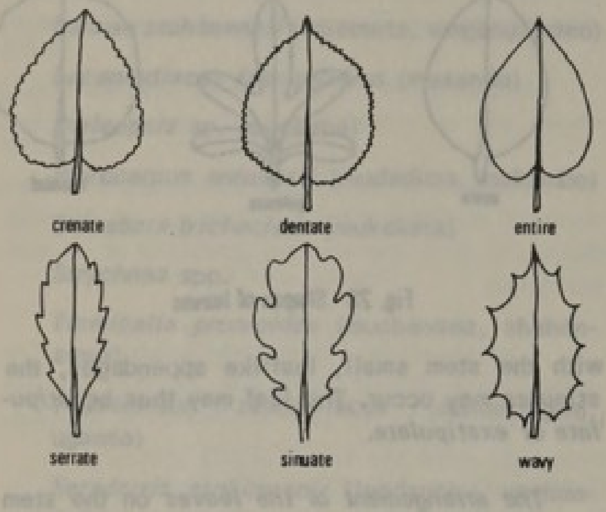


Fig. 22 Margins of leaves

The parts of the flower may be separate, or they may be fused together, sometimes producing *tubular* flowers. The ovary can be visible, with the other parts arising around its base, when it is described as being *superior,* or it may be apparently enclosed in the stem with the other parts originating above it. It is then described as being *inferior.* Male and female parts of the flower may occur together or separately, or on different plants. The arrangement of flowers on the stalks or *peduncles* is shown in Fig. 23. If the flowering shoot or inflorescence ends in a bud, further growth must take place from a point lower down on the stem, producing the *cyme.*

If the buds mature as they are produced along a stem, the oldest being at the lowest part of the stem, the inflorescence is a *raceme,* with its variations, the spike, corymb, panicle etc.

After pollination and fertilisation have taken

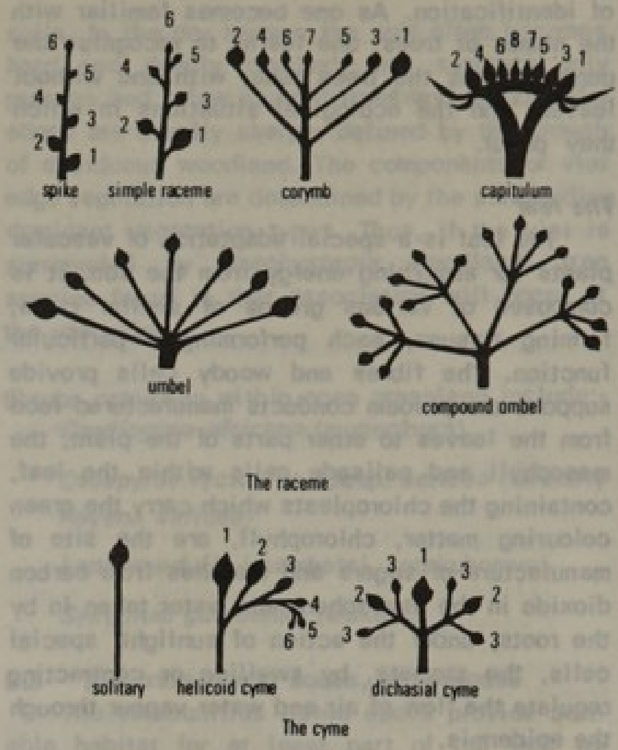


Fig. 23 Arrangements of inflorescences

place, seeds are produced in the ovary. The ovary with its mature seeds becomes the *fruit,* (regardless of whether it is edible or not). The fruits may be fleshy or dry, and dry fruits may split or *dehisce* to liberate the seeds.

Fleshy fruits that contain a 'stone' enclosing the free seed, like a plum, are *drupes.* Those without a stone, sometimes with hard seeds are *berries,* like a tomato.

Dry dehiscent seed pods are *capsules,* of which there are several kinds. The *legume* is formed from a single carpel, like the garden pea, or like the msasa and splits along both margins to liberate the seeds.

Some dry fruits do not dehisce. The grasses, wheat, maize, many winged fruits, like those of *Combretum* spp, produce fruits in which the seeds are enclosed in a part of the ovary. The names of these fruits should be learned as you encounter them.

An alphabetical list of local names of trees and shrubs is given to enable the field officer to interpret the names of trees given by the local Africans. A short description of each species can be obtained from 'The Rhodesian Botanical Dictionary of African and English Plant Names' H. Wild, available from the Senior Field Officers in each region.

5.5 Local and Botanical names of some common trees and shrubs

The local names of trees and shrubs are arranged alphabetically following the prefixes chi-, i-, isi-, mu-, ru-, u-, and um-.

mu-anga	*Pericopsis angolensis*
ru-anzili	*Teclea nobilis*
ru-anziti	*Teclea nobilis*
i-baghabhaga	*Combretum fragrans*
um-bambangwe	*Acacia ataxacantha*
bambanwenya	*Combretum microphyllum. C. mossambicense*
i-banda	*Lonchocarpus capassa*
um-banga	*Pericopsis angolensis*
chi-bayamakono	*Xeromphis obovata*
mu-bạyamhondoro	*Acacia karroo. A.nilotica. A.sieberana A. polyacantha*
mu-bhubhunu	*Euclea divinorum*
u-bhuzu	*Grewia flavescens*
u-bima	*Combretum imberbe*
bombolokoto	*Combretum mossambicense*
bonda	*Combretum apiculatum*
mu-bondo	*Combretum molle*
um-bondo	*Baphia massaiensis. Combretum apiculatum Combretum molle*
um-bondo omkhulu	*Combretum fragrans*
mu-bondorokoto	*Combretum mossambicense*
mu-boorashomwe	*Xeromphis obovata*
bumbunzwa	*Urochloa mosambicensis*
mu-bungati	*Albizia versicolor*
mu-buni	*Parinari curatellifolia*
um-buze	*Brachystegia glaucescens*
mu-bvamakavo	*Pterocarpus angolensis*
mu-bvamaropa	*Pterocarpus angolensis*
mu-bvee	*Kigelia africana*
mu-bveve	*Kigelia africana*
mu-bvinzaropa	*Pterocarpus angolensis*
mu-bvumbu	*Lannea discolor*
mu-bvumira	*Kirkia acuminata*
mu-chakata	*Parinari curatellifolia*
mu-checheni	*Ziziphus mucronata*
mu-chechete	*Mimusops zeyheri, Ziziphus mucronata*
mu-chemavanhu	*Xeroderris stuhlmannii*
um-chenalota	*Combretum imberbe*
mu-chenarota	*Combretum imberbe*
mu-chendewabasokwe	*Grewia flavescens*
mu-chenja	*Combretum zeyheri*
mu-chenje	*Diopyros mespiliformis*
mu-cherekese	*Swartzia madagascariensis*
mu-chetuchetu	*Xanthocercis zambesiaca*
mu-chichiri	*Trichilia emetica*
mu-chinga	*Friesodielsia obovata*
mu-chirara	*Pterocarpus rotundifolius*
mu-chirinje	*Mimusops zeyheri*
i-chitamuzi	*Lonchocarpus capassa*
mu-chiva	*Guibourtia coleosperma*
mu-dadima	*Pterocarpus antunesii*

dasasandu-dasaya	*Flacourtia indica*
um-dhlandhlovu	*Pterocarpus rotundifolius*
um-dhlawuzo	*Diospyros mespiliformis*
um-dubu	*Combretum erythrophyllum*
mu-dudwe	*Flacourtia indica*
dungamuzi	*Lonchocarpus capassa*
mu-dyahumba	*Albizia antunesii*
mu-dyamhara	*Markhamia acuminata*
mu-dyamhembwe	*Pseudolachnostylis maprouneifolia*
dzedze	*Peltophorum africanum*
mu-dzivirirashuro	*Euclea divinorum*
mu-dziyaishe	*Combretum apiculatum. C.molle*
mu-dzungu	*Xeroderris stuhlmannii*
mu-fonda	*Cordyla africana*
mu-fukamhunze	*Rhoicissus* spp.
um-fula	*Bridelia zeyheri*
mu-fulamamba	*Dalbergia melanoxylon*
mu-fulanama	*Dalbergia melanoxylon*
mu-funa	*Sclerocarya caffra*
mu-fununu	*Combretum mossambicensis*
mu-futi	*Brachystegia boehmii*
gakaunga	*Acacia nigrescens*
mu-galusaka	*Combretum celastroides*
um-gamanzi	*Acacia robusta* subsp. *robusta*
um-gampa	*Afzelia quanzensis*
mu-ganacha	*Lannea discolor*
mu-gangacha	*Lannea discolor*
isi-gangatsha	*Lannea discolor*
si-gangatsha	*Lannea discolor*
mu-ganso	*Triplochiton zambesiacus*
um-ganu	*Sclerocarya caffra*
ganyi	*Sclerocarya caffra*
mu-gara	*Celtis africana*
mu-garamhanga	*Berchemia discolor*
mu-garanyenze	*Albizia antunesiana. A.versicolor*
mu-garazvuru	*Euclea divinorum*
mu-gato	*Acacia ataxacantha,* generally, climbing plants with hooked thorns
mu-godo	*Combretum apiculatum, C.molle*
mu-godzonga	*Rhoicissus* sp.
mu-gogoma	*Afzelia quanzensis*
mu-goko	*Crossopteryx febrifuga*
um-goma	*Ricinodendron rautanenii*
i-gonde	*Brachystegia spiciformis*
um-gongo	*Ricinodendron rautanenii*
mu-gonyogonyo	*Grewia flavescens*
mu-gopo	*Markhamia acuminata*
mu-goriondo	*Afzelia quanzensis*
mu-goro	*Combretum apiculatum*
mu-gosa	*Sterculia africana*
mu-gulasaka	*Combretum celastroides*
mu-garameno	*Euclea divinorum*
gusi	*Baikiaea plurijuga*
mu-guunga) mu-guwunga)	*Acacia macrothyrsa, A.nigrescens.* Acacias with hooked thorns
guzhe	*Brachystegia glaucescens*

mu-gwabwa	*Combretum fragrans*
um-gweze	*Dalbergia melanoxylon*
mu-gwiti	*Dalbergia melanoxylon*
i-habahaba	*Piliostigma thonningii*
chi-hacha	*Euphorbia cooperi*
mu-hacha	*Parinari curatellifolia*
mu-hara	*Ochna schweinfurthiana*
mu-hati	*Dalbergia melanoxylon*
um-hlale	*Strychnos spinosa*
um-hlampunzi	*Grewia bicolor. G.flavescens*
hlangula	*Euclea divinorum*
hlanzwa	*Mimusops zeyheri*
mu-hlati	*Xanthocercis zambesiaca*
i-hlene	*Afzelia quanzensis*
hlofungu	*Acacia albida*
um-hlonhlo	*Euphorbia cooperi. E.ingens*
um-hobohobo	*Uapaca kirkiana*
um-hohlo	*Acacia giraffae. A.polyacantha*
nya-hoko	*Balanites aegyptiaca*
i-holotshane	*Ximenia americana*
mu-honde	*Euphorbia ingens*
mu-huku	*Piliostigma thonningii*
mu-humbukumbu	*Lannea discolor*
mu-hunga	*Acacia nilotica. A.rehmanniana. A.sieberana A.karroo*. Acacias with straight, light-coloured thorns.
mu-hwiti	*Dalbergia melanoxylon*
mu-isha	*Parinari curatellifolia*
mu-jarakamba	*Afzelia quanzensis*
jejeni	*Ziziphus mucronata*
jelenga	*Acacia xanthophloea*
mu-jiza	*Peltophorum africanum*
mu-jonjoma	*Grewia flavescens*
kahla	*Peltophorum africanum*
kaho	*Acacia ataxacantha. A.schweinfurthii*
mu-kakanyuro	*Acacia ataxacantha*
kalaunga	*Acacia albida. A.galpinii*
mu-kalusaka	*Combretum celastroides*
mu-kamba	*Afzelia quanzensis*
um-kamba	*Afzelia quanzensis*
nya-kambariro	*Peltophorum africanum*
mu-kambira	*Pterocarpus angolensis*
mu-kambo	*Pterocarpus antunesii*
um-kanu	*Sclerocarya caffra*
mu-kapati	*Burkea africana*
mu-karamadzi	*Ficus capreifolia*
karanga	*Combretum molle*
mu-karati	*Burkea africana*
kashishe	*Diospyros quiloensis*
mu-kato	*Acacia ataxacantha.* Climbing shrubs with hooked thorns.
mu-kauzane	*Albizia versicolor*
mu-kaya	*Acacia nigrescens*
um-ketsheketshe	*Swartzia madagascariensis*

um-khamba	*Afzelia quanzensis*
um-khaya	*Acacia galpinii. Acacias* with light coloured bark and dark, hooked thorns.
um-khayaemhlope	*Acacia nigrescens*
um-khuna	*Parinari curatellifolia*
um-klampunzi	*Grewia bicolor. G.flavescens. G.monticola*
um-kojombo	*Friesodielsia obovata*
mu-koko	*Crossopteryx febrifuga*
kolokotso	*Piliostigma thonningii*
um-kololo	*Lonchocarpus capassa*
i-koloshane) i-kolotshiyane)	*Ximenia americana*
mu-komanyati	*Baphia massaiensis*
mu-kombe	*Strophanthus kombe*
kombegwa) mu-kombegwa) mu-komberwha) mu-kombigo)	*Crossopteryx febrifuga*
mu-kombokunono	*Acacia ataxacantha*
mu-komborakombora	*Acacia ataxacantha*
mu-konambiti	*Pterocarpus angolensis*
mu-konazhou	*Pterocarpus antunesii*
mu-konde	*Euphorbia ingens*
mu-kondotewa	*Dombeya rotundifolia*
mu-konono	*Terminalia sericea*
konze konze	*Euphorbia ingens*
mu-kosho	*Swartzia madagascariensis*
mu-kosvo	*Artabotrys brachypetalus*
mu-kotokoto	*Acacia nigrescens*
kovakova	*Acacia polyacantha*
mu-kovonga	*Garcinia livingstonei*
mu-kowe	*Ficus capreifolia*
um-kozombo	*Friesodielsia obovata*
mu-kudziti	*Dalbergia melanoxylon*
kuhlu	*Trichilia emetica*
chi-kuhlule	*Lecaniodiscus fraxinifolius*
chi-kutekute	*Combretum apiculatum*
mu-kula	*Diospyros mespiliformis*
mu-kulambira	*Pterocarpus angolensis*
mu-kulasaka	*Combretum celastroides*
mu-kumku	*Pseudolachnostylis maprouneifolia*
mu-kurambira	*Pterocarpus angolensis*
um-kushi	*Baikiaea plurijuga*
chi-kushule	*Lecaniodiscus fraxinifolius*
um-kusu) um-kuswi)	*Baikiaea plurijuga*
mu-kuu	*Acacia nigrescens*
mu-kuvazviyo	*Pseudolachnostylis maprouneifolia*
kuwane	*Ficus capreifolia*
mu-kwaka	*Acacia polyacantha*
mu-kwakwa	*Strychnos* spp. with medium sized fruits
kwambila	*Pterocarpus angolensis*
mu-kwatikwati	*Commiphora mossambicensis*
mu-kwezha	*Combretum fragrans*
mu-kwidzi	*Rhoicissus* sp.
mu-kwirambira	*Pterocarpus angolensis*

um-laladwayi	*A. sieberana*; Flat topped *Acacias*
um-lalanyathi	*Combretum celastroides*
ka-launga	*Acacia galpinii*
mu-lele	*Sterculia africana*
lidlwaya	*Commiphora mossambicensis*
chi-lole	*Xeromphis obovata*
mu-lukwa	*Drypetes mossambicensis*
mu-lundu	*Ochna pulchra*
luntwele	*Acacia polyacantha*
chi-lutsu	*Dalbergia melanoxylon*
mahobohobo	*Uapaca kirkiana*
chi-mande	*Antidesma venosum*
u-mangwe	*Terminalia sericea*
nya-manyoka	*Peltophorum africanum*
mu-mara	*Ochna schweinfurthiana*
marorwe	*Combretum mossambicense*
mu-mbeza	*Berchemia zeyheri*
mboza	*Combretum fragrans*
mbula	*Parinari curatellifolia*
mu-mbumbu	*Lannea discolor*
mu-mbungu	*Pterocarpus rotundifolius*
mbwele	*Combretum imberbe*
mu-merofodya	*Lonchocarpus capassa*
mu-mhingwe	*Dalbergia melanoxylon*
mu-mhinu) mu-minu)	*Ochna pulchra. O.schweinfurthiana Psorospermum febrifugum*
mu-mhudzungwa	*Grewia flavescens*
mu-mhungu	*Pterocarpus rotundifolius*
mnondo	*Julbernardia globiflora*
monzo	*Combretum imberbe*
mopane	*Colophospermum mopane*
motso	*Combretum imberbe*
mpalazwe	*Holmskioldia tettensis*
msasa	*Brachystegia spiciformis*
mtowa	*Diplorhynchus condylocarpon*
mtwetwe	*Combretum mossambicense*
mufuti	*Brachystegia boehmii*
muhacha	*Parinari curatellifolia*
mukarati	*Burkea africana*
mukwa	*Pterocarpus angolensis*
munyi	*Berchemia discolor*
muwanga	*Pericopsis angolensis*
mumvee) mumveva)	*Kigelia africana*
mumwambizi	*Xeroderris stuhlmannii*
mwani	*Colophospermum mopane*
umnaba	*Grewia flavescens*
mu/chi-n'anga	*Acacia galpinii. Ziziphus mucronata.* Trees and shrubs with hooked thorns.
isi-nanga	thicket, usually of thorn scrub
mu-nanzwa	*Albizia anthelmintica*
um-ncaga	*Berchemia discolor*
mu-nchola	*Diricletia pubescens*
mu-nchovwa	*Ximenia americana*

mu-ndalama	*Ricinodendron rautanenii*
mu-ndale	*Acacia robusta* subsp. *robusta*
ndeywha	*Grewia bicolor*
mu-nera	*Sterculia africana. S.quinqueloba*
isi-nga	*Acacia karoo*
um-nganu	*Sclerocarya caffra*
mu-ngenje	*Guibourtia conjugata*
ngiri	*Grewia bicolor*
ngoka	*Acacia tortilis*
ngonde	*Euphorbia ingens*
mu-ngongoma	*Azelia quanzensis*
mu-ngonya	*Guibourtia conjugata*
mu-ngoriondo	*Azelia quanzensis*
mu-ngosa) mu-ngoza)	*Sterculia africana*
mu-ngwinzwi	*Afzelia quanzensis*
mu-nhacha	*Berchemia discolor*
mu-nhara) mu-nharauta)	*Ficus capreifolia*
mu-nhengeni	*Ximenia caffra*
mu-nhinzwa	*Garcinia livingstonei*
mu-nhondo	*Julbernardia globiflora*
mu-nhongotowa	*Dombeya rotundifolia*
mu-nhowe	*Dalbergia melanoxylon*
mu-ni	*Berchemia discolor*
mu-njiri	*Grewia inequilatera. G.monticola*
i-nkamamasane	*Diplorhynchus condylocarpon*
nkanyi	*Sclerocarya caffra*
nkawu	*Acacia ataxacantha. A.schweinfurthii*
nkoho	*Acacia nigrescens*
nkonde	*Euphorbia cooperi. E.ingens*
mu-nogo	*Sclerocarya caffra*
nombe	*Acacia nilotica*
um-nondo	*Burkea africana*
nongoloko) nongonoko) nongonongo)	*Maerua edulis. M.junca. M.parvifolia*
mu-nongotowa	*Dombeya rotundifolia*
um-nonjwana	*Albizia antenusiana. A.versicolor*
um-ngamanzi	*Acacia robusta* subsp. *robusta*
nsengele	*Ximenia americana*
i-ntakubomvu	*Lannea edulis*
ntewa	*Grewia monticola*
mu-ntondo	*Cordyla africana*
mu-ntowu	*Diplorhynchus condylocarpon*
mu-ntyoka	*Diricletia pubescens*
nulu	*Balanites aegyptiaca*
mu-nungu	*Pterocarpus rotundifolius*
mu-nyii) um-nyiyi)	*Berchemia discolor. B.zeyheri*
mu-odza	*Lonchocarpus capassa*
um-ohlo	*Acacia giraffae. A.polyacantha*
mu-oma	*Ricinodendron rautanenii*
mu-ongo	*Balanites aegyptiaca*
mu-ororo	*Lonchocarpus capassa*

palagwe	*Diricletia pubescens*
i-mu-panda) mu-pandapanda)	*Lonchocarpus capassa*
mu-pane	*Colophospermum mopane*
panza	*Lonchocarpus capassa*
mu-para	*Ficus capreifolia*
mu-paramhosva	*Ochna pulchra. O.schweinfurthiana*
mu-parurapweza	*Combretum fragrans*
um-pasamala	*Ziziphus mucronata*
mu-pembere	*Combretum molle*
mu-pembere-kono	*Combretum zeyheri*
pepe	*Albizia antunesiana*
pesa	*Rhoicissus* spp.
mu-pfiti	*Combretum fragrans*
mu-pfura	*Sclerocarya caffra*
mu-pfuti	*Brachystegia boehmii*
um-phafa	*Ziziphus mucronata*
i-phane	*Colophospermum mopane*
mu-pimbi	*Garcinia livingstonei*
mu-pimbiri	*Grewia monticola*
mu-pondo) mu-pondopondo)	*Bauhinia tomentosa*
mu-pudzungwa	*Grewia flavescens*
um-pumbu	*Acacia albida. A.polyacantha*
mu-pumha	*Combretum erythrophyllum*
mu-pumhazvuru	*Diospyros lycioides*
um-pumpu	*Acacia albida. A.polyacantha*
um-pumpulwane	*Grewia bicolor. G.monticola*
mu-punduru	*Dombeya rotundifolia*
mu-pungu	*Pterocarpus rotundifolius*
mu-pwanda	*Lannea discolor*
mu-pweza) mu-pwezha)	*Combretum fragrans*
um-qaqawe	*Acacia ataxacantha*
um-qathuva	*Diospyros lycioides*
um-qhobampunzi	*Pseudolachnostylis maprouneifolia*
mu-rambambare	*Ochna schweinfurthiana*
mu-rere	*Sterculia africana. S.quinqueloba*
mu-riranyedzi) mu-riranyenje) mu-riranyenzi)	*Albizia antunesiana. A.versicolor*
mu-riravanhu	*Xeroderris stuhlmannii*
chi-role	*Xeromphis obovata*
mu-rorongwe	*Garcinia livingstonei*
chi-rovaduru	*Xeromphis obovata*
mu-rumanyama	*Xeroderris stuhlmannii*
mu-rurugwi) mu-ruruwi)	*Drypetes mossambicensis*
mu-rwiti	*Dalbergia melanoxylon* (also — -witi, -hwiti, -bwiti, -gwiti)
mu-sakasa	*Piliostigma thonningii*
mu-salati	*Albizia anthelmintica*
mu-sangu	*Acacia albida*
mu-santa	*Kirkia acuminata*
mu-saru	*Colophospermum mopane*
mu-sasa	*Brachystegia spiciformis*

um-sasane	*Acacia sieberana*
mu-savamhanga	*Acacia ataxacantha*
mu-sekesa) mu-sekese)	*Piliostigma thonningii*
i-sendendwangu	*Grewia herbacea*
mu-senga	*Acacia albida*
sesani	*Acacia robusta. A.tortilis*
um-shabunga	*Acacia robusta*
mu-shakarta	*Parinari curatellifolia*
shakwari	*Drypetes mossambicensis*
mu-shambaropa	*Pterocarpus angolensis*
shanatsi	*Colophospermum mopane*
mu-shangura	*Euclea divinorum. E.natalensis*
mu-sharo	*Xanthocercis zambesiaca*
mu-sharu	*Colophospermum mopane*
shashanzowa	*Terminalia prunioides*
mu-shawebungu	*Diospyros lycioides*
shenhe	*Afzelia quanzensis*
mu-shenje	*Diospyros kirkii. D.mespiliformis*
mu-shesheni	*Ziziphus mucronata*
mu-shinga	*Friesodielsia obovata*
ka-shishe	*Diospyros quiloensis*
shojowa	*Pseudolachnostylis maprouneifolia*
mu-shomvwa	*Ximenia americana*
mu-shonjowa	*Pseudolachnostylis maprouneifolia*
um-shonkwe	*Julbernardia globiflora*
mu-shozhowa	*Pseudoloachnostylis maprouneifolia*
mu-shuku	*Uapaca kirkiana*
mu-shuma	*Diospyros mespiliformis*
mu-shumadombo) mu-shumho)	*Diospyros lycioides*
i-shungu	*Julbernardia globiflora*
mu-siabwele	*Diospyros quiloensis*
sihana	*Grewia bicolor*
mu-sika	*Tamarindus indica*
mu-sikanyimo	*Diplorhynchus condylocarpon*
mu-sikalanganga	*Albizia versicolor*
siloka-mungini	*Pseudolachnostylis maprouneifolia*
simbili) simbiti)	*Androstachys johnsonii*
mu-siyasitu	*Dombeya rotundifolia*
mu-somba	*Pterocarpus angolensis*
mu-sonya	*Kigelia africana*
mu-sorokoto	*Xeroderris stuhlmannii*
mu-sosahwai	*Terminalia randii*
mu-sosobiana	*Grewia occidentalis*
soswe	*Maerua edulis*
mu-sukachuma	*Berchemia zeyheri*
mu-suma	*Diospyros mespiliformis*
mu-sungu	*Julbernardia globiflora*
mu-susu	*Terminalia sericea*
mu-svodzabveni	*Ochna pulchra, O.schweinfurthiana*
mu-svosvamhungu) mu-svotamhungu) mu-svovamhungu)	*Diospyros lycioides*
um-swanja	*Ximenia americana*

mu-swe	*Ochna pulchra*
mu-swezu	*Maerua edulis*
mu-tabvu	*Terminalia sericea*
isi-talagwa	*Xeromphis obovata*
mu-tamba	*Strychnos* spp. with large fruit ± 15cm diameter
mu-tamba-bungu	*Strychnos mitis*
mu-tamba-mnono	*Strychnos spinosa*
mu-tamba-muzhinyu	*Strychnos cocculoides*
mu-tamba usiku	*Strychnos pungens*
mu-tangazhizha	*Lonchocarpus capassa*
mu-tatya	*Berchemia discolor*
mu-tedza	*Sterculia africana. S.quinqueloba*
mu-tehwa	*Grewia inaequilatera. G.monticola*
um-teme) mu-teme)	*Strychnos madagascariensis*
mu-tengeninyatwa	*Ximenia americana*
mu-tepe	*Combretum erythrophyllum*
mu-teswa) mu-tewa)	*Grewia inaequilatera*
um-tewa) n-tewa)	*Grewia flavescens. G.monticola*
u-thathawu	*Acacia ataxacantha. A.schweinfurthii*
i-thetshane	*Combretum hereroense*
um-thombothi	*Spirostachys africana*
um-thundulu	*Xeroderris stuhlmannii*
mu-timi	*Strychnos madagascariensis*
mu-tisiyane	*Combretum zeyheri*
mu-tivoti	*Spirostachys africana*
mu-tohwa	*Diplorhyncus condylocarpon*
chi-tohwe) mu-towhechuru)	*Dombeya rotundifolia*
mu-toma	*Diospyros mespiliformis*
mu-tombololo	*Combretum mossambicense*
chi/mu-tomborashomwe	*Xeromphis obovata*
mu-tomboti	*Spirostachys africana*
mu-tondo	*Cordyla africana*
mu-tondo	*Julbernardia globiflora*
mu-tondokatura	*Dombeya rotundifolia*
mu-tongoro	*Grewia bicolor. G.inaequilatera. G.monticola Uapaca kirkiana*
mu-tongotohwa) mu-tongotowa)	*Dombeya rotundifolia*
tonoa	*Friesodielsia obovata*
mu-toranhundu	*Dombeya rotundifolia*
mu-tototo	*Pseudolachnostylis maprouneifolia*
mu-towa	*Diplorhynchus condylocarpon*
mu-tsakatidze	*Kirkia acuminata*
um-tshakatsha	*Swartzia madagascariensis*
mu-tsambasi) mu-tsambati) mu-tsambatsi)	*Lannea edulis*
tsangalagova	*Albizia anthelmintica*
mu-tsangu	*Acacia albida*
mu-tsatsa	*Brachystegia spiciformis*
tsele	*Grewia inaequilatera*
tsengele	*Ximenia americana*
mu-tserekese	*Swartzia madagascariensis*

i-tshabela	*Brachystegia boehmii*
i/um-tshekesane	*Euclea crispa. E.divinorum. E.monticola*
um-tshibi)	*Guibourtia coleospermum*
um-tshini)	
mu-tshwele	*Diospyros quiloensis*
tsingidzi	*Combretum apiculatum*
mu-tsiri	*Combretum imberbe*
um-tsombole	*Lannea edulis*
mu-tsomo	*Sclerocarya caffra*
mu-tsomvori	*Spirostachys africana*
mu-tsonga	*Berchemia zeyheri*
mu-tsonzowa	*Pseudolachnostylis maprouneifolia*
tsopoli	*Spirostachys africana*
tsotso	*Brachystegia glaucescens*
tsowa	*Diplorhynchus condylocarpon*
tsulu	*Strophanthus kombe*
mu-tsvanzva	*Ximenia caffra*
mu-tsvatsvamudiki	*Ochna macrocalyx*
mu-tsvedza	*Sterculia africana*
nya-tsvipa	*Diospyros lycioides*
mu-tswatswari	*Ochna pulchra*
um-tswili	*Combretum imberbe*
mu-tuhwa	*Kirkia acuminata*
mu-tukutu	*Piliostigma thonningii*
mu-tungababala	*Xeromphis obovata*
ka-tunguru	*Maerua edulis*
mu-tungwa	*Garcinia livingstonei*
mu-tunhondo	*Dombeya rotundifolia*
mu-tuva	*Kirkia acuminata*
mu-tuvuti	*Spirostachys africana*
mu-twankololo	*Xeroderris stuhlmannii*
mu-twetwe	*Combretum mossambicense*
mu-tyoka	*Diricletia pubescens*
mu-umi	*Strychnos cocculoides*
mu-unga	*Acacia nilotica. A.sieberana. A.karroo*
chi-ungadzi	*Acacia macrothyrsa. A.polyacantha*
mu-unze)	*Brachystegia glaucescens*
mu-uzhe)	
um-vagazi	*Pterocarpus angolensis*
mu-vambangoma	*Balanites aegyptiaca*
mu-vanga	*Pericopsis angolensis*
um-vebe)	*Kigelia africana*
um-vebve)	
mu-veve)	
mu-vezeramhanga	*Ochna pulchra. O.schweinfurthiana*
i-vezha	*Combretum fragrans*
vheve	*Kigelia africana*
mu-vhiyambudzi	*Combretum molle*
mu-vhumati	*Kigelia africana*
mu-vhumira	*Kirkia acuminata*
mu-vhunambezo	*Berchemia zeyheri*
i-vikane	*Terminalia prunioides. T.stuhlmannii*
i-vikane elincinyane	*Terminalia randii*
um-vimila	*Kirkia acuminata*
um-vula	*Combretum zeyheri*

vumaila	*Kirkia acuminata*
vumbangwenya	*Acacia robusta*
mu-vumbu	*Terminalia prunioides*
um-vumela) um-vumila)	*Kirkia acuminata*
um-wakwa	*Strychnos madagascariensis*
um-wane	*Dombeya rotundifolius*
mu-wanga	*Pericopsis angolensis*
mu-wani	*Dombeya rotundifolia*
ru-wanziri	*Teclea nobilis*
um-wawa	*Strychnos madagascariensis*
mu-wayawaya	*Pterocarpus angolensis*
mu-witi	*Dalbergia melanoxylon*
mu-wodza	*Lonchocarpus capassa*
mu-wondekatowa	*Dombeya rotundifolia*
mu-wonongwa	*Garcinia livingstonei*
mu-wunga	*Acacia nilotica. A.rehmanniana. A.sieberana*
mu-wunze	*Brachystegia glaucescens*
mu-yando	*Combretum imberbe*
mu-yataha	*Pterocarpus rotundifolius*
mu-zhanje) mu-zhanje kabudya)	*Uapaca kirkiana*
mu-zhinyu	*Strychnos cocculoides*
chi-zhuzhu chitsuku	*Xeromphis obovata*
mu-zilawa	*Pseudolachnostylis maprouneifolia*
mu-zimbiti	*Androstachys johnsonii*
zingililo	*Pseudolachnostylis maprouneifolia*
mu-zumi	*Strychnos cocculoides*
mu-zunga	*Acacia tortilis. A.nilotica. A.sieberana*
zungu	*Xeroderris stuhlmannii*
mu-zungula) mu-zunguru)	*Kigelia africana*
mu-zwanganzi	*Xeroderris stuhlmannii*

6. THE CONTROL OF TSETSE FLIES IN RHODESIA

6.1 Tsetse behaviour in relation to control measures

Control measures against pests and parasites of crops and stock can be regarded as being means of reducing the numbers and therefore the depredations of the pest or parasite to a level at which they cease to be of economic importance. This does not necessarily mean the complete elimination of the pest or parasite. In some circumstances, the cost of continuous application of control measures to keep the numbers of a pest within bounds is justified by the increased yields that result. The complete eradication of a pest or parasite may be extremely difficult or impractical, or the cost involved may be unbearable.

In Rhodesia, because of our geographical position at almost the southern limit of *G. morsitans* and with the Zambezi and its impounded water as a barrier to invasions from the north and because of the continued success of present operations, it is becoming current among glossinologists to regard the term 'Tsetse Control' as implying control leading to complete eradication. Control measures will be used in that sense here.

Control measures are most effective when they are directed at the vulnerable stages in the life cycle of the pest. It is essential therefore, that a detailed knowledge is obtained of the behaviour and life history of the pest, so that control measures can be most effectively, precisely and thus economically, applied. In the tsetse fly, the egg and larval stages are spent within the body of the adult female, and are inaccessible to direct control measures.

The free living larva spends a very short period on the ground before burrowing underground and pupating, where it, also, is inaccesible to control measures. Accordingly, the only direct control measures that can be effectively applied against the tsetse fly are those directed against the adult. These must, inevitably, depend for their success upon a knowledge of the behaviour and requirements of the adult fly.

The particular habits of tsetse flies which make them vulnerable to control measures are:-

(i) they feed entirely on the blood of vertebrates, and the Rhodesian species show a marked preference for certain game animals.

(ii) they are woodland creatures requiring shade for their continued existence.

(iii) they spend most of their adult lives resting in sheltered places, becoming active to feed and mate.

(iv) the females generally mate only once.

With this information once could suggest, in a general way, a number of means of combating tsetse flies. Thus, since tsetses feed exclusively on vertebrate blood, it follows that if the source of the blood meals were removed, the flies would starve. Or, since they are dependent on shade conditions, the removal of favoured vegetation would restrict their distribution, and, therefore, their numbers. Since they spend much of their lives resting, the application of a lethal insecticide to the places where they rest would kill them. Or again, since the females mate once only, if this mating were with a male that had been sterilised no viable progeny would result, and the population would decline.

These methods have all had their place in tsetse control operations with the exception of the male sterilisation technique which is still in the experimental stage.

6.2 Tsetse control by means of hunting operations

6.2.1 The scientific basis for tsetse control by means of hunting operations

Periods of stress

Tsetse flies feed entirely on blood of vertebrates. The products of digestion are utilised by the fly to replace or add to the tissues of its body in the process of growth, and to provide a source of energy for its activities. Material surplus to immediate requirements is converted to fat, and is stored in the fat bodies within the abdomen. It is estimated that of a normal blood meal weighing 25mg, about a twelfth is stored as fat. The fat is readily broken down to release energy as it is required. In an active creature like the tsetse fly the expenditure of energy is both rapid and high. The female tsetse fly does not lay eggs, but incubates the egg and nourishes the larva to maturity from her own food and energy reserves within her body. This process in particular, involves a heavy drain on the insect's reserve of fat.

The activities of living things, like the rates of most chemical processes increase with increasing temperature (below the lethal limits). Tsetse flies thus expend energy more rapidly in the hot dry season than in cooler conditions. There is, in consequence, a need to take more frequent blood meals at this time, to replenish their energy and water reserves. Failure of the pregnant female fly to obtain three adequate and regularly spaced blood meals leaves her unable to produce a viable offspring. Depending on the reserves available, the larva could die in the uterus and be aborted or it could mature and be deposited but without sufficient reserves for it to complete its development to an adult, or it could become adult successfully, but without the reserves necessary for it to survive as an active adult until it had successfully hunted and found its first blood meal. This period between emergence and obtaining the first blood meal is the most critical period in the life of the fly. Any stress that can be brought on the fly at this period would reduce the chances of its survival. Hunting operations directed against the most favoured hosts of the fly provide such a stress, particularly if they are intensively pursued during the hot dry season. By reducing the availability of suitable hosts the pregnant females have fewer opportunities of obtaining adequate food reserves to produce viable larvae. If she produces less than two in her lifetime the population will decline.

Host preferences

The dependence of the savanna tsetse flies on game animals for their food supply has long been common knowledge, and as long ago as 1914 a committee of British scientists and administrators concerned with the increasing importance of trypanosomiasis in Africa, recommended that an experiment be conducted to observe the effect on *G.morsitans* of removing the game animals on which it fed. Although the operation was not conducted as an experiment, the hunting campaign carried out as a necessity from 1919 to 1922 in the Shangani-Gwaai basin was followed by the disappearance of *G.morsitans* from the area and of trypanosomiasis from the local cattle. The effectiveness of the method had been demonstrated but little was known of the critical factors that had brought about the improved situation.

The extension of shooting operations to cover the main tsetse belts of Rhodesia between 1927 and 1945 resulted in the recovery of 25 000 km² from the tsetse fly, but again, for lack of information it was not possible to make a critical examination of the method or to make any rational refinements. It was notable, however, that duiker, kudu and warthog formed the highest proportion of the kills.

If it had been possible to demonstrate a preference in the tsetse fly for certain hosts, the shooting operations could have been made more selective. But although it had, at that time, been possible to distinguish avian and reptilian blood (with nucleated red corpuscles) from mammalian blood, and larger red corpuscles (from elephant), from small (impala, sheep and goat) in blood meals taken by recently fed tsetse flies, it was not until Dr. B. Weitz in Britain had developed and applied a reliable immunological technique for identifying the source from which tsetse blood meals had been taken that the importance of the various host species to the tsetse fly could be determined with confidence. From identifications made of such tsetse 'blood meals' collected from various parts of Africa it became apparent that tsetse flies had marked host preferences. It is now known that in Rhodesia the bloods of warthog and bushpig (but particularly warthog), make up over 50% of the meals taken by *G.morsitans* and that kudu and bushbuck meals (but mainly kudu) are represented in about 20% of the cases. The occurrence of feeds from elephant, rhinoceros, buffalo and even birds is not infrequent in collections of tsetse blood meals and it has become evident that marked local preferences are sometimes shown. For example, a collection of tsetse blood meals from *G.morsitans* made in the northern flybelt showed 61,7% from warthog and bushpig, 20% from kudu and bushbuck and 2,7% from elephant, while one made at about the same time from the Chuhanja and Sibonja Hills in the southeast of Rhodesia produced 47,0% from kudu (a fairly common animal here), 20,5% from unidentified bovids (probably kudu or bushbuck) and 4,2% from elephant. The roles of bovids and suids in the diet of the tsetse are reversed in these two areas.

Most of our game species have been recorded at one time or another in tsetse blood meal collections, but in small proportions and not at all regularly. Although impala and zebra are both common animals in the tsetse belts only very few meals have been identified from these animals in the thousands that have been identified. The important species fed upon are kudu, bushbuck, warthog and bushpig, and these are hunted as the 'favoured species'.

The importance of the warthog in the economy of *G.morsitans* in the northern flybelt had been so clearly demonstrated that it was considered worthwhile removing this one species alone from an area while measuring changes in the tsetse population. A *G.morsitans* infested area at Sengwa in Gokwe district was enclosed by a warthog-proof fence 2 miles by 2 miles long forming a square. Within this enclosure the numbers, species, sex, distribution, physiological state and age of the tsetse were continuously recorded within a central sampling area of one square mile. When sufficient data had been collected and all the warthog burrows had been identified, the warthog population was rapidly captured in nets and removed. A few warthog were shot. Measurements on the behaviour of the tsetse population continued. The population, mainly *G.morsitans*, did not decline, but the diet changed from consisting mainly of warthog to being mainly elephant and kudu, which were abundant in the area. It appears that hunting operations, to be successful, must include warthog and kudu where these are present. The close similarity between the blood of kudu and bushbuck, and of warthog and bushpig has, until recently, made the ultimate separation of bloodmeals from these hosts uncertain and they were all regarded as potential hosts. However, progress in the technique has been made and we may have to reconsider the status of bushbuck and bushpig in the diet of tsetse flies.

For shooting operations to be effective in eliminating *G.morsitans* it is not necessary to remove all game animals or even all of the selected species from an area but only to reduce their numbers to a level at which the female fly fails to make sufficient contacts to obtain two sets of three regularly spaced bloodmeals during her life. Game animals in an area free of tsetse flies do not present a trypanosomiasis hazard.

6.2.2 The conduct of hunting operations

The present hunting operations are conducted against kudu, bushbuck, warthog, bushpig, elephant and buffalo within certain defined controlled hunting areas along the Zambesi fronts by Tsetse Field Officers and their African staff under permit from the Minister of Lands and Natural Resources. The hunting areas are demarcated from settled agricultural areas with cattle by 5-strand, government standard cattle fences, and at a suitable distance away by 8 or 9 strand, high-strain steel wire game fences supported on hardwood poles or steel rail posts, see Map 1. Certain qualified Tsetse Field Officers are permitted to kill elephant and buffalo, since these can contribute up to 6% of *G.morsitans* diet, and other large game under certain conditions where they are causing damage to fences.

Hunting operations are carried out within areas scheduled for occupation by tribesmen and their stock. Game has no future in these areas under present social conditions.

6.2.3 The hunting team

The hunting team is the unit of operations. It consists of:-

1 Tsetse Field Officer
1 Supervisor, who may be armed
20 to 25 armed African hunters
1 Senior Assistant/Labourer, for surveys
6 Labourers (hunters/assistants)

It is assisted in selecting the areas of hunting by information provided by tsetse survey teams using bait oxen. The armed Africans are permitted to shoot only warthog, bushpig, kudu and bushbuck. Teams are allocated to areas in accordance with the local requirements. Thus, at present, Sebungwe has six teams; Gokwe, seven; Urungwe, five and Sipolilo five. The teams and the European field staff are identified by a code which is used in reporting kills and the localities where they are made.

Each team is mobile, moving out from a base camp to the hunting area allocated to it at the beginning of a month by the Senior Tsetse Field Officer of the Area.

Conditions of employment of hunters

a. Non-indigenous Africans will *not* be employed. Only Rhodesian Africans from local districts and approved by the District Commissioner are to be engaged.

b. Employment of hunters is on a daily basis. Unsuitable employees should be discharged immediately, and monies due to them should be collected by them at Area base camp at the next pay-day. The officer in charge cannot be recompensed if he pays a discharged employee from his own pocket.

c. All recruit hunters must be finger printed, and their impressions together with the details of their Registration Certificates sent by the Senior Tsetse Field Officer to the Central Criminal Bureau, Bulawayo, for approval. The recruit may then be engaged, but if an adverse report is received subsequently he must be dismissed forthwith. If a favourable report is received the Senior Tsetse Field Officer will submit it to the local District Commissioner with an application for the recruit to carry arms. If permission is given on the appropriate form the recruit can be confirmed in employment as a hunter. If permission is withheld the person must be dismissed forthwith. A list must be made of discredited persons to avoid making subsequent futile applications.

d. Each armed African employee must be issued with an identity card, which he must carry with him at all times, and this must be withdrawn temporarily from him when he is on leave from his area and permanently when he ceases to be employed as a hunter.

e. An African may not leave his appointed hunting area whilst in possession of a firearm or ammunition.

f. No African employee will be in possession of a firearm at night except with special authority from Headquarters, Salisbury.

g. The Tsetse Field Officer must submit to the Senior Tsetse Field Officer each month, on the prescribed form, a list of his armed African employees.

6.2.4 Organisation of hunter assistants

It is the responsibility of the Tsetse Field Officer i/c to ensure that the six labourers allocated to the team are fully occupied at all working times. This labour force will be used to establish camps at the beginning of a month's hunting operation, and to carry out daily camp routine, carrying wood and water, drying meat, preparing hides and retrieving carcases of larger animals. It is the duty of the Tsetse Field Officer to supervise this labour gang in road maintenance when necessary, involving the construction and maintenance of negotiable stream crossings and the construction of contour ridges and ditches to prevent water from scouring roads and tracks. The more defined duties of the labour gang are listed:-

a. The camp cook, usually a 'madala' (old man), cooks all the meals for hunters and labourers. He is also mainly responsible for preparing and drying the meat brought in from kills, but must be assisted by all available labourers when large amounts of meat have to be butchered and dried, to ensure that none is wasted.

b. The specialist in preparing hides, assisted by other labour when necessary cleans, stretches and dries the hides that can be made marketable.

c. The supply of wood and water for the hunters' camps is maintained by all available labour together. It need not take more than half an hour in the early morning or late evening.

d. Retrieving carcases which are too large to be handled by the pair of hunters making the kill may be carried out by the labour, as a gang. Where it is economical to do so large kills near roads may be recovered by vehicle.

e. The Senior Hunter Assistant, aided by a labourer is used to conduct daily surveys for the presence of tsetse throughout the hunting area, using oxen as bait.

f. All available labour is to be used on road and track maintenance and repair in the vicinity of the camps. Labour should not be idle during working hours.

6.2.5 Observation of hunting regulations

Hunting operations are carried out under permit from the Minister of Lands and Natural Resources and are subject to inspection by officers of the Department of National Parks and Wild Life Management. These officers must be given all assistance in their investigations into misconduct regarding hunting operations. Any infringement of the terms of the hunting permits issued to the staff of this Branch may be investigated.

It is stressed that no support or sympathy will be given by the Branch to an officer or employee who deliberately infringes the terms of the hunting permit. The case will be investigated by officers of the Department of National Parks and Wild Life Management and placed before the courts if they so decide. If an employee should be successfully charged with an infringement of the hunting conditions the officer responsible for his conduct will be called upon to demonstrate that lack of hunter control was not a contributory factor in the infringement.

It is appreciated that under conditions of thick bush or during night hunting operations, species other than those permitted may be killed by mistake. No attempt must be made to cover up the matter. The officer in charge of the team involved will advise area headquarters immediately. The Senior Tsetse Field Officer of the area will arrange for an enquiry to be made, and will require a full written report on the circumstances. He will approve of the completeness of the report and submit it to the Assistant Director, Salisbury, who will then advise the Director of National Parks and Wild Life Management of the incident.

It is usual for the integrity of the staff to be accepted, and no further action is taken. However, if an unreported incident is detected and brought to the notice of the Assistant Director, the employee or officer concerned will be given no assistance or sympathy in defending himself against any charges that may be made.

A hunter who shoots an animal not belonging to the permitted species should be severely reprimanded for a first offence, and dismissed forthwith if a repetition occurs.

6.2.6 Control of hunting

It is the duty of the Tsetse Field Officer in charge of a hunting team to ensure that the hunters hunt in pairs wherever possible; that they operate only within the selected area, and that they hunt diligently with intent to kill throughout the appointed hours. The most productive periods of the day are usually the early morning and late evening. All hunters should be operating at these times.

Hunting at midday in the hot, dry season when surface water is scarce is rarely productive. It is usual for hunters to operate during the morning, starting at 0500 hrs for most of the year; to return to camp at midday for their meal from 1200 to 1300 hrs to rest, and then to resume hunting locally from 1500 to about 1830 hrs. Hunters who find spoor of far ranging species such as kudu, usually follow it continuously, returning to camp only in the late afternoon for food and water. Hunters may be transported by the Tsetse Field Officer and deposited at a point some miles from the camp thus ensuring that a wide area will be traversed and determining the direction in which the hunting will take place. He can also direct the course of hunting by arranging meeting places where he will recover his various hunters later in the day.

The officer will instruct his hunters where and in which direction they must hunt and will arrange for them to meet him at mid morning or midday at an easily located place, such as a known hunting camp, river crossing, road junction or water hole accessible to his vehicle. He must insist on being met at these arranged meeting places. Failure on the part of the hunter, other than for genuine reasons of having followed fresh spoor or of having made a kill, will be treated as a breach of discipline, deserving appropriate action.

Random hunting

In the case of the more reliable and experienced hunters the officer may permit them to exercise their skill and knowledge of an area by hunting in a direction of their choice. Very successful hunters should be allowed greater freedom of choice but checks must still be made to ensure that their kills come from within the scheduled area. This manner of hunting has come to be known as 'Random Hunting'. It could be applied while the Tsetse Field Officer is engaged on other tasks than hunting (surveys, patrols or administration) or when hunting is resumed after a break, before the distribution of game in the area is known.

Checking reports of kills and misses

In order to discourage hunters from operating outside their allotted areas and from shooting other than the permitted species, the officer should let it be known that he will be making unannounced visits to the allotted areas accompanied by the supervisor.

Reports of kills for the previous day or early in the day should be investigated. The officer, led by the hunter concerned should visit the alleged site where the carcase was cut up. Blood and gut contents should still be visible, or if the carcases were removed whole, the spoor of the hunters, confirming the record.

Reports of misses should also be investigated. The Tsetse Field Officer must get the hunter to lead him to the point where contact was made so that the hunter's account can be checked. The excuse that the hunter cannot find the place must not be accepted. It should be regarded as an indication of guilt, and an investigation insisted upon.

Recovery of a lost hunter

In the event of a hunter failing to appear at the evening meeting place, the Tsetse Field must advise his Senior Tsetse Field Officer of the fact by radio on the evening radio schedule. If the loss of the hunter becomes known after the evening radio schedule has been completed, the Tsetse Field Officer must inform his Senior Tsetse Field Officer at the next early morning schedule.

If the hunter fails to appear during the night, all hunting must cease on the following day and all available labour must search for the missing man. The Tsetse Field Officer must enquire from the partner of the lost hunter the probable area, direction and time in which he was last seen, and make an estimate of his probable whereabouts. He should drive along the roads or tracks in the likely areas. The search party must be unarmed, except for one or two hunters who will carry rifles with which to fire signal shots. They will not use their rifles for any other purpose during the search, to avoid confusion. Progress must be reported to area headquarters by radio as often as is practical.

Neighbouring hunting teams may be required to assist in the search, and finally the Senior Tsetse Field Officer may consider it necessary to report the incident to the B.S.A.P., who may decide to take further action.

The recovery of the hunter must be reported to the Senior Tsetse Field Officer as soon as is possible.

Action to be taken by hunters on sighting Security Personnel

The Tsetse Field Officer must frequently instruct his hunters on the action to be taken on sighting or being challenged by security forces. The procedure is for the hunter to stand clearly in view with both his hands above his head, holding his rifle if armed, and to produce his identity card on demand. For the hunter to run away from security forces may draw their fire.

A standard of achievement

Most hunters are extremely fit for walking and will follow fresh spoor or a wounded animal, travelling over 32 km in a day, but not, of course, every day. Hunters frequently retrieve kills from a distance of up to 16 km. In choosing reporting points and distribution points for his hunters, the Tsetse Field Officer should have regard to the terrain in which they have to work. In rough hilly country a hunting speed of over three km per hour can be maintained, while in flat open country five km per hour can easily be achieved. In thick bush, as along rivers and in 'jese' where hunters pursue bushbuck and bushpig, they prefer to creep slowly and quietly, or to sit still for long periods. Under these conditions, the speed achieved could be less than two km per hour.

From a local knowledge and from information provided by a study of aerial photographs of the area, the distance that hunters can be expected to cover can be estimated. A radius of from 13 km to 16 km is well within the capacity of hunters in most areas, but during the rains when grass is high the area that can be covered is reduced because of the difficulty of walking quietly in long grass. When camp is moved to a place less than 20 km away the hunters should be instructed to hunt to the new site.

Hunters vary considerably in their ability to achieve kills. The majority are of poor quality, particularly amongst recruits. But these receive the same wages as the efficient hunters, (apart from bonus awards). It follows that in order to get value for money the standard of the poor hunters must be improved. It is the function of the Tsetse Field Officer to improve the efficiency of his teams and to maintain it at a high level. It must not be forgotten that there is no ready supply of trained African hunters. We have to recruit and train our own hunting staff. This involves training in both marksmanship and in tracking.

The following instructions should help to improve hunting standards:-

(i) The performance of each hunter will be recorded at the end of each month on the Hunters Performance Record Tsetse Form No. 69. Analysis of a few months' records will reveal the poorer hunters, who will require special attention.

(ii) The poor performances may be due to bad marksmanship or to inaccurate rifles. The Tsetse Field Officer must inspect each hunter's rifle, personally, to ensure that it is serviceable and accurate. He may be able to make adjustments to the sights himself, but there is a plentiful supply of reliable rifles at Salisbury H.Q. armoury, so so that no hunter need be equipped with a substandard weapon.

(iii) In order to improve marksmanship, target practice should be held regularly. The cost of ammunition spent in this way is much less than the cost of inefficient hunting. All those who register a miss on a target should be given a period of training on the handling and aiming of a rifle under the personal supervision of the Tsetse Field Officer and supervisor. They should practice aiming the rifle supported on a rest, and 'squeezing' the trigger of unloaded rifles, to acquire a steady pull. These exercises should be supplemented by target practice with live rounds to record progress.

Cardboard targets are supplied for practice. They are marked with a bull, an inner ring and an outer ring. By scoring four for a bull, three for an inner, two for an outer, and one for hitting the supporting board outside the target at 80 paces, the shooter's performance can be assessed. The recruit should be able to return an average score of 15 with five shots before he is allowed to start hunting. An average of 10 rounds per hunter per month may be expended on target practice and team competitions could be held to assess their abilities and to encourage their improvement.

(iv) Few Africans today are brought up in areas where game is abundant and where they can learn the habits of animals and acquire the art of tracking. Most recruit hunters have no knowledge of hunting and, to be useful employees, must be taught by us. The recommended method of training recruits is to put a small group in the charge of the supervisor to be schooled for several days in hunting methods in the field, supplemented by target practice on return to camp. Those who are recommended by the supervisor as being likely hunters should then start hunting accompanied by an efficient, experienced hunter for a few days. The recruit should now be able to develop his skill as a hunter.

(v) The Tsetse Field Officer and the supervisor should concentrate their attention on the new and poorer hunters, who should be made to realise that their lives would be made less arduous if their performances improved. But reason must prevail. In some areas, where game is scarce, it may take up to six months for a recruit to learn to hunt well enough even to make contact with an animal of the selected species. During this period, however, the Tsetse Field Officer must assure himself that the recruit is making a good effort, by requiring him to report at selected reporting points and by transporting him to distant areas by Land Rover.

(vi) It is for the Tsetse Field Officer, aided by the advice of the supervisor, to decide when further training would be wasted on a recruit and that he should be dismissed. The teams should be maintained at all times at full strength, up to ten of which may be trainees receiving instruction.

Hunting is likely to remain an important tsetse control method for many years to come. The success of these operations will depend on our ability to produce and retain good, skilled hunters, and this will depend largely on the training, supervision and management given by the Tsetse Field Officer.

(vii) The Tsetse Field Officer must make a study of the hunters' performances in the field. Recorded misses must be analysed. When a hunter records a miss, one of several events could have happened.

a. The animal was missed because it was running, or the range was too great. Where two or three rounds are reported to have been used to kill an animal, one or two may be genuine misses.

b. The hunter has reported a miss to cover the expenditure of rounds on animals not included in his permit.

c. The hunter has reported a miss to cover the fact that although he has killed a permitted animal, he has not reported the kill, and has disposed of the carcase for his own ends.

d. The hunter has reported a miss to cover the fact that he has been shooting outside his allotted area for his own ends.

(viii) The hunter's results obtained from the target practices should be used to confirm his performances in the field. If the Tsetse Field Officer suspects that a hunter's target results are not consistent with his record of misses when hunting he must visit the places where the alleged misses occurred with the hunter concerned to verify, by the evidence from the spoor, the credibility of the hunter's tale.

(ix) *The bonus scheme* has been introduced as an incentive to improve hunters' performances. All hunters are engaged on a basic daily rate of pay, without annual increment. The wages of new recruits and long service hunters are the same. In order to recompense hunters for the increase in skill and efficiency that should accompany longer service, a *bonus* is paid to hunters who achieve kills above a minimum number. The minimum number is arbitrary, and is set for each month at Headquarters, Salisbury. It may vary from area to area and from time to time according to the local abundance of game. In areas where game is scarce the minimum number may be nil, where each kill qualifies for a for a bonus. The best hunters, in the most productive months of September to December may double their basic wage. The monthly payment of the bonus to a hunter should be made as a separate exercise from paying him his wage. It should be made in the presence of the whole team, thus increasing his status amongst his colleagues. Confirmation of his performance must be provided to the Senior Tsetse Field Officer by the production of the Hunters Performance Record – Tsetse Form No.69.

The Senior Tsetse Field Officer will enter on this form the amount of bonus paid to the individual and sign it. *This form becomes a receipt for the expenditure of Public Funds and is thus subject to Audit.* It must be retained in a safe, readily available place for up to three years. It will be referred to in completing the next month's record.

This bonus scheme is subject to abuse, and it is the duty of the Tsetse Field Officer to disclose and report malpractices. In order to qualify for the bonus a hunter might hunt outside of his allotted area where game may be more plentiful. The Tsetse Field Officer should visit the alleged scene of the kills if he has any suspicion concerning the hunter, and should make unannounced visits to the hunting areas.

In order that bonuses may be achieved, and the proceeds shared, hunters may pool their kills. The Tsetse Field Officer should ensure that a hunter claiming a kill has discharged his rifle (the barrel will show the marks) and has produced a marked cartridge case, and that he knows exactly where the kill was made.

6.2.7 The care and security of firearms and ammunition

All hunting operations are conducted with the utmost regard to security precautions. If the occasion arises the Tsetse Field Officer in charge of the hunting team will be required to establish beyond doubt that any failure on the part of his hunters to observe security precautions has not been due to his laxity.

Equipment issues

At the start of a month's shooting operations the *Tsetse Field Officer* will collect, from the Area Armoury, his issue of rifles and ammunition and targets from the Senior Tsetse Field Officer, which will consist of one rifle per hunter with two or three spare weapons, and a maximum issue of 400 rounds of ammunition (of any calibre or type, including privately owned ammunition). The Senior Tsetse Field Officer will make the appropriate record of the issue, and will submit summarised returns of *all* (including privately owned) arms and ammunition held by officers in his area to Headquarters, Salisbury, at the month end.

Rifles

The *Tsetse Field Officer* will be responsible for zeroing the rifles, where necessary, for his team. Each rifle is numbered. The *Tsetse Field Officer* will issue a clean serviceable rifle to a hunter recording the number against the man's record. He must *not*, at any time be in possession of more than one firearm. It will be the responsibility of the hunter to maintain the rifle in a clean and serviceable condition, and of the Tsetse Field Officer, by frequent inspections, to ensure that firearms are being treated properly. The hunter will use only the rifle issued to him, until it is replaced for some reason.

At the end of a day's hunting, hunters who have fired shots will clean their rifles with the rods, cleaning cloths and oil provided. They must not use the bronze brushes, which cause abrasion of the barrel. If a barrel needs cleaning with a brush, the *Tsetse Field Officer* should carry out the operation, and must regard the occasion as an offence. He should enquire into the circumstances which led to the need for such drastic cleaning and warn the hunter against repetition of the offence. In dry weather only those rifles that have been discharged on the day should be cleaned, but in wet weather all should be cleaned and lightly oiled, every day, to prevent rust. The *Tsetse Field Officer* will check that the correct number of rifles is returned.

Whenever rifles are not being carried on hunting operations they should be stored in the back of the Land Rover and secured to the steel cash/ammunition box by means of a lock and chain passing through the handle and through the trigger guards. The bolts, with the hunter's identification mark, ammunition and spent cases are secured in the cash/ammunition box. In the intervals between hunting operations, the firearms and ammunition must be lodged in the Area Armoury under the control of the Senior Tsetse Field Officer.

It will be more expeditious to arrange for the cleaned rifles to be deposited in and removed from the Land Rover in a regular order, (traditionally reflecting the length of service of each hunter in the team).

Ammunition

Before issuing live ammunition to the hunters, the *Tsetse Field Officer* will mark each cartridge to indicate the month of issue by stamping a letter on the collar of the casing where it is crimped over the bullet. The distinguishing letter will be changed each month and a record kept of the key letters. Punches for the purpose are issued by the Senior Tsetse Field Officer.

At the start of the day's operation, each hunter will be issued with *not more than six rounds of ammunition* depending upon the likelihood of finding suitable targets. Those hunters being transported *will not* be issued with ammunition until they have been deposited at their destination. During the day they may replenish their stock from the Tsetse Field Officer, up to a maximum of six, by surrendering the appropriate number of spent cartridge cases.

At the end of the day's hunting the *Tsetse Field Officer* will receive, and record the live and spent ammunition from each hunter, ensuring that the totals amount exactly to the number of live rounds issued during the day, and that each spent case bears an identification stamp appropriate for the month.

The production of an unstamped case or a case stamped with the wrong mark indicates an irregularity which must be investigated thoroughly and immediately.

All soft-nosed ammunition bearing a stamp must be reserved for use on hunting operations. Only hard-nosed ammunition should be used for target practice.

Spent cartridges bearing the appropriate monthly mark and those used in target practice must be distorted by the *Tsetse Field Officer* using the hammer provided, and the number checked and recorded. The distorted cases must be secured and returned to area headquarters at the end of the month.

The number of rounds fired by each hunter will be recorded each day by the *Tsetse Field Officer* in the respective columns of the Hunter Record, (Tsetse Form No. 22). It is convenient for the Tsetse Field Officer to receive ammunition, spent cases and the cleaned rifle bolts from the hunters in the order in which they appear in the Hunter Records.

6.2.8 The planning of hunting operations

The efficient use of maps and aerial photography forms the basis of tsetse control operations. Reference should be made to Chapter 9 of this Handbook if the terms used here are not fully understood. The Tsetse Field Officer must make himself familiar with his area by careful study of the relevant aerial photography, supported by ground checks. The overall strategy of hunting operations is planned by the glossinologists attached to the areas, usually for a period covering two to four months. By considering the distribution of trypanosomiasis in the cattle in neighbouring areas, the recorded distribution and abundance of tsetse in the area, the reports from the Senior Tsetse Field Officer and Tsetse Field Officer in the area, and the recent history of the hunting operations, a plan is devised and sent to the Senior Tsetse Field Officer in the area. The plan gives directions where camps will be sited, where each team will be required to hunt, the areas to be covered and the periods of time to be spent in each. These directions, issued each month, are subject to minor modifications *by the Glossinologists concerned* based on recommendations from the Senior Tsetse Field Officer. The Senior Tsetse Field Officer then directs individual teams to their appointed camps and instructs them in their hunting programme for the month.

The Tsetse Field Officer in charge of a hunting team will decide where and how the daily hunting effort will be carried out, basing his tactics on the general directions given him by the Senior Tsetse Field Officer at the beginning of the month. His area of operations is usually too large for effective hunting to be carried out by random hunting by all twenty hunters. It has been found to be more productive if hunters are concentrated within a small defined area such as a thicket, a wooded drainage system or an area bounded by roads and fences to find, flush and kill all the animals there, and then to move off to another small area. Knowledge of the whereabouts of these defined areas is derived from the distribution of tsetse flies recorded in the ox surveys and by captures by hunters. It should be taken as a rule that where a population of tsetse exists, there must be a source of mammalian blood nearby, even if it is only one animal. Vast numbers of tsetse can be supported by one wart-hog. It is by the persistent efforts of hunters at high density that these last animals will be removed and the tsetse population eliminated.

The distribution of kills in previous months can indicate the type of vegetation that the selected species are using in the area at that time. Hunting should be concentrated on those localities where tsetse flies can be caught within this type of vegetation.

The presence of tsetse flies must be taken as a better indication of where to hunt than the presence of game in the absence of tsetse flies.

6.2.9 Recording the progress of hunting operations

Each team is issued with a 1:50000 map of its operation area. This scale is large enough for the exact location of each kill, or capture of a fly to be recorded. *The Tsetse Field Officer* must record:

(i) the position of each kill

(ii) the position of each sighting or wounding

(iii) the routes taken by the ox survey team and the site of each tsetse fly capture

(iv) the location of waterholes and pools in rivers, boreholes, and any other water source

(v) any other points of interest.

Records of game must be differentiated from records of tsetse by the use of coloured pens or pencils. Explanatory remarks should be printed neatly on the map, and the symbols given in the appended legend should be used to record observations of game and tsetse.

The position of every kill is recorded on the Shooting Records in the 'locality' column as a U.T.M. grid reference (see Chapter 9) from which the locality can be identified on a 1:250000 scale map.

At the end of the month the Tsetse Field Officer will return the completed map to the Senior Tsetse Field Officer who in turn submits it to Headquarters.

A neat, fully documented map conveys information more accurately and briefly than a written account of the month's activities and it should form the basis of the Tsetse Field Officer's monthly report.

6.2.10 Disposal of the products of hunting

The hunting permits under which the hunting is conducted indicate that the hides, horns and tusks of animals killed are to be collected, cleaned and prepared in the prescribed manner and despatched to the area headquarters. All concerned must be made thoroughly aware that any part of any species of animal killed in a controlled hunting area is a Government trophy and, therefore, that it is an offence for any employee to retain any part thereof, without a written permission issued by the Department of National Parks and Wild Life Management. Written applications to retain such trophies may be made, in special cases, through the Senior Tsetse Field Officer for submission to Headquarters, Salisbury.

HUNTING MAP LEGEND.

	Species killed (in red)	Tsetse flies caught (in blue)	Other information (in green)	Hunting team survey routes (in brown)
Name of T.F.O. :-	Kudu +	● G.m or	Use symbols for	Mark routes taken in brown.
Area :-	Bushbuck X	● Gp	sightings, spoor,	
Team :-	Warthog ▲	(indicate species)	animals wounded or	
Month :-	Bushpig ▼	Comment on map,	missed, and indicate	
Year :-	Elephant ●	in pencil, on road	category in pencil	
	Buffalo ■	conditions and water	alongside. Use pencil	
		availability.	for data on non	
			selected species.	

Meat

A special authority allows the Branch to dispose of meat from animals shot in these operations. All meat from animals shot must be recovered, weighed and utilised for rations. By convention, the internal organs and the head alone are retained by the hunter who made the kill. In cases where the carcase cannot be collected before dark it should be cut up, and the meat and skin securely stored high in a tree overnight. All meat recovered is to be smoked on racks over wood fires in the traditional African manner. This work is normally carried out by the camp cook, but he may be provided with assistance if there is the need.

The Tsetse Field Officer should ensure that members of the hunting teams receive no more than their normal ration of meat. All meat surplus to rations must be surrendered to the area headquarters at the end of the month, for issue as rations to those labourers not engaged on hunting operations. No meat should find its way into the home villages of the hunters or into Tribal Trust Land.

Trophies

Each tusk of an elephant killed on these operations will be marked with the prefix and serial number of the officer who shot it. Elephant tusks and warthog tusks (except of juveniles) must be extracted and cleaned. The horns of horn bearing species, except buffalo, should be drawn off the central core of bone, cleaned and tied in neat bundles.

Any exceptionally large horns should be submitted, intact, and attached to the upper part of the skull, as saleable trophies.

The preparation of antelope hides, but not skins of warthog and bushpig, is to be undertaken by the labourers attached to the team, under the supervision of the supervisor.

In order that a high standard of product shall be maintained the following procedure should be carried out in preparing hides:

a. Do not damage the skin by dragging the carcase along the ground or across the floor of vehicles before skinning.

b. *As soon as is possible* after the animal has been killed, especially in hot weather, remove the skin, complete with tail.

c. Remove all particles of meat and fat and wash the skin free of all blood and dirt before putting it to dry.

d. Dry the skins on stretching racks in deep shade. Do not place them on the ground or in direct sun. Protect the skins from hyenas at night by hanging them high or placing them very close to occupied tents and fires.

e. After the skins have dried, if there is time before despatching them, scrape the skin on the inside to remove any traces of blood, fat and cartilage.

f. Fold the hides with the hair on the inside making the fold along the direction of the backbone. Hides in this condition are very susceptible to damage from damp and from hide beetles. They and any trophies should be transported to area headquarters at the end of each month.

6.2.11 Other matters

Special situations may arise that require appropriate action.

a. *Pursuit of wounded animals.*

Wounded animals must be pursued relentlessly by the pair of hunters concerned, assisted by other hunters and the Tsetse Field Officer in charge, with his dogs if required and available, until the kill is made.

If the wounded animal should escape from the Controlled Hunting Area the following procedure will be adopted:-

(i) If the animal is a kudu, bushbuck, warthog or bushpig, the hunters, accompanied by the Tsetse Field Officer in charge of the team, will continue the search, if necessary until dusk. If no contact has been made, but signs indicate probable early success next day, the pursuit may be resumed early next morning.

(ii) Elephant or buffalo wounded by European officers must be pursued with utmost determination. Should the wounded animal pass out of the Controlled Hunting Area, there is no limit on the period of pursuit. Any such woundings should be reported to the Senior Tsetse Officer as soon as possible and neighbouring hunting teams should be informed of the circumstances.

The pursuit of wounded animals may conflict with the obligation of the Tsetse Field Officer to maintain radio communications with his area headquarters at set times. There must be no doubt in the mind of the Tsetse Field Officer that *establishing radio contact takes precedence.*

b. *Action to be taken where animals have been shot in error, or found dead.*

It must be impressed on the hunting staff that carcases of animals shot in error or found dead *must not be interfered with* in any way until an investigation has been made by the Tsetse Field Officer in charge.

On receiving a report of an animal having been shot in error or found dead the officer will visit the site and examine the carcase. If the signs near the scene or the condition of the carcase suggest that foul play may be involved the party should withdraw. The Tsetse Field Officer must inform his Senior Tsetse Field Officer of the incident, and he will relay the information to Headquarters, Salisbury, who will advise the Department of National Parks and Wild Life Management.

Instruction may be given to the Tsetse Field Officer to collect or protect the carcase, pending the arrival of a warden or his staff to investigate further. Detailed investigations of this nature are the sole responsibility of the staff of the Department of National Parks and Wild Life Management, and *must not* be undertaken by anyone else, except at their request.

Whenever the remains of an elephant or rhinoceros are found, an immediate report must be made irrespective of their condition.

When investigations are completed, any trophies are to be collected, and the entire remains destroyed by burning. *Not a scrap* of meat from such animals shot in error or found dead should be made available for human consumption.

c. *Fence Protection.*

Provision is made in the hunting permits for the killing of animals other than kudu, bushbuck, warthog, bushpig, elephant and buffalo as a fence protection measure. Where the monthly records of fence breaks indicate that a portion of a fence has suffered repeated breakages that threaten to exceed the capacity of the fence guards to maintain repairs the Senior Tsetse Field Officer should report the circumstances to the Regional Authority (Regional Glossinologist and Glossinologist) indicating the locality of the breaks, the species and the probable numbers of animals involved. If the circumstances warrant it the Regional Authority may issue an instruction stating the number and species of animals to be shot in a defined locality adjacent to the fence by a named officer.

d. *Collection of scientific data*

The completed Shooting Records provide a valuable source of information for scientific enquiry. Additional information may be required at times involving the collection of specimens such as skulls and reproductive tracts. The staff will be fully informed on the material required and methods of collection and preservation when the occasions arise.

Tsetse Field Officers should be proficient in taking and despatching blood smears when requested from themselves, their African staff, from oxen and from freshly killed animals. Recruit officers receive instruction on these techniques in their initial training.

6.2.12 The daily routine

The daily programme for a hunting team is given. It may be modified, where necessary, to suit the needs of moving camp, or other special contingencies, but some activities must be carried out regardless of other circumstances. Thus, radio schedules must be kept regularly, rifles and ammunition must be secured in the officer's Land Rover at the end of the day, and returns of the day's activities made.

(i) Rise before dawn, to ensure an early start to hunting.

(ii) Instruct each hunter where he must hunt; ensure that he is aware of the limits beyond which he must not hunt, and instruct him to which point he should return and when.

(iii) Issue each hunter with his rifle and, if he is hunting from the camp, with up to six rounds of marked ammunition; hunters that are transported by vehicle will be issued with ammunition only when they leave the vehicle. Record the issues.

(iv) Establish radio contact with the Senior Tsetse Field Officer at the appointed time and report items of interest.

(v) The Tsetse Field Officer with the Supervisor will spend the remainder of the day in attending to various duties, including inspection of the hunters to ensure that they are hunting diligently in their allotted areas; supervising the training of hunters in shooting and hunting; planning the course of the next day's bait ox survey and inspecting the survey teams to ensure that the correct procedure is being followed.

(vi) All hunters should return to camp by the time appointed by the Tsetse Field Officer in charge. In winter, this is usually before the time of the evening radio schedule, so that the officer can make his report. However, since the period just before sunset is the best time for hunting the hunters are usually instructed to delay their arrival until sunset, which in the wet season may be after the radio schedule has been finished, and their reports are then not transmitted until the next morning radio schedule.

When the needs of security require it, hunters are instructed to report before the time of the evening radio schedule, regardless of hunting conditions.

(vii) When all hunters have assembled the *Tsetse Field Officer* will withdraw ammunition and spent cases and cleaned rifle bolts from each, checking that the returns correspond with issues in numbers and identification mark, make the appropriate entries in the respective column of the Hunter Record Form No. 22, and after distorting the spent cases will make all secure in the strong box.

(viii) The *Tsetse Field Officer* will assemble those hunters who have made kills, or have missed, for questioning.

(ix) When all ammunition has been withdrawn and accounted for, and secured, those hunters who have fired shots will clean their rifles and present them for inspection to the Tsetse Field Officer.

(x) When satisfied with their condition the *Tsetse Field Officer* will secure the rifles by lock and chain in the Land Rover.

(xi) The hunters who have registered misses will be questioned on the numbers and whereabouts of the animals missed, in the presence of the whole team, so that the hunt can be resumed by other hunters in the appropriate area next day.

(xii) The hunters who have shot an animal during the day are then questioned in the presence of the Supervisor who should act as interpreter, if necessary, to obtain the information required for the Shooting Record. The exact location of the kill should be identified on the map, and the U.T.M. Grid reference recorded.

It is important that this enquiry should be carried out on the same day as the kill and not later, because the hunter's memory is often blurred by camp fire discussions. Questioning should be thorough, bearing in mind that a hunter might wish to conceal the whereabouts and numbers of animals from his colleagues. Do not deride a hunter for shooting only one animal of a large group. It could encourage him to to report having seen single animals or small groups.

(xiii) The *Tsetse Field Officer* will report on the day's activities to the Senior Field Officer at the evening radio schedule. Failure to make radio contact causes alarm and may set in train search procedures costing much time and money.

If Government is involved in milage costs due to forgetfulness or carelessness on the part of an officer, a *Surcharge* may be raised against the officer.

(xiv) The *Tsetse Field Officer* will write up the returns for the day – (Shooting Record, milage log book etc.) and give an account of the day's activities in his daily diary.

6.3 Tsetse control by means of removal of vegetation

6.3.1 The scientific basis for tsetse control by removal of vegetation

All tsetse flies are dependent upon woodland shade for their continued existence, but the various species have their own particular preferred habitats. They all avoid open grassland, and stretches of sand and water. Those species, like *G.morsitans* which can tolerate drier conditions, will venture into open grassland only for brief excursions from the fringing woodland. This habit can be exploited to make life more difficult for the flies by cutting down the woodland in which they live. The practice of some African tribes living within tsetse infested country of creating treeless grazing areas for their cattle had demonstrated to early travellers in Africa the value of total removal of the woody vegetation as a means of reducing the adverse effects of tsetse flies.

For many years tsetse ecologists have sought to define the habitats of the various species of tsetse flies with the practical object of achieving their elimination by removing those elements of the vegetation that were considered essential for the flies' survival. It was thought that by more intensive examination of the distribution of a species of tsetse fly a closer identification of the essential habitat could be obtained. The fewer elements that needed to be removed to achieve elimination of the fly, the cheaper would the operation be.

These ideas gave rise to the concept of *selective clearing* of vegetation as a means of tsetse control, as a refinement of *total* or *ruthless* clearing.

6.3.2 Total clearing of vegetation

It is easy to appreciate that as tsetse flies require tree shade, the removal of all trees from an area would deny suitable habitat to the flies in that area, and they would leave or die out. But such removal of trees would also alter the habitat of the animals on which tsetse flies feed, and they, too, would leave. Their absence, just as after a successful hunting operation, would bring about the starvation of the fly. It would be difficult to measure the effect of one of these factors in the absence of the other. Ecologists are beginning to regard the total removal of tree vegetation as a far greater ecological hazard than the killing of some individuals of a few species of mammals. Clearing of tree vegetation has been used successfully to exclude *G.palpalis* from stretches of river in East and West Africa where this species inhabits the dense gallery forest lining the larger rivers. Such clearings have to be maintained free of regrowth, by repeated slashing or by the application of cultivation, or of grazing stock in sufficient intensity to keep the areas open. In Rhodesia, where the important tsetse flies are those inhabiting open savanna woodland, it would be impractical, totally uneconomical and ecologically highly undesirable to denude the vast tracts of woodland within which the tsetses live. In the past, efforts were made to halt the spread of *G. morsitans* by felling certain tree communities in the Sabi-Lundi basin by means of bulldozers and hand labour. Large tracts of *Androstachys johnstonii* in the Chikombedzi area and of *Brachy-*

stegia-Pterocarpus woodland at Lusongo were felled, but without appreciable success in arresting the spread of the fly. This method is no longer used in Rhodesia as a means of controlling tsetse fly, but its use in normal agricultural practice for growing crops and providing pasture prevents the fly from reestablishing itself in its former haunts once it has been removed.

6.3.3 Barrier clearing

A form of total clearing has been employed since 1933 in the Chipinga district along the international border with Mocambique, where all tree vegetation within a strip, between 1,6 km and 4,8 km wide was felled. By 1944, this *border clearing* was 70 km in length, and in 1957, it was extended to 84 km, running from Mayfield farm near the Lusitu river in the north to Mwangazi Gap in the south. Maintenance of the clearing involved continuous slashing of regrowth and annual burning of grass.

The barrier has played an important part in the control of trypanosomiasis in the Chipinga European farming area, where *G.brevipalpis* and *G.pallidipes* were the main vectors, and has made it possible for cattle to be introduced to the Tamandayi African Purchase Land. Both species are found in Portuguese territory, along the drainages of the Busi river, where they inhabit the heavily wooded country lying below 1 000 m. Although no tsetse have been recorded from the European farms, the distribution of trypanosomiasis in the area suggested that it had followed invasions of tsetse up the steep wooded valleys leading into the farms. By removing tree growth from these valleys and from the hilltops, an effective barrier to the passage of tsetse flies was created. These farms lie at an altitude of from 1 000 m to 2 000 m which is approaching the altitude limit for *G.pallidipes* and *G.brevipalpis* at this latitude. The natural barrier had been made more effective by the creation of an artificial barrier. The local farmers came to regard the barrier clearing as an indispensable feature in their lives. Their losses from trypanosomiasis dwindled, and their farms prospered. The trypanosomiasis problem on the farms had become so insignificant by 1967, that the slashing and burning had assumed the function of a bush encroachment control operation and thus had become the proper concern of another department. The development of large blocks of uniform vegetation, such as conifer afforestation, and tea and wattle plantations adjacent to the border fortified the barrier further. Clearing operations were discontinued in 1967, since when there has been only one case of trypanosomiasis in cattle on these border farms.

6.3.4 Selective clearing of vegetation

Elsewhere in Africa the removal of a small proportion of the vegetation within tsetse habitats has led to the disappearance of certain species of tsetse fly. The reasons for the disappearance are not clear. In Rhodesia, however, selective clearing operations have not produced a marked effect on tsetse populations.

It is a matter of common experience during the hot, dry months that male tsetse flies appear to be more numerous in the neighbourhood of river courses than in the surrounding woodland. A vehicle approaching a dry river crossing within tsetse country will often fail to encounter tsetse flies until it is within a few metres of the river bed, when the flies will swarm around it. After emerging from the riverine canopy of vegetation, the vehicle will lose its attendant flies within a short distance. This habit of the fly of congregating in vegetation lining the drainages during the hot, dry months has influenced those concerned with tsetse control in concentrating control measures within this particular element of the fly's habitat.

The removal of riverine tree vegetation has been carried out along the drainages of the Lundi river in the southeast lowveld. Here, the drainages, lined with trees, traverse black, basalt soils where other tree vegetation is scarce or absent. It was thought, with some reason, that if the tsetse flies were denied this shade, they would disappear. Riverine vegetation clearing was also applied along the drainages of the Shangani river in Lupane district, to remove a potential fly habitat along an advancing fly front. In both cases, this selective bush clearing was used as a supplementary method to other forms of tsetse control, so that its precise contribution to the success of the combined operations cannot be assessed, but those people who carried out the operations did not consider that selective bush clearing alone would have had any permanent effect in reducing the *G. morsitans* population.

The large clearings made at great expense in the South Lundi and Sabi East areas did not achieve the expected result of halting the advance of *G.morsitans.* In this area, however, progressive applications of insecticide aided by the establishment of a barrier zone, kept free of the selected game species, have now removed the threat of tsetse from the Nuanetsi and Chiredzi cattle areas.

Recent investigations into the habits of *G.morsitans* carried out by this Branch have shown that while male tsetse flies occur in apparent concentrations in riverine vegetation during the dry period of the year, the female flies, at least in the middle veld, are more widely distributed throughout the general woodland, even in dry leafless mopane woodland. The persistence of female flies under these conditions indicates that selective clearing would have to be more extensively applied than had been thought necessary, and may well require to be more extensive than is practical or economic, to achieve elimination of tsetses. This method is not used now in Rhodesia.

6.3.5 The use of grass fires

This could be described as a burning question! Ecologists hotly contest the merits and demerits of grass burning as a means of management of the vegetation. Those whose concern is primarily the arresting of bush encroachment advocate withholding fires until the grass has seeded and dried out, in August or September, and the production then of hot burns to produce cleared pasture land. Others, like foresters, whose concern is for the protection of young tree growth recommend the use of early, patchy and therefore cooler burns. Both are agreed, and the law enforces, that grass fires should not be started wantonly and should be kept under control. It has been a tradition amongst rural Africans to start grass fires as soon as the grass will burn. There is no accompanying tradition to ensure their control. In earlier tsetse control shooting operations, nothing was done to discourage this innate tendency of the rural African to set fire to grass as soon as it would give a good burn. We could not have stopped the practice if we had wanted to. Clearance of the old grass enabled hunters to see their prey better, and provoked the growth of new grass for their cattle. There was also a firm belief that good burns encouraged early rains. The policy of tsetse control was to withhold burning until really hot burns could be obtained to encourage leaf fall, and so to restrict the available refuges for the fly.

Nowadays, fire is used as an adjunct of spraying operations. Generally, insecticide is applied to the more shaded situations in a tsetse habitat, where grass does not grow thickly. Attempts are made to burn the grass before the spraying operations begin in June. The grass does not burn well, and cool patchy burns are the result. The object is to ensure that after the insecticide has been applied, fires started by the local people will not be hot enough to destroy the insecticide deposits. A hot grass fire can reduce the effectiveness of a DDT deposit by about 80 per cent. Where it has not been possible to produce early burns, every effort is made to prevent hot fires from causing damage once the insecticide has been applied.

6.4 Tsetse control by means of insecticides applied to resting and refuge sites

6.4.1 The insecticide of choice

Insecticides are substances which when applied to or taken into the body of an insect cause its death. The insect may make *contact* with an insecticide by walking over, or resting upon a treated surface, or by receiving particles of insecticide as a dust or spray on its body as it rests, walks or flies. It may also ingest the insecticide into its stomach by consuming food that has been treated with insecticide, or it may breathe in, through its spiracles, insecticides in the form of *fumigant* gases or vapours.

Insecticides in the form of gases and vapours are used to kill insects within confined spaces, such as food warehouses or dwellings, and stomach poisons are used mainly against insects that chew their food, such as beetles and caterpillars. Some insecticides can be introduced into the tissues of the host from which insects, (such as aphids, bugs and horseflies) suck living fluids, and so act as stomach poisons. These are called systemic insecticides. From our knowledge of the habits of the tsetse fly it can be seen that fumigant poisons and stomach poisons can have no application in the eradication of tsetse flies. They do not live naturally in confined spaces, and do not chew their food. It is impractical to kill them by introducing insecticide into the blood of their major source of food, the game animals. Attempts have been made to render the blood of cattle poisonous to tsetse flies by injecting the animals with insecticides, but the doses required to kill the tsetses before they can reproduce are toxic to the host animal. New insecticides may yet be found that can be tolerated by the host animal at concentrations that are toxic to tsetse.

However, we know that the tsetse fly spends much of its life resting on vegetation in shady situations. It is reasonable to suppose that treatment of these places with an effective contact insecticide would provide a means of controlling tsetse.

It is worth considering the minimal requirements of a contact insecticide:-

(i) It must be lethal to the insect after brief contact.

(ii) It must not be too toxic to the operators to be used with safety.

(iii) It must retain its toxic properties for a long period, certainly throughout a full life cycle of the fly.

(iv) It must be concentrated for ease of transport.

(v) It must be capable of being diluted readily for use.

(vi) In the diluted form it must be stable and easily applied without damaging the equipment.

(vii) It must be cheap enough and effective enough to warrant its use.

Certain other qualities would be desirable in an insecticide used against tsetse flies:-

(i) It should not be lethal to other organisms than tsetse flies, particularly to those that feed on or parasitize tsetses.

(ii) After the tsetses have been killed the the insecticide should rapidly disintegrate into substances that are not toxic to other organisms.

(iii) It should not damage the vegetation to which it is applied.

The insecticide that has been found to satisfy the minimal requirements most satisfactorily is the chlorinated hydrocarbon DDT (dichlor-diphenyl-trichlorethane) 75% highly dispersible wettable powder. It is persistent, relatively cheap, highly concentrated, is readily diluted with water to a stable mixture and does not damage the spraying equipment. As ecologists we must be concerned with the facts that DDT is a highly persistent poison and that it can enter food chains and be accumulated in the bodies of predatory animals. It is a serious pollutant, and there is world wide pressure to avoid its use, but until it can be satisfactorily replaced by safer insecticides, it will continue to be used in developing countries where its withdrawal would mean death for millions from disease and starvation.

The Branch's contribution to ecological pollution is relatively small. The average application of DDT in the 1973 spraying operation was 16,5kg, per km², applied to sheltered places during the hot dry season, when the risks of scattering it by run-off are minimal. By comparison, in normal farming practice, the application of DDT to cotton crops is up to 500kg per km², (or thirty times as much) during the growing (rainy) season to the same areas of ground, year after year. To abandon the use of DDT as an insecticide in tsetse control would make little difference to the country's annual consumption of DDT, but it would seriously reduce the efficiency of our control measures.

As used in our spraying operations the DDT insecticide is a white crystalline substance, finely divided and carried on an inert substance, such as talc, to which are added powerful detergents or 'wetting agents' which keep the fine particles in suspension in water. When the suspension is applied to a surface, the water evaporates, leaving a film of insecticide and carrier. This film can be brushed, blown or washed away if it is deposited in exposed places, or subjected to rain.

Insecticides can also be applied by discharge from aircraft or from the ground by special aerosol or fog producing machines in the form of a solution in very fine oil droplets. In special circumstances, where cost is not of prime importance, these methods can have application in tsetse control.

The discovery and production of a chemical attractant that would cause tsetse flies to congregate where it is distributed, would greatly enhance the effectiveness of the insecticide techniques now in use, and would make the male sterilisation technique a more practical proposition.

6.4.2 Diluting the insecticide

For economy of transport, insecticides are sent in bulk in as concentrated a form as is practical, to be diluted for use. The Branch uses a 75% DDT highly dispersible wettable powder delivered in 25kg polythene bags. To obtain the working concentration the contents of a 25kg bag are added to 375 litres of water in a tank to obtain a 5% suspension.

A simple relationship exists between the concentration of the original insecticide, the required concentration of the spray, the mass of the insecticide and the volume of the water required to make up the spray, thus:-

$$\frac{\text{required strength of spray}}{\text{strength of original insecticide}} = \frac{\text{Mass of insecticide (kg)}}{\text{Volume of water required (l)}}$$

Since the strength of the original insecticide (75%) and the mass (25kg) are fixed, and the required strength is 5%, this formula can be expressed as:-

$$\text{Volume of water required} = \frac{25 \times 75}{5} = 375 \text{ litres}$$

The insecticide used mixes readily with water, but mixing must be assisted by the use of wooden paddles.

6.4.3 Safety precautions

The chlorinated hydrocarbon insecticides, which include DDT, BHC, dieldrin, aldrin, chlordane and others are strong, persistent poisons. Not only can they be swallowed or breathed in by the operators, but they can also be absorbed through the skin, particularly when concentrated preparations are being handled. Oily preparations are more dangerous to handle than powders. When taken into the body, these substances are absorbed into the body fat and liver, where they can accumulate and cause serious bodily disorders. Great care must be exercised in their use, not only in handling them, but also in their application and in the disposal of waste.

The following warnings should be given to operators handling insecticides:-

(i) Do not take insecticides into the mouth or breathe in dusts.

(ii) Do not allow insecticide to contact the eyes or wounds in the skin.

(iii) Wear protective clothing whenever handling or spraying insecticides.

(iv) Report any leaks in the spraying equipment immediately. These should be repaired forthwith.

(v) Do not spray against the wind, the spray may be blown back over the operator.

(vi) Empty the washings from the spraying equipment into a hole in the ground, well removed from a water course.

(vii) Overalls must be washed twice each week.

(viii) Wash the body completely after each day's operations.

(ix) Do not eat or drink from containers that have been used to hold insecticide.

(x) Report symptoms of headache, dizziness, vomiting after handling insecticides to the Tsetse Field Officer in charge, who should instruct the opertor to cease work, wash himself and rest. If the condition does not improve he should be sent to the nearest hospital with an explanatory note.

(xi) As the insecticide is extremely poisonous to fish and other aquatic life, operators must make sure that spray does not fall on rivers or pools, and that the washings from machines and overalls do not enter watercourses. Pits must be used to receive these washings, and filled up afterwards.

6.4.4 Spraying machines

Several forms of equipment have been used to apply insecticide from the ground as a means of tsetse control, including fog generators, motorised knapsack sprayers, pneumatic pressure retaining sprayers, and pneumatic sprayers. After much experience, we have found that the most suitable for use under the rough usage of field conditions are the 'Favori Colibri' Pneumatic Pressure Retaining Knapsack Sprayers. Unfortunately, these are no longer produced and the second choice are the more robust forms of the pneumatic knapsack sprayer, such as the 'Urania' These have a capacity of about 13,5 and 12,0 litres and are operated at pressures of 11,72 bars (170 p.s.i.) and 5,07 bars (73,5 p.s.i.) respectively. We consider that they have the following advantages over motorised units:-

(i) there are very few moving parts, and therefore fewer spares are needed to be carried

(ii) there are fewer adjustments to be made by unsophisticated operators and therefore fewer stoppages

(iii) there is no noise to contend with and therefore coordination of operations is easier

(iv) the machines are lighter to carry and therefore less labour is required

(v) they are far cheaper to buy and to operate, and more funds can be made available to buy more insecticide.

The Favori Colibri machine is charged initially by a detachable pump to a pressure of 1,72 bars (25 p.s.i.) which is retained by means of a valve throughout the working period. It is then filled by means of the pump with insecticide fluid to a pressure of 11,72 bars (170 p.s.i.), and operated, by means of a Pressure Regulating or Pressure Control Valve at an optimum pressure of 2,97 bars (30 p.s.i.) (a latitude of 1,72 – 2,07 bars is allowed). The Urania is charged with air by means of an internal pump, after it has been filled to the mark with 12 litres of insecticide, to a pressure of 5,07 bars. It operates, through the pressure control valve, like the Favori Colibri machine, at 2,07 bars.

Both machines can be fitted with a standard spraying lance carrying at its base an 'Alpha' Instant Shut-Off Valve and an adjustable 'Regula' Nozzle at the discharge end. The shut-off valve ensures that the spray is either full on or off, giving a uniform spray determined by the setting of the nozzle which should be set by the Tsetse Field Officer in charge, and not tampered with by the operator.

The disc in the nozzle through which the spray emerges should be 1,6mm in diameter for our purposes. The Tsetse Field Officer must frequently check this aperture with the gauge provided. Deceitful operators have been known to enlarge the aperture in order to speed up the rate of emission of the insecticide. This results in shorter periods of work for the operator, and an over-application of insecticide.

Although these machines are robust and there are few moving parts, items do need replacement. Requests must be made to the Senior Tsetse Field Officer, and must include:-

(i) The type of spraying unit.

(ii) The code No. and description of the item required.

(iii) The quantity required.

6.4.5 The spraying team

The spraying organisation is composed of a number of units, the spraying teams, which are deployed according to the needs of the operation in any year.

Normally, one Tsetse Field Officer will be in charge of four spraying teams, but where necessary this number may be decreased.

The spraying team will consist of:-

1 Graded Field Assistant who will lead the team

1 Ungraded African who will assist the Field Assistant leader

1 Lorry driver, (temporary appointment)

8 Sprayer operators (employ the more intelligent labourers)

8 Insecticide carriers

2 to 6 Additional labourers, to be used as replacements in case of sickness, to develop access, if needed, to carry out controlled burning of grass ahead of operations, and to carry insecticide where terrain is impassable to transport. It may be necessary to engage more than six labourers, under particularly difficult conditions.

Transport

Each team is supplied with one 5 tonne long wheel base truck for the transport of spraying equipment, insecticide and personnel. The Tsetse Field Officer is provided with a Land Rover. Its use must be restricted, to ensure utmost economy in milage consistent with the efficient performance of his duties, and should be used for the following purposes only:-

(i) travelling between his teams on supervisory duties

(ii) travelling to area headquarters to collect spares or miscellaneous stores

(iii) when moving camp

(iv) for reconnaisance work

(v) when supervising grass burning operations

(vi) in rough country, it may become necessary to use the Land Rover to transport insecticide and spraying equipment.

Spraying equipment

Each team will be provided with the following equipment. It is the responsibility of the Tsetse Field Officer to ensure that he receives a full issue for his teams at the beginning of an operation, that it is cared for and replaced where necessary during the operation, and is fully accounted for and returned to his area headquarters at the end of the operations:-

Boxes, metal storage	: 2 (for spares and first aid)
Buckets, G.I.	: 4
Bucksails	: 3 (1 large, 2 medium)
Bung openers	: 2
Chart board	: 1
Containers, 5 litre	: 4 (for drinking water)
Containers, 20 litre	: 20 (for transport of insecticide from lorry to operating team)
Containers, 100 litre, or 114 litre	: 10 (for transporting insecticide in bulk on lorry)
Haversack, with strap	: 1
Insecticide	: as required, in numbered bags issued by the Senior Tsetse Field Officer
Instructions and Spares Book	: 1
Maps 1:50 000	: appropriate sections
Measuring wheel	: 1 (bicycle wheel, front fork and cyclometer)
Mutton cloth	: 2 rolls
Nozzle aperture gauge	: 1 to T.F.O. in charge
Overalls, blue denim	: 20 suits, (one each for the ungraded Africans, the driver, eight sprayer operators, eight insecticide carriers, and two spare suits)
Overalls, white	: 1 suit (for Field Assistant)
Overalls, various colours	: as required for grid spraying, by special arrangement
Photographs, aerial	: 'Spraying Set' appropriately marked.
Pouring pipes 2" or ¾"	: 6 (for Urania machines only)
Pots, 3-legged, cooking	: 4
Pressure regulator valve checking equipment	: 1 to T.F.O. in charge
Pump, water, with engine and piping	: 1, issued to T.F.O. in charge
Soap	: 2 cases (for washing overalls and persons)
Spraying machines	
Favori Colibri *or*	: 4, plus one or two as spares per operations area
Urania, each complete with a funnel and tools	: 4, plus two per camp as spares
Sprayer charge pumps	: 2, only for teams using Favori Colibri spraying machines which are not fitted with Leo pumps
Spraying machine spare parts	: sufficient quantity
Stationery —	
Carrier Forms TF No. 38b	: sufficient quantity
DDT consumption forms	: sufficient quantity
Field forms TF. No. 36b	: sufficient quantity
Folio books	: 1
Pencils H.B.	: 3
Spraying summary sheets TF. 37	: sufficient quantity
Stereoscope	: 1 to T.F.O. in charge, from Headquarters, Salisbury. (One will already be in the possession of the Field Assistant).
Tank, insecticide, mixing with cover	: 1
Taps, gate valve	: 2 (for installation between mixing tank and bulk transportation container, and between bulk transportation container and

container for carrying insecticide from lorry to team).

Tools –

Box spanner $^{11}/_{16}$" with 6" shank	: 1
Pliers, electrical	: 1
Screwdriver, broad ended	: 1
narrow ended	: 1
Shifting spanner 6"	: 1
10"	: 1
Spoke spanner	: 1
Stilson wrench 10" or 12"	: 1
Wax pencils, or coloured crayons	: 2
Whistle	: 1

6.4.6 Selection and preparation of the mixing site

The spraying camp site will be selected for its proximity to the area of spraying operations, to an adequate water source, and for its accessibility by road. A site should be selected a short distance from the camp where the insecticide mixing and loading operations will take place. It should be open, level and of adequate size, near to the water source, but at a sufficient distance to prevent contaminating the water supply with insecticide.

The carrying drums should be filled from the mixing tank by gravity feed. To achieve this a trench should be dug at the mixing site to a depth of 1,5m, 2m wide and 6m long. The spoil from the trench should be thrown on to one bank, and supported by horizontally placed poles held in place by a few vertical poles. The spoil should be levelled to support the mixing tank at the lip of the trench, half way along its length. In this way an effective head will be obtained for pouring with minimum expenditure of labour. Any spillage will be confined to the floor of the trench. At the end of the operation at that site, the spoil must be thrown back into the trench to cover the spillage, and the surface levelled off. The ends should be gradually sloped to allow easy access and exit.

A further pit must be dug measuring 1,5m long by 1,5m wide by 1,5m deep, into which will be poured the washings from the spraying machines at the end of each day's operations, and the waste from washing clothes and spraying equipment.

Where two or more teams are operating from the same camp, these pits may be made contiguous and of appropriate size.

Except where the ground does not permit the digging of trenches, the practice of constructing platforms raised on poles to carry the mixing tanks should be discontinued. There is a greater danger of collapse, more labour would be involved in their construction, and the risk of spillage contaminating the soil surface would be greater.

6.4.7 The mixing procedure

It is appropriate here to stress the need for care in using and moving spraying equipment. The bottom of the mixing tank should rest on a smooth, level bed, preferably of river sand, to reduce shocks and strains. Containers, particularly when loaded, should not be dropped or allowed to collide. It is the duty of the Tsetse Field Officer in charge to see that proper care is exercised.

(i) Water is poured into the mixing tank to a level about 30cm below the *blue* 375 litre mark, and the cover is replaced.

(ii) A numbered 25kg bag of 75% DDT wettable powder is opened, and swiftly upended into the sleeve of the mixing tank cover, so that the entire contents enter the tank.

(iii) The powder is light and some remains airborne within the tank for a time. Allow 3 minutes to elapse during which the contents are being stirred, for the powder to settle.

(iv) Remove the mixing tank cover, and wash off any powder adhering to it or to the walls of the tank while adding water to the 375 litre mark. Stir vigorously.

(v) Draw off the agitated suspension into three 100 litre containers and the balance into the 20 litre containers, stirring until the tank is empty.

(vi) To prevent excess frothing of the insecticide, ensure that the nozzle of the flexible delivery pipe from the mixing tank is close to the bottom of the containers.

(vii) So that the contents of the 100 litre containers can be agitated, an air space of at least 15cm depth should be left when they are charged with insecticide.

(viii) The process i – vii is repeated, resulting in a daily issue of 750 litres of 5% DDT suspension.

(ix) The numbers of the 25kg bags of DDT used are recorded on the 'DDT Consumption Record' form (GB/2/154 of 11.5.73) by the Tsetse Field Officer in charge, and the empty bags preserved for return to the area headquarters.

(x) The utilisation of the numbered 25kg bags *must be consecutive* to ensure that full bags are not mislaid or lost. Any loss of bags must be reported at the next radio schedule to the Senior Tsetse Field Officer of the area.

6.4.8 Where to apply the insecticide

It must be obvious that the most economic and effective way to apply insecticide as a means of tsetse control would be to concentrate the treatment on those places where tsetse flies congregate. Detailed observations on the habits of *G.morsitans* and *G.pallidipes* have shown that during the hot, dry months of October and November, they tend to concentrate within those situations that provide a variety of shade conditions, such as:-

(i) the leafy vegetation (riverine vegetation) bordering rivers, streams and dry watercourses

(ii) the transition vegetation (contact vegetation) between riverine and *Brachystegia* spp. woodland or mopane woodland along river banks, or open grassland (vlei edges)

(iii) the contact vegetation between *Brachystegia* spp. woodland and mopane woodland or vlei edges

(iv) the contact vegetation between mopane woodland (particularly that growing on alluvial soils) and vlei edges

(v) the contact vegetation on rocky footslopes between *Brachystegia glaucescens* (formerly *tamarindoides*) and *Brachystegia* spp. or mopane woodlands

(vi) the vegetation around natural pans

(vii) the vegetation along road and track verges

(viii) the vegetation along well used game and cattle paths

(ix) the vegetation around established cattle kraals, dips and inspection races

(x) the vegetation along the edges of cultivated fields

(xi) the trees with a bole diameter of 15cm or more flanking each side of the spray lanes to a depth of 45m, where spraying is carried out on a predetermined grid pattern.

Within these situations tsetse flies have been found to seek out and occupy resting and refuge sites especially during the hot period of the day during October and early November. These sites are sought out by the spraying teams and treated with insecticide during the cool dry season so that a deposit is in place by the time that the tsetses are compelled to retire to them. The more severe the dry, hot conditions are, the more selective will the tsetses become in choosing sites. Conversely, if conditions are not so severe, they will occupy a more extensive range of sites. The glossinologist must use his knowledge of the habits of the tsetse fly and of the prevailing climatic conditions in deciding on the extent of the habitat to be sprayed during the planning stage of operations.

The resting and refuge sites that must be treated within these habitats are:-

(i) the boles and horizontal branches of trees with boles in excess of 15cm diameter occurring within the spraying zone, up to a height of 3 to 4 metres

(ii) trees on termite mounds and trees with dark bark within and adjacent to the spraying zone

(iii) places where the female is likely to rest to deposit a larva within and adjacent to the spraying zone, such as the undersides of fallen logs, rot holes in trees, antbear and warthog holes, under rock overhangs, holes in river banks and on the friable soils beneath thicket species

(iv) in the vicinity of water holes, springs and pools, every tree will be treated

(v) where spraying is directed against *G.pallidipes* the vegetation will generally be denser, even approaching thicket. Here the above requirements must be met, but with a more extensive use of insecticide. Particular attention must be paid to clumps of *Acacia ataxacantha*. The nozzle of the spray lance should be inserted within the bush at several places with the spray directed in various directions so that the branches are well covered with insecticide.

Recent observations and experiences have shown that female *G.morsitans* can exist in dry, leafless mopane woodland where shade is minimal, even under intensely hot, dry conditions, and that populations of *G.morsitans* occur in situations where there are no clearly recognisable shady conditions as defined in i – x above. In such situations it has been found necessary to apply insecticide along the lines of a grid (xi above), previously marked through the bush at intervals, arbitrarily chosen according to the extent and density of the vegetation. In the Sabi/Lundi-Mocambique spraying operations where this technique has been applied with success, the spray lanes are spaced 200m apart.

6.4.9 The spraying procedure

So that those planning the spraying operations can assess the degree of success or lack of success in these operations in order to determine the nature of future operations, it is essential that the application of insecticide be carried out in as near a uniform manner as possible. If, after a spraying operation, success has been obtained in one area, and not in another, the lack of success could be attributed to deficiencies either in the planning or in the application of insecticide. But if the planner is satisfied that the spraying has been uniform throughout he must accept that there are shortcomings in the planning, sometimes aggravated by vagaries of the weather.

The following instructions must be observed in spraying operations:-

(i) *Make sure that the spray falls where it is intended.* Do not spray against the wind so that the spray is blown back over the operator and away from the target.
Do not hold the spray nozzle too far from a tree trunk or branch so that most of the spray misses the tree, or so near that only a portion of the tree is covered in one stroke of the spray lance.

(ii) Arrange the work of the operators so that each one will cover a swathe of 15m width as he progresses from tree to tree, except where grid spraying is undertaken, where a swathe width of about 22,5m is treated by each operator.

(iii) This will mean that –
Two sprayers will be used on either side of rivers and long narrow vleis, covering the vegetation to a depth of 30m on each side.
Two sprayers will be used on each side of roads, track, and game and cattle paths.
Two sprayers will be used on the vegetation lining wide vleis and in contact vegetation, accompanied by another pair of operators who will be ready to take over spraying as soon as the first pair have emptied their machines. These will be refilled, and the operators must be ready to take over as soon as the second pair have emptied their machines. In this way closer control can be kept by the supervisor and Tsetse Field Officer than if both pairs are working independently.
Two sprayers will be used on each side of the spray lanes where there is a

predetermined grid pattern. As they will each have to cover a wider swathe width than in the conventional spraying, their progress will be, on average, correspondingly slower, and the consumption of insecticide greater.

So that progress shall be under control under these conditions where the limits of the spraying zones are arbitrary and not indicated by changes in the vegetation, the limits will be marked by labourers dressed in distinctively coloured overalls. One such labourer, provided with the measuring bicycle wheel will walk ahead along the spray line, and on each side, at a constant distance of 45m from the line a similarly clad labourer will keep abreast of the sprayers to mark the limits of the spraying zone.

(iv) The emptying of a spraying machine will be the signal for *all* spraying by the team to cease. A whistle will be blown by the supervisor in charge. All spraying machines will be refilled, records completed, and spraying operations then resumed.

6.4.10 The daily routine

The daily routine can now be outlined, starting on the afternoon before the insecticide is applied:-

A. *On the afternoon before each spraying day* the *Tsetse Field Officer* will, personally, supervise the following activities for each team under his control:-

(i) The preparation of 750 litres of spray suspension (see 6.4.7), which is a normal day's quota. This will *not be exceeded* except on instruction from the *Regional Glossinologist*. The officer in charge of a team may decide to mix a *lesser* amount, after advising the Regional Glossinologist, when working in difficult terrain, where 750 litres could not be dispensed in one day.

(ii) The pouring of insecticide into six 100 litre containers and the balance into the 20 litre containers.

(iii) The loading of the lorry with clean spraying machines, charge pumps (where Favori Colibri machines are used), the containers with insecticide and all other heavy equipment required for the next day's spraying operation.

(iv) Study of the aerial photographs of the areas to be treated next day with the Field Assistants.

(v) Packing of the haversack with chartboard, field record forms, pencil, aerial photographs and stereoscope.

B. Procedure *on the spraying day*, which will be mainly under the control of the Tsetse Field Assistant:

(i) Personnel must rise in time to get the teams transported at first light. *There must be no driving in the dark.* Teams must be at the spraying site and ready to begin spraying as soon as possible after it is light enough and warm enough to do so effectively.

(ii) When the lorry arrives at its appointed destination near the spraying site, the insecticide must be thoroughly agitated in the containers while still on the lorry, and before it is transferred to the spraying machines. (This is essential because the suspended matter in the spraying fluid slowly settles to the bottom of the containers overnight). To ensure the even distribution of the insecticide *it must be thoroughly agitated before transferring it from one container to another*, by inserting a stout stick through the bung hole, reaching to the bottom of the container, and stirring vigorously until the contents are uniformly mixed.

(iii) Unload the lorry, with the exception of the 100 litre containers.

(iv) Set up and charge the spraying machines with thoroughly mixed insecticide.

(v) Fill all the 20 litre insecticide containers.

(vi) Instruct the driver on the day's spraying plan so that he is fully aware of the movements of the team for the day and that he knows the appointed meeting places and times for maintaining the supply of insecticide.

(vii) It must be ensured that the driver knows the procedure for recording issues of insecticide from the lorry, namely:- He will enter the number of the 20 litre container issued by him to a carrier, the time of issue and the carrier's name on Tsetse Form No. 38b, (Carrier Form). When the carrier arrives at the spraying team, the *Field Assistant* in charge will check that the 20 litre container is *full*, and will enter the time of arrival and the number of the container against the name of the carrier, also on a Tsetse Form No. 38b. The officer in charge knows the volume of insecticide mixed for the day, and therefore the number of 20 litre units required. Analysis of the Tsetse Forms No. 38b at the end of the day will reveal any discrepancies, and also the performance of each carrier for that day.

(viii) Spraying will be started according to instructions in 6.4.8, 'Where to apply the insecticide'.

(ix) *The Field Assistant* in charge must constantly supervise the operators, checking where and how the insecticide is being applied.

(x) *The Field Assistant* must be constantly relating the progress of spraying operations to the aerial photographs, and noting mentally the areas treated, so that areas to be sprayed will not be omitted, and areas already treated will not be resprayed.

(xi) *The Field Assistant* must keep accurate records of the progress of spraying operations on the Field Form, Tsetse Form No. 36b(1972). These will include:-

a. the date, team identification number, name of the Field Assistant in charge.

b. the reading on the cyclometer of the measuring wheel when the sprayers start and when they finish each charge of insecticide. The measuring wheel is pushed along the course taken by the spraying team by one of the operators not engaged in spraying at the time, to record the average distances covered between refills of the spraying machines.

c. the times at which spraying activities start and stop throughout the day's operation. After the start of the day's work, these times will refer to stops for refills, and to resumption of spraying. The period of spraying is also recorded.

d. the numbers of the relevant aerial photographs.

e. the numbers of the spraying machines used by the team for each discharge.

f. brief notes on the habitat including, where possible, the names of rivers, vleis, pans and other such features.

(xii) *The Tsetse Field Officer* must visit each team under his charge frequently while they are actually spraying, to satisfy himself that they are carrying out their duties in accordance with these instructions.
He must also visit as much as possible of the areas that have been recorded as having been sprayed in his absence, to satisfy himself from the appearance of the insecticide deposits that the resting and refuge sites have been adequately treated. If he considers that areas have been missed or insufficiently treated, he must instruct the team or teams responsible that they must return at an appropriate time to treat these areas in the proper manner. Where he finds such cases of negligence, the Tsetse Field Officer must produce a written report, through his Senior Tsetse Field Officer, to the Assistant Director for his consideration, naming the Field Assistant concerned and describing the full circumstances.

(xiii) *The Tsetse Field Officer* when making his inspection of a team must make the following records on the Tsetse Form No. 36b(1972):-

a. his times of arrival and departure

b. his signature acknowledging the accuracy of times of stopping for refills and resumption of spraying during his inspection. This procedure should encourage accuracy in recording in the absence of the field officer.

He must make a careful inspection of the spraying equipment, to assure himself that:-

a. the nozzle aperture corresponds with his gauge. Oversize apertures must be replaced with standard discs,

b. that the pressure control valve is at the correct setting, and has not been tampered with, and

c. that the spray nozzle is set to give an acceptable spray cone size.

(xiv) The team will return to the lorry when the issue of insecticide for the day, normally 750 litres, has been dispensed. There will be times, when working in very open country, or very rough and hilly situations, when a good day's work will have been done before the day's quota of insecticide has been dispensed. On these occasions spraying should not continue after 14.30 hrs. The balance of insecticide should be included in the next day's quota.

(xv) On arrival at the lorry, the team will drain the dregs of insecticide from the spraying machines, pack the machines into their boxes, load the lorry, and return by lorry to camp.

(xvi) On return to camp the *Tsetse Field Officer* will supervise the unloading, thorough cleaning, and where necessary, adjustment of the spraying machines. He must exercise careful judgement in the utilisation of spare parts, which form a considerable item of expense.

(xvii) *The Tsetse Field Officer* will supervise the mixing, pouring, loading of insecticide and other preparations for the next day as under 6.4.10.

(xviii) *The Tsetse Field Officer* will issue soap to all personnel who have made contact with insecticide during the day. He must impress upon them the need to wash thoroughly, *before taking food,* and to wash their overalls at least twice a week.

(xix) *The Field Assistants* with the collaboration of the *Tsetse Field Officer* will mark up the progress of the day's operation on the 1:50 000 maps provided.

(xx) *The Tsetse Field Officer* will probably need to make a reconnaissance in the late afternoon to determine the next day's work.

(xxi) *The Tsetse Field Officer* will make his Field Assistants aware of the next day's spraying operations.

(xxii) *The Field Assistants* will complete their field forms Tsetse Form No. 36b (1972), which will be checked by the Tsetse Field Officer, who in turn will transfer the information to the Summary Sheet Tsetse Form No. 37(1972).

6.5 Tsetse control by means of discharging insecticides from aircraft

Where large areas have to be treated with insecticide, the use of aircraft for its distribution would seem to be an obvious choice. But until recently the recorded cost of aerial spraying operations has been about five times the cost of our very successful ground spraying operations. The development of aircraft with slow stalling speeds, large payloads and great manoeuverability and the perfection of navigational aids, have made it practical and economical to give chemical protection against insects, diseases and weeds to vast areas of crops and forest. Aircraft have been used successfully to spray young locusts with insecticides and to distribute poison baits in the remote, inaccessible swampy areas where they congregate before developing into the swarming phase.

Aircraft have also been used to apply insecticides to tsetse flies, but the peculiar life cycle of the tsetse presents special problems. Only the adult fly is vulnerable, and it lives almost entirely near ground level beneath the tree canopy. For an insecticide to reach the tsetse fly under these conditions it must be discharged from the aircraft in the form of small particles that are fine enough to remain airborne until they penetrate the canopy to ground level and yet large enough for the insect to receive a lethal dose before they dissipate. Insecticides in the form of aerosols meet these requirements. These are oily solutions of insecticide in the form of minute droplets of average diameter of 0,05mm or less. Larger droplets, such as sprays (droplets of 0,1 to 3mm diameter) would be received by the leaves and upper parts of the trees, or would fall directly on the ground, and would not come in contact with the tsetse fly.

Insecticide aerosols can be readily produced from aircraft by introducing a regulated amount of a high flash point oil solution (diesoline) of a suitable insecticide into the exhaust stacks during flight, or by using specially prepared insecticide solutions dispensed from rotary atomizers carried on the wings and driven by a windmill. The latter give a more uniform spectrum of droplets. These aerosols are used as contact insecticides with a quick knockdown effect but with *no residual effect*. Within a short time after application, depending on atmospheric conditions, the insecticide dissipates.

If an area were treated with such an aerosol or insecticide smoke and every tsetse fly in the area were killed, a new generation of adults would soon emerge from pupae in the ground, unaffected by the treatment. These would mate, and within about 18 days, depending on the prevailing temperature, the females that emerged on the day of treatment would begin dropping larvae. In order to forestall the production of another generation of flies, it would be necessary to apply a second treatment just before the first larvae were dropped. But since pupae can take as long as 80 days to mature and emerge in Rhodesia during the cool months of June to August, these applications of insecticide must be repeated at 18 day intervals to cover the maximum pupal term, which could necessitate four or five applications to the same area.

Aerial application of insecticide has been used on four occasions in Rhodesia. The aim on each occasion was to give five or six applications of 4% gamma BHC in diesoline at 18-21 day intervals to the selected areas. Ideal conditions for applying aerosols occur in Rhodesia only during the night extending from late afternoon to very early morning during the cool months June to August. When the sun sets on a clear still day, the earth radiates heat rapidly causing a static layer of air to develop which is cooler at ground level than at tree top height. This is a condition of inversion. A vehicle travelling along a dusty road under these conditions of atmospheric inversion can raise a cloud of dust that will hang about, a few feet from the ground, for prolonged periods. Where there is no wind at night inversions can continue until sunrise, when aircurrents develop and the inversion breaks up. If the aerosol could be applied just before dusk, during the night or at dawn, it would have its maximum effect. Unfortunately, flying conditions and particularly landing conditions on bush airstrips deteriorate at sunset, while at sunrise, although flying conditions improve, spraying conditions deteriorate rapidly. In Rhodesia it was found that up to an hour of effective flying could be achieved on some afternoons and about one and a half hours at dawn. The pressing need is, within these limitations to cover the selected area completely and thoroughly at 18 to 21 day intervals, five or six times. The aircraft used in Rhodesia were obsolete and ill adapted for aerial spraying work. To fly at tree top height over the uneven canopy of savanna woodland carrying maximum loads in uncertain light, with no emergency landing places, called for special skills and courage. It is surprising considering the circumstances that no more than one fatal and two near fatal accidents occurred.

It was found that with the ill adapted aircraft and with major repair and replacement facilities so far removed from the scene of operations it was not possible to maintain the full complement of aircraft in operation. Therefore, even under ideal conditions it would not have been possible to treat the entire area adequately. But ideal conditions do not occur every day. At times the 21 day cycle was not achieved, which meant that a generation of larvae had been dropped, had pupated, and would be ready to regenerate the tsetse population when they became adult.

Two of the operations were undoubted failures, one achieved the very limited objective of reducing a local tsetse population for a few months, and one reduced the local tsetse population to a level which allowed people and their stock to reoccupy successfully an area that before treatment, had been heavily infested with tsetses and which had formerly been a focus of human sleeping sickness.

But these operations were carried out as long ago as 1953, 1954 and 1957. Since then the development of aircraft specially designed for crop spraying, of reliable and minutely precise navigational aids, and of insecticide formulations (ultra-low volume) that produce effective insect kills at extremely low dosage rates, has made the application of insecticide from aircraft a far more feasible means of eliminating tsetse flies.

In an aerial insecticide spraying operation against tsetse flies, it is necessary to give complete cover to the target area. This is achieved by ensuring that the applications of insecticide overlap slightly. The swathe widths are determined by the rate of emission of the insecticide, the height of the aircraft above ground, and its speed. Modern navigational aids make it possible to fly accurately on predetermined paths, even in the dark, at as little as 50m intervals. A swathe width of 200m, with a slight cross wind to carry the emission would be quite suitable for tsetse control.

In the earlier tsetse control spraying operations it was essential to devise and operate a series of visual markers to enable the pilots to fly on course as the insecticide was discharged and to indicate the position and direction of subsequent runs. This involved the costly business of cutting tracks through the target area, and operating a system of beflagged Land Rovers throughout the period of operation. During an aerial spraying operation carried out against tsetse flies in Zambia in 1968, over an area of 600 square miles, the cost of the marker system and ground preparation amounted to nearly 15% of the total, or $36,75 per square mile. The use of electronic navigational aids has eliminated the need for markers, and has reduced operational costs accordingly. Moreover, their use has made it possible to operate accurately and safely at night, when conditions of inversion are prolonged, and aircraft can discharge their entire load under good conditions.

The use of U.L.V. sprays in which an effective dose of insecticide is applied at the low rate of 7 litres/km², together with the greatly increased payloads of spraying aircraft, has increased the area that can be covered by an aircraft in one sortie, and has reduced the costly periods when aircraft are idle. Insecticide transport costs are reduced in proportion to the bulk of insecticide used.

Aerial spraying operations have recently been carried out in Botswana, using U.L.V. sprays applied from aircraft fitted with modern navigational aids, but assisted by a system of ground markers. The effective dose was 7 l/km², the area treated 1 500 sq. miles (3 885 km²) and the overall cost estimated at R61 500 for insecticide and flying time. The effectiveness of the operation has still to be determined, but early indications are satisfactory.

Since so many variable factors operate during an aerial spraying operation it is necessary to monitor as many as is practical. The size and composition of the tsetse population before and after the treatment will indicate the degree of success of the operation. It will be necessary to record the consumption of insecticide used, the area flown, the size and the volume of droplets reaching the target area, and their effect on captive tsetse flies. Similar population estimates would be required from a similar but untreated area. Since tsetse flies can fly, the target area could become invaded by tsetses after treatment. Subsequent treatments would need to include marginal areas of which the extent of overlap would be determined by intensive surveys.

Meteorological conditions within the target area would need to be recorded so that warning of impending suitable or unsuitable spraying conditions could be given and unproductive operations minimised.

The cost of modern U.L.V. aerial insecticide spraying is beginning to compare with that of spraying DDT from knapsack sprayers to the resting sites of *G.morsitans* as practised in Rhodesia, and it may become the method of choice in some circumstances.

In a situation where the target area is inaccessible because of lack of roads, or tracks or because of military complications, it may be necessary, despite the cost, to use aircraft to dispense the insecticide. There are areas, too, in Rhodesia and in neighbouring territories where the recognisable tsetse habitat is so diffuse as to make it necessary to make a liberal and general application of insecticide (as in 'grid' spraying). Under such circumstances it could be a saving in material and effort, and produce a quicker control to use aerial spraying.

In the past few years the more developed countries of the world have become disenchanted with the use of persistent insecticides, and their production has been deliberately and drastically reduced. The persistence and toxicity of DDT to a wide range of organisms make it a valuable insecticide but a highly undesirable pollutant, and developed countries have legislated against its use. Although its relatively low cost and marked effectiveness have made it the insecticide of choice in our operations in recent years, we must look to the time when it will either be unavailable or, because of the limited demand, become very expensive. Ultra low volume insecticides, with little or no persistent effect may become the most useful, and available type of insecticide. In the insecticide Endosulphan (Thiodan) there is an effective, though more expensive substitute for DDT for use in tsetse control. In an aerial spraying operation involving four applications of a 20% Endosulphan preparation, at 7 litre/km² per cycle, the output of pollutant would be 5,6 kg/km². In the current ground spraying operations using DDT, the output is about 15,5 kg/km², but the application is applied discriminatively to the bark of trees or holes in the ground within tsetse habitat. (Cotton farmers, by contrast, use up to 500 kg/km² per annum of DDT, together with further applications of Endosulphan and carbaryl insecticides). Application of insecticides by means of aircraft involves a very real risk of treating areas marginal to the target. It may be impossible to avoid discharging insecticide over open water, where its effect could be particularly severe on aquatic organisms.

At the present stage of availability of effective insecticides, it seems that DDT will be used as long as it is available, and that research into alternative substances and methods of application must continue.

6.6 Male sterilization techniques

These techniques have been successfully applied to certain insect pests of plants and animals where it is practical to breed large numbers of the pest under artificial conditions, to treat the males on a large scale and to liberate them rapidly over a wide area. In Texas, for example, where the screw-worm fly, *Cochliomyia hominovorax* caused millions of dollars worth of damage annually to cattle, particularly to the hides, it has been found economical to breed vast numbers of these flies on lumps of meat in buildings resembling aircraft hangars, to sterilize the males, and to scatter them over wide areas from aircraft in such numbers as to give them more chance than the wild males of finding and mating with females. Since the mated female, like the female tsetse fly rejects subsequent advances from males, after mating with a sterile male she produces no viable offspring. In this operation, 6000 million sterilised male flies were liberated in one year.

The female tsetse fly mates once only, which satisfies one condition for this method of control, but it is very difficult to rear tsetse flies in captivity and to develop colonies that will yield large enough numbers to carry out the method on a grand scale. Colonies appear to require reinforcement from natural populations, and insects kept and reared in captivity over long periods often do not behave normally when liberated.

In Rhodesia, a team under the auspices of the former Agricultural Research Council successfully developed a colony of *G.morsitans* and assayed the dosages of chemo-sterilant and of irradiation with gamma rays required to sterilize the males without impairing their length of life or their eagerness to find and mate with females. Males so sterilized were thus able to compete on equal terms with wild males.

Trials were carried out on a tsetse infested island in Lake Kariba. The wild population of male tsetses on the island greatly outnumbered the available sterile males and needed to be reduced by means of insecticide. After the sterile males were liberated there was no appreciable decline in the tsetse population. It was found that the sterile males that had been reared in captivity were not able to fly as well as the wild males and so could not compete successfully in finding females.

A later trial, in which puparia which had been treated with sterilant were used, was more successful. Here the males picked up the sterilant as they emerged from the pupa case, and were able to fly away normally afterwards. Estimates made of the population following the liberation of the sterile males indicate that the population has dwindled to extinction.

This trial was carried out on an island where immigration and emigration were not complicating factors. It has yet to be shown that the method will be successful in an extensive tsetse belt.

A special feature of the sterile male technique is that, unlike other control methods, it works most efficiently and economically when fly densities are low. It is likely that if it becomes a practical method it will find its greatest use as a supplementary measure, to be used after the application of other control measures has reduced the tsetse population to a low level.

6.7 The control of the dispersal of tsetse flies by traffic

Tsetse flies, particularly male *G.morsitans*, are readily attracted to moving objects during the daytime. Traffic, and in particular, cyclists, thus provide the means of transporting flies beyond their natural areas of habitation. In order to reduce the transport of flies from tsetse infested areas to fly-free areas, inspections of traffic are made at strategic points and accompanying flies are caught, or dislodged by the use of irritant insecticide.

These traffic control points are situated near to the tsetse fly limits on major roads which run through fly country to fly-free country, and where our cattle and game fences cross roads or tracks. They are sited and signposted to conform with the Traffic Regulations, and operate under legislation provided in the Animal Health Act, 1960. Traffic is halted and visible tsetse flies are caught by the attendants. The number and type of traffic (car, bicycle or pedestrian), and the number, species and sex of the tsetse flies are recorded on the appropriate form. Cars are sprayed with an oil based insecticide, (1 part pyrethrin concentrate with 88 power paraffin), paying particular attention to the underneath parts, in order to stimulate any remaining flies into flight.

At Makuti, 80 km northwest of Karoi on the Karoi-Chirundu road, southbound traffic is halted at Makuti Chamber. Vehicles should not halt in front of the chamber but should slowly enter and stop near the closed exit doors. The chamber can accommodate up to three saloon cars at a time. The car engines must be stopped. The sliding entrance doors are then closed, leaving the interior of the chamber in relative darkness.

Let into one wall of the chamber is a collecting cage, fitted with internal sliding doors. When a vehicle enters the chamber the sliding doors of the cage are closed to allow a 7,5cm gap, through which light enters. The operator moves around the vehicle applying insecticide to the underneath parts of the car. Tsetse flies which have been dislodged by the spray leave the vehicle and fly towards the source of light, where they enter the cage and become trapped. The sliding doors of the cage are closed, the exit doors of the chamber are opened and the vehicle proceeds on its way. The attendants collect and examine the flies, and record the details. Since the chamber makes use of the tsetse fly's reaction to a light source, it does not operate at night.

Elsewhere, traffic is inspected at traffic control gates or barriers. Here traffic is halted, flies are removed and recorded, and vehicles are sprayed with insecticide. In order to reduce the chances of flies resuming their journey on the traffic, small, open sided huts are erected adjacent to the barriers, to offer shade and resting sites to dislodged flies. The undersides of the grass roofs of these huts are liberally coated with a residual insecticide which is intended to kill any alighting fly. Where possible, tree vegetation surrounding the barriers is removed for a distance of about 300m to remove alternative resting sites.

Not only do these control points reduce the carriage of tsetse flies, but since the numbers caught have been shown to fluctuate very consistently with the numbers of flies caught on neighbouring bicycle flyrounds, they can also provide a source of information on the abundance of the local tsetse flies.

The traffic control barriers and gates are operated by two uniformed gate guards each. Where it is necessary, they are supplied with a labourer as a water carrier. Where several gates are operated in an area, a relief gate guard works at the gates in turn for a period, to allow a permanent guard to take time off.

At Makuti, where heavy sliding doors have to be moved and traffic is heavy, four guards may be required to be on duty.

For special reasons, some gates are required to operate during the night. Appropriate arrangements have to be made to man these adequately.

6.8 Control by Parasites and Predators

It is true that 'Large fleas have small fleas
Upon their backs to bite 'em.
And small fleas have smaller

fleas,
And so ad infinitum.'

Tsetse flies have their quota of parasites and predators. If a collection of tsetse puparia is made, particularly during the warm, dry period of the year, and kept under observation, it will be seen that not only tsetse flies emerge from the puparia, but also small, adult, parasitic flies and wasps, the larvae of which have fed upon and destroyed the tsetse pupae. The parasites more commonly obtained from *G.morsitans* puparia are the wasps *Mutilla* spp. and *Syntomosphyrum* spp. and the fly *Thyridanthrax* sp. These, together with spiders and such insects as robber flies, dragonflies and hunting wasps, and birds such as bee-eaters, drongos, and fly catchers, and small mammals such as elephant shrews are natural enemies of the tsetse fly, in either the adult or pupal stages.

It would be fascinating and aesthetically satisfying to the entomologist to be able to manipulate the numbers of these enemies so that they could bring about the control and even the elimination of the tsetse fly. Unfortunately, the ecological situations in which tsetse flies live are so complex that there is little hope, as yet, of achieving this ideal. Attempts have been made to rear and liberate large numbers of tsetse parasites, without observable success. Tsetse flies and their enemies have lived together in Africa long enough to have struck a fairly stable equilibrium, at which level the tsetse fly can thrive. It is extremely difficult to upset this equilibrium permanently in favour of the enemies.

Some of the factors which make up the environment of a tsetse fly can be favourable to the fly's survival and others unfavourable. Some of these factors can be regarded as being *independent* of the density of the population, as, for example, the climate, which generally affects all individuals of a population irrespective of their numbers. A spell of very cold weather or contact with a lethal insecticide would be expected to result in the death of the same proportion of the tsetse population whatever its density. Others may be *dependent* on the density of the population. The effect of predation and parasitism for example is dependent on the density of the population. Parasites and predators are more likely to find hosts and prey when these are very numerous than when they are scarce; communicable diseases spread more rapidly when the hosts are crowded than when they are scattered.

Independent factors would not produce stable populations. When they are favourable, the population would increase indefinitely (in theory) and when unfavourable, the population would die out. But dependent factors, on the other hand, would tend to cause populations to rise and fall about a mean. As parasites and predators increased their toll of the host species, there would be fewer hosts left to parasitize or kill, and the populations of parasites and predators would decline, which then would be followed by an increase in the host species, now relieved of its natural enemies. This sort of fluctuation occurs in populations of tsetse flies and their enemies.

Tsetse flies do not appear to compete amongst themselves for food, as do, say, blowfly maggots or plant eating insects. If a suitable host is available to a tsetse population the flies will survive whether they are many or few.

These considerations have a bearing on tsetse control operations. Research may yet find ways of rearing large numbers of tsetse parasites on other hosts than tsetse (which are difficult to rear), so that they can be liberated when tsetse populations have been reduced by other control methods to a low level at which it is uneconomic to continue using such other methods.

Fleas,
And so ad infinitum.

Tsetse flies have their quota of parasites and predators. If a collection of tsetse puparia is made, particularly during the warm, dry period of the year, and kept under observation, it will be seen that not only tsetse flies emerge from the puparia, but also small, dark, parasitic flies and wasps, the larvae of which have fed upon and destroyed the tsetse pupae. The parasites most commonly obtained from *Glossina* puparia are the wasps *Mutilla* spp. and *Syntomosphyrum* spp., and the fly *Thyridanthrax* sp. These, together with spiders and such insects as robber flies, dragonflies and hunting wasps, and birds such as bee-eaters, drongos, and fly-catchers, and small mammals such as elephant shrews are natural enemies of the tsetse fly, in either the adult or pupal stages.

It would be fascinating and aesthetically satisfying to the entomologist to be able to manipulate the numbers of these enemies so that they could bring about the control, or even the elimination of the tsetse fly. Unfortunately, the ecological situations in which tsetse flies live are so complex that there is little hope, as yet, of achieving this ideal. Attempts have been made to rear and liberate large numbers of tsetse parasites, without observable success. Tsetse flies and their enemies have lived together in Africa long enough to have struck a fairly stable equilibrium, at which level the tsetse fly can thrive. It is extremely difficult to upset this equilibrium permanently in favour of the enemies.

Some of the factors which make up the environment of a tsetse fly can be favourable to the fly's survival, and others unfavourable. Some of these factors can be regarded as being independent of the density of the population, as, for example, the climate, which generally affects all individuals of a population irrespective of their numbers. A spell of very cold weather or contact with a lethal insecticide would be expected to result in the death of the same proportion of the tsetse population whatever its density. Others may be dependent on the density of the population. The effect of predation and parasitism for example, is dependent on the density of the population. Parasites and predators are more likely to find hosts and prey when these are very numerous than when they are scarce; communicable diseases spread more rapidly when the hosts are crowded than when they are scattered.

Independent factors would not produce stable populations. When they are favourable, the population would increase indefinitely in theory, and when unfavourable, the population would die out. But dependent factors, on the other hand, would tend to cause populations to rise and fall about a mean. As parasites and predators increased the control of the host species, there would be fewer hosts left to parasitize or kill, and the populations of parasites and predators would decline, which then would be followed by an increase in the host species, now relieved of its natural enemies. This sort of fluctuation occurs in populations of tsetse flies and their enemies.

Tsetse flies do not appear to compete amongst themselves for food, as do, say, blowfly maggots or plant eating insects. If a suitable host is available to a tsetse population the flies will survive whether they are many or few.

These considerations have a bearing on tsetse control operations. Research may yet find ways of rearing large numbers of tsetse parasites on other hosts than tsetse (which are difficult to rear), so that they can be liberated when tsetse populations have been reduced by other control methods to a low level at which it is uneconomic to continue using such other methods.

7. RECORDING THE DISTRIBUTION AND ABUNDANCE OF TSETSE FLIES

7.1 Introduction

In order to gauge the risk of trypanosome infection to cattle or to assess the effect of control measures on the tsetse population, it is necessary to know where tsetse occur, and in what density. It is impractical to count the true population in any area, but estimates of it can be made by taking samples under certain conditions. Different sampling techniques give different information about the same population and caution must be used in interpreting the results. Thus the same population of *G.pallidipes* would yield different samples if these were taken off humans, or from screens, or from moving or tethered oxen or from resting sites, and at different times of the day. The significance of these differences is still being investigated. It is clear that any estimates of populations of tsetse flies must be considered in relation to the manner in which the sampling was done.

Estimates of the true population can be made by using a system of marking individual flies, normally by applying small spots of paint to the dorsal surface of the thorax. Fundamentally, the technique depends on catching, marking and releasing tsetses on a particular day and recapturing as many as possible of the marked flies at a later date. The assumption is made that the proportion of recaptured flies to the total caught on the second occasion is equal to the proportion of flies marked on the first day to the total population on that day, so that, knowing the total marked on the first day, the total population at that time can be estimated. The method is refined considerably, in use, to take account of emigration, immigration, emergence and deaths. It has given rise to the concept of *'Standard Availability'*, which is *Apparent Density* (number of non-teneral males per 10 000 yards of flyround), expressed as a percentage of the population per square mile.

In East Africa the populations per square mile of *G.morsitans* and *G.pallidipes* have been worked out by means of these marking experiments. The Standard Availability has been shown to be almost 10% for *G.morsitans* and 0,3% for *G.pallidipes*. This means that an A.D. of 100 *G.morsitans* indicates a true population of 1 000 non-teneral males per square mile, and a population of 1 000 non-teneral male *G.pallidipes* per square mile would be indicated by an A.D. of 3.

It must be borne in mind that these standard availability indices are derived from catches made from humans. The standard availability for *G.pallidipes* estimated from catches from bait oxen which are attractive to *G.pallidipes* would, of course, be much higher. It can be appreciated how the capture of one *G.pallidipes* by man in an area adjacent to cattle would indicate a greater threat of infection than a capture of one *G.morsitans* and that the capture of a female of either species would indicate a greater threat than the capture of a male, because they are less available.

The composition of a tsetse population changes throughout the year. We record the percentage of male, female and young adults in the catch, and try to relate these changes to other changing factors such as climate, condition of vegetation (leafless or otherwise), and availability of food. Male tsetses in the wild state are more active than females and do not live as long. As males and females are produced in roughly equal numbers, it follows that at any time there are more females in a population than males although catches on fly rounds may not indicate this. There may be twice as many females as males, thus to arrive at a rough estimate of the total population the non-teneral male population should be multiplied by 3.

The number of insects attracted to a catching party is directly related to the total numbers in the population and to its state of activity. Thus, by any sampling technique, a similar catch might be expected from one population of tsetses as from another twice as large but half as active. Or again, at night, when activity of *G.morsitans* is almost zero, no captures would be expected in an area known to harbour the fly. The actual catch made would, of course, be influenced by the ability of the party to make and record the catches. It must be stressed that the utmost reliability is expected from those engaged in taking samples. From the data obtained from the flyround and its modifications, we attempt to relate numbers of tsetses caught to changing environmental conditions such as temperature, humidity, time, shade, abundance of food and vegetation in such a way that by calculating the effect of these changes on activity, relative changes in abundance can be estimated. These relative changes can be translated to quantitative changes by the use of marking experiments. We are actively seeking means of refining our sampling techniques as an essential preliminary to quantitative investigations.

As yet our methods of sampling relate only to the adult population, which represents, perhaps, only a fifth of the entire population, and of this most of the adults caught are non-teneral males. We are thus gaining information about a limited section of the population, and making assumptions from it to apply to the complete population.

We can judge the reliability of some of our sampling methods by the extent to which they give information that satisfies theoretical considerations. Thus, if we wish to consider the behaviour of the female population, we should, with the knowledge that there are more female adults in a population of tsetses than males, place more reliance on samples that are likely to yield over 50% females in the catch, i.e., those taken by means of traps, stationary oxen or bait oxen patrols, electrical trapping devices, or by searching for resting flies, than on those taken by fly boy patrols. On the other hand, since male *G.morsitans* are for the greater part of their adult life readily attracted to moving objects, we can be fairly confident that samples of adult males caught by fly boy patrols will reflect changes in the total adult male population, although the numbers fall far short of those caught by electrical trapping devices.

The various sampling techniques may now be considered.

7.2 The basic flyround

The selection of the site for a flyround depends upon the nature of the information that is required. If a general picture of the changes in the tsetse population of an area is required, it would be necessary for the flyround, or flyrounds, to traverse several different vegetational types, so that several tsetse communities would be sampled. But if it were required to compare the tsetse population of one vegetational type with another, the flyrounds would be restricted to sampling these two types.

Flyrounds can best be planned from aerial photographs of the areas under investigation. From these the vegetation to be traversed can be selected and the most useful traverses indicated. Compass bearings and distances can be estimated and transferred to the ground, (see instructions for trace cutting). It is important not to interfere with the vegetation any more than is necessary to allow passage of the catching party. Where special information is required on the presence of game, a hoed path may be necessary, but it should be kept as narrow as is practical. The line is followed according to given compass bearings and distances and measured with a chain. At intervals, usually of 50m or 100m for foot patrols, and 400m for cycle patrols, posts are set up or prominent trees are blazed, on which the 'station' numbers are marked. It may be necessary on a new flyround to blaze intermediate trees between stations as indicators of the path to be followed before this path has become worn. Flyrounds nowadays are clearly marked with metal plates with indented or painted numbers. Damaged or missing numbers must be replaced immediately to avoid errors in procedure.

Since the sector is the collecting ground and the station is the catching site it is necessary to ensure that the catching party is not carrying any flies as it begins its traverse of the first sector, which ends at Station 1. Consequently the round begins at Station 'O', at which all attendant flies are caught and killed, so that they do not influence the catch over the first sector. Their numbers are not recorded in the total catch for the flyround, but are recorded separately.

7.2.1 The composition of the flyround party

The flyround party consists of at least two catchers, one of whom is the recorder. They both serve as the bait to attract flies. Where oxen, screens or other baits are used, additional assistance is necessary. It has even been necessary on occasion to have a hunter to provide protection from lions. The members of the party should be uniformly attired, and similarly dressed on each traverse to present a standard source of attraction to the flies.

7.2.2 Equipment

The data required from the flyround usually include the species, number and sex of the flies, their state of hunger, game seen or noted from spoor, weather conditions and date and time of day. It may be required to make live collections of flies during the flyround or to make blood meal collections. The following equipment should be carried on all flyround partrols:

On routine patrols

a. Collecting nets (Nylon mesh)

b. Recording sheets

c. Pencil

d. Chartboard

e. Watch

f. A small pack to carry the above equipment.

The following additional equipment may be required on special investigations (as instructed):

g. Whirling psychrometer

h. A small bottle of clean distilled water for use with the whirling psychrometer

i. Filter papers for collecting tsetse blood meals

j. A bottle of preserving fluid for collecting and preserving material

k. Clean 75mm x 25mm corked tubes for collecting live tsetse flies.

7.2.3 Notes on recording equipment used on the flyround

Collecting nets

These are mesh bags measuring 45 x 30cm when closed, supported on a flexible cane rim and handle. They must be kept clean and must not be torn. Torn fly nets are useless and must be repaired or discarded. It is difficult to find tsetse flies within a dirty net.

The record sheet

Clear entries must be made on the record sheet, using a sharpened pencil, and care must be taken to make the entries in the appropriate spaces. Each record of a young, unfed (teneral) and of an old (non-teneral) fed male or female tsetse fly is recorded by a stroke (1). Where blood meals are being collected all fed flies, i.e. those with recognisable red or blue/black blood, are indicated by dots (.). *It is important not to record as fed flies those that have fed upon the ox during an ox flyround.* It is convenient to record the strokes in groups of five, thus (卌), four upright, and the fifth oblique, to cross the four.

The whirling psychrometer

This instrument provides a means of measuring the differences in temperature between the prevailing air temperature and the lower temperature produced when water evaporates from a surface. From these two temperatures the relative humidity or saturation deficit of the air at that temperature can be calculated. Before use, both thermometers should read the same temperature. The wet bulb reservoir must have sufficient water to ensure that the wick covering the bulb is completely wet. Face the direction from which the wind is coming, hold the handle of the psychrometer in the right hand with the arm fully extended horizontally (so that your body temperature does not influence the reading), and whirl the instrument rapidly for 5 seconds. Withdraw the extended arm, steady the instrument with the left hand, and quickly read the temperature on the wet bulb thermometer, shading it with your body. Repeat the process until two consecutive wet bulb readings are the same. Then read the temperature of the dry bulb thermometer. The wet and dry bulb readings at this stage are recorded on the record sheet.

Take great care not to drop the instrument or to knock it against a branch or other hard object, because the thermometers are very fragile.

Care of watches

Take proper care of watches. *DO NOT* attempt to adjust or repair a watch. If it requires attention return it to your Senior Tsetse Field Officer. The watches should be correctly set at the base station before leaving for the flyround.

7.2.4 Procedure

Instructions will be given to the catching party on the identity of the flyround to be traversed and the time at which a start is to be made by the officer responsible for the flyround. The time of start will vary with the season. Morning rounds will be earlier in summer than in winter and afternoon rounds will be later. The time may not be stated precisely but may be indicated as the time at which the air temperature reaches 21°C for morning catches.

a. Before starting the flyrounds, the catching party should assemble at Station '0' at 5 minutes before the scheduled start of the round, and check that it possesses the appropriate equipment as listed above. Entries should be made in the appropriate places at the top of the record sheet to indicate the name or number of the flyround, the date (or in some cases the week), the team identification (where appropriate), and the kind of bait used. This may be flyboys only, with or without screens, with oxen or on bicycles.

Finally, all attendant tsetse flies must be caught and killed and the appropriate entries made on the record form at Station '0'.

b. In cases where temperatures are being recorded, at one minute before the scheduled start, dry and wet bulb temperature readings are taken with the whirling psychrometer. In all cases, weather conditions are noted (wind, rain, cloud and sun), and recorded in the appropriate spaces for Station '0'.

c. At the time scheduled for the start of the round, the party moves from Station '0', along Sector 1 to Station 1, making observations on game spoor as it proceeds.

d. On arriving at Station 1 the party immediately begins to catch and kill (or collect if so instructed), all tsetse flies around the party, continuing until the party moves off to Sector 2.

Appropriate records including observations on weather, and game on Sector 1 and on the vegetation surrounding Station 1, must be entered on the record sheet.

If a recently fed tsetse fly is caught on a flyround from which blood meals are being collected it will be dealt with as described below.

After all flies have been caught and the appropriate records made, a wet and dry bulb reading is taken and recorded (in cases where temperature records are being made) and the party moves along Sector 2 to Station 2, repeating the previous procedure, and so to the end of the flyround. In the case of the Foot Flyround the party moves as soon as all flies have been caught and records have been made, but when oxen or bicycles are used the psychrometer readings are taken one minute before the set time to resume moving.

e. On completing the flyround the recorder must total the row and column entries of flies caught, *and must ensure that these agree.*

f. Finally, the recorder *MUST* sign his name in the appropriate place at the bottom of the form.

7.2.5 Notes on recording weather conditions

The following system is to be used for recording weather conditions:-

Wind

Wind is recorded according to its effect on surrounding vegetation:-

No movement shown by leaves on trees	- calm
Leaves rustle	- breeze
Small trees swaying	- windy
Large branches on the bigger trees moving	- very windy

Rain

Rain is recorded according to its intensity:-

Heavy rain

Medium rain

Light rain or drizzle.

Cloud

The amount of cloud present is expressed as eighths of the sky obscured by cloud. Thus a completely overcast sky is recorded as 8 eighths, a sky half covered as 4 and when there is no cloud, as 0. Since it is accepted that eighths are indicated only the numerator is recorded.

Sun

When the sun is shining record as (+) and when it is hidden by cloud as (–).

Game

Under the heading 'Spoor', record all spoor observed on the sector. All spoor marks should be covered over as soon as they have been recorded.

Under the heading 'Seen', record all game as species and number seen, e.g. Eland (4).

Vegetation

Since the fly round will have been planned in relation to the associated vegetation, there is no need to record its components. It is necessary, however, to record its general state, seasonal changes, or changes due to fire or frost.

Special recommendations

Once begun, the flyround must be completed, irrespective of weather conditions, such as rain. Capes are provided to field assistants to cope with such events.

It is essential that flyrounds are carried out with as little noise as possible, since noise disturbs game, and information on game is important. Remember, correct information on the recording sheet is valuable. Incorrect information is worse than useless; it can be misleading.

7.3 Kinds of Fly round

7.3.1 The foot fly round

The fly round in its simplest form is a measured path of fixed length running through tsetse habitats. It is divided into sectors of 50 metres or 100 metres, at the end of each of which is a fixed station at which all attendant tsetse flies are captured and recorded. The number of sectors varies with the nature of the country, but usually between 10 and 60 are used. The fly round is traversed periodically by a catching party of standard composition, with or without a screen as a bait, which records the catch at each station and such information as prevailing weather conditions (temperature, humidity, wind and cloud), the game seen or recorded from spoor and the state of the vegetation. It is often used to make a preliminary assessment of the abundance of fly. Nowadays foot fly rounds are being superseded by the more informative ox or bicycle fly rounds.

7.3.2 The ox fly round

Variations in the form of the fly round are introduced to suit special circumstances. Thus, when populations of *G.pallidipes* are being investigated, an ox or oxen are used to act as bait in the early morning and late afternoon. *G.pallidipes* does not readily come to man, but is attracted to oxen. It has been shown that on the same fly round an ox attracts up to fifteen times as many *G.pallidipes* as are attracted to man alone, and although *G.morsitans* will readily come to man it has been shown that the presence of an ox on a fly round will increase the catch threefold. It is important therefore to use a bait ox on a fly round when low density populations are being investigated. Furthermore, female flies also are attracted to an ox, making the ratio of male to female non-teneral flies caught more balanced. Samples of flies taken in this way reflect more closely the real condition of the general population.

It has been found convenient in some areas to arrange ox fly rounds on the basis of 30 x 100 metre sectors to form a closed fly round, in which the start and finish points are adjacent, but the number of sectors is chosen to suit the requirements of the situation. Ox rounds should be conducted with strict attention to timing. Approximately two minutes are spent in walking the animal along the sector to the station, and eight minutes are spent in catching and recording, making a period of approximately ten minutes per sector. (In certain cases, e.g. when fly densities are extremely low, it may be desirable to reduce the time spent per sector to less than ten minutes). Each animal requires an attendant. The animals are usually more docile when worked in pairs, but can be quite manageable when used singly.

Bait oxen must be properly tended. They must be watered regularly and must be allowed to graze during daylight hours when they are not working.

7.3.3 The bicycle fly round

It is a matter of frequent observation that cyclists are particularly attractive to *G.morsitans*. Use is made of this fact in conducting the bicycle fly round in which the catching party proceeds on bicycles along the prescribed route for 1½ to 2 minutes. It then dismounts at a fixed station, catches attendant flies and makes records for 3 to 3½ minutes, making a total of 5 minutes per sector.

Bicycle fly rounds are able to cover long traverses usually of 30 x 400 metre sectors, and are of particular use in following the fluctuations in the catches of *G.morsitans* during our large scale reclamation operations, and along the perimeter of our extensive tsetse areas. They are limited to use along roads or tracks.

These techniques have been described fully, so that they may be applied where needed. The continued success of spraying operations and the emphasis now on eradication have brought about modifications of the basic fly round. The need is, in several areas, to detect the presence or absence of tsetse flies rather than to measure seasonal fluctuations in their numbers. Patrols, using oxen as bait, are carried out in the places where flies might be expected to occur, over an area due to receive treatment. The distribution and numbers of flies caught indicate the extent and intensity of the treatment that will be required, either application of insecticide or selective hunting. During the hunting operations, and immediately after the spraying operations, these patrols are continued, to reveal the major

changes that take place in the tsetse population following the treatment.

8. THE USE OF SURVEYS

8.1 Introduction

We use the term 'Survey' in a general way to include any operation designed to collect information on the distribution in time and space of tsetse flies, cattle, game, vegetation, human habitation, communication routes, water sources or any other feature in which we have an interest.

An efficient surveyor, (in this sense), would be able to read a map and to interpret aerial photographs. He would be able to identify ground objects from aerial photographs, to locate them on the photographs, and to transfer such information accurately on to appropriate maps.

The surveyor may expect to be provided with carefully planned instructions relating to the nature and extent of the area to be surveyed, and of the extent of the information to be collected. In planning a survey operation, care must be taken to economise in effort by arranging to collect as much relevant information as is practical, even if some is not of immediate practical use.

8.2 Trypanosomiasis Survey

In areas where the incidence of the fly is so low that it is unlikely that patrols would encounter any without prolonged effort, its presence can be detected and its probable distribution assessed from the pattern of typanosomiasis in cattle. This information is used in planning control measures.

Where cattle are privately owned and herded, use is made of them as indicators, but in areas where privately owned cattle are absent, it is necessary to introduce small 'test herds' strategically placed, for this purpose.

The trypanosomiasis survey can be classified according to the conditions to be encountered.

8.2.1 In the presence of privately owned cattle ('Kraal Plotting')

The survey will accurately record on a map or an aerial photograph the disposition of kraals, cattle dips and inspection races at which cattle congregate. All infected dips are marked, and as many uninfected dips as will indicate the probable limits of the disease.

When infected dips have been identified, the survey will record the kraals from which the cattle are drawn to the dips and indicate the recent incidence of disease from each kraal. This information is transferred to 1:50 000 maps.

The survey should then record the summer and winter watering and grazing areas of the cattle within the infected area. These surveys should be carried out at different periods of the year so that a seasonal picture can be obtained.

A completed survey should produce information that can be used to assess the urgency for tsetse control measures to be applied and the form they should take.

8.2.2 By means of test herds

In so far as any non-teneral tsetse can be assumed to be infected with trypanosomes the capture of a single tsetse in an area means that there is a risk of neighbouring cattle contracting trypanosomiasis, but after successful tsetse control operations have been completed or where the tsetse density is very low, the usual sampling techniques, fly boy patrols, bait oxen and traps may not be sensitive enough to reveal the presence of even a single tsetse. Under these conditions a more delicate sampling technique is utilised to detect the presence of fly. Cattle known to be free of trypanosomiasis are introduced to the area under investigation and herded there under close veterinary supervision. Frequent and regular examinations are made for the presence of trypanosomes in the blood or lymphatic systems of the animals. When an animal is found to be infected it is treated with Berenil, which is a drug that quickly cures it, but which gives almost no protection against a further infection. Under these conditions it should be possible to record successful infected bites. The rate at which the animals contract the disease is a measure of the risk of infection, which itself depends on the number of infected tsetses visiting the animals to feed. Where critical information is required, the use of these 'test herds' in an area would be recommended, in place of fly patrols with their inherent sources of error.

Test herds should consist of not less than 10 animals distributed so as to cover the more likely tsetse haunts in the area under survey. Their ultimate distribution will be governed by the distribution of water, vegetation and predators, but the aim of the survey should be to cover as large an area as possible.

Each herd should be separated from its neighbour by a distance of 8 to 16 km, depending upon the intensity of the survey.

By recording the localities where the disease is contracted, and moving infected test herds away from the suspected source of infection and uninfected herds towards it, it should be possible to define the limits of the fly, at that time. The distribution of the disease and of the fly will change seasonally.

There should be no intermingling of animals between herds, and grazing areas of neighbouring herds should not overlap.

This type of survey has been used for several years in the Sabi-Lundi area both to measure the effectiveness of the insecticide spraying operations, and to give early warning of any further extension of the southerly advance of fly.

8.2.3 Assessment of trypanosomiasis risk

An extension of the trypanosomiasis survey is used to estimate the degree of risk to which cattle would be exposed if introduced into a fly infested area. Where land has been settled and developed initially without cattle, it sometimes becomes expedient to introduce cattle, for example, as draught animals, under drug protection, and some measure of the expected risk of infection is required, so that the required amount and frequency of drug administration can be gauged.

A numerical index has been devised to indicate the degree of risk to which cattle are exposed when in the presence of tsetse flies. This index, termed the *'Trypanosome Risk'* or *'Trypanosome Challenge'*, is the product of the tsetse fly density and the trypanosome infection rate of the flies, and serves to indicate the relative frequency of infected bites from tsetse flies that might be expected at different times or in different areas. In practice, however, this index has not given a very satisfactory indication of the probable incidence of trypanosomiasis in cattle. In using the index the assumptions are made that each infected tsetse fly bites one animal once per unit time, and that each infected bite produces the disease.

The method involves assessing the Apparent Density of the tsetse flies in an area by means of a standard fly round technique, and dissecting representative samples of the flies caught to measure their infection rate. The product of these two quantities would give a measure of the number of infected tsetse flies available within the area covered by the fly round, which in turn is an indication of the risk of trypanosomiasis facing cattle inhabiting the area.

It is a refinement of this technique to count the number of flies visiting one or more oxen in an area, and to assess their infection rate. These quantities give an indication of the number of infected tsetse flies seeking to feed per hour or per day. This method give more precise information on the risk of cattle contracting trypanosomiasis, but it is certainly more laborious for general use.

It still presumes that each appearance of an infected fly would be followed by the appearance of the disease in cattle, and that the appearance of disease in an animal was attributable to only one fly.

A more useful index that avoids these assumptions has been introduced by Whiteside, which he terms the *Natural Incidence*. This simply measures the frequency with which cattle contract trypanosomiasis in an area. He used the drug Berenil to cure every infection. Since the drug gives virtually no protection, he was measuring the natural incidence as closely as was practical, although the reaction of the animal to repeated infection and drug treatment was an unknown but complicating factor.

Whiteside found that the length of the interval between Berenil treatments was related inversely to the trypanosome risk, that is, in situations where the interval between Berenil treatments was short, the trypanosome risk was high, and vice versa.

Both trypanosome risk and natural incidence can be used to arrive at an estimation of the disease risk, in terms of 'high', 'low' or 'medium' that will suggest the appropriate drug regime.

8.3 Tsetse Survey

8.3.1 Capture of flies on traverses

As a preliminary inspection of an area and for general surveillance in the course of control operations, the tsetse survey can yield valuable information and is extensively used. Ideally the route to be taken should be planned from aerial photographs and accurately indicated on a map. The stopping places along the route are selected with regard to vegetation patterns. At each stop, the number of flies caught and other data are recorded, as for fly rounds (see 7.2). When searching for *G.morsitans*, and if no flies are caught, an attempt should be made to lure them from their resting sites in the surrounding vegetation by slowly walking backwards near these sites, keeping a careful watch on the ground for alighting flies. About a quarter of an hour should be spent at each stopping place where flies cannot be readily caught.

The attractant or bait used depends upon its availability and the needs of the survey. Thus, if time is a consideration or when large distances are to be covered, a vehicle or cycle may be used. Such surveys are usually restricted to roads and tracks. If time is not so important, surveys on foot are used, since these are not limited to roads or tracks. The use of cattle as bait increases efficiency when surveying for *G.morsitans* and is essential for *G.pallidipes*. Moreover, since *G.pallidipes* are most active early in the morning and towards sunset, searches for this species should be made at these times, and not during the middle of the day.

In the very rare event of searching for *G.brevipalpis*, it should be borne in mind that this species is active at dusk. Searching should be carried out in likely areas, on the ground along tracks, at sunset.

Since tsetse flies exhibit changing behaviour patterns throughout the day, the survey instructions must be drawn up with due regard to the expected availability of the fly. As extreme examples, one would not look for flies by means of fly rounds or random tsetse survey after dark or when temperatures are over 40°C.

8.3.2 Examination of resting sites

We require information on the changing resting habits of tsetse flies throughout the day. Such information is used to ensure that insecticide is directed to places where flies rest so that it can have greatest effect. When flies are inactive, or, as in the case of *G.pallidipes* which does not readily come to man, searching of resting sites may reveal their presence.

8.3.3 Searching for puparia

The fly round and random survey techniques are designed to collect information about the abundance of the adult fly. It is sometimes necessary also to gain information about the numbers and distribution of puparia, or to make collections of pupae for the purpose of breeding out adult flies or their parasites.

Searching for puparia may in some cases be a most effective way of discovering the presence or the former presence of tsetse flies, particularly of those species that do not readily come to man, e.g. *G.pallidipes, G.austeni* and *G. brevipalpis*. Empty cases may remain in the soil in breeding sites for many years and can thus reveal the former distribution of tsetse flies, long after tsetse flies have disappeared from the neighbourhood. The tsetse control authorities have made great use of puparia surveys to reveal the presence or former presence of *G.pallidipes*.

Searching for puparia is tedious and often unrewarding. It is advisable to make use of juveniles (picannins) of the 10 - 12 year age group for this work since they are more willing to sit around searching for puparia than either teenagers or adults, and they often become more skilled at finding likely pupal sites. They can be encouraged in their work by awarding a bonus for production. At most, 12 picannins should be allocated to one efficient field assistant.

Searching for puparia of *G.morsitans* at Kariangwe during 1958 - 1959 revealed that there is a marked seasonal shift of 'breeding grounds'. During the early dry season puparia were found mostly beneath rocks and fallen logs on the slopes of the escarpment hills. In the mid dry season they were more numerous under fallen logs, in rot holes in trees in mopane woodland and along the contacts between mopane woodland and 'sinanga' thicket. During the late dry season, puparia could be found in large numbers in association with drainage lines, being found in holes, under logs, and roots along the banks, and under the leaf layer on sandy river beds.

The puparia of *G.pallidipes* showed a more restricted distribution. They were never found away from the riverine areas, and were generally found under small thickets and shrubs, in holes and under logs along river banks. They were also numerous beneath the leaf layer on dry sandy river beds during the latter half of September when they could be found together with *G. morsitans* pupae.

At the breaking of the rains, in early November, 1958, pupal searching became more difficult and less were recorded. Wet soil conditions, dispersal of female flies and the flushing of riverine pupal sites were probably responsible.

8.4 Vegetation Survey

8.4.1 General Survey

Tsetse flies inhabit a complex of vegetation types. In recording their distribution in relation to the vegetation we describe the vegetation in the simplest possible terms. Thus, in making a vegetation survey, we begin by outlining by coloured wax pencil or ink the various patterns of vegetation that appear on aerial photographs of the area under survey. The vegetation appears as lighter or darker clumps indicating dense or diffuse stands. Where there is contact between two distinct types of vegetation such as pure mopane woodland and riverine fringe a clear line of demarcation can usually be seen. After the outlines of the more distinct patterns have been drawn, a ground traverse of the country is made with the aid of the photographs so that the outlined patterns can be identified and recorded in terms of the tree species composing them. Where two adjacent patterns are found from the ground check to be of similar composition they are treated as one unit, and the pencilled outlines on the photographs are amended accordingly.

With experience, it is possible to recognise particular patterns on the photographs as indicating particular tree species, and the need for ground checks diminishes. However, when opportunities arise, ground checks should always be made.

Having related the patterns to particular groupings of tree species, one can proceed to outline these patterns on photographs of neighbouring areas until new patterns are encountered. These will require to be investigated on the ground after having been marked off on the photographs.

Ground checks of the vegetation patterns appearing on the photographs can also be made by identifying them from the vegetation encountered on a long road traverse, by car or on foot.

For the purposes of this general survey, the vegetation is classified as:

a. Riverine fringe

b. Deciduous thicket ('Sinanga', 'Jese')

c. Mopane woodland

d. *Brachystegia* with other spp.

e. *Acacia* woodland

f. Other species woodland (e.g. *Combretum* woodland)

g. Grassland vlei

h. Grassland

8.4.2 Intensive Survey

This type of survey is an extension of the general survey. The vegetation patterns as they appear on the aerial photographs are examined more critically, and outlined in greater detail. Ground checks are more thorough and the number and species of trees in individual groups are recorded, to present a more precise description of the vegetation. This type of survey is usually made as part of an investigation into the behaviour of game or tsetse.

In counting numbers and species of trees the following procedure can be followed. A vegetation unit is selected from the aerial photographs and identified on the ground. From a selected and identified point on the fringe of this vegetation a traverse is made on a compass bearing chosen to take it through most of the unit. From the starting point, and at convenient regular intervals, the number and species of plants (usually trees or shrubs) within a radius of 2m, measured with a pole, are recorded. The chosen interval is related to the density of the vegetation. For example, intervals of 20m may be required in the denser and varied riverine fringe, but these could be extended to 50m or 100m when crossing the more uniform open mopane or *Brachystegia* woodland.

All data concerning the date, time, direction of traverse, sampling intervals, number, species of plants and their estimated heights, and animals seen should be neatly and accurately recorded.

8.4.3 Special Surveys

Access roads and tracks

As a preliminary to these surveys, the distribution and the condition of the means of access should be carefully investigated. The roads and tracks appearing on the map or photograph and any more recent tracks should be traversed, and their position recorded on the photographs. Reports should be made on the state of the access.

Distribution of water

The distribution of permanent or semi permanent water is of prime importance in siting camps and cattle dips and in conducting tsetse control operations, particularly those involving hunting operations and the application of insecticide. These operations are preceded by a survey of water sources based on local knowledge, but conducted ideally from light aircraft during the hot dry season.

of water sources based on local knowledge, but conducted ideally from light aircraft during the hot dry season.

8.4 Vegetation Survey

8.4.1 General Survey

[illegible]

[illegible]

[illegible]

Ground checks of the vegetation patterns appearing on the photographs can also be made by identifying them from the vegetation encountered on a long road traverse, by car or on foot.

For the purposes of this general survey, the vegetation is classified as:

a. Riverine fringe

b. Deciduous thicket [illegible]

c. Miombo woodland

d. [illegible]

control operations, particularly those involving hunting operations and the application of insecticide. These operations are preceded by a survey

g. Grassland vlei

h. Grassland

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9. MAPS AND AERIAL PHOTOGRAPHS AND THEIR APPLICATION IN TSETSE CONTROL OPERATIONS

9.1 Mapping and aerial photography

A map is a conventional representation of part of the earth's surface. The relative positions of natural features on the ground – coastlines, rivers, valleys, hills or lakes – and artificial features such as roads, railways, fences, dams, bridges or canals are indicated on a map by means of lines or shading. These relative positions were formerly arrived at after painstaking measurements on the ground of angles and distances, but modern maps are all based upon the use of aerial photography, which has made it possible for large areas to be mapped quickly and accurately, based on a minimum of ground measurement.

The aerial photograph records everything on the earth's surface that is visible at the time, and it is the function of the cartographer to extract from the mass of detail in the photograph those particular features which he is required to portray.

An inherent source of error in a map arises from the need to depict the curved surface of the earth on the flat surface of a map. The cartographer has to consider all the sources of error that arise in collecting the information needed for his map, to devise methods for correcting these errors, and then to portray the corrected information in an intelligible form on the map.

For our purposes in tsetse areas, the exact distribution of rivers, hills, roads, fences, kraals, pans and dams are of particular importance. For special purposes, such as insecticide spraying, tsetse surveys, or bush clearing operations the distribution of various elements of the tree vegetation must also be portrayed. In practice, maps are used to interpret the general features of an area, while the details are supplied by reference to the appropriate aerial photographs.

The interpretation of aerial photographs at this level must be frequently checked by reference to features seen on ground patrols. As skill and experience in interpretation is gained, the need for ground checks diminishes.

9.2 Scale of maps

The scale of a map (or of an aerial photograph) is the ratio between distances on the map and distances on the relevant portion of the earth's surface. Thus, a 1:1 000 000 map of Rhodesia, measures about 74cm x 84cm. Two points 5cm apart on this map would be, on the ground, 5 x 1 000 000cm, or 5 000 000cm, or 50 000m, or 50km apart. Such maps are useful as road maps but are not used in tsetse control work. They are described as *small scale maps.*

The maps in general use in tsetse control work are *medium scale maps* of scale 1:250 000 and *large scale maps* of scale 1:50 000.

Two points 5cm apart on a 1:250 000 map would be 5 x 250 000cm, or 1 250 000cm, or 12 500m, or 12,5km apart on the ground.

On a 1:50 000 map two points 5cm apart on the map would be 5 x 50 000cm or 2,5km apart on the ground.

Conversely, two points 5km apart on the ground would be shown on a 1:50 000 map as being

$$\frac{5\text{km}}{50\,000}, \text{ or } \frac{5\,000\text{m}}{50\,000} \text{ or } \frac{500\,000\text{cm}}{50\,000} = 10\text{cm}$$

apart on the map. On a 1:250 000 map this distance would be 2cm, and on a 1:1 000 000 map, 5mm.

On a hunting or insecticide spraying operation setting out from Salisbury a 1:1 000 000 map would be of use in finding the nearest town and major road junction nearest to the site of operation. The 1:250 000 map would be used from there to reach the chosen site, and the 1:50 000 maps and 1:25 000 aerial photographs would be used to identify the drainages, clumps of vegetation and hills within which the operations would take place.

A scale should always be shown on a map so that it can be properly interpreted.

9.3 Identification of localities on maps

In some circumstances it is possible to describe one's position on earth by indicating the conjunction of two recognisable features. Thus, the corner of First Street and Manica Road, Salisbury, or the bridge on the Salisbury to Norton Road over the Hunyani river are readily identified and are unambiguous, although they require to be amplified by the addition of 'Rhodesia' and 'Southern Africa' to be readily identifiable to everyone. Where there are no such recognisable features, such as at sea or away from habitations, it is more precise and universally intelligible to use a grid reference in describing the location of a point on the earth's surface.

9.3.1 Latitude and longitude

The earth is regarded as being a sphere slightly flattened at the poles, divided along the line of the equator into two roughly equal parts. In order to locate places on its surface lines of latitude are drawn on a model, parallel to the equator (parallels), so as to divide each hemisphere into 90 strips of equal width, starting at 0° at the equator to 90° at the north pole and to 90° at the south pole. Lines of longitude are drawn between N and S poles (meridians) starting with 0° which passes through Greenwich, England, dividing the surface of the earth into 360°, described as being from 0° to 180° E or W of Greenwich. For navigational purposes, bearings are given in degrees 0° – 360° in a clockwise direction from magnetic north.

The length of a degree longitude at the equator is determined by dividing the circumference of the earth at the equator, by 360. This is approximately 40 000km divided by 360 or 111km. This distance diminishes to zero as the poles are approached. To be more precise in fixing a position, degrees are divided into 60 minutes, and each minute into 60 seconds, so that at the equator, a bearing expressed in degrees, minutes and seconds would be accurate to $\frac{111}{60 \times 60}$ km or about 30m x 30m, and at latitude 45° N or S to 30m x 15m.

Because the distances between degrees latitude are constant (at about 111km) and those between degrees longitude decrease as the poles are approached, the representation of the earth's curved surface on the plane surface of a map involves increasing distortions in the more northerly and southerly regions. An area of 1° by 1° at the equator differs from an area 1° by 1° anywhere else.

9.3.2 U.T.M. Grid

In order to compensate for this kind of distortion and to introduce greater uniformity into the relationship between distances on a map and distances on the ground, the Universal Transverse Mercator (U.T.M.) grid is used. This is a grid of lines running approximately north-south and east-west dividing the map into equal squares representing areas on the earth's surface of 100km by 100km, wherever they may be.

A locality on a map can be identified by referring to its position in relation to either the latitude and longitude grid or to the U.T.M. grid. In tsetse control work, the U.T.M. Grid is used in giving map references.

The lines at 100km intervals both N-S and E-W are designated by a letter, so that a 100 km x 100km square is designated by two letters. These large squares are divided into 100 squares of 1 000m x 1 000m each by lines numbered at the top and bottom and at the sides of the map. Use only the *larger* of the printed figures, since these are all that are necessary within Rhodesia.

To give a map reference of a point on a map, first quote the two letters in the 100km square, then give the 'easting' which is the number of the nearest *vertical* grid line to the *left* of the point, and the number of tenths from this grid line to the point, and then give the 'northing' which is the number of the nearest *horizontal* grid line *below* the point and the number of tenths from the grid line to the point.

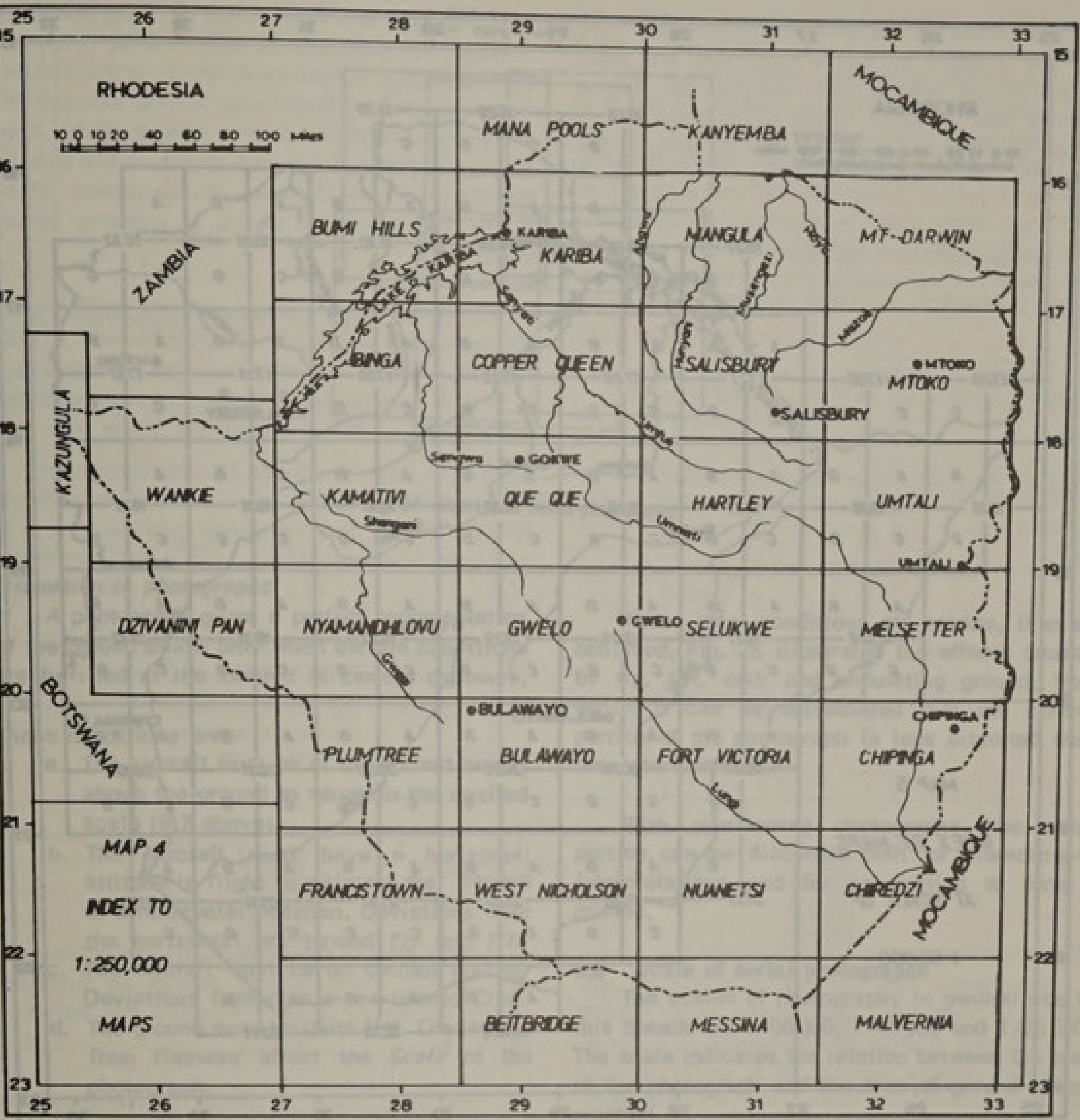
More accurate grid references can be given with aid of a romer which enables the sides of a grid square to be measured in tenths. Transparent romers as issued to staff are numbered from the lower left hand corner. To determine a reference the romer is placed over the map square containing the required locality, and readings are taken to the east and then to the north from the lower left corner.

9.4 Identification of maps

So that maps can be identified and related to the appropriate portion of the earth's surface they are classified by a system of numbers and letters. The maps issued from our Mapping Section are to the scales of 1:250 000 and 1:50 000. For special purposes other maps on other scales are available from the Department of the Surveyor General.

Map 4 (Scale 1:5 000 000) is an index of the 1:250 000 Rhodesian series which now extends to cover parts of Mocambique. It can be seen that each map covers 1,5 degrees of longitude by one degree of latitude.

These maps are usually described in this

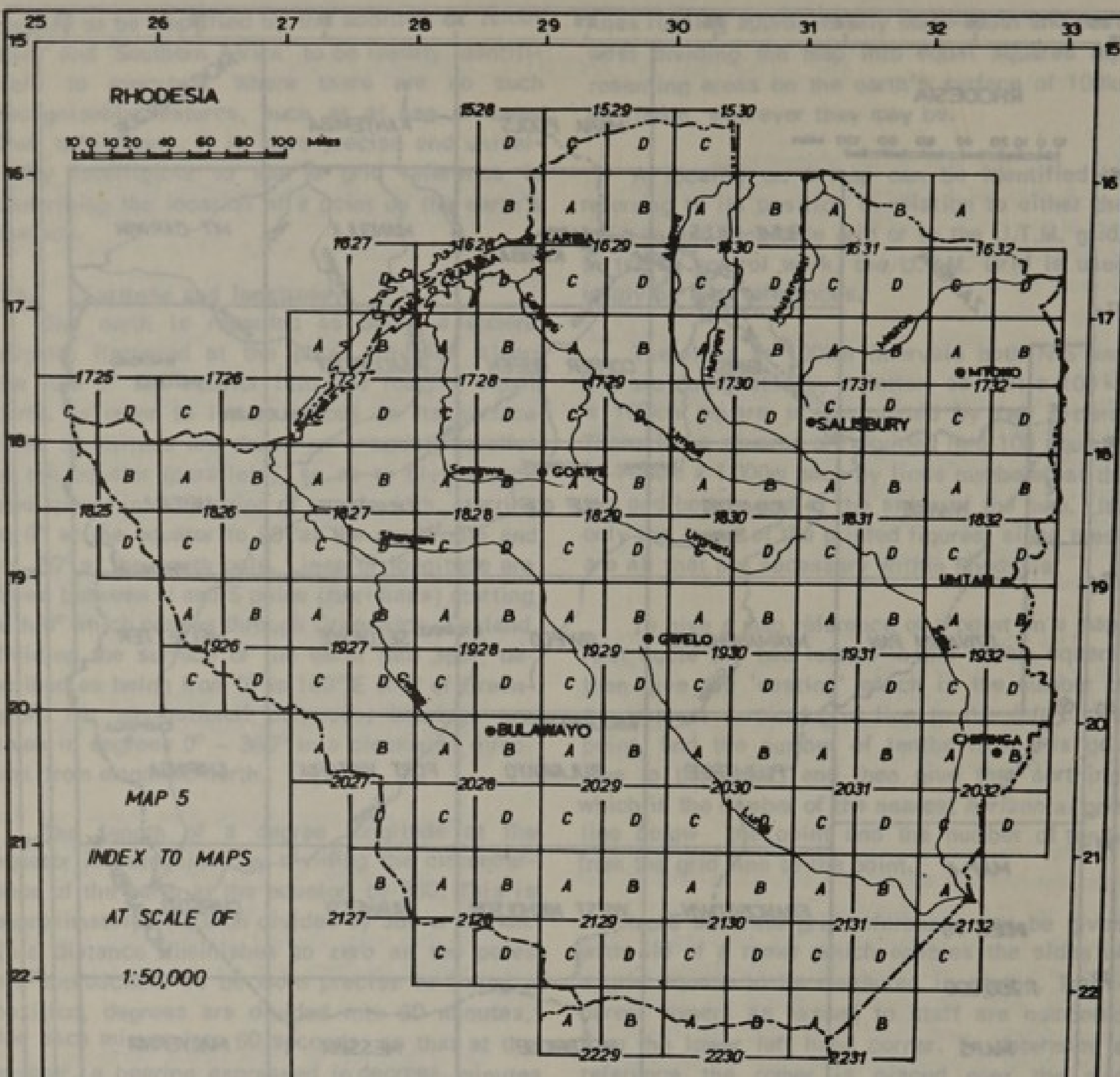


Branch by the scale and name only, e.g. 1:250 000 Copper Queen, but they are also numbered according to an international system.

Each map is the 1:50 000 series as indexed on Map 5, is numbered according to the latitude and longitude shown at the N.W. corner of the degree 'square' (covering an average area of about 110 x 105km in Rhodesia). Thus, the number 1629 refers to the maps covering the area of land lying between latitudes 16° and 17°S. and longitudes 29° and 30°E. The degree 'square' is divided into squares A, B, C, D of ½° x ½°, and each of these squares is further divided into four ¼° degree squares, numbered 1, 2, 3 and 4 to give the individual 1:50000 sheets. To identify a 1:50000 sheet adequately requires the latitude, longitude, a letter and a number, e.g. the 1:50 000 sheet in which Salisbury appears is 1731 C3.

9.5 The aerial photograph

Aircraft fitted with specially designed cameras, and flying at a fixed altitude on a predetermined course - the *Run* - record a series of overlapping photographs of the ground below. Each run of the aircraft is directed so that each photograph includes a portion of the ground photographed on the previous run and the operation of the camera is synchronised with the speed and height of the aircraft so that each photograph in a run includes a portion of the ground covered by the preceding photograph.



Each photograph presents the appearance of the ground in shades of black, grey and white, as if there were no height factor involved in the objects photographed. Trees, hills and buildings are not seen to have height, although this can be inferred from the associated shadows when these occur. However, when two photographs of the same objects but taken from slightly different positions are viewed through a pair of lenses – a stereoscope – the factor of depth or height becomes apparent, often in an exaggerated manner. Trees and hills appear as if raised up out of the photograph. Thus the use of a stereoscope on the overlapped portions of two adjacent photographs enables us to view the ground stereoscopically, as if observing from an aircraft.

Overlap

The extent to which the area covered by one photograph overlaps that covered by an adjacent one is usually expressed as a percentage. The *overlap* of consecutive photographs taken in the line of flight is about 60%, and is known as the *End Lap*. The overlap of adjacent runs is about 30% and is known as the *Side Lap*. The extent of overlapping ensures that any portion of the terrain appears in at least two photographs, and is therefore capable of being inspected stereoscopically, see Fig. 24. Only the overlapping areas are available for stereoscopic interpretation. Elsewhere distortion interferes with accuracy.

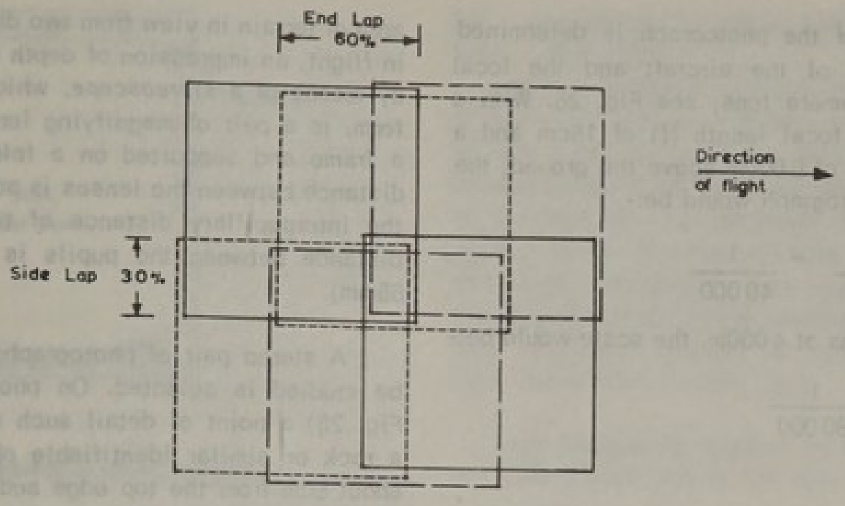


Fig. 24 Overlap in aerial photographs

Distortion in photographs

A photograph gives a perfect representation of the ground below only when certain conditions are fulfilled at the moment of camera exposure.

These conditions are:-

a. The aircraft must be at the correct height above the ground to maintain the desired scale (9.2 above).

b. The aircraft must have a horizontal attitude in flight to maintain the camera in a horizontal position. Deviations from the horizontal are termed *Tip* and *Tilt*.

c. The aircraft must be on correct course. Deviations from course are termed *Crab*.

d. The ground must be quite flat. Deviations from flatness affect the *Scale* of the photograph.

These ideal conditions are seldom, if ever, achieved. Fig. 25 illustrates the effects caused by tip, tilt, crab and undulating ground, from which it can be appreciated that the central portion of the photograph is less distorted than the outer portions.

With overlapping photographs, the outer portion can be discarded both for stereoscopic interpretations and for assembling to form a mosaic.

9.6 Scale of aerial photographs

The scales of photography in general use in this Branch are 1/50 000, 1/40 000 and 1/25 000. The scale indicates the relation between the area of the photograph and the area of ground photographed.

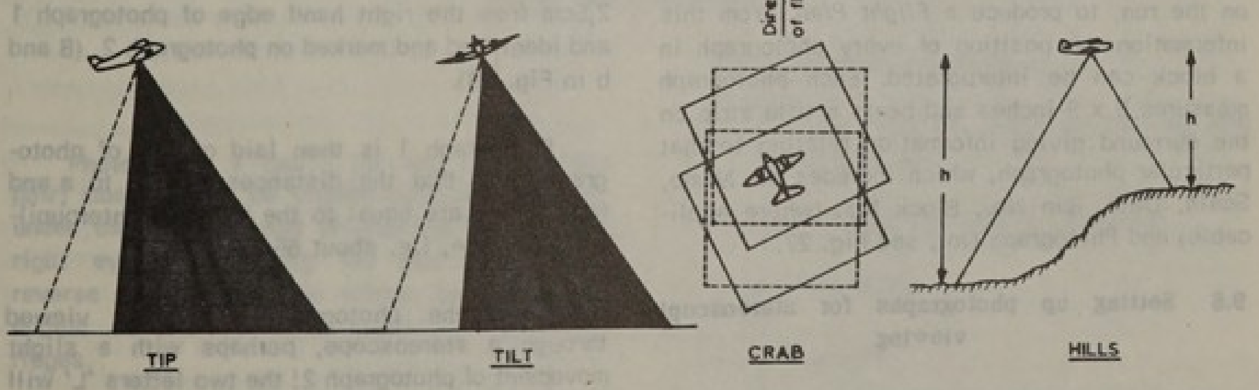


Fig. 25 Effect of the attitude of the aircraft on photographs

The scale of the photograph is determined by the altitude of the aircraft and the focal length of the camera lens, see Fig. 26. With a camera lens of focal length (f) of 15cm and a flying height (h) of 6 000m above the ground, the scale of the photograph would be:-

$$\frac{f}{h} = \frac{15}{600\,000} = \frac{1}{40\,000}$$

or with a 5cm lens at 4 000m, the scale would be:-

$$\frac{5}{400\,000} = \frac{1}{80\,000}$$

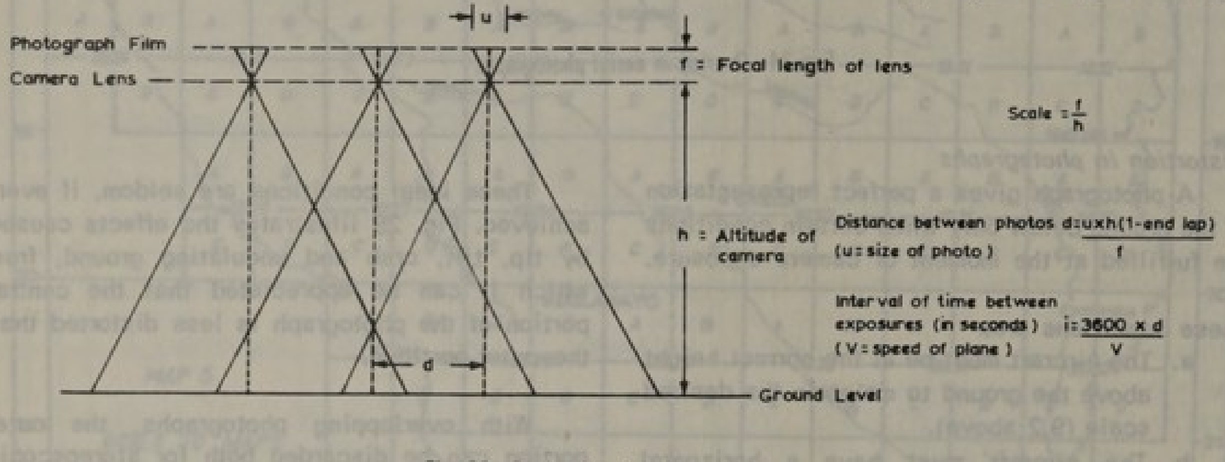


Fig. 26 Scale of aerial photographs

9.7 Identification of aerial photographs

Government has undertaken a 5 year programme to cover the entire country with 1/25 000 scale *Blanket Photography*, arranged in a series of *Blocks*. Blocks consist of a series of runs numbered within the block, and the individual photographs are numbered consecutively within each run. All photographs are indexed on a 1/250 000 scale map with individual photographs, (usually every 5th or 10th photograph) positioned on the run, to produce a *Flight Plan*. From this information the position of every photograph in a block can be interpolated. Each photograph measures 9 x 9 inches and bears a title strip on the surround giving information relating to that particular photograph, which includes the Name, Scale, Date, Run No., Block No. (where applicable) and Photograph No., see Fig. 27.

9.8 Setting up photographs for stereoscopic viewing

In order to view photographs stereoscopically two adjacent, overlapping photographs (a stereo-pair) are required. Since these contain a common area of terrain in view from two different positions in flight, an impression of depth can be obtained by means of a *stereoscope*, which in its simple form, is a pair of magnifying lenses mounted in a frame and supported on a folding stand. The distance between the lenses is adjustable to suit the interpupillary distance of the viewer. (The distance between the pupils is normally about 65mm).

A stereo pair of photographs of the area to be studied is selected. On photograph 1, (see Fig. 28) a point of detail such as a large tree, a rock or similar identifiable object is chosen about 5cm from the top edge and 2,5cm from the right hand edge of the photograph, and is marked with an 'L', (with a wax pencil) so that the corner of the letter just touches the point of detail, A.

The same point of detail is identified on photograph 2 and marked with an inverted 'L', a.

A further point of detail is selected and marked at a point 5cm from the bottom edge and 2,5cm from the right hand edge of photograph 1 and identified and marked on photograph 2, (B and b in Fig. 28).

Photograph 1 is then laid on top of photograph 2 so that the distances from A to a and from B to b are equal to the viewer's interpupillary distance, i.e. about 65mm.

When the photographs are now viewed through a stereoscope, perhaps with a slight movement of photograph 2, the two letters 'L' will appear to fuse to form a cross, and the detail on the photograph will appear in three dimensions.

Fig. 27 Annotation of aerial photographs

The front edge of the stereoscope should be maintained parallel to the line between A – a or B – b throughout movement over all the area of stereo-vision. Failure to do this will result in unnecessary eye strain.

After only a little practice the user should be able to lay down a stereo pair of photographs for viewing without the need for marking points of detail on each photograph.

9.9 Application in tsetse control operations

9.9.1 The Trace

As a preliminary measure to making a road or track, or building a fence, it is necessary to lay out a 'trace' or narrow track along the pre-arranged course, which would have been decided at Headquarters by reference to aerial photographs. The construction of roads and the erection of fences is preceded by cuts made by bulldozers. If errors should arise over bearings and distances they are much cheaper to correct from trace lines than from bulldozer cuts.

The equipment required by a party engaged on trace cutting should include:-

a. Instructions on the project with relevant bearings and distances.

b. The relevant aerial photographs and maps.

c. A stereoscope.

d. An oil prismatic field compass.

e. A 100ft surveyor's chain.

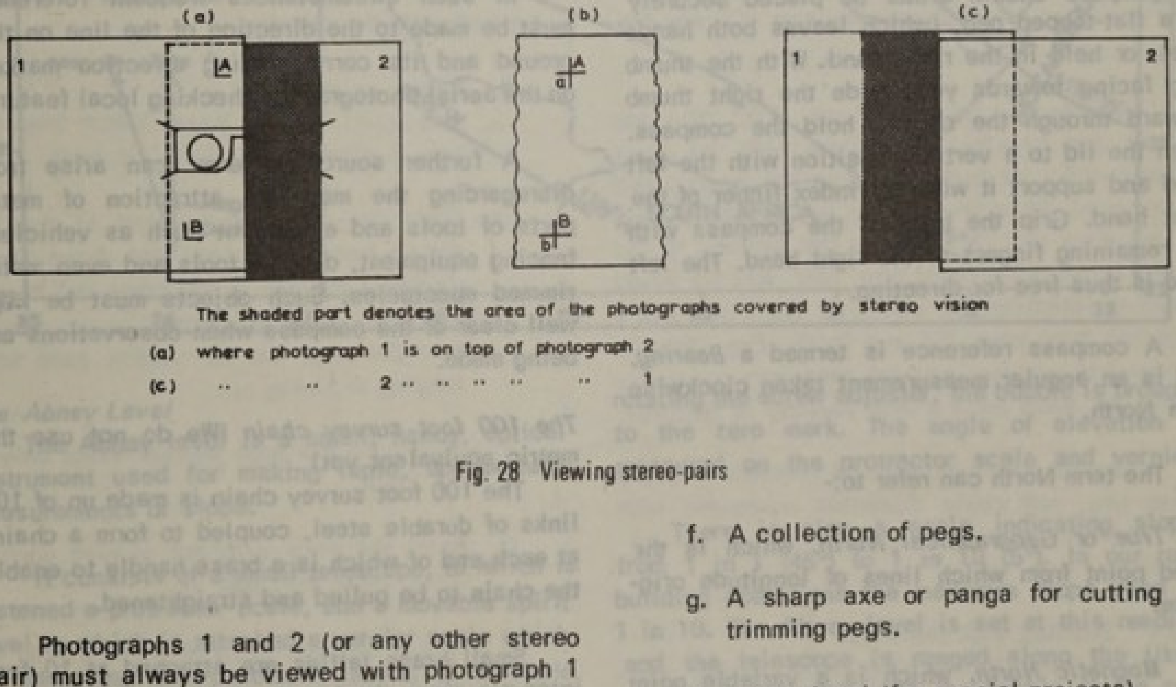


Fig. 28 Viewing stereo-pairs

Photographs 1 and 2 (or any other stereo pair) must always be viewed with photograph 1 under the left eye and photograph 2 under the right eye. Transposing the photographs will reverse the stereoscopic effect, and hills will appear as valleys, with rivers flowing along ridges.

Fig. 29 summarises the relationships between scale, areas and distances, for quick reference.

f. A collection of pegs.

g. A sharp axe or panga for cutting and trimming pegs.

h. Abney level (for special projects).

i. A sharp pencil.

j. A notebook.

k. Wax pencils.

l. Marking paint and paint brushes.

m. Binoculars.

n. A file for sharpening the axe or panga.

o. Two grass slashers.

p. A 4 lb hammer.

9.9.2 Equipment

The compass

This is usually the oil prismatic type, with a rotating disc immersed in oil which dampens the oscillations and permits of rapid readings. *It is a delicate instrument and great care must be exercised in its use.*

The rotating disc is calibrated in degrees from 0 to 360 which can be read through the movable prism eyepiece. The line of sight for taking bearings runs through the middle of the 'U' sight of the prism and the vertical black line on the glass of the compass lid. The base of the 'U' sight should appear just to make contact with the edge of the revolving disc when a reading is taken. When bearings are to be taken the compass should either be placed securely on a flat-topped peg, (which leaves both hands free), or held in the right hand. With the thumb ring facing towards you, slide the right thumb forward through the ring to hold the compass. Open the lid to a vertical position with the left hand and support it with the index finger of the right hand. Grip the base of the compass with the remaining fingers of the right hand. The left hand is thus free for directing.

A compass reference is termed a *Bearing,* and is an angular measurement taken clockwise from North.

The term North can refer to:-

True or *Geographical North,* which is the fixed point from which lines of longitude originate.

Magnetic North, which is a variable point near True North, and to which the needle of a compass points.

Grid North, which is an arbitrary point used for calculations involved in surveying and mapping. Except in certain localities, True North and Magnetic North do not coincide. The angle between the two directions as measured by an observer is termed *Magnetic Declination.* In Rhodesia, Magnetic Declination is always West of True North, and increases from 9° in the N.E. to almost 14° in the S.W. of the country. Map 6 illustrates *Isogonals* which are lines joining all points on the earth's surface having equal magnetic declinations.

It is very important to distinguish between a *True Bearing* and a *Magnetic Bearing* when setting out traces for roads, fences, etc., since confusing the two can produce errors in direction of up to 13° or more in some areas.

Bearings calculated in Headquarters for trace cutting instructions and sent to Field Staff *are always Magnetic Bearings.*

It is necessary to know that to convert a Magnetic Bearing to a True Bearing, the Magnetic Declination must be *subtracted,* and that to convert a True Bearing to a Magnetic Bearing the Magnetic Declination must be *added.* In operation, the compass can be seriously deflected from its normal position by the presence of local deposits of magnetic rock.

In such circumstances frequent reference must be made to the direction of the line on the ground and its corresponding direction marked on the aerial photographs, checking local features.

A further source of error can arise from disregarding the magnetic attraction of metal parts of tools and equipment such as vehicles, fencing equipment, digging tools and even metal rimmed spectacles. Such objects must be kept well clear of the compass when observations are being made.

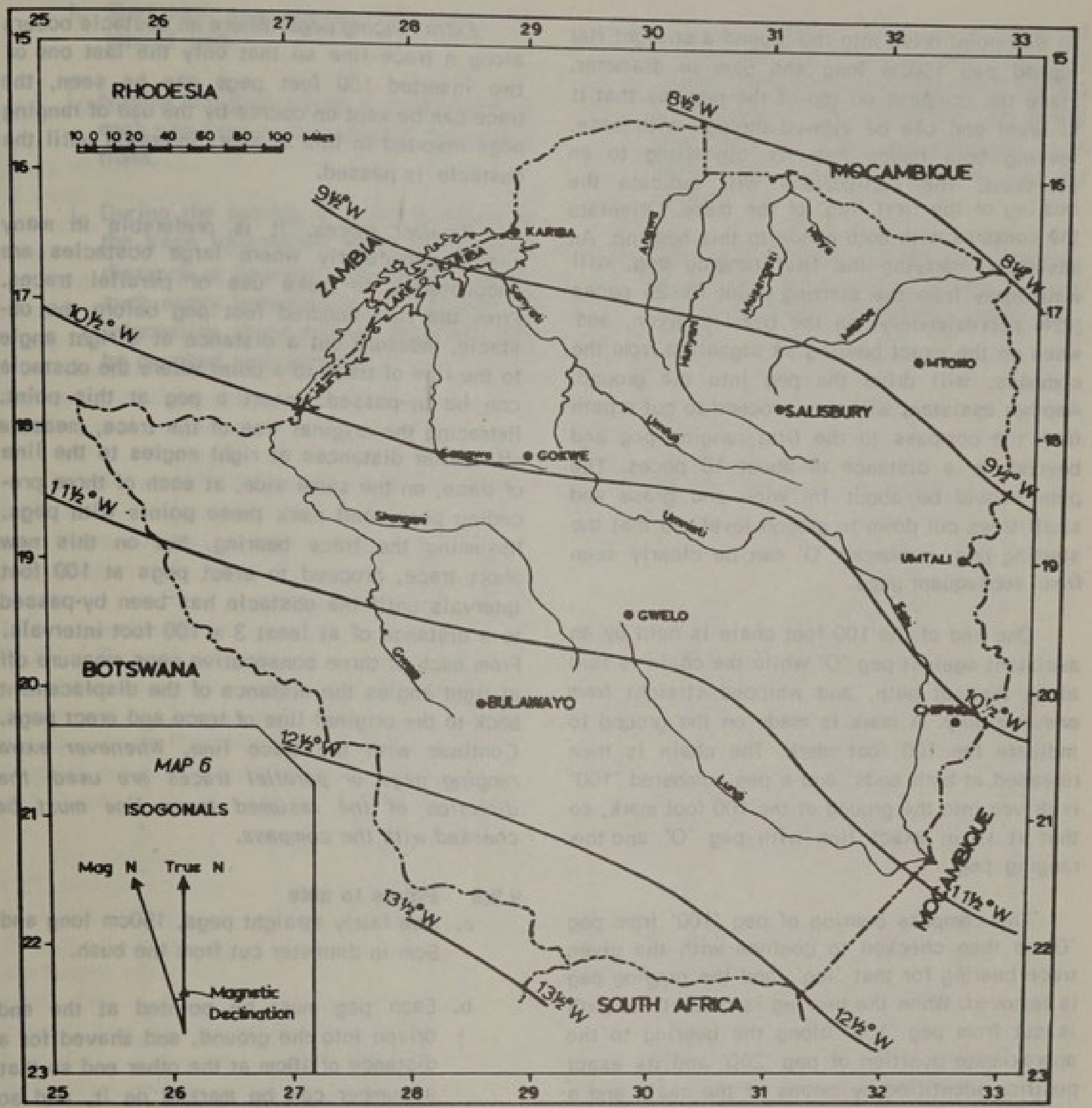
The 100 foot survey chain (We do not use the metric equivalent yet)

The 100 foot survey chain is made up of 100 links of durable steel, coupled to form a chain, at each end of which is a brass handle to enable the chain to be pulled and straightened.

Small brass tallies are attached at 10 foot intervals along the length of the chain to enable distances of less than 100 feet to be readily measured.

Care must be taken to ensure that the links are not bent in any way. Chains with bent links are inaccurate.

Before packing up the chain after use make sure that all links are straight.



The Abney Level

The Abney level is a small, handy, optical instrument used for making rapid, approximate measurements of slope.

It consists of a small telescope, to which is fastened a protractor scale, and a movable spirit level to which is attached a vernier scale which moves along the protractor scale. A movable reading lens covers the range of the protractor scale. By means of a prism the image of the bubble is seen through the telescope ranged alongside the object and a zero mark.

To measure the angle between the observer and an object, the vernier is set at zero, the object is sighted through the telescope, and by rotating the screw adjuster, the bubble is brought to the zero mark. The angle of elevation is measured on the protractor scale and vernier.

There is also a scale indicating slope, from 1 in 1 (45°) to 1 in 10 (5°). In our road building operations the maximum slope used is 1 in 10. The Abney level is set at this reading and the telescope is ranged along the likely course of the road, with the bubble at the zero mark. When a suitable site appears in the telescope, a ranging peg is driven into the ground at that point.

9.9.3 Cutting the trace

The starting point of any operation must be accurately identified from the instructions given.

At this point drive into the ground a straight flat topped peg 150cm long and 5cm in diameter. Place the compass on top of the peg, so that it is level and can be viewed through with ease, leaving both hands free for signalling to an assistant. The instructions will indicate the bearing of the first 'leg' of the trace. Orientate the compass with both hands to this bearing. An assistant, carrying the first ranging peg, will walk away from the starting point for 25 paces (22m approximately) on the bearing given, and when on the exact bearing as signalled from the compass, will drive the peg into the ground. Another assistant will then proceed to cut a path from the compass to the first ranging peg and beyond for a distance of about 10 paces. The path should be about 1m wide and grass and small trees cut down to ground level, so that the starting peg, numbered 'O' can be clearly seen from subsequent pegs.

One end of the 100 foot chain is held by an assistant against peg 'O' while the chain is laid along the cut path, and whipped straight *from one end only*. A mark is made on the ground to indicate the 100 foot mark. The chain is then released at both ends, and a peg numbered '100' is driven into the ground at the 100 foot mark, so that it is in exact line with peg 'O' and the ranging peg.

The compass bearing of peg '100' from peg 'O' is then checked to conform with the given trace bearing for that 'leg', and the ranging peg is removed. When the bearing is correct the path is cut from peg '100' along the bearing to the approximate position of peg '200' and its exact position identified by means of the chain and a sighting from pegs 'O' and '100'. Peg '200' is driven into position and the procedure continues along the trace until a new bearing is required.

Compass bearings *must* be checked at every tenth peg, and chain distances measured with the chain held or laid *horizontally* as far as possible.

9.9.4 Dealing with obstacles

It is likely that during trace cutting operations obstacles such as rock outcrops, rivers, ant heaps or large trees will be encountered which will prevent the above procedure from being followed.

In these circumstances use can be made of extra ranging pegs to overcome the obstacle, or of parallel traces to avoid it.

Extra ranging pegs. Where an obstacle occurs along a trace line so that only the last one or two inserted 100 feet pegs can be seen, the trace can be kept on course by the use of ranging pegs inserted in line at short intervals until the obstacle is passed.

Parallel traces. It is preferable in many cases, particularly where large obstacles are encountered, to make use of parallel traces. From the last hundred foot peg before the obstacle, measure out a distance at a right angle to the line of trace to a point where the obstacle can be by-passed. Insert a peg at this point. Retracing the original line of the trace, measure off similar distances at right angles to the line of trace, on the same side, at each of three preceding pegs, and mark these points with pegs. Resuming the trace bearing, but on this new short trace, proceed to erect pegs at 100 foot intervals until the obstacle has been by-passed to a distance of at least 3 x 100 foot intervals. From each of three consecutive pegs measure off at right angles the distance of the displacement back to the original line of trace and erect pegs. Continue with the trace line. *Whenever extra ranging pegs or parallel traces are used, the direction of the resumed trace line must be checked with the compass.*

9.9.5 Points to note

a. Use fairly straight pegs, 150cm long and 5cm in diameter cut from the bush.

b. Each peg must be pointed at the end driven into the ground, and shaved for a distance of 10cm at the other end so that a number can be marked on it, and so that the pegs can be readily seen when ranging or lining up.

c. Writing on the pegs should relate only to the trace.

d. Insert the pegs with the shaved portion facing *away* from peg '0'.

e. Hammer the pegs well into the ground so that they are firmly held and *vertical*. Ensure that the trace line is quite *straight*.

f. Start points and end points of each leg of a trace must be clearly marked.

g. Every 10th peg must be a flat topped peg on which the compass can be placed for a compass bearing check.

h. Start each new bearing (leg) with a flat topped peg.

i. Number the pegs afresh from the start of each new bearing according to the instructions.

j. During the cutting of a trace, errors in the trace information sheet in regard to distance or bearings may appear. Report such errors immediately so that both the information sheet and the trace line may be checked and rectified.

k. Do not attempt to correct a misdirected trace line by ending it at the correct end point. Measure the distance and bearing of the correct end point from the wrong end point and note the readings. From these the correct trace line can be plotted.

l. Always record on the trace information sheet the occurrence of rocks, stream crossings, pans, footpaths, roads etc.

MAPPING AND AIR PHOTOGRAPHY DATA

Scale	1 cm on Map or Photo =	1 cm^2 on Map or Photo =	1 Km =	Linear Distance per Photo (9" x 9" Format)	Gross Area per Photo (9" x 9" Format)	Nett Area per Photo 60% and 30% side overlap (9" x 9" Format)	Flying height (above ground level)	
							Camera f-6"	Camera f-3.5"
1/25,000	250m	6.25 Ha	4cm	5.72 Km	32.66 Km^2	9.14 Km^2	3810 m	2223 m
1/40,000	400m	16 Ha	2.5cm	9.14 Km	83.65 Km^2	23.42 Km^2	6096m	3556m
1/50,000	500m	25 Ha	2cm	11.43 Km	184.39 Km^2	37.13 Km^2	7620m	4445m
1/100,000	1 Km	1 Km^2	1 cm	22.86 Km	522.36 Km^2	146.26 Km^2	15240m	8890m
1/250,000	2.5 Km	6.25 Km^2	4 mm	—	—	—	—	—
1/1,000,000	10 Km	100 Km^2	1 mm	—	—	—	—	—

Fig. 29 Mapping and air photography data

10. FENCES IN TSETSE CONTROL OPERATIONS

10.1 The purpose of fences

The restriction of game and cattle movements plays an important part in the control of disease of stock. Fences are used in tsetse control operations to prevent cattle and game from entering areas where shooting operations are being carried out and to demarcate our areas of operation. Strong *Game Fences* are constructed between these areas and the areas where game and tsetse live unmolested, and *Cattle Fences* are erected between the operation areas and the tsetse free, stock raising areas.

The fences constructed by this Branch are built to a high standard of excellence, which must be maintained by regular and conscientious inspection and repair.

10.2 Specifications

10.2.1 The game fence

Game fences are constructed of high strain, galvanised iron wire of 12/14 S.W.G. and 6,00 kN breaking strain supported on steel posts. These supports are termed *Standards, Intermediate Posts* and *Corner Posts,* and *Strainer Units.*

The Standard is a 2,74m length of 12,7mm (½") plough or I beam, of mass 10 kg/m. Holes of 10mm diameter are made along its length, through which lengths of 12 S.W.G. binding wire are looped to support the fence wires against the head. One end is pointed for driving into the ground. At a distance of 0,91m from the point, a hole marks the level to which the post is sunk into the ground, by means of the cylindrical post hammers provided. Fig. 30.

Intermediate Post

The intermediate post is a 3,05m length of rail of mass 40 kg/m. Holes are made along its length through which lengths of 12 S.W.G. binding wire are looped to support the fence wires against the head. The hole at a distance of 1,07m from the base marks the level to which the post is to be sunk into the ground, (see Fig. 31).

A hole of about 0,25m diameter is dug to a depth of 1,07m opening up at ground level to a diameter of 0,6m. The post is introduced in a *vertical* position. A concrete mix, consisting of 1 cement: 3½ sand and 5 stone is added and tamped down, so that it forms an inverted cone at ground level, see Fig. 31. Tests have shown that posts are satisfactorily embedded if $0{,}108m^3$ of concrete is required to fill the holes. Holes of this capacity should be the standard.

The Corner Post

At each point where the line of the fence changes direction a corner post is erected, and supported by an anchored stay wire which bisects the outside angle of the corner. It, also, is a 3,05 m length of rail of mass 40 kg/m. Holes are made along its length through which lengths of 12 SWG binding wire are looped to support the fence wires against the head, which must face the *outside* of the bend. A hole at 1,07 m from the base marks the level to which the post is to be sunk into the ground, and embedded in concrete, as for the Intermediate post.

The stay wire is fashioned from 2 strands of 8 SWG galvanised wire, of about 20 m length, looped through the uppermost hole in the corner post, with the loose ends brought down and securely tied around a cylindrical block of concrete, as an anchor. The concrete blocks are precast in the moulds provided of volume $0{,}048\,m^3$.

To obtain the correct angle for the stay wire, mark a point on each arm of the fence wire, six paces from the corner. Stand at the spot halfway between these two points and face the corner post. The stay wire should line up with you and the corner post.

A hole of 1,22m depth, where it is practical, and of sufficient capacity is dug to embed the anchor securely, ensuring that the stay wire is not bent between the top of the post and the anchor. The hole is filled, and the four stay wires brough under tension by using a Spanish windlass.

The Strainer Unit Fig. 32

The unit consists of a pair of intermediate posts fitted with a crossbar between wires 7 and 8, counting from the ground. They are erected at intervals of 1500 metres and the fence wires are pulled up to them to proper tension and tied off on the farther post. The new strands are tied to the other post. The crossbar, a 1,83m length of 50,8mm pipe, fits at each end into a socket which is welded to a malleable iron plate, 108mm x 101,6mm x 6,4mm. Each plate is secured to the post by two 31,8mm x 9,5mm bolts (each with a nut and washer) which pass through corresponding holes drilled through the posts.

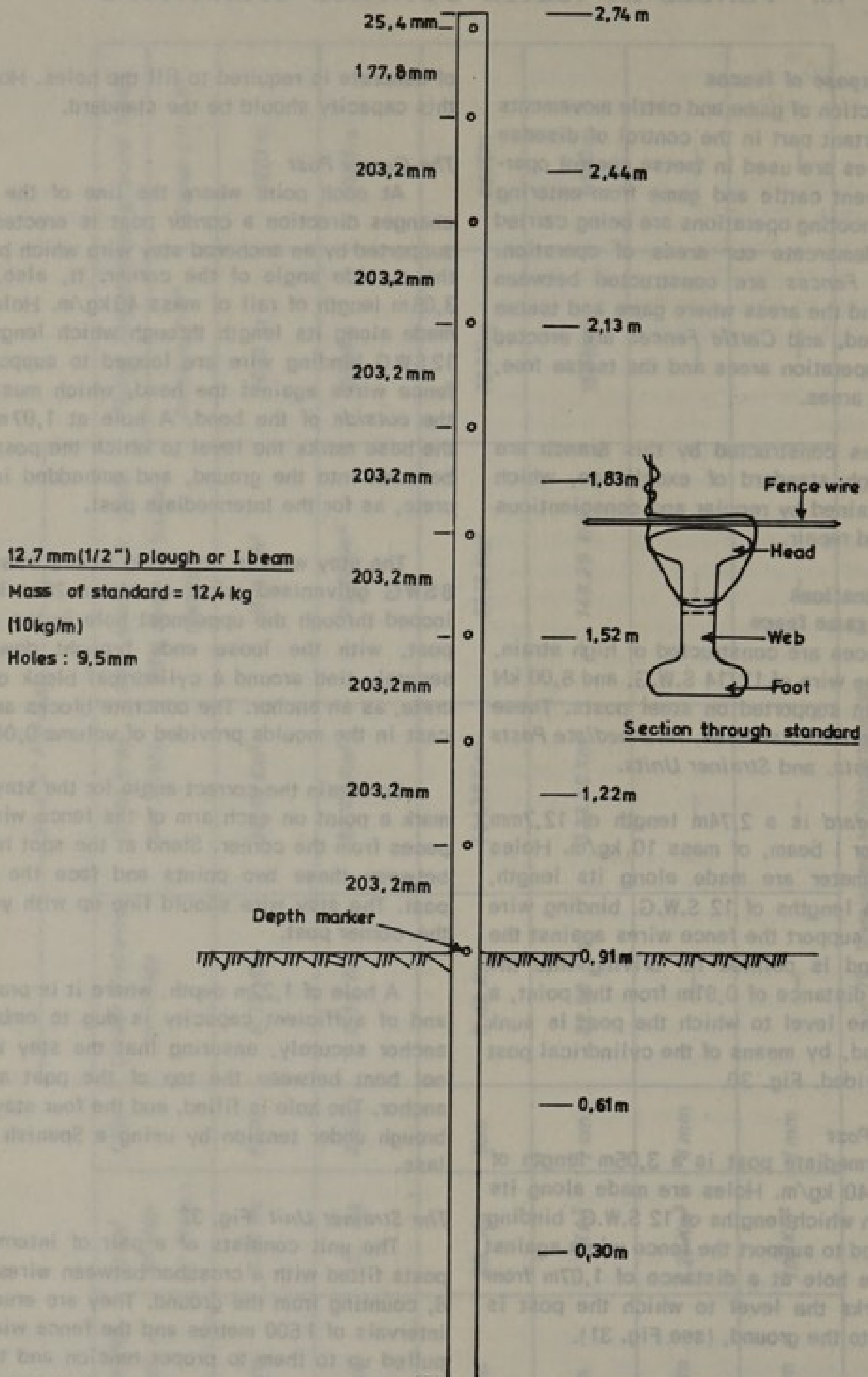


Fig. 30 The fence standard

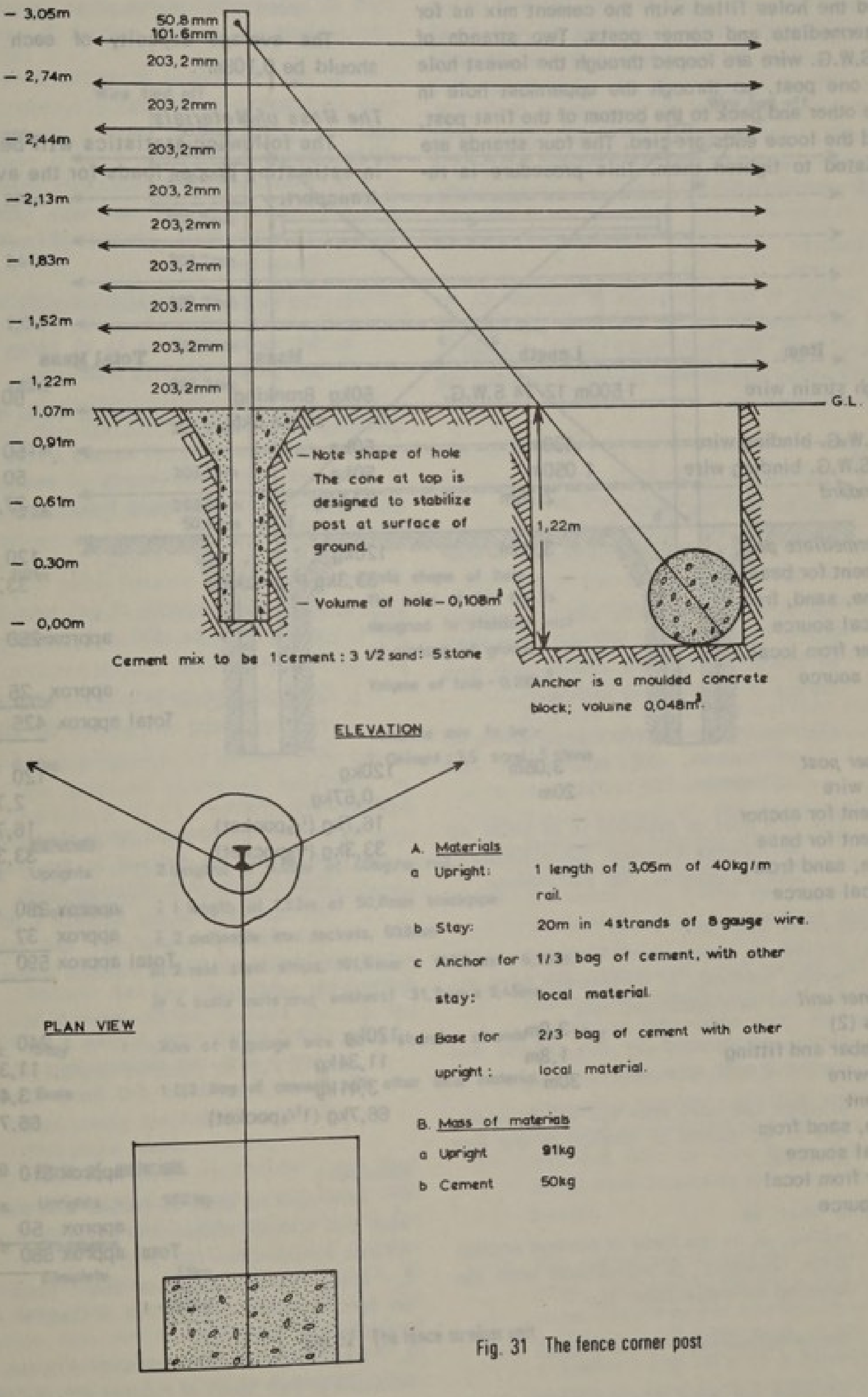


Fig. 31 The fence corner post

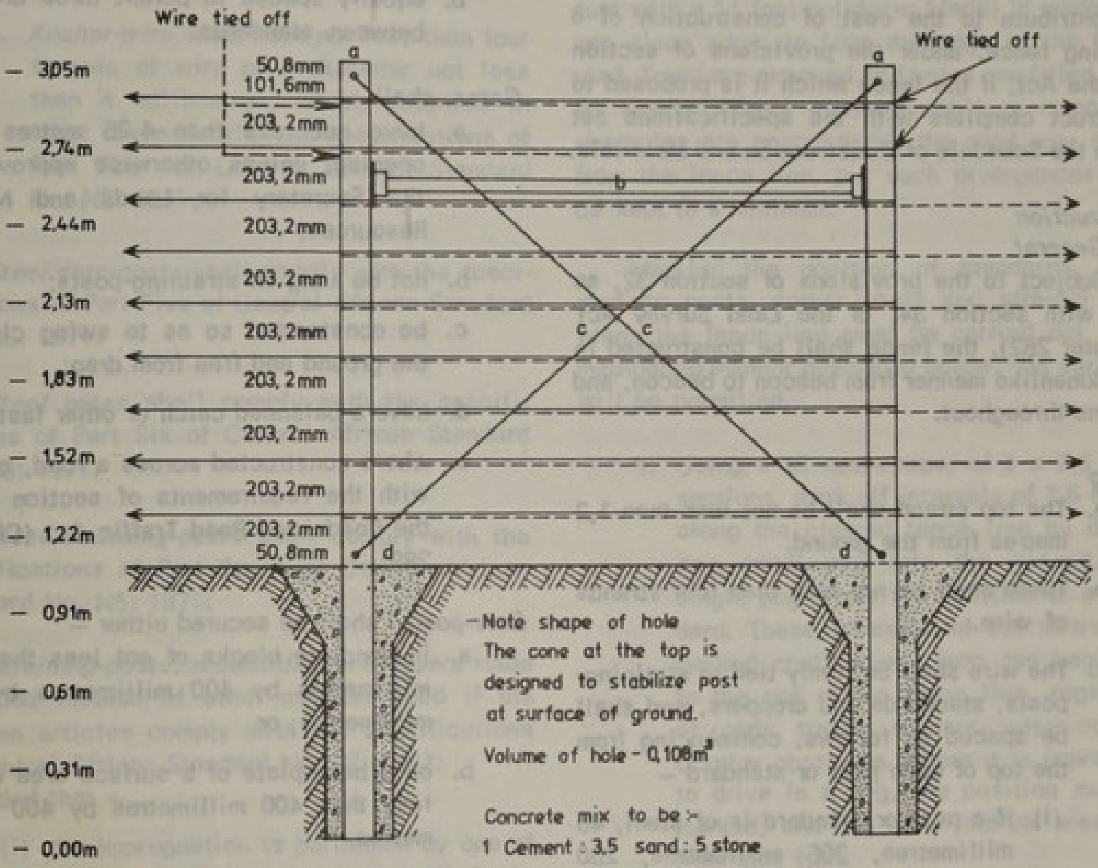
Two holes are dug each as for the intermediate posts. The articulated unit is slid into the holes, with the posts in the line of the fence, and the holes filled with the cement mix as for intermediate and corner posts. Two strands of 8 S.W.G. wire are looped through the lowest hole of one post, up through the uppermost hole in the other and back to the bottom of the first post, and the loose ends are tied. The four strands are twisted to tighten them. This procedure is repeated using the remaining pair of holes to produce a cross stay. A length of 30m is ample for this operation.

The average capacity of each post hole should be 0,108m³.

The Mass of Materials

The following statistics will be of value in estimating proper loads for the available transport.

Item	Length	Mass	Total Mass	
High strain wire	1 500m 12/14 S.W.G.	50kg Breaking strain 6kN	50	kg
8 S.W.G. binding wire	439m	50kg	50	kg
12 S.W.G. binding wire	1 050m	50kg	50	kg
Standard	2,75m	27,5kg	27,5	kg
Intermediate post	3,05m	120kg	120	kg
Cement for base	–	33,3kg (⅔pocket)	33,3	kg
Stone, sand, from local source			approx 250	kg
Water from local source			approx 25	kg
			Total approx 425	kg
Corner post	3,05m	120kg	120	kg
Stay wire	20m	0,67kg	2,7	kg
Cement for anchor	–	16,7kg (⅓pocket)	16,7	kg
Cement for base	–	33,3kg (⅔pocket)	33,3	kg
Stone, sand from local source			approx 380	kg
			approx 37	kg
			Total approx 590	kg
Strainer unit				
Posts (2)	3,0m	120kg	240	kg
Crossbar and fitting	1,8m	11,34kg	11,3	kg
Stay wire	30m	3,41kg	3,4	kg
Cement	–	66,7kg (1⅓pocket)	66,7	kg
Stone, sand from local source			approx 510	kg
Water from local source			approx 50	kg
			Total approx 880	kg



A. Materials

a.	Uprights	2 lengths of 3,05m of 40kg/m rail.
b.	Crosspieces	i 1 length of 1,83m of 50,8mm blackpipe.
		ii 2 malleable iron sockets, 50,8mm
		iii 2 mild steel strips, 101,6mm x 107,9mm x 6,3mm.
		iv 4 bolts (nuts and washers) 31,7mm x 9,45mm.
c.	Stay	30m of 8 gauge wire for 2 stays, 4 strands per stay.
d.	Base	1 1/3 bag of cement, with other local material.

B Mass of materials

a.	Uprights	182 kg
b.	Crosspiece complete	11kg
		193kg

Fig. 32 The fence strainer unit

10.2.2 The cattle fence

These specifications comply with those set out in Government Fencing Specifications, 1973, Rhodesia Notice No. 509 of 1973, in terms of the Fencing Act (Cap. 185). Subject to the provisions of this notice, the Government will be prepared to contribute to the cost of construction of a dividing fence, under the provisions of section 5 of the Act, if the fence which it is proposed to construct complies with the specifications set out in the Schedule of Construction and Materials.

Construction

General

Subject to the provisions of section 32, as read with section 34, of the Land Survey Act (Chapter 262), the fence shall be constructed in a workmanlike manner from beacon to beacon, and on line throughout.

Wiring

a. The top strand shall be not less than 1,2 metres from the ground.

b. There shall be not less than four strands of wire.

c. The wire shall be firmly tied to straining-posts, standards and droppers, and shall be spaced as follows, commencing from the top of each post or standard –

   (i) if a post or standard is of steel, 40 millimetres, 305 millimetres, 250 millimetres, 195 millimetres; or

   (ii) if a post or standard is of wood, 40 millimetres minimum, 305 millimetres, 250 millimetres, 195 millimetres.

Straining-posts shall be –

a. drilled, or, in the case of treated wooden posts, notched, to correspond with the required wire-spacings; and

b. firmly established in the ground and anchored with wire; and

c. situated not more than 420 metres apart, and at all points of change in the line of fence.

Standards shall be –

a. drilled, or, in the case of treated wooden posts, notched, to correspond with the required wire-spacings; and

b. firmly established in the ground; and

c. situated not more than 14 metres apart.

Droppers shall be –

a. drilled or crimped, or, in the case of treated wooden posts, notched, to correspond with the required wire-spacings; and

b. equally spaced to permit three droppers between standards.

Gates shall –

a. have not less than 4,25 metres clear opening, unless otherwise approved by the Secretary for Lands and Natural Resources;

b. not be hung on straining-posts;

c. be constructed so as to swing clear of the ground and free from drag;

d. have a balanced catch or other fastener;

e. where constructed across a road, comply with the requirements of section 33 of the Roads and Road Traffic Act (Chapter 289).

Gate-posts shall be secured either –

a. in concrete blocks of not less than 400 millimetres by 400 millimetres by 300 millimetres; or

b. on a base-plate of a surface area of not less than 400 millimetres by 400 millimetres.

Cattle-grids shall –

a. not be constructed other than by a road authority, as defined in the Roads and Road Traffic Act (Chapter 289), without the approval of the Secretary for Lands and Natural Resources, and then only according to specifications given by him for each grid; and

b. where constructed across a public road, comply with the requirements of section 32 of the Roads and Road Traffic Act (Chapter 289).

Materials

1. *Fencing-wire* shall be barbed wire complying with the specifications of Part One of Central African Standard No. N5: 1971.

2. *Steel fencing-standards* shall comply with the specifications of Part Two of Central African Standard No. N5: 1971.

3. *Steel droppers* shall comply with the specifications of Part Three of Central African Standard No. N5: 1971.

4. a. *Tying-wire* for both standards and droppers shall be of a diameter of not less than 2,65 millimetres, and otherwise shall comply with the specifications of Part Four of Central African Standard No. N5: 1971.

   b. *Anchor-wire* shall have not less than four strands of wire of a diameter not less than 4 millimetres, which complies in other respects with the specifications of Part Four of Central African Standard No. N5: 1971.

5. *Steel gate-posts* shall comply with the specifications of Part Five of Central African Standard No. N5: 1971.

6. *Steel gates* shall comply with the specifications of Part Six of Central African Standard No. N5: 1971.

7. *Steel straining-posts* shall comply with the specifications of Part Seven of Central African Standard No. N5: 1971.

8. *Straining-posts, standards and droppers* made of wood instead of steel may be used if the wooden articles comply with the specifications of Central African Standard No. 07: 1972: Provided that —

(i) the impregnation is performed by one of the pressure processes specified in paragraph 6.3.1. of Central African Standard No. 07: 1972, and only with creosote or creosote containing additives approved by the Standards Association of Central Africa; and

(ii) the articles bear the stamp of the manufacturer and the Standards Association of Central Africa, except that, in the case of droppers, one dropper in every bundle of 20 shall be so stamped.

10.3 Constructing the fence

10.3.1 The game fence

The line of a fence is decided upon from inspection of aerial photographs, with due regard to its function and to the topography of the country through which it will run. For the purpose of ready inspection and repair of fences, to render them more visible to game and as a fire precaution they are flanked on one side by a road, usually on the side towards the area of operations, and on the other by a cleared strip, capable of being converted into a road.

The trace for the fence (see 9.9.1 'The trace') is cut along the bearings and distances given from the inspection of aerial photographs. The initial clearing is made either by hand labour, or as is now the general practice, by bulldozer. A clearing from 6,3 to 8,4 metres wide (1½ or 2 cuts with a 14 foot bulldozer blade) is made with one clean edge, to form the edge of the future road. Trees are removed and holes are filled along its course. Where insurmountable or immovable obstacles are encountered, the road may depart from the fence line, but such divergences must be kept to a minimum.

Marking the position of standards, intermediate posts, corner posts and strainer units along the fence line must be carried out in the methodical manner described below. No variation will be permitted.

a. Using a 30 metre tape, of 4 x 7,5 metre sections, mark off intervals of 7,5 metres along the cleared fence line by driving *one* small peg into the ground. This single peg marks the position of a standard. These intervals of 7,5 metres are marked continuously from the beginning to the end of the fence line, regardless of roads, tracks, corners, water courses or other obstacles. Where it is impractical to drive in a peg, the position must be marked, and the next interval measured from that spot.

b. Every interval of 300 metres (10 x 30 metre tapes) from the start will be marked by driving a *second* peg alongside the 7,5 metre peg. These two pegs indicate the position of an intermediate post.

c. Every interval of 1 500 metres (50 x 30 metre tapes) from the start will be marked by driving *two* pegs into the ground, alongside the 7,5 metre peg. These three pegs indicate the position of the centre point of a strainer unit. The uprights of the strainer unit will straddle this point, and will thus be only about 6,5m from the nearest standards when sunk into the ground.

d. The corner posts will be sited at the points indicated in the trace line instructions. They may not correspond with the positions of 7,5 metre pegs. It the site of a standard peg falls at a distance of *3 metres or more* from a corner post, the peg will be driven into the ground, but if the site of a standard peg is less than 3 metres from a corner post, the peg, and standard, will be omitted.

e. If the position for an intermediate post falls at a point less than 100 metres from a corner post, a standard will be erected in place of an intermediate post, and the position for the next intermediate post will be 300 metres from that spot.

f. If the allocated position for a strainer unit falls within 75 metres of a corner, the strainer unit will be erected so as to straddle the *tenth* 7,5 metre peg *before* the corner (75 metres before the corner). The position of the next strainer will be 1 500 metres from the allocated position, not from the actual site of the strainer unit. Strainer units *must not* be erected at corners.

g. The fence will be erected to follow the insertion of the pegs. Standards will be erected at the sites of single pegs, intermediate posts at the sites of double pegs, and strainer units at the sites of treble pegs, (allowance being made as in (e) and (f) above).

h. The posts will be erected so that the head of the posts will face the expected impact from game animals. This means that, generally, the foot of the rails will face towards the service road or track, and the fence wires, resting against the head of the rail will face away from the service road in relation to the support. But, on corners, the posts will be turned so that the head of the rail and not the 12 S.W.G. attaching wire will bear the strain as the fence wires are strained up.

i. Where it is necessary to install gates in the fences at road crossings or to erect temporary barriers across river courses, these will be fitted into the intervals of 7,5 metres, but a strainer unit will be erected where the fence reaches the road or river, and another on the far side where it resumes its course. These will be in addition to the strainer units at 1 500 metre intervals. If the position for a gate or river crossing falls within 100 metres of the site for a strainer unit, the strainer unit must be sited at the position of the gate or river crossing.
When the position of a strainer unit has to be changed from the regular 1 500 metre sequence, the position of the next strainer unit will be 3 000 metres from the previous regularly sited unit.

j. The length of the fence will be progressively calibrated in kilometres.
Kilometre Ticket *No. 1* will be attached to the 13th standard after passing three intermediate posts (3 x 300) + (13 x 7,5)m = 997,5m. Kilometre Ticket *No. 2* will be attached to the 26th standard after passing the first strainer unit and the fifth intermediate post (1 500) + (300) + (26 x 7,5)m = 1 995m.
Kilometre Ticket *No. 3* will be attached to the centre point of the third strainer unit. (The distance between the first and third of any trio of regular strainer units is exactly 3km. The interpolated strainer units at road or river crossings are not used in this calibration, unless they coincide with kilometre marks). From this point the process is continuous. After each kilometre distance divisible by 3, the next kilometre distance (4, 7, 10, 13 etc) is arrived at as for Kilometre Ticket No. 1. For kilometre distances of one less than a number divisible by 3, (5, 8, 11, 14 etc) the procedure is as for Kilometre Ticket No. 2. Kilometre distances exactly divisible by three fall at alternate regular strainer units.

The sequence of work should be:–

a. Instructions regarding distances, bearings, rate of progress, etc. are given from Headquarters to the trace cutter.

b. The trace cutting gang cuts the trace.

c. Approval of the trace line is given from Headquarters.

d. The bulldozer cuts along the trace, according to instructions.

e. The cut is approved by Headquarters.

f. Materials and labour are moved on site.

g. The pegging gang marks the positions of the standards, intermediate posts and strainer units. The positions of corner posts are as indicated by the trace cutter.

h. The post hole excavators make holes for intermediate posts, corner posts and and anchors and for strainer units at the points indicated.

i. The post erection gang erect the intermediate posts, corner posts and strainer units, and embed them in concrete, and bury the corner post anchors.

j. The standards are driven in, maintaining a straight line.

k. The fence wire is attached loosely to the supports, using two loops of 12 S.W.G. wire, through the corresponding hole in the web of the support and around the fence wire, and twisting to finish off.

l. The wire is strained at 1 500m intervals and at road or river crossings.

m. The ironwork is painted.

n. The work is frequently inspected by the officers in charge.

10.3.2 The cattle fence

Cattle fences are erected so as to comply with the specifications set out in Government Fencing Specifications, Rhodesia Notice No. 509 of 1973, shown in 10.2.2.

h. The post hole excavators make holes for intermediate posts, corner posts and end anchors and for strainer units at the points indicated.

i. The post erection gang erect the intermediate posts, corner posts and strainer units, and embed them in concrete, and bury the corner post anchors.

j. The standards are driven in, maintaining a straight line.

k. The fence wire is attached loosely to the supports, using two tones of 12 S.W.G. wire through the corresponding hole in the web of the support, tied around the fence wire, and twisting to finish off.

l. The wire is strained at 1500m intervals and at road or river crossings.

m. The ironwork is painted.

n. The work is frequently inspected by the officers in charge.

10.3.3. The cattle fence.

Cattle fences are erected so as to comply with the specifications set out in Government Fencing Specifications, Botswana Notice No. 109 of 1972 (shown in 10.3.3).

11. THE TRYPANOSOME

11.1 Introduction

Trypanosomes belong to a large group of animals, the *Protozoa,* the members of which possess the common features that the body is composed of a single cell, that they live their active lives surrounded by fluid and that they multiply by dividing into two or more daughter cells. All their vital activities – feeding, digestion, respiration, excretion, movement and reproduction – are carried out within this single cell. Some protozoa exhibit marked sexual differences but no such specialisation has been recorded in the trypanosomes. The more complex multicellular animals begin their lives from single male and female generative cells which live for a time as protozoans.

The group has recently (Hoare, 1972) been revised and reclassified, inevitably involving some new nomenclature. Where necessary these new terms have been adopted.

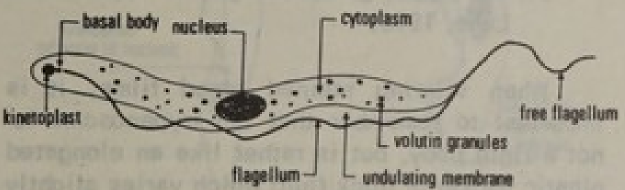


Fig. 33 Structure of a trypanosome

11.2 Morphology and life history

The trypanosomes found in the blood of mammals form a group of elongate protozoa that are mobile, swimming by means of eel-like movements of the body and its undulating membrane, aided, in some cases, by an anterior, whip-like organ, the *Free flagellum.*

The body of the trypanosome is composed of protoplasm, which is the fundamental living substance. It is enclosed in a fairly resistant envelope, the *pellicle,* which gives the organism its characteristic shape. The general protoplasm of the cell is called the *cytoplasm,* which can be seen through the microscope to be faintly granular. Embedded in the cytoplasm is a concentrated mass of *protoplasm,* the *nucleus,* which controls the general activities of the cell, and plays a vital part in the reproductive process. In stained preparations of trypanosomes the nucleus shows up under the microscope as a rounded, centrally placed deeply staining body. In such preparations a smaller, deeply staining body the *kinetoplast* is seen. The shape, size and position of the kinetoplast are characteristic of certain species of trypanosome. It is one of the sites of production of the chemical substances, enzymes, which organise the manufacture of the particular proteins which go to make the protoplasm of the trypanosome, Fig. 33.

The kinetoplast is always situated close to the *basal body* from which the flagellum arises. In the bloodstream forms of trypanosomes the flagellum grows out from the basal body, situated posteriorly to the nucleus, runs forward along the side of the body as a tubular extension of the pellicle, and forms the outer support for the fin-like *undulating membrane* which attaches the flagellum to the body. It may terminate at the anterior end of the body or continue as a *free flagellum.* The trypanosomes found within the tsetse may be of this type, or the kinetoplast, basal body and origin of the flagellum may be anterior to the nucleus.

The trypanosome is an animal, and feeds on complex foods such as proteins, fats and carbohydrates in solution. These substances, present in the plasma of the host, are absorbed by the trypanosome, and, through enzyme action, provide its vital energy and the basic materials from which it builds its own protoplasm. These processes, known collectively as *metabolism,* produce waste materials which are excreted into the plasma of the host. It also absorbs oxygen from its liquid environment and liberates carbon dioxide into it.

When the trypanosome reaches maturity, it divides by a process of binary fission, Fig. 34. The kinetoplast divides into two. A new basal body develops alongside the old one and from it a new flagellum grows out from the side of the body of the trypanosome, and forward within its own extension of the pellicle like a finger in a glove. The nucleus divides into two as the new flagellum increases in length. When a duplicate set of organs has been produced, the body itself divides into two, starting at the anterior end, resulting in two detached daughter trypanosomes. This doubling process can take place within the

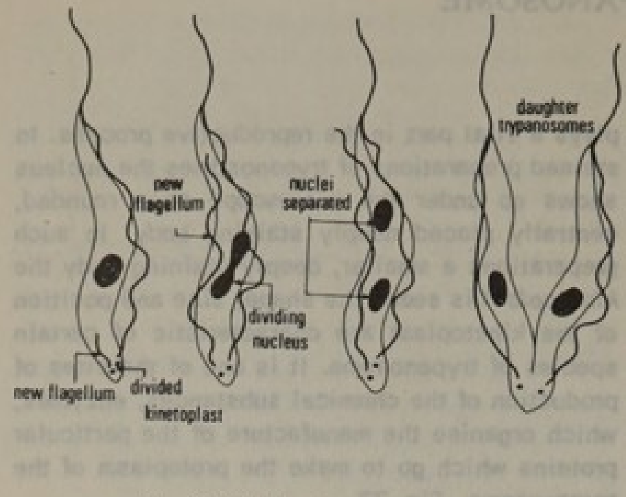


Fig. 34 Division of a trypanosome

bodies of both vertebrate host and of the tsetse fly, and can produce enormous numbers of trypanosomes within a short time.

11.3 Pathogenic trypanosomes transmitted by the tsetse fly

The trypanosomes transmitted by the tsetse fly live at the expense of their hosts, and are thus parasites. Some produce a disease in certain mammalian hosts, and are therefore also *pathogenic.* The pathogenic trypanosomes transmitted by the tsetse fly spend their lives either in the blood or tissues of the vertebrate host, or within the body of the tsetse fly. They cannot survive elsewhere, and die when the host animal dies.

The tsetse fly, which feeds entirely on blood, is well suited to act as a *vector* or carrier of the trypanosome. When the fly feeds on an infected animal it ingests the blood form of the trypanosomes with its meal. These undergo a cycle of development and multiplication within the fly and ultimately appear in the mouthparts as the infective *metacyclic trypanosomes,* or *metatrypanosomes,* in a position to be injected with the saliva of the fly at a subsequent meal. This process is known as *cyclical transmission* and is the normal manner of transmitting the disease. However, *direct* or *mechanical transmission* can occur when blood forms of trypanosomes taken up by the fly during a meal survive within, or upon the mouthparts, and, without undergoing any form of development, are transferred to a new vertebrate host when the fly feeds again. Such an event could occur when a tsetse fly is interrupted during feeding, and resumes feeding on another host after a brief interval. A hypodermic needle contaminated with blood forms of trypanosomes might also serve to transmit the disease in this way.

Although direct transmission of trypanosomiasis by blood sucking flies other than tsetse has been found to occur elsewhere in Africa, and in S. America where *T.vivax* is enzootic, attempts to demonstrate it experimentally in this country have achieved such very limited success that this mode of transmission is considered to be unimportant here.

11.3.1 Classification and life history

The blood forms of the pathogenic trypanosomes exhibit distinct morphological characteristics by which the various species can be identified. Within the tsetse fly, however, the changes undergone by the trypanosomes during development make identification difficult and uncertain, except by the expert, and they are best described as belonging to one or another group according to their distribution and development. The groups are:-

a. the *vivax* group (Subgenus *Duttonella* Chalmers, 1918)

b. the *congolense* group (Subgenus *Nannomonas* Hoare, 1964)

c. the *brucei* group (Subgenus *Trypanozoon* Lühe, 1906)

When viewing stained blood films, it is important to remember that the trypanosome is not a rigid body, but is rather like an elongated plastic packet of thick fluid which varies slightly in shape according to the outside stresses which were applied when the blood film was taken and dried.

The characteristics referred to when identifying blood forms of trypanosomes, as listed below, will, therefore, vary slightly, and, as it is clearly impossible to illustrate all the variations which can occur, the scheme detailed and the accompanying diagrams can only serve as a guide. The variations which occur on each blood smear are confusing to the beginner and experience is necessary before identification becomes rapid and certain. Thus, when the term 'monomorphic' is used to describe a trypanosome one should not expect to find all individuals conforming strictly to the text book description. It is necessary to examine a number of trypanosomes and to base one's conclusions upon the overall picture.

The characteristics considered in identifying the blood forms are:-

a. the presence (polymorphism) or absence (monomorphism) of clearly different forms in a blood film,

b. the presence or absence of a free flagellum,

c. the size and shape of the body,

d. the size and position of the nucleus,

e. the size and position of the kinetoplast,

f. the degree of development of the undulating membrane,

g. the reaction of the mammalian host to the presence of the trypanosomes,

h. the presence or absence of volutin granules.

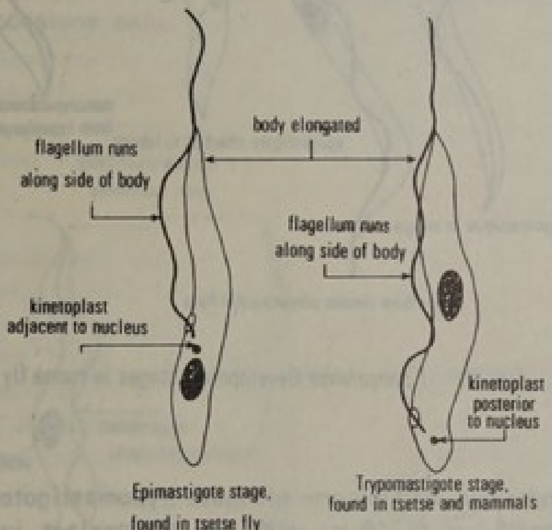


Fig. 35 Stages of tsetse-borne trypanosomes

The developmental stages in the tsetse fly are identified by the mode of development within the fly and by the point of origin of the flagellum, its course and the point of emergence of the free portion, Fig. 35. The tsetse fly ingests the blood forms, *trypomastigotes,* from the host. These are elongated forms in which the kinetoplast is situated posterior to the nucleus. The flagellum arises near the kinetoplast, emerges from the side of the body, and runs along its surface or along an undulating membrane to the anterior end, where it may emerge as a free flagellum.

Within the tsetse fly the trypomastigotes change their form and become *epimastigotes,* in which the kinetoplast lies adjacent to the nucleus; the flagellum arises near the kinetoplast, emerges from the side of the body and runs along its surface or along a short undulating membrane. The epimastigotes undergo a cycle of development and become the infective *metatrypanosomes* (metacyclic trypanosomes), located ultimately within the hypopharynx of the fly. The metatrypanosomes are trypomastigotes in form. The intermediate epimastigote stages are not infective to the vertebrate host.

The following should be read with reference to Figs. 43 and 44.

The *vivax* group (Subgenus Duttonella Chalmers, 1918)

T.vivax Figs. 36 and 37. The blood forms are monomorphic, with free flagella. Typically, the body is swollen at the posterior end, which is rounded or bluntly pointed. The nucleus is situated approximately in the middle of the cell, but as the posterior end is enlarged, the bulk of the cytoplasm is situated posterior to the nucleus.

The kinetoplast is large, and terminal or subterminal. Slender forms are occasionally seen, in which the undulating membrane is better developed.

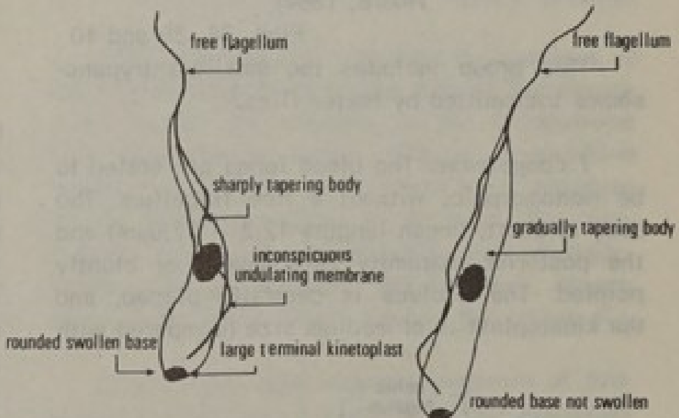


Fig. 36 *T.vivax:* blood forms

The mean lengths of these forms, including the free flagellum (3 – 6μm long) is from 21 – 25,4μm and mean breadths 2 – 4μm. When blood containing *T.vivax* is ingested by the tsetse fly, some trypanosomes successfully anchor themselves to the wall of the food canal and become developmental forms, 16 – 35μm in length which divide intensively to form clusters attached to the inner walls of the labium and labrum. Individuals eventually detach themselves from the

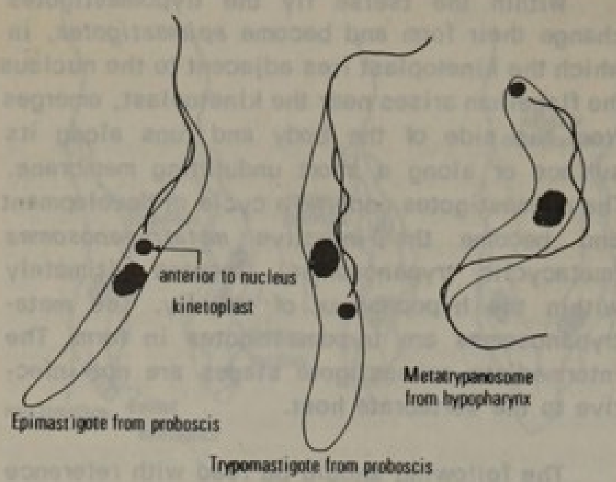


Fig. 37 *T.vivax:* Developmental forms from tsetse fly

clusters and make their way into the hypopharynx and there change into the preinfective form, in which the kinetoplast moves to a position just posterior to the nucleus. These change into the infective forms, which resemble the blood forms in having the kinetoplast in the terminal position, but which are shorter, mean length 15μm.

The trypanosomes which enter the midgut with the ingested blood degenerate and die.

The *congolense* group (Subgenus Nannomonas Hoare, 1964)

Figs. 38, 39 and 40

This group includes the smallest trypanosomes transmitted by tsetse flies.

T.congolense. The blood forms are stated to be monomorphic, without a free flagellum. The body is short, (mean lengths 12,2 – 17,6μm) and the posterior extremity is rounded, or bluntly pointed. The nucleus is centrally placed, and the kinetoplast is of medium size (compared with

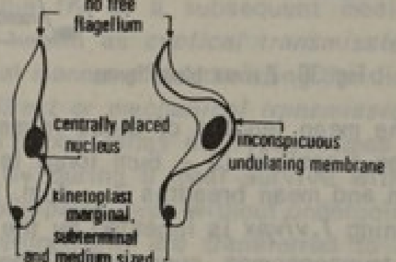


Fig. 38 *T.congolense* : Blood forms

that of *T.vivax* and *T.brucei*), is marginal and sub-terminal. The undulating membrane is typically inconspicuous. Although *T.congolense* is stated to be monomorphic, it is known that three types are invariably present in any infection. There are long and short forms, with forms of intermediate lengths. The proportions of these types vary from case to case, and also between localities.

When the blood forms are ingested into the tsetse fly they undergo development within the midgut and the proboscis. The salivary glands are never invaded. In the midgut, they multiply within the endoperitrophic space towards the

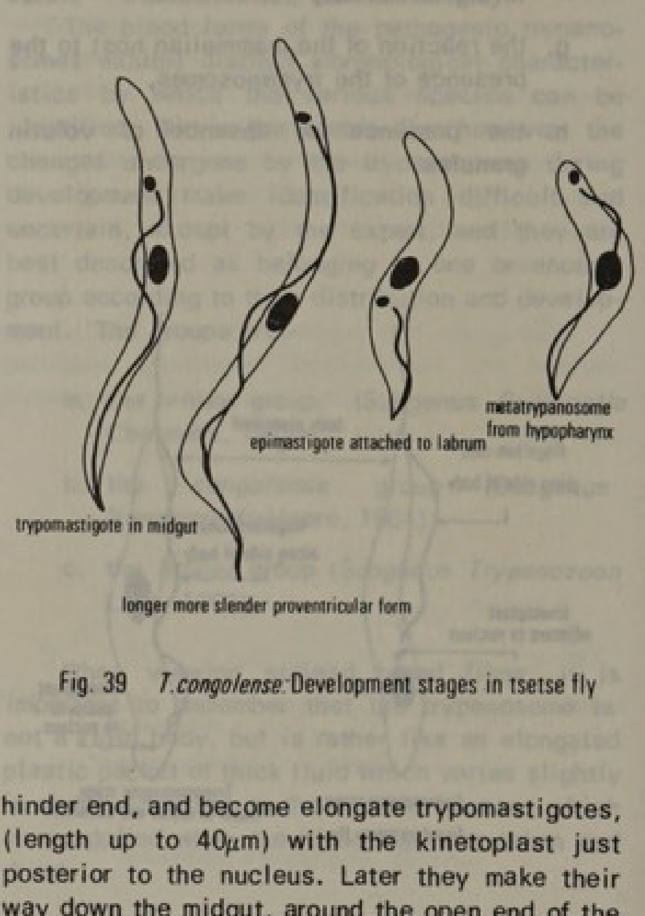


Fig. 39 *T.congolense:* Development stages in tsetse fly

hinder end, and become elongate trypomastigotes, (length up to 40μm) with the kinetoplast just posterior to the nucleus. Later they make their way down the midgut, around the open end of the peritrophic membrane into the ectoperitrophic space, in which they migrate forward to reach the region of the cardia. They penetrate the gut wall at the cardia and again enter the endoperitrophic space, as the more slender and longer 'proventricular forms'. They move forward up the oesophagus to the proboscis where they become attached to the walls of the food canal and change into the epimastigote forms, of lengths 14,2 – 36μm. They make their way from the food canal into the hypopharynx where they become the infective metatrypanosomes, which resemble the small blood forms.

T.simiae.

T.simiae. This trypanosome is polymorphic, exhibiting forms with and others without a free flagellum. Three types are recognised:-

(i) a long, stout form in which there is a medium sized, marginal and subterminal kinetoplast, and an inconspicuous undulating membrane.

(ii) a long slender form with a conspicuous undulating membrane

(iii) a shorter form morphologically indistinguishable from *T.congolense.*

The proportions of these forms vary but in an uncomplicated infection in a domestic pig, the expected frequency would be 90 per cent. long, stout forms; 7 per cent. long, slender forms; and 3 percent. *congolense* type.

This trypanosome causes a heavy parasitaemia with acute signs and rapid death in domestic pigs, but is rarely seen, and is of minor importance in other domestic animals. In Rhodesia, it has been noted in sheep on two occasions only.

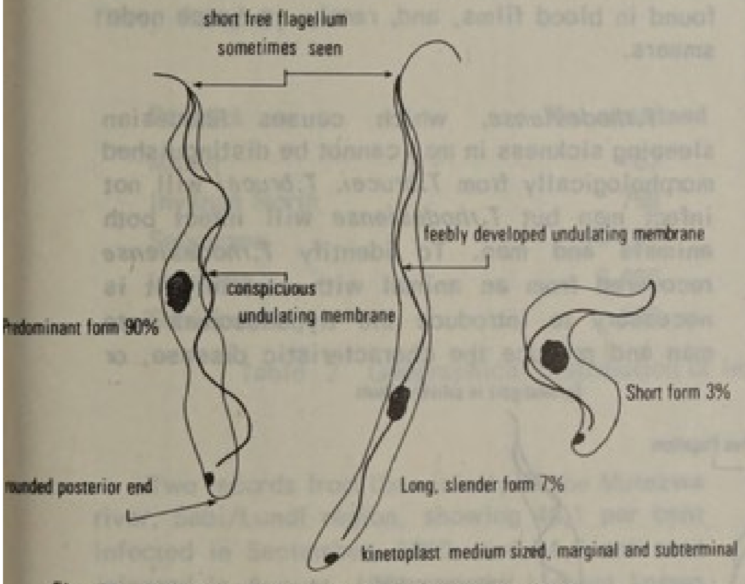


Fig. 40 *T.simiae:* Blood forms showing pleomorphism

The extreme virulence of the disease and the great difficulty in effecting cures make the raising of pigs in tsetse infested areas a most hazardous undertaking.

The natural hosts are wild pigs and warthogs.

The *brucei* group (Subgenus Trypanozoon Lühe, 1906) Figs. 41 and 42.

Under natural conditions all the species in this group are polymorphic, with and without a free flagellum.

In the mammalian blood they occur as:-

(i) Long slender forms, of length 23 – 30μm, with a free flagellum. The body tapers, almost to a point posteriorly. The nucleus is centrally placed and frequently fully occupies the girth of the body. The kinetoplast is small, and is situated some distance (up to 4μm) forward of the posterior extremity. The undulating membrane is conspicuous.

(ii) Short, stumpy forms, of length 17 – 22μm, in which the posterior extremity is bluntly pointed. These forms vary from very broad, squat individuals to those which bear some resemblance to *T.congolense* in shape, but which are much larger. The position of the nucleus is variable. In some cases it may lie posteriorly, and, rarely, even to the extent that the kinetoplast is anterior to it. The kinetoplast is small and subterminal. Well defined granules, appearing deep blue in stained preparations, are present in the cytoplasm, often arranged along the margins of the cell. These are called *volutin granules.*

(iii) Intermediate forms, in which the mean body length lies between those of the long and of the stumpy forms. The posterior end of the body is pointed, and a free flagellum is always present.

The polymorphism exhibited by members of the *brucei* group differs from that of the *congolense* group. The changes in the trypanosome from long slender forms, through intermediate forms to the short, stumpy forms are a response to the defence reactions of the host. The long, slender form is the true blood form which reproduces by simple division, and the short, stumpy form is the stage which infects the tsetse fly.

When blood containing trypanosomes of this group is taken into the tsetse fly the parasites develop in the gut and in the salivary glands. They pass into the endoperitrophic space of the midgut where the stumpy forms (the other forms degenerate) change into a new trypomastigote form (up to 35μm in length) in which the undulating membrane is less conspicuous than in the slender blood forms, the kinetoplast is nearer to the nucleus and a free flagellum is always present. These multiply intensively in the midgut, and extend to the hinder, open end of the peritrophic membrane. They pass around this into the ectoperitrophic space and migrate forwards

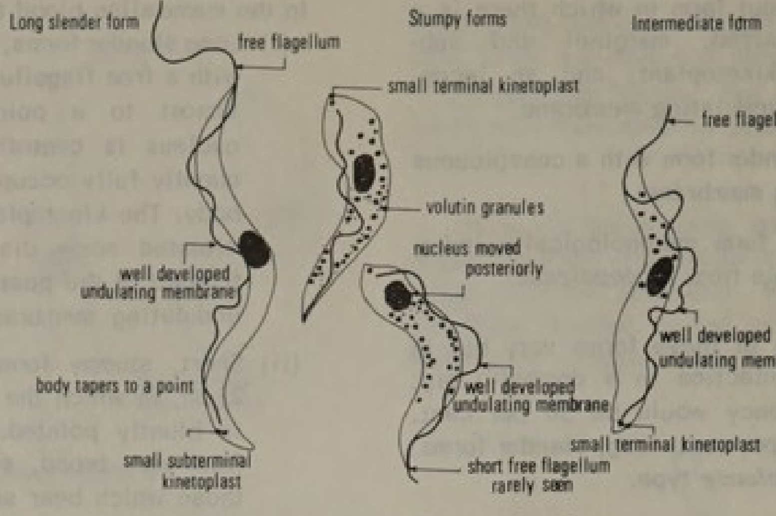


Fig. 41 *T.brucei*: Blood forms

to reach the cardia. Here they become the more slender elongated 'proventricular' forms, which penetrate the gut wall at the site of production of the peritrophic membrane, and enter the endoperitrophic space. From here they make their way forward along the oesophagus into the proboscis, and into the open end of the hypopharynx. They proceed up the hypopharynx into the salivary ducts and reach the salivary glands, where they accumulate. The proventricular forms are transformed into broad epimastigotes which multiply and give rise to the stumpy infective metatrypanosomes, in which the free flagellum is typically absent, the kinetoplast lies near the posterior end and the nucleus lies in the middle of the body. These pass down the hypopharynx, and are discharged with the fly's saliva into the wound.

T.brucei can infect all domestic animals, but, in Rhodesia, it causes a virtually inapparent condition in cattle and pigs, although trypanosomes may persist in the blood for long periods at a very low level. In members of the horse family, and in dogs it causes a severe disease which is invariably fatal. Trypanosomes may be found in blood films, and, rarely, in lymph node smears.

T.rhodesiense, which causes Rhodesian sleeping sickness in man cannot be distinguished morphologically from *T.brucei*. *T.brucei* will not infect man but *T.rhodesiense* will infect both animals and man. To identify *T.rhodesiense* recovered from an animal with certainty it is necessary to introduce the trypanosomes into man and produce the characteristic disease, or

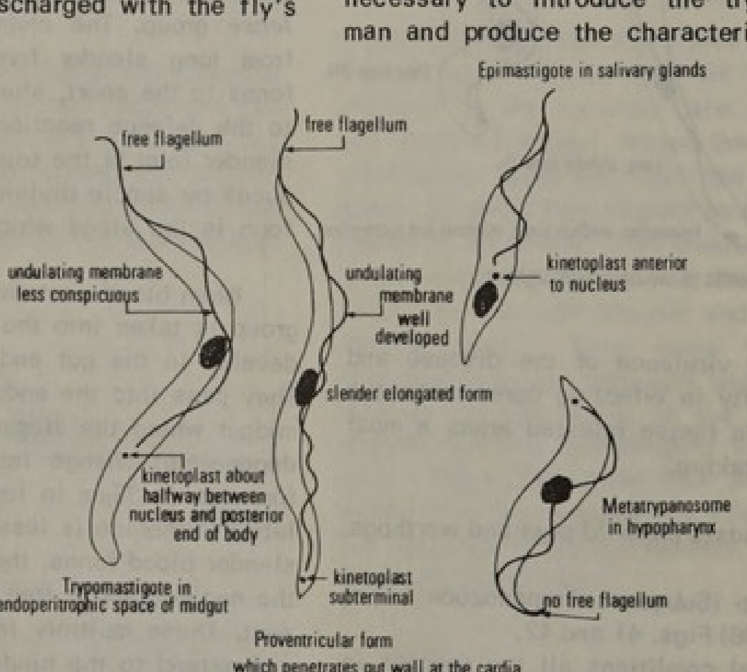


Fig. 42 *T.brucei*: Developmental stages in tsetse fly

to use complicated immunological tests.

T.gambiense a related species, morphologically identical to both *T.brucei* and *T. rhodesiense* produces the chronic form of sleeping sickness in man in West Africa.

11.4 The factors affecting the transmission of trypanosomes by the tsetse fly

11.4.1 Trypanosomes in the tsetse fly

Not all tsetse flies become infected with trypanosomes. For a fly to become infected, it must be in a receptive condition, must take blood from an infected animal, must absorb trypanosomes in its blood meal and these must survive within the fly and develop into the infective forms (metatrypanosomes) before the fly can transmit them successfully. Logically, comparisons of infection rates in tsetse flies should be made of those showing infective forms.

Examination of the mouthparts of tsetse flies from different parts of Rhodesia has shown that there is a considerable geographical variation in the proboscis infection rate of tsetse flies, Table 2.

District	No. examined	No. infected	% infected
Mtoko	67	5	7,5
Inyanga North	798	94	11,8
Sebungwe	10 121	1 509	14,9
Urungwe	6 466	1 005	15,5
Sabi/Lundi	182	82	45,1

Table 2 Geographical distribution of infection rates in *G.morsitans*, 1961–62

Two records from the vicinity of the Mutezwa river, Sabi/Lundi region, showing 46,1 per cent infected in September, 1960, and 44,6 per cent infected in August, 1961 are the highest known for wild *G.morsitans*. Rhodesian tsetse flies show a generally high gut and proboscis infection rate compared with those from other parts of Africa.

Samples of *G.morsitans* taken throughout the year in Urungwe and Sebungwe operations areas in the period November, 1961 to October, 1962 showed a higher infection rate from May to September, (range 18,2 – 20,5 per cent) than during the hot dry months of October and November (range 9,6 – 10,9 per cent).

The species of fly may influence the rate of infection. Thus, at Rekomitjie, *G.morsitans* showed 18,6 per cent infections out of 4500 examined while 3500 *G.pallidipes* taken at the same time from the same place produced 8,6 per cent infections.

Temperature affects the development of the trypanosome and the ability of the fly to become infected and transmit disease. It has been shown that the temperature to which the pupae are exposed affects the ability of the resulting adults to become infected.

Ambient temperatures appear to affect the ability of the tsetse to become infected. Experiments carried out in Northern Rhodesia in 1911 and 1912 indicated that *T.rhodesiense* could be transmitted by *G.morsitans* in the Luangwa valley during the hot season but not in the cooler months, and not at all in the cooler hilly regions.

Adult *G.morsitans* from pupae that had been incubated at 30°C showed significantly higher infections than those from pupae that had been kept at room temperature, after similar exposure to infection from the *brucei* group of trypanosomes. It was also shown that male flies are more readily infected than female flies.

Ford and Leggate, (1961), by analysing all the available data on infection rates in tsetse flies from various localities in Africa were able to demonstrate that a general relationship exists between infection rates and prevailing mean annual temperature on a continental scale. Infection rates were high when the mean annual temperatures were high, and increased as the distance from the 'Glossina equator' increased. While such a relationship may exist, its effect is often obscured by local conditions, such as age, sex, species of tsetse, availability of infected hosts, local temperature and sampling conditions.

11.4.2 Trypanosomes in the mammalian hosts

Both the wild game animals of Africa and *Glossina* species appear to tolerate the trypanosomes that infect them. In West Africa, certain species of cattle also have developed a resistance to the local strains of trypanosomes. Some species of game animals harbour trypanosomes more frequently and for longer periods than others, and therefore play a greater role in the infection of tsetse flies.

Ashcroft (1959) investigated the extent to which game animals were infected with pathogenic trypanosomes, by means of blood smear examinations and also by inoculating blood from these animals into rats. Trypanosomes were found most frequently in reedbuck, kudu and waterbuck. Bushbuck, roan antelope and buffalo were less frequently found to be infected, while warthog, eland, impala, zebra and elephant were seldom infected. The species of host animal available to the fly thus influences its likelihood of becoming infected. But the choice of host by the fly is also a major factor influencing its infection. From the identification of blood meals taken by *G.morsitans* in this country it has been shown that warthog is by far the most favoured host, with kudu, bushbuck, buffalo, eland, bushpig, reedbuck and elephant as regular, but less frequent hosts. Impala and zebra figure exceedingly rarely in the blood meal identifications despite their widespread occurrence in tsetse areas.

It would seem that in Rhodesia kudu may play an important role in enabling the fly to become infected, and the warthog in maintaining the tsetse population by providing a regular source of food.

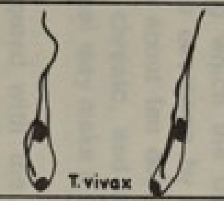
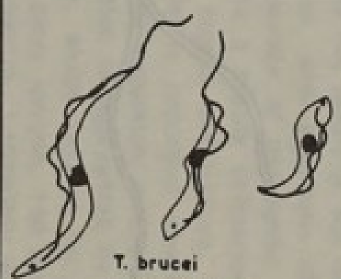
Subgenus	General appearance of trypanosome in mammalian host	Morphology			Development in tsetse			Mammalian hosts
		Free flagellum	Kinetoplast	Undulating membrane	Proboscis	Salivary glands	Midgut	
Duttonella (vivax group)	 T. vivax	Present in all stages.	Large and terminal or sub-terminal	Inconspicuous	Trypomastigotes epimastigotes and metatrypanosomes Development occurs.	No development	No development	Cattle hórses (very rare) sheep goats antelopes
Nannomonas (congolense group)	 T. congolense	Absent in all stages.	Medium, marginal and subterminal.	Inconspicuous	Trypomastigotes epimastigotes and metatrypanosomes	No development	Trypomastigotes	Cattle horses pigs goats dogs sheep antelopes
	 T. simiae	Absent in most forms. 1% to 4% of long forms may have short free flagellum.	Medium, marginal near posterior end of body.	Conspicúous especially in long forms.	Trypomastigotes epimastigotes and metatrypanosomes	No development	Trypomastigotes	pigs warthogs camels (rare) cattle (rare) horses (rare) sheep (rare) goats (rare)
Trypanozoon (brucei group)	 T. brucei T. rhodesiense	Present in all stages except in metatrypanosomes where it is typically absent, and in short stumpy blood forms where it may be very short or absent	In long and intermediate forms, small and subterminal.	Conspicuous	Present, but no development.	Trypomastigotes epimastigotes and metatrypanosomes.	Trypomastigotes	T. rhodesiense Man antelope all domestic animals T. brucei All domestic animals. antelopes

Fig. 43 Key to species of *Trypanosoma* in tsetse flies

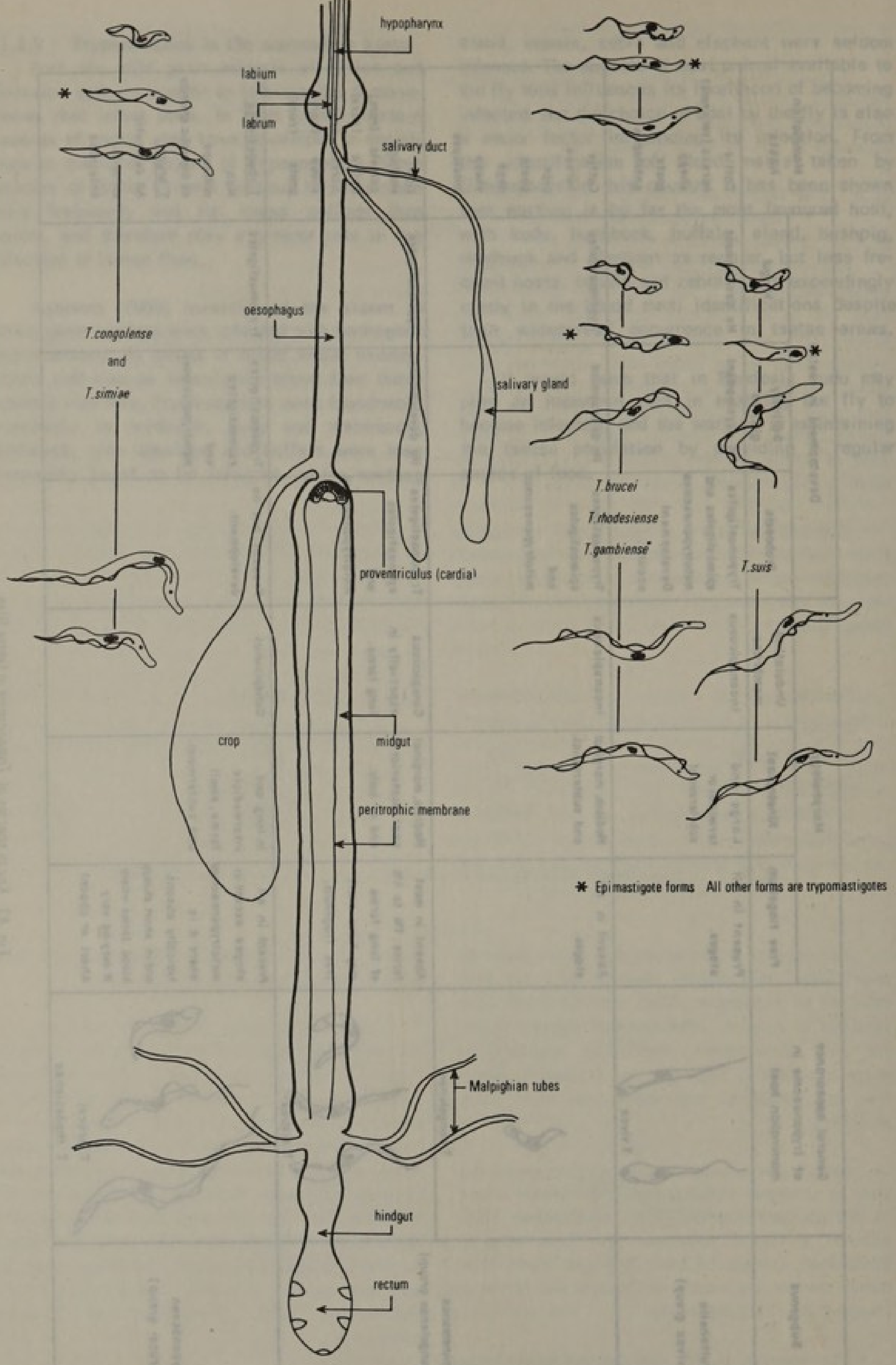


Fig. 44 Developmental stages of trypanosomes and sites within the tsetse fly (modified from Hoare)

12. ANIMAL TRYPANOSOMIASIS

12.1 History

African cattle owners learned long ago from experience, that there was an association between biting flies and the spread of trypanosomiasis in their stock, and during the 19th century European hunters in Africa spoke and wrote of 'tsetse fly disease' affecting their draught oxen. That trypanosomes could cause disease was established by Evans (1880) who showed that a trypanosome, (named *T.evansi* after him), was the causal agent of the horse disease surra. In 1895, David Bruce demonstrated in Zululand that the disease nagana was caused by a trypanosome, and, moreover, that it was transmitted by a tsetse fly, (probably *G.pallidipes*). He later followed out the life cycle of the trypanosome within the tsetse. The trypanosome which causes a fatal disease in horses and dogs was named *T.brucei* after him.

In 1904, *T.congolense* and in 1905, *T.vivax* were identified. These trypanosomes can be highly pathogenic in cattle. Bruce and his team of workers, in 1912, first reported *T.simiae* which causes a virulent disease in pigs and may also affect camels.

12.2 The disease in domestic stock

The several species of trypanosome produce varying ill effects in the different host animals, but they are all collectively referred to as trypanosomiasis. Table 3 lists the commoner trypanosomes of domestic stock, their hosts and the effects produced by them on the host. Mixed infections may occur, with corresponding variations in the clinical signs. Even within the same species of trypanosome different strains may produce widely different effects. *T.vivax* and *T.congolense* sometimes produce an acute disease in cattle, during which the defence mechanism of the animal is overcome by the parasite, and death occurs in about ten days. At other times, the disease is chronic, and after a protracted illness, the animal may make a complete recovery.

When confronted with the defence mechanisms of the mammalian host, and also in the presence of subcurative doses of trypanocidal drugs, trypanosome species have a tremendous capacity for producing variations or 'strains', some of which may be able to overcome the defences of the host or be tolerant of the drug. Usually these variations are trivial and temporary, but occasionally strains arise that cause exceptionally acute disease, or that are quite resistant to the normal doses of drugs. In Mocambique, for example, it is reported that cattle in one area had developed a tolerance to the local strain of *T.congolense* which broke down when they were moved to another area and became exposed to different strains of the same species of trypanosome.

In Rhodesia, *T.vivax* generally produces a milder trypanosomiasis than *T.congolense* but from time to time it produces a virulent haemorrhagic form of disease, with rapid death.

Intermediate conditions occur, in which the defence mechanism maintains an uneasy equilibrium with the parasite, which, although present within the animal, does not cause obvious signs of ill health. In this condition the animal may succumb to the disease when it is subjected to stress, such as concurrent diseases or undue physical strain.

The presence of pathogenic trypanosomes causes malfunctions in various tissues, of which those that produce red blood corpuscles are amongst the most sensitive.

The red blood corpuscles undergo a cycle of development. They are produced within the bone marrow and enter the blood stream, where they serve to carry oxygen to the tissues of the body and to remove the waste carbon dioxide. They become mature, they age and die, and are finally removed from the blood stream as waste products. As the production of new red blood corpuscles is restricted by the effects of trypanosome infection the net result of the disease is that of blood loss, with symptoms of general anaemia. The presence of pathogenic trypanosomes also exerts a steady deleterious effect upon other vital organs and tissues, including the liver, the vitally important storehouse of energy, and a major regulatory mechanism. This general deterioration is aggravated by the progressive anaemia, which reduces the capacity of the blood to carry oxygen, and produces a growing general debility. Ultimately some vital body function fails, and death ensues.

12.3 Diagnosis

In arriving at a diagnosis, attention is paid to both the reaction of the host (*signs*, which are the visible evidence of the disease, and *symptoms*, which are the effects felt by the patient), and to the causative organism. The veterinarian, unlike the physician, cannot obtain much help, (or be confused) in his diagnosis from what the patient tells him he feels.

12.3.1 Reaction of the host

Cattle

An infected ox becomes progressively thinner to the point of emaciation. The hair has a characteristic rough and upstanding appearance (staring coat), and the skin is drawn tightly over the ribs and pelvis, and lacks the looseness of healthy animals. There is a muscular wasting clearly visible over the hips. There may be a discharge from the eyes, varying between a copious weeping with photophobia (avoidance of light by closing the eyes) to a slight but definite crusting of the discharge at the inner corner of the eyelids. This condition is much more common in *T.vivax* infections, which may also produce visible swellings of the superficial lymph nodes, particularly the prescapular and precrural nodes. The tail brush may fall out, but this is a variable sign, commoner in young animals.

The animal becomes listless. It lags behind the herd, loses interest in its surroundings, its ears and tail hang limply and it ceases to react to the irritating attentions of insects.

The signs of disease appear from 11 – 21 days after an infected bite as a relapsing fever, with temperature peaks. These peaks are associated with an increase in the number of trypanosomes in the circulating blood, followed by the destruction of large numbers of the parasites and a return to a more normal temperature. The end of the period of parasite destruction is the *crisis*, when antibodies (see 4.2.1) are being produced, and large quantities of trypanosome protein are liberated into the blood stream. Death commonly coincides with one of these crises (the last, of course). In areas where reinfection is frequent, death may occur within periods of from three weeks to three months, depending upon the individual resistance of the animal, the availability of food and water, and the physical strain to which it is subjected. In an area of very high trypanosome risk in Rhodesia, four animals were allowed to become infected, and left without treatment. The first infection was recorded on the 17th day and by the 24th day all had become infected. Deaths occurred on days 36, 42, 45 and 56.

Equines

In horses, donkeys and mules infections with *T.brucei* are often severe and short lasting (acute), with anaemia, weakness and rapid loss of condition. In stallions and geldings, oedema of the scrotum and sheath often occur, appearing as a pendulous swelling, full of fluid and pitting under pressure.

Pigs

In the pig, the only trypanosome which causes serious disease is *T.simiae* which produces a peracute, fulminating infection with rapid death.

Dogs

The disease caused by *T.congolense* is often acute with rapid prostration. It varies in intensity with the strain of parasite involved.

T.brucei causes a less acute disease but death usually supervenes. The eyes are often affected, and there may be temporary blindness.

The signs can be confused with those of biliary fever.

Table 3 lists the trypanosomes causing disease in livestock in Rhodesia.

12.3.2 Identification of the causative organism

Although an indication of the disease can be obtained from inspection by an experienced observer, definitive diagnosis depends upon the identification of the infecting organism. This is done by microscopical examination of a drop of blood, a dried and stained blood smear, or sometimes a preparation of lymphatic gland tissue.

A sample of blood is easily obtained from a small peripheral ear vein or at the tip of the tail. The vein is punctured with a blood lancet or a sliver of glass from a broken, clean glass slide.

The wet preparation

To make a wet preparation a clean microscope slide is brought into contact with the exuding blood so that a drop is collected in the middle of the slide, and a coverslip is gently lowered over it. The presence of trypanosomes can be readily detected by the agitation they produce in the red blood corpuscles.

Species	Wild hosts	Stock affected	Nature of the disease
T.brucei Plimmer and Bradford 1899	African *ungulates	Horses, dogs, cattle, pigs, sheep and goats	Infections in cattle and pigs are rare and self-cure is usual.
T.congolense Broden 1904	African *ungulates	Horses, cattle sheep, goats, pigs, dogs	Typically a chronic wasting infection, often fatal. Sometimes acute. Pigs are least affected. Most important in Rhodesia.
T.simiae Bruce 1912	Bushpig, warthog	Pigs, and occasionally ruminants	Rapidly fatal in domestic pigs.
T.vivax Ziemann 1905	African *ungulates	Cattle, sheep, goats and, rarely, horses	Great variation in strains. Causes a chronic debilitating disease in Rhodesia. Acute infections occur rarely. Not as important as *T.congolense,* least important in sheep, goats. Very rare in horses.

* The term ungulate is used to include antelopes, elephant, hippopotamus and rhinoceros.

Table 3 Trypanosomes causing disease in livestock in Rhodesia

The thin smear

Specific identification may require the preparation of thin, stained blood smears. To prepare a thin blood smear a drop of blood is collected on the narrow edge of a clean 75 x 25mm glass slide. This edge is held against the upper surface of another slide at an angle of about 45° so that the drop of blood lies in the acute angle between them. The slide on which the blood was collected is then pushed along the other while in contact with it, so that a thin smear of blood is left behind. The film is then allowed to dry away from direct sunlight. The preparations should preferably be fixed in alcohol and stained with Giemsa's stain within a day or two of collection. They should be identified by numbering on the dried film with a pencil. The wrapper should be labelled with the date and the nature of the patient, the locality of origin and the name of the operator. Collections should be wrapped in clean paper and stored in a dry place. Smears should be submitted for identification as soon as possible.

The thick smear

The thin smear is made from a very small sample of blood, and light infections of trypanosomes may not be readily detected. To increase the likelihood of detecting the presence of trypanosomes a thick smear of blood is made on the same slide as the thin smear. A drop of blood is collected towards one end of a clean slide and, using a needle or a corner of another slide, is spread out to cover an area of about the size of a five cent piece. A satisfactory thick smear would be one through which the figures on a wrist watch can just be read. The preparation is laid flat to dry thoroughly and must be protected from insects.

This preparation is *not fixed in alcohol* but is treated directly with Giemsa's stain. The water in the stain causes lysis of the red blood corpuscles, and the colouring matter, haemoglobin, escapes, rendering the thick layer of blood transparent, and permitting the stained trypanosomes to be seen.

To study the detailed structure and ultimate identification of the trypanosomes, however, thin smears should be examined.

12.4 Treatment

Some diseases caused by bacteria or viruses can be prevented by vaccination, which is the introduction of a dead or mild form of the causal organism in order to stimulate a reaction in the host which prevents a subsequent serious attack of the disease. As yet, it has not been possible to produce a vaccine effective against trypanosome infections and cure of the disease has depended upon killing the trypanosome by means of the use of drugs. Many of the drugs that kill trypanosomes within the body of the mammalian host are also highly toxic to the host, and experience is required in selecting and administering them if they are to be efficacious.

The control of trypanosomiasis is further complicated by the versatility of the trypanosome in reacting to the presence of drugs and to the defence mechanisms of the host. It seems inevitable that as a new drug is used, so will strains of trypanosome arise that are resistant to it, and to drugs of similar chemical composition. However, several drugs of dissimilar chemical composition are available, which can be used to deal with most conditions in the field, and the appearance of trypanosomiasis in an area, while still highly undesirable, is no longer the forerunner of complete evacuation of livestock and economic disaster.

Drugs are used in the control of trypanosomiasis as therapeutics (curatives) or as prophylactics (preventatives).

12.4.1 Curative treatment

Curative compounds are administered with the intention of curing the animal only. It is open to reinfection within a variable, but short time after treatment. These drugs are used in areas where infections are infrequent and where individual cattle can be readily and effectively inspected. Their use does not obscure the progress of the disease in an infected area, so that the probable distribution of the tsetse fly may still be detected from the pattern of infections. In Rhodesia, the curative drug of choice for the control of trypanosomiasis in cattle is Berenil, prepared by Hoechst A.G.

Drug	Type	Effective period of treatment	If resistance develops, parasite may also be resistant to	Remarks
Berenil (Hoechst)	Curative	Approx. 36 hours	Does not develop	Rapidly absorbed and rapidly excreted. Ultra short acting. Low toxicity.
Homidium) Ethidium) (Boots))	Curative	4–6 weeks	Antrycide	Low toxicity. Tendency for resistant strains to develop but eliminated by Berenil.
Antrycide di-methyl-sulphate (I.C.I.)	Curative	4–8 weeks	Ethidium If at high level, Samorin (partial) Berenil	Owing to the widespread development of resistance this drug is reserved for use in dogs.
Iso-metamidium = Samorin (M & B)	Prophylactic. May be used as a curative by reducing the dosage rate	1–6 mths. depending on dosage and challenge	Antrycide Ethidium	An irritant but valuable drug which eliminates strains of trypanosomes resistant to other drugs. It is the only proplylactic compound in use in Rhodesia.

Table 4 Drugs used in the control of animal trypanosomiasis in Rhodesia

12.4.2 Prophylactic treatment

The prophylactic compounds when administered in appropriate doses not only cure the disease, but also exert a pronounced residual effect, depending upon the amount of drug used and the rate at which it is excreted from the the animal. The difference between curative and prophylactic drugs is thus a difference of degree rather than of kind. Prophylactic drugs are used in areas where infections are so frequent that treatment by curative drugs would become too laborious to be practical, or even quite ineffective, or in inaccessible areas that can only be inspected irregularly and at long intervals. Such treatment has the disadvantage that the progress of the disease in the treated area cannot be used as an indication of the presence of the fly, and its advance towards marginal, uninfected areas may be undetected until it occurs in sufficient numbers to be detected by conventional tsetse surveys.

Moreover, the introduction of prophylactic drugs is recommended only where complete and regular production of stock can be guaranteed. This insistence upon complete and regular inspection and treatment is based upon sound theory. The prophylactic drug when injected into the animal may be regarded as a reservoir which gradually dissolves into the blood stream and is excreted slowly, allowing sufficient to be circulating in the blood stream to prevent the establishment and development of the parasite. As the reservoir of drug becomes depleted it may reach a level at which it just fails to kill trypanosomes. Under these conditions the trypanosomes and their descendants can develop a resistance to the drug even when it is later administered at increased doses. The aim of a prophylactic regime is thus to maintain the drug at a curative level in the blood by repeated injections at fixed intervals.

Some trypanocidal drugs are very toxic to mammals, and their successful administration depends upon maintaining a delicate balance between killing the parasite and not harming the host. The dosage rate at which the drugs are administered between these levels is determined with regard to the estimated intensity of the trypanosome risk encountered, the nature of the drug, the tolerance of the species for the drug and the frequency at which treatments can be maintained. Table 4 indicates the drugs used in Rhodesia and the treatment procedure applicable to each.

Prophylactic treatment is never undertaken without due regard to attendant precautions and only then as a necessity. It should not be adopted unless the requirements of complete and regular treatment of the infected herds (not only the sick individuals) can be assured. Similarly, a course of prophylactic treatment must not be abandoned without taking appropriate precautions. As the amount of drug from the last treatment declines and approaches the critical level at which there is danger of the development of resistance in the trypanosomes, another drug must be administered which will eliminate all the remaining trypanosomes within the body, including strains resistant to the drug used as the prophylactic. Fortunately the drug Berenil, at the correct dosage rate, is usually most effective

Drug	Dosage rate (mg/kg body weight)	Preparation of solution	Dosage rate (ml/45kg or ml/100 lb)	Route of administration
Berenil	3,5	7% in water	2,5	Subcutaneous or intramuscular
Ethidium	1,0	2,5% in water	1,0	intramuscular
Samorin	1,0	1% in water	4,5	intramuscular
	or 2,0	2% in water	4,5	intramuscular

Note: Samorin is highly irritant. If the total dose exceeds 10ml it should be equally divided and given deep into the muscles on each side of the neck.

Table 5 The preparation of drugs used in the control of animal trypanosomiasis in Rhodesia, their dosage rates and rates of administration.

for this purpose.

In practice, the curative drug Berenil is used in treating individual animals, and in dealing with new or sporadic outbreaks, until such time that prophylaxis becomes necessary. It is a quick acting drug with little persistence in the animal. Where the incidence of disease in a herd is of long standing and where infections recur too frequently for short acting drugs to achieve effective control, prophylactic drugs are used with due regard to the precautions stated above.

A complicating factor in the administration of drugs is the development of 'cross resistance'. Strains of trypanosomes that develop resistance to one compound may also be resistant to drugs of similar chemical structure.

Table 5 lists the drugs used in the control of trypanosomiasis in livestock in Rhodesia, their dosage rates, and routes of administration.

13. CARE AND MAINTENANCE OF LIVESTOCK

13.1 Introduction

Increasing use is being made of cattle as baits to attract tsetses and as indicators of the existence of trypanosomiasis and of the tsetse fly by using them as 'test herds', and all officers must become acquainted with the procedure for their care and maintenance. The test herds and individual bait animals represent valuable Government assets, and their care and maintenance are the special responsibility of the Tsetse Field Officer. They must be under the constant supervision of competent African staff whenever they are out of the kraal, and their numbers and condition must be inspected and reported upon regularly by the Field Officer.

The welfare of these animals placed under the care of a Field Officer must take precedence over his personal activities. Such animals in need must be given prompt attention whatever the time of day or night. Failure of an officer to arrange for the prompt treatment of an animal in need will be regarded as a severe breach of discipline. The officer will be held responsible for any mishaps involving animals in his care due to negligence or ignorance on the part of his African staff. It is his duty, therefore, not only to ensure that his African staff in immediate control of the animals are fully informed and conversant with their duties but he must inspect their work frequently and irregularly.

13.2 General care of stock

a. Before animals are introduced into an area facilities must be made available and a routine planned so that they will have adequate and regular access to water and grazing.

b. Animals must be given the maximum opportunity of utilising the available grass, herbs and shrubs by ranging freely within the confines of the 'test' area. They should be out of their kraals at daybreak and should return at sunset.

c. Where animals are required to operate away from a source of water, provision must be made for adequate supplies to be brought to them regularly both at night and in the morning. A full grown ox can drink more than 50 litres of water per day.

d. Special care must be exercised in the control of grazing. Cattle must not be allowed to feed exclusively upon the succulent grasses that appear during the early rains on places such as burnt vleis. Such a diet can give rise to digestive disorders such as indigestion, diarrhoea and its attendant dehydration, and even death. A common condition produced by consumption of young grasses is that of *hoven* or *bloat* in which the gases produced from the chewed up grasses during the early process of digestion greatly distend the stomach and cause abdominal pressures which can affect respiration and even cause a rapid and painful death. It should be regarded as a rule to satisfy the animal's appetite partially on coarser grazing and roughage before allowing it access to young grasses. Rich young grass that has become wilted in the sun should be strictly avoided as grazing. Some indigenous and imported grasses can, under these conditions, produce sufficient quantities of prussic acid to cause the animals acute distress and even death. Sheep are particularly prone to this condition, known as 'Geilsiekte'. A sound depasturing routine should make the fullest use of all the available types of grazing throughout the year.

13.3 Signs of ill health

Since signs of ill health are recognised as departures from the normal, it is essential to be able to recognise the appearance and behaviour of a healthy animal. The officer should devote some time to studying the condition and habits of stock at rest and during their normal activities, so that he can recognise and report on abnormal conditions.

The healthy beast is alert and active and is very aware of its surroundings. Its eyes are bright, its ears are cocked, and its tail is continually swishing at attendant insects. Its coat is smooth and shows a sheen. The coats of indigenous cattle, with which Field Officers will be dealing, are usually short haired and close throughout the year, but in some cases a longer haired and rougher coat may develop during the winter months. This condition should not be confused with the harsh, dull 'stary' coat of an animal in a state of chronic ill health.

The *muzzle* should be cool and show beads of moisture over its surface. The animal continuously clears discharge from its nostrils with its tongue.

The *eyes* should be bright and should not show a dried crusty discharge at the inner corners or a profuse clear or purulent discharge. Screwing up the eyelids against the light (photophobia) may be an indication of damage to the eyeball, or a secondary sign of disease.

The *ears* are normally held upright, they readily respond to the presence of insects by twitching, and are quickly turned toward the sources of sounds. They are cool to the touch in the normal animal, but in the sick animal often hang down, and do not react to slight stimuli. They may be hot to the touch in conditions of fever.

The *tail* is almost perpetually in motion dislodging the insects that are constantly around the animal under bush conditions.

The *faeces* vary somewhat according to the diet of the animal, but are usually quite soft in the female and rather firmer in the male. The passing of fluid faeces (diarrhoea) which foul the hindquarters and hocks of the animal is an important sign of internal irritation caused by such as worm parasites, intoxication from plants or improper diet, and certain bacterial and protozoal diseases. The colour and consistency of the faeces and the presence of blood and mucus should be commented upon when reporting on sick animals.

The normal *urine* varies in colour from a pale straw shade to deep amber. The presence of clots of blood or of uniform deep red colour in unhealthy animals should be noted. Abnormal urine should be noted from the staining of the tuft of coarse hairs at the opening of the sheath of the penis or at the anterior end of the vulva. Care should be taken in distinguishing between a discharge from the urinary system or from the vagina in the female. The passing of a clear or slightly opaque mucus discharge from the vagina is often associated with the period of oestrum (heat).

Respiratory movements in the resting animal are regular, easy and unhurried, (in cattle from 10 to 30 per minute). They are more rapid in young animals and are greatly increased as a result of exercise. Rapid breathing accompanies febrile and anaemic conditions and reaches an extreme in acute infection of the lungs (pneumonia).

The *heart rate* is normally 40 to 60 beats per minute, indicated by the arterial pulse, or by listening to the heart itself. It is increased in feverish conditions and becomes very rapid and weak in acute anaemic conditions, as in infections with certain tick-borne disease, (see under Red Water (13.4.1) and Anaplasmosis (13.4.2)). The heart rate increases greatly with exertion, and slightly during the heat of summer.

The major portion of the food of herbivorous animals is composed of cellulose, the substance which forms the tissues of plants other than the cell contents. The animal cannot digest cellulose directly, but relies upon the activities of vast numbers of microscopic organisms which inhabit its digestive tract to convert cellulose into simpler soluble substances that can be absorbed. In cattle and sheep, as the food is cropped and swallowed it passes into the large stomach or *rumen* in which, by contractions of its walls, it is thoroughly mixed with the large numbers of cellulose splitting microorganisms which live there. The rumen of the healthy animal contracts steadily and regularly. The contractions can be felt as slow, steady, in and out movements high up in the left flank of the animal, in the hollow behind the short ribs. The arrest of these regular movements, or *atony of the rumen* may be partial or complete and is associated with indigestion, acute infectious conditions and poisoning, particularly from irritant substances. Animals at rest and placidly cudding indicate general well-being.

The *posture* of the animal can be indicative of its condition. The normal animal at rest stands easily with its weight distributed evenly on the four feet. Its back is level and the abdominal muscles are relaxed.

The animal often reacts to a pain or other disturbances in the abdomen by assuming a 'tucked up' appearance and arching its back, and, to acute spasmodic abdominal pain, by performing uneasy paddling movements, kicking at the affected area with its hind feet, and turning its head towards the source of the pain with an inquisitive expression. Grinding of the teeth is indicative of an internal disorder.

The normal *gait* is rhythmical and easy. A laboured or stilted gait is produced as a result of injury, weakness, pain or certain diseases. Staggering and weakness of the hindquarters, and a fine or coarse tremor of the limbs and in groups of muscles may occur. This latter condition should not be confused with lameness caused by injury to one or more limbs which usually produces a more definite and local abnormal movement.

13.4 Some common ailments

13.4.1 Redwater (Babesiosis)

This is an acute or subacute febrile disease, caused by the protozoan *Babesia bigemina* which is transmitted by the blue body tick, *Boophilus decoloratus*. The breakdown products of the red corpuscles may appear in the urine and colour it a deep red, which gives the name to the disease.

Young animals are more resistant to the disease and their contact with infected ticks early in life may result in a mild, cryptic infection, followed by freedom from the disease later in life.

There is a high temperature and rapid loss of condition. The destruction of the red blood corpuscles by the parasite produces a progressive anaemia. Respiration and pulse rate are greatly increased. Care must be taken in handling affected animals since any extra exertion from their struggling could result in the sudden failure of the heart, already strained from the anaemia.

The final diagnosis is made on the demonstration of the causal agent in a stained thin blood smear, but, since the disease can kill rapidly, *treatment should not await confirmation by blood smear.* Recommended treatment is by the sub-cutaneous injection of Berenil at 3,5mg/kg body weight, as a 7 per cent. solution. Control of the vector prevents the occurrence of epizootics.

13.4.2 Gallsickness (Anaplasmosis)

Gallsickness is an acute or subacute febrile disease, caused by the protozoan *Anaplasma marginale* which is transmitted by ticks of the genera *Boophilus* and *Rhipicephalus*. Young animals are not severely affected, and recovery from the disease may result in freedom from further attacks later in life. The causal organism invades the red blood corpuscles, causing an acute anaemia and severe digestive derangements as a result of its effects on the internal organs, particularly the liver. A high temperature develops and the respiration rate increases. The animal rapidly loses condition and suffers severe constipation. The faeces are much reduced in quantity and take the form of hard balls often with a coating of mucus.

The affected animal is dull, eats and drinks little or nothing and is disinclined to move, but, on occasion, may be ferocious (mad gallsickness) and charge when disturbed.

Terramycin is a specific cure in the early stages of the disease; other treatment consists mainly of nursing and relieving the constipation.

Laxatives, such as saline purges, molasses, linseed oil, calomel, etc., have a use in treating this condition. They should be administered in large quantities of water, best administered by stomach tube, because of the bulk. As with all febrile cases the patient should be kept quiet, in an even temperature and be offered a supply of succulent food and clean water. Struggling and other forms of violent exertion must be avoided to prevent further strain on the heart.

Definitive diagnosis of the disease is made by the demonstration of the causal organism in stained thin blood smears.

Control of vector ticks leads to control of the disease.

13.4.3 Quarter Evil

This hyperacute disease is caused by the bacterium *Clostridium chauvei*. The site of infection is within the muscle masses, usually of the fore and hind quarters. The bacteria multiply rapidly and produce a gas which disrupts the the muscle fibres and escapes under the skin, so that the site of infection crackles under touch, and feels as though the skin overlies sheets of stiff paper or parchment. Death is extremely rapid and animals are seldom seen to be sick.

An efficient vaccine is available, the use of which will ensure that no losses are suffered from this disease. Cattle used on tsetse control operations are given the appropriate vaccination at the age of about six months with a booster dose one year later.

Proper disposal of the carcase by burning after death from Quarter Evil is important, since, when exposed to the air, the causal organism forms resistant spores which can remain infective for years.

13.4.4 Parasitic gastro-enteritis

This is an intestinal disorder brought about by the presence of parasitic intestinal roundworms or *nematodes*. The species range in size from the thickness of a stout thread to that of a fine hair, barely visible to the naked eye. Females produce vast numbers of eggs, and reproduction is extremely rapid. When they occur in an animal in large numbers, they cause a rapid loss of condition. Many of them are voracious blood suckers, which reduce the host to a state of extreme weakness, inanition and anaemia which can cause death. They set up an irritation in the lining of the gut which produces the effects of indigestion evinced by diarrhoea, a stary coat and loss of condition.

Diagnosis depends upon the identification of the worm eggs in the faeces. Unless they have been refrigerated, specimens of faeces must reach the laboratory within 24 hours of being collected. Treatment involves the application of a drench, administered according to the manufacturer's or veterinarian's instructions.

13.4.5 Poisoning

Poisoning in livestock is common in Rhodesia, and can be discussed as:

a. Plant poisoning

b. Other poisoning

Plant poisoning

Many naturally occurring plants in the Rhodesian veld have been listed as the cause of outbreaks or of individual cases of stock poisoning, and the number still grows. The incidence of plant poisoning can be related to the condition of the veld. For example cases of poisoning are most likely to occur during the late dry season, particularly after a burn, when deep rooted bulbous plants, such as those belonging to the lily family produce succulent green leaves that although not their normal diet are attractive at this time to stock that have been deprived of fresh green food for several months. It is also asserted by some that stock, particularly young stock, when moved from one area to another with different edible plants are more liable to develop plant poisoning.

The signs of plant poisoning vary greatly, according to the nature and quantity of the particular poison ingested. An important sign differing from that seen in febrile conditions is that the body temperature is normal or subnormal. Ruminal movements are reduced or absent. There may be diarrhoea with intense pain and the faeces may contain blood with or without a slimy mucus. The animal may be disinclined to move, prostrate, or even insensible.

Some plants, of which Umkauzaan *(Dichapetalum cymosum)* is an outstanding example, produce poisons which are extremely rapid in their action, and treatment can rarely be undertaken in time.

General treatment should aim first at preventing the absorption of further poison from the alimentary tract, and then encouraging its elimination from the body. Very strong black tea is a useful antidote since it often renders the poison insoluble, and also acts as a stimulant. Elimination is aided by a saline purge. Oily purges should be avoided since they are slower in action and may increase the absorption of the poison.

A recommended purge is compounded of:

350 gm Common salt

350 gm Epsom salts or Glauber salts

dissolved in 2,5 litres water

This is sufficient for a large ox. Smaller animals require less according to size.

Some grasses and other plants particularly when wilted by a hot sun produce lethal quantities of prussic acid when they are eaten at certain stages in their growth, and according to the amount eaten, bloat or death may result. The condition is known as Geilsiekte. In bloat or hoven, due to prussic acid poisoning, the muscles in the walls of the rumen become paralysed and the normal eructation, or belching cannot take place. The resulting large accumulation of gases brings pressure upon the chest causing respiratory distress and even death. Sheep are particularly liable to this condition.

Treatment of acute bloat is designed to prevent further evolution of gas and to encourage eructation. Bloated animals should, whenever possible, be made to stand and walk about, and *never* be allowed to remain lying on their sides. To prevent further formation of gas it is usual to give a drench of 500 ml of linseed oil or liquid paraffin to which has been added 50 to 80 ml of *natural turpentine* NOT 'mineral turps' or 'turpentine substitute'. Where these cannot be obtained, one tablespoonful of 'Dettol' in 500 ml of water can be administered as a drench. These doses are for mature cattle and should be reduced according to size for smaller cattle or sheep.

Other poisoning

Arsenic. Under Rhodesian conditions of regular dipping of cattle as a tick control measure, arsenic poisoning is by far the most common other form of poisoning, and is regarded by some as being second only to poverty as the cause of cattle deaths in the country.

The source of the arsenic is invariably dipping fluid and the deaths are invariably due to carelessness in its use and disposal.

The signs produced from lethal doses of arsenic are those of an acutely irritant poison, with diarrhoea – often bloody, rapid dehydration (loss of tissue fluids), weakness, staggering and prostration, ending in death. Arsenic is also absorbed through the intact skin and similar but less acute signs are produced if stock are dipped in too strong a solution. In this case the skin becomes burnt and damaged and the cause is clearly indicated.

The progress and severity of the condition depends upon the amount of poison absorbed. A specific antidote, if given early in the course of the intoxication, is sodium thiosulphate (photographer's 'hypo'). One heaped tablespoonful of the crystals dissolved in 500 ml of water should be administered, and repeated, if necessary, in four hours.

The source of the poison must be traced and rendered harmless. Arsenic is attractive to stock and is very persistent. If it is spilled on to the soil or posts or left on utensils animals can lick at the contaminated area and absorb the poison.

Organic insecticides. Modern organic insecticides should all be regarded as being poisonous to stock. They must be handled by the stockman with due precaution. Cases of poisoning usually arise from contact with leaking drums, washings from spraying equipment and used containers that have been carelessly disposed of. All poisonous substances *must* be tidily stored in lockable premises and repeatedly inspected and checked. In cases of poisoning the source must be sought and rendered harmless. The signs of poisoning from insecticides relate to nervous disorders rather than to gut irritants, and require the administration of specific antidotes.

13.5 Treatment of sick animals

13.5.1 Dosing

Where it is indicated, the field officer will be required to administer medicines to sick animals either:–

a. by the mouth, or drenching

b. by injection.

Dosing by the mouth

The situations in which an officer may be required to administer medicines by the mouth have been indicated. The following procedure will be adopted. Where possible, the animal should be restrained, preferably in a race. The correct dose of the medicine should be mixed in a bottle with a *tapering neck* which allows the complete dose to be administered smoothly. Certain wine bottles or beer bottles are suitable for dosing. Great care must be taken not to allow medicines to enter the windpipe, because if they enter the lungs they can set up a fatal pneumonia.

Right handed operators will find it easier to work on the right side of the race, and left handed operators on the left side. These instructions will apply to right handed operators, and left handed operators should construe them accordingly. Hold the bottle in the right hand and face the same direction as the animal. Pass the left hand over the head of the animal and insert the fingers under its left upper lip near the rear corner. The animal now usually remains still. Raise the mouth, by slight upward pressure, slightly above the horizontal and insert the mouth and neck of the bottle into the right corner of the lips, and into the mouth in a downward and backward direction to a depth of seventy five millimetres.

The body of the bottle is now raised, to allow the contents to run slowly into the back of the mouth. Should the patient cough the bottle must be removed immediately and the head released until the animal has recovered. The procedure is then resumed. With correct handling and observation of instructions accidents from bad dosing should not occur.

Treatment by injections

Injection provides a simple means of administering an exact amount of medicine or vaccine. The injections administered by the field officer may be given by three routes:-

(i) by the subcutaneous route

(ii) by the intramuscular route

(iii) by the intravenous route

(i) *The subcutaneous route*
The injection is delivered under the skin. Convenient sites for this method are behind the shoulder, over the ribs, or the neck. If large doses are being given the site should be massaged after dosing to disperse the swelling. If the dose exceeds 20 cc it is good practice to divide it and give it at two sites.
Irritant substances are not given subcutaneously since absorption is slow and a skin slough may result. Vaccines, antrycide compounds and Berenil are given subcutaneously.

(ii) *The intramuscular route*
The injection is given at least 37mm deep into suitable muscle masses, preferably into the neck. Absorption is more rapid than by the subcutaneous route, since there is a more copious blood supply. The relative scarcity of sensory nerves in the muscle tissues allows the more irritant drugs to be given in this manner. Such drugs are penicillin, Terramycin, Ethidium, and Isometamidium.

(iii) *The Intravenous route*
Field officers are not usually called upon to use this method, but must be aware of it.
Intravenous injection is reserved for certain classes of drug which are either *highly irritant* and require to be diluted rapidly in the blood stream to avoid undesirable side effects, or where a *rapid effect* is required.

13.5.2 Treatment of wounds and common injuries

Wounds and injuries are frequent in animals herded under bush conditions and the stockman should be able to apply first aid quickly and effectively.

Flesh wounds

All wounds should be inspected carefully, and any foreign bodies removed. Copious bleeding should be arrested by pressure of the fingers at the appropriate places, followed by the application of a pressure pad and bandage. Pressure should be maintained until the bleeding is arrested. After bleeding has been reduced or stopped, the wound should, if dirty, be cleaned by bathing in a solution of common salt and water (one handful of salt to 4½ litres of water). Stock wounds, even minor ones, may be attacked by screw worms, which are maggots of flies belonging to the family Calliphoridae, (usually of *Chrysomyia bezziana).* The maggots should be removed while alive and then killed. They should not be discarded and left alive on the ground where they can pupate and continue the cycle. The wound, when cleaned should be treated with BHC powder (Gammatox, Multibenhex etc.) or some other proprietary insecticide or disinfectant. Regular treatment of the animals with insecticides during the 'fly season' should prevent fly strike, which are always secondary to wounds, and especially to tick bites.

If wounds are very deep and extensive, advice from Headquarters or from the local veterinary staff should be obtained.

Lameness

Most lameness is confined to the feet. An inspection of the foot is the first rule. The under side of the claws and the cleft should be cleaned and carefully examined for stones, thorns or other penetrating foreign bodies, which, if present should be removed completely. Severely lamed animals should be rested, and even confined to a kraal and hand fed and watered.

13.5.3 Reporting on ailments in stock

The informed Field Officer should be able to provide a comprehensive description of the animal, either verbally or as a written report that will enable a professional officer to arrive at a diagnosis and make a plan of treatment, or to decide to make a personal inspection.

The report should be in the following form:-

Description of animal

Colour, sex, age and number

Function of animal

Bait, test herd, slaughter

Routine drug regime

Drug in use, date of last injection

Disease report

This should be a concise but detailed report of the onset and progress of the disease or condition with relevant previous history.

Action taken

Treatment given, specimens submitted, (blood smears, faecal specimens, etc.) giving date of submission and destination. If an animal has died naturally, a similar report should be sent, together with blood, spleen and gland smears, *dried in air*, wrapped individually in clean paper and enclosed in a suitable container to protect them during transit.

(ii) by the intramuscular route

(iii) by the intravenous route

(i) The subcutaneous route
[illegible]
After dosing to disperse the swelling. If the dose exceeds 20 cc it is good practice to divide it and give it at two sites.
Irritant substances are not given subcutaneously since absorption is slow and a skin slough may result. Vaccines, antrycide compounds and Berenil are given subcutaneously.

(ii) *The intramuscular route*
The injection is given at least 37mm deep into suitable muscle masses, preferably into the neck. Absorption is more rapid than by the subcutaneous route, since there is a more copious blood supply. The relative scarcity of sensory nerves in the muscle tissues allows the more irritant drugs to be given in this manner. Such drugs are penicillin, Terramycin, Ethidium, and Isometamidium.

(iii) *The intravenous route*
Field officers are not usually called upon to use this method, but must be aware of it.
Intravenous injection is reserved for certain classes of drug which are either *highly irritant* and require to be diluted rapidly in the blood stream to avoid undesirable side effects, or where a *rapid effect* is required.

13.5.2 Treatment of wounds and common injuries
Wounds and injuries are frequent in animals kept under bush conditions and the stockman should be able to apply first aid quickly and efficiently.

Stock wounds
All wounds should be inspected carefully, and any foreign bodies removed. Copious bleeding should be arrested by pressure of the fingers at the appropriate places, followed by the application of a pressure pad and bandage. Pressure should be maintained until the bleeding is arrested. After bleeding has been reduced or stopped, the wound should [illegible] by bathing in a solution of common salt and water (one handful of salt to [illegible] of water). Stock wounds, even minor ones, may be attacked by screw worms, which are maggots of flies belonging to the family Calliphoridae, (usually of *Chrysomyia bezziana*). The maggots should be removed while alive and then killed. They should not be discarded and left alive on the ground where they can pupate and continue the cycle. The wound, when cleaned should be treated with BHC powder (Gammatox, Molliberonex etc.) or some other proprietary insecticide or disinfectant. Regular treatment of the animals with insecticides during the 'fly season' should prevent fly strike, which are always secondary to wounds, and especially to tick bites.

If wounds are very deep and extensive, advice from Headquarters or from the local veterinary staff should be obtained.

Lameness
Most lameness is confined to the feet. An inspection of the foot is the first rule. The underside of the claws and the cleft should be cleaned and carefully examined for stones, thorns or other penetrating foreign bodies, which, if present should be removed completely. Severely lamed animals should be rested, and even confined to a kraal and hand fed and watered.

13.5.3 Reporting on ailments in stock
The informed Field Officer should be able to provide a comprehensive description of the animal, either verbally or as a written report that will enable a professional officer to arrive at a diagnosis and make a plan of treatment, or to decide to make a personal inspection.

The report should be in the following form:-

Description of animal

Colour, sex, age and number

Function of animal

Bull, test herd, slaughter

Routine drug regime

Drug in use, date of last injection

14. EXPENDITURE, ACCOUNTING AND ADMINISTRATION

14.1 Expenditure and accounting

One of the most important, but more onerous and less exciting tasks of tsetse control operations is accounting for the expenditure of money. Every item of material bought or service paid for by Government costs the taxpayer money. It is a most serious obligation on every Civil Servant to ensure that the utmost value is extracted for public funds spent, not only from his subordinates and from tradespeople and businessmen, but also from his own activities.

This Branch has a high reputation for the accuracy of its accounting and for obtaining value for money spent. It is possible, any day, and at a glance, to know how much money has been spent or is committed to be spent of our annual allocation of funds, and thus, how much is left to be spent. In a service such as the control of animal disease where crises can develop rapidly and without much warning it is essential to know the exact state of available resources and how the manipulation of funds to meet a crisis will affect the various activities of the Branch.

14.1.1 How funds are obtained

Each year the Ministers responsible for the various Government departments present to Parliament their estimates of expenditure for the coming year and seek its approval and sanction. After individual estimates have been fully debated by Parliament, which forms a Committee of Supply for this purpose, they are approved and accepted by vote either in their entirety or with incorporated amendments. At the conclusion of the debates on official estimates an Appropriation Act is proposed and passed, which empowers Ministers to expend public funds up to the amounts allocated for the purposes set out in their estimates. The accounting year begins on July 1st, but the Appropriation Act is usually not passed until late in August or even later. So that government can function in the interim, the President authorises Ministers to spend up to a third of their anticipated requirements before the Act of Appropriation is passed. This device enables our salaries, amongst other expenditure, to be paid in the interim.

14.1.2 Preparation of Estimates of Expenditure

For most administrative purposes, this Branch is treated as having Department status. In particular, it prepares and defends its applications for funds and spends its own votes.

The funds allocated to a Department are referred to as a Vote and are numbered annually. Thus this year, 1973/74 the Department of Veterinary Services operates Vote 36. The Branches of Field Services and of Research and Veterinary Headquarters use Vote 36 I, and the Branch of Tsetse and Trypanosomiasis Control uses Vote 36 II.

Usually during November of each year, the Secretary of a Ministry requires his Heads of Departments to prepare and present estimates of expenditure for the period July 1st of the next year to June 30th of the following year. The estimates are prepared to cover:-

(i) Requirements covering capital expenditure, e.g. houses, offices, laboratories, reclamation of land.

(ii) Requirements in respect of additional staff.

(iii) Requirements covering transport (lorries, Land Rovers, trailers, tractors, caravans).

(iv) Requirements of funds to operate the Branch.

Requirements of funds for capital expenditure

Long notice is required, usually an advancing three year programme, for expenditure of this nature on the provision of buildings, roads, dams etc. which requires forward planning. Arrangements must be made well in advance to make land available, plans must be drawn and approved by the various interested bodies, and supplies of materials must be secured. Estimates under this head for this Branch involve requests to the appropriate Ministries for the provision of dwelling houses in centres such as Gokwe, office and laboratory accommodation.

Recently Tsetse Control Operations have become accepted by Treasury as constituting Land Reclamation activities, and, as such, as items of capital expenditure.

Requirements in respect of additional staff

As Parkinson has demonstrated, once a service is provided, the staff requirements must expand. In the case of tsetse control operations, as the numbers of cattle bordering the tsetse areas increase and more cattle/tsetse contacts are made, more staff are needed to provide an adequate control service. This process will continue until large areas have been cleared of tsetse flies and the dangers of reinvasion have been removed. Applications for additional staff are submitted in the first place to the Secretary of Agriculture for his approval. These will include detailed reasons for the need for additional posts and the costs, involving salaries and ancillary expenditure such as housing, travelling and subsistence costs, camp kit, provision of transport, R/T radio, radio licence, office furniture (tables, chairs, cupboards) arms and ammunition etc. If the Secretary is convinced that the reasons justify the expenditure involved, in terms of his scheme of priorities (which usually differs considerably from that of a Head of Department), he will forward the application to the Secretary of the Treasury for his recommendation. In due course, after Treasury approval, the Inspectorate Branch of the P.S.B. will critically discuss the need for the extra posts with the Head of Department. If the Inspectorate can be convinced they will make their report accordingly to the Department of the Treasury, and the Head of Department will be advised to include the recommended additional posts and ancillary expenditure in his estimates.

Requirements covering transport

A submission is made to the Director of the C.M.E.D. as early as August of the previous year, for anticipated additional vehicles required to carry out the projects for the coming year. This includes 5 tonne lorries, Land Rovers, trailers, caravans, water trailers. The Director of C.M.E.D. knowing what funds are likely to be made available to him, makes his list of priorities and advises the Head of Department what fraction of his submission he may expect to receive. The Head of Department must then make his dispositions of staff and transport accordingly.

Requirements for funds to operate the Branch

Information is first required on the anticipated overall costs of

a. maintaining existing services

b. meeting committed expansion (if a fence has been partly built, there is a commitment to complete it even if costs have risen)

c. meeting desirable expansion. (It may be desirable, or more likely imperative, in the interests of tsetse control to operate in areas hitherto avoided).

Items under (a) are usually accepted without further justification.

Items under (b) are examined cirtically by the Secretary and very valid reasons must be given. Expenditure for items under (c) is approved only if it can be shown to be of national urgency.

The detailed requirements are based on the expenditure in previous years, adjusted for salary increases, increases in costs of materials, labour and transport, and the anticipated costs of new services.

The detailed estimates are initially scrutinised by the Secretary and his accountant staff who have already been advised by Treasury (who hold the purse strings) of the amount of money likely to be allocated to the whole Ministry. The Secretary will make his allocation according to his interpretation of the needs of the various departments. If the requirements exceed the funds available (which they invariably do) the Secretary will return the estimates to the appropriate Head of Department with suggestions, (which are interpreted as instructions) where cuts should be made. When agreement is reluctantly reached the Secretary, accountants and individual Heads of Departments discuss the estimates with Treasury officials. These officers have had long experience in paring down requests for funds, and in detecting inconsistencies in budgeting. Each item must be defended with cogent arguments. When agreement is reached at this stage, the estimates are prepared for printing and presentation to Parliament.

The Vote is divided into sub-heads and items. Thus, for the year 1974/75 the vote is numbered:-

Vote 36.II Branch of Tsetse and Trypanosomiasis Control

Current Expenditure

A *Salaries, wages and allowances*

1. Salaries and wages of all staff except casual labour.

2. Allowances, including acting, responsibility, Kariba, quarters, cycle and annual bonus.

3. Cash in lieu of leave (reserved leave commitment, and on leaving the Service).

B *Subsistence and Transport*

1. Fares. Cost of air fares and air charter.
2. Official milage in private vehicles, and for medical trips.
3. Subsistence and transfer allowances.
4. Vehicle hire (heavy lorries, Land Rovers, caravans, trailers, water bowsers).

C *Incidental Expenses*

1. Books and periodicals (technical and scientific).
2. Air freight, port and agency charges.
3. Maintenance of office equipment.
4. Office and miscellaneous.
5. Posts and telecommunication services.
6. Printing and stationery.
7. Recruiting expenses.
8. Water, light and sanitary charges.

D *Trypanosomiasis Control*

1. Purchase of trypanosomicidal drugs.

E *Research*

1. Aerial spraying trials
2. Laboratory maintenance
3. Research stations running expenses

   Labour (wages and rations)

   J1 Equipment, materials and stores for research

   K1 Equipment, materials and stores of a camp and office nature

   K1A Maintenance of radio equipment

   L1 Camp maintenance requirements

   M1 Camp construction requirements

   Uniforms and protective clothing

4. Test animals (cattle, sheep, rabbits, rats, etc.)

F *Contributions*

Interterritorial scheme for the control of tsetse and trypanosomiasis in South East Africa

Capital Formation

G *Furniture and equipment*

1. Purchase of furniture and office equipment
2. Laboratory equipment

H *Land reclamation*

1. Tsetse fly control for the purposes of land reclamation

The headings are self explanatory. The item 'Land reclamation' is a major item and is further divided into the following heads for ease of administration:-

Labour, (wages and rations)

Mechanical clearing

Borehole maintenance and development

Equipment, materials (inclusive of insecticide) stores, etc

Mapping and planning

Uniforms and protective clothing

Although this fragmentation is extensive and involves a considerable amount of time spent in book-keeping it provides the means of assessing the cost of each operation in the various operational areas, so that costs can be compared and over-expenditures detected. It also provides a ready and accurate means of estimating the costs of mounting extra operations should these become necessary and if appeals must be made for further funds.

Expenditure within each item of the subhead is at the discretion of the Head of Department, so that within vote H he may increase the expenditure on one sub item but at the expense of another, since he has been authorised to spend only a certain amount on 'H Tsetse Fly Control for the purpose of land reclamation', and he may not exceed this amount without authority.

Contingencies do arise, however, where there is a pressing need for more funds than have been voted for a particular item. For example, if the cost of recruiting a glossinologist from overseas exceeded the amount set aside for this purpose, on Subhead C item 7 the Head of Department would be required to apply to the Secretary to authorise a virement from another item in Subhead C, and he would have to provide sound reasons why overspending cannot be avoided and to indicate the item from which an equivalent amount of saving would be made. An adjustment would then be made. But this transfer and enforced saving brings with it the suspicion that if a saving can be tolerated, too much money was asked for in the first place.

If an adjustment cannot be made from the same subhead, because no savings can be made without seriously affecting the purpose of the allocations, application is made, through the Secretary, to the Department of the Treasury to virement from another subhead. In this case, very strong reasons must be given to explain why a virement is necessary. Since these are the people who finally assess estimates it is with great reluctance that a Head of Department would allow Treasury officials to entertain any doubts on the accuracy of his budgeting.

It sometimes happens that a national crisis occurs that involves one department of a Ministry, as for example an outbreak of foot and mouth disease in an important agricultural area. In such an event the Director of Veterinary Services would be required to estimate the costs of control in terms of men, materials and services, and these would be presented to Parliament as Supplementary Estimates, or the President may issue a Warrant to provide the necessary funds.

14.1.3 Auditing

Spending public funds wisely and to best advantage is not the end of the story. The Auditor General and his staff are charged with the task of ensuring that all Government property is properly cared for and accounted for, and that all transactions involving transfer of money to or from Government funds are recorded in the prescribed manner. The Government Auditors may inspect any office or camp or store at any time without warning, and have access to all keys, safes, books, records and money.

The Head of a Department must render annually to the Secretary a statement that the movable assets in his charge have been accounted for and physically checked at least once during the year. Items of equipment wear out or are lost. There is a prescribed procedure for accounting for such events, the Board of Survey, by means of which authority may be obtained to remove the items from the list of movable assets. Until this authority has been obtained the items remain the responsibility of the person who signed the receipt for them. No items may be discarded without authority.

14.1.4 Where the money comes from

When estimates of expenditure have been submitted by Ministries to the Treasury, the total sums required by Government can be assessed. If this amount falls short of the anticipated income from taxes, dues, customs and excise, fees, rents etc. then government must decide between operating at a loss over the year or increasing taxation, or seeking loans so that a suitable and tolerable equilibrium may be maintained.

Loans to Government are usually reserved to finance capital expenditure such as the building of schools, hospitals, roads, bridges, dams, while annual expenditure on government operations is serviced from revenue (taxes, customs, excise etc.).

The cost of Tsetse and Trypanosomiasis Control Operations is running at about $1 500 000 per annum. Regarded as an insurance policy, it is giving protection from tsetse and trypanosomiasis to about a third of the Rhodesian livestock industry at a premium of less than 2% of its capital value.

14.2 Administration involving the Senior Tsetse Field Officer and Tsetse Field Officer

The system of accounting adopted by the Branch has been streamlined as far as possible to facilitate the work of the field staff, and no deviations from laid-down procedure can be tolerated. Where improvements in procedure can be seen, they should be brought to the notice of the Administrative Officer, Salisbury, who will consider their application, and, if changes are to be made to the procedure, will authorise them by letter or circular to all concerned.

The various field activities of the Branch are organised, financed and accounted for as *Projects*. Thus, the costs of fence construction, road construction and hunting operations are budgeted and accounted for as separate items under the appropriate vote.

In order that the expenditure incurred, progress made and information gathered by each field officer during the month shall be made available to Headquarters early and regularly, he is required to submit a number of completed forms. Although the number of forms is formidable, their completion ensures that Headquarters obtains the information it requires, and the field officer is relieved of the anxiety of covering all aspects of his work in a written report. A written report on an officer's observations of special interest, not covered in the standard forms is always welcomed.

Some of the forms listed below are completed normally by the S.T.F.O. but he should instruct his T.F. Officers in the procedure so that, if the need arose, a T.F.O. could complete the month end returns accurately.

14.2.1 Engaging, paying and discharging labour

Engaging, paying and discharging labour is the responsibility of the Senior Tsetse Field Officer. A Tsetse Field Officer may have occasion to recommend to his S.T.F.O. the hiring or discharging of a labourer, but the ultimate decision rests with the S.T.F.O. who will take the appropriate action.

The wage paid to labourers is usually determined by local conditions. Where labour is at a premium wages are higher than where it is abundant. The advice of the local District Commissioner is taken as a guide, but the S.T.F.O. is instructed by Headquarters on the wage rates. All labourers are engaged on a daily basis, so that unsatisfactory workers can be dismissed forthwith, but they are paid monthly. Uniformed casual employees are an exception in that they are engaged and paid on a monthly basis.

Casual employees may be engaged within the limits for which approval has been granted. When engaging African employees the S.T.F.O. must make the appropriate entry in the Registration Certificate and complete an African History Sheet (Form Z 856 (R)) in respect of each employee. The History Sheets will be filed under Project headings, kept up to date, and given utmost security.

When a casual employee leaves his employment, the officer in charge will sign off the employee's Registration Certificate and return it to him.

So that money can be made available to the S.T.F.O. to pay staff at the month end, he must submit to Headquarters an estimate of the current month's labour costs, *not later* than the 5th of the month. A cheque for that amount will be sent to him in time to cash it before the next pay day.

At each month end, the S.T.F.O. or his deputy will arrange with his employees a time and place for making payment. Payment will be made by handing over the full appropriate wage and the signing of a receipt, or affixing a mark on the paysheet witnessed by at least one literate employee, who will add his signature in the appropriate place on the paysheet.

If an employee who is due wages is absent from a pay parade, his name will be scored from the paysheet and his wages will be returned with the completed paysheet to Headquarters, Salisbury. On no account will his wages be paid to a third person.

When the absent employee again reports to the paying officer he may be paid from an imprest (advances) account held by the S.T.F.O. in charge. The payment will be recorded on the usual African Paysheet (Form Z 289A(T)), even if only one payment is involved. Withdrawals from the Imprest Account must be recorded at the time in the Imprest Ledger, and at the month end a copy of all transactions sent to Headquarters, Salisbury, on Form No. 11 'Imprest Account'. The completed paysheet and surplus money from one month must be returned to Headquarters, Salisbury, to arrive not later than the 8th of the following month. They must be delivered in person, or sent by registered post, with money covered by Government Money Orders, obtainable from a Post Office.

14.2.2 Recording movable assets

An officer in carrying out his duties inevitably uses Government equipment for which he is responsible while it is on charge to him. He is liable to surcharge for its culpable misuse or loss.

The issue and receipt of movable assets (that is anything that is not money or buildings and their fixtures) is carried out by means of issue and receipt vouchers with signatures given and received, (Form Z 837). Changes are recorded daily in the appropriate register of movable assets, one of which is maintained at each station, and a copy of the Issue/Receipt Voucher is submitted to Headquarters, Salisbury.

When an officer is required to relinquish responsibility for Government movable assets, whether on personal issue to him or the contents of a camp, he must arrange the transfer with another officer, and obtain a signed and dated receipt for all items. His responsibility for the items signed over then ceases. Any shortfalls or damage to items must be recorded at the time, and Headquarters advised immediately.

14.2.3 Recording the issue of rations

Rations are bought in bulk and may require to be stored for several months. They should be stored in weatherproof shelters, and protected from vermin, insects and fungi by tight packing of bags, use of bucksails and avoidance of litter.

An *up to date* register must be kept, on view within the store, of all additions and withdrawals, in which the dates and quantities of each commodity involved are recorded. The source of additions and the destination of withdrawals must be recorded including the masses involved. The ultimate ration issue to individuals will be assumed to have been made after the person responsible for making the ration issue has recorded the receipt of the relevant rations. Queries regarding the issue to individuals must be referred to this person (e.g. the African supervisor in charge of a gang).

14.2.4 Recording the issue of fuel and lubricants

An up to date record of issues, receipts and the balance of stocks on charge must be kept, and must be available for inspection by an authorised person.

At the month end the S.T.F.O. will submit to the Director, C.M.E.D., via Headquarters, Salisbury, an interdepartmental requisition for issues of fuel and oil used in Branch equipment such as power saws, water pumps and jack-hammers.

14.2.5 Safes

Safes must be securely fixed so as to be immovable. The location of the duplicate key must be indicated on the safe and the receipt for it must be readily available, outside of the safe, but in a secure place.

Normally only Government cash and records may be housed in Government safes, but special permission has been given to keep rifle bolts in safes also. Items other than these, such as personal property, may be removed forthwith by a visiting auditor.

14.2.6 Use and care of Government transport

Our operations are dependent on the availability of functional transport. Every effort must be made to keep vehicles serviceable and clean. The appearance and condition of vehicles under his supervision will be regarded as an indication of an officer's general efficiency. Major breakdowns requiring the services of a C.M.E.D. mechanic must be reported at the first opportunity to area headquarters from where arrangements will be made for assistance.

Reports of prolonged unserviceability of transport will normally be regarded as an indication of inefficiency on the part of the officer concerned.

14.2.7 The issue of uniforms

Uniforms are issued to African staff who come into frequent contact with the public, such as gate guards, fence patrol guards and office messengers; to field assistants and ungraded field assistants who carry out tsetse surveys so that they may present a more standard source of attraction to tsetse flies and to supervisors of labour gangs to support their status and authority.

Protective clothing also is issued in special circumstances. Drivers, mechanical saw operators and insecticide sprayer operators are issued with overalls. Those handling concentrated insecticides should be supplied with gloves of a resistant material. Mechanical saw operators wear protective helmets. In the rainy season uniformed Africans and herd boys are issued with waterproof capes.

Personnel issued with uniforms are expected to present a clean and tidy appearance when on duty. Issues of soap are made to them for this purpose. They should not wear uniforms when not on duty.

The various items of uniform have different life expectancies, and issues are made accordingly. The S.T.F.O. should keep a record of the issue of each item of uniform to each uniformed African, and should request replacements only at the appropriate times. The rates of uniform and protective clothing issues are listed in Branch advice Ref AA/2/5/19 of 7.12.1971, to which reference should be made.

The clothing sizes of each African entitled to an issue of uniform should be recorded by the S.T.F.O. The records for casual employees should be kept on the African History Sheet.

14.2.8 Submission of returns

The several forms listed alphabetically in Tsetse Form No. 54, 'Summary of Monthly Returns' must be completed (including NIL returns) and submitted to Headquarters, Salisbury at each month end in time to arrive by the 8th of the following month. These returns cover the activities carried out in the area during the month from pay day to pay day. Field Officers and certain Field Assistants will make their reports to their Senior Field Officer, or, when he is not available, direct to Headquarters.

Two forms refer particularly to labour:-

1. *African History Sheet* (Form Z 856 (R))
   This form records the required details of African casual employees, which must be entered on the engagement of each employee, and kept up to date during his period of employment. It is the basis from which the paysheets are compiled, and serves as documentary evidence of an employee's service when he becomes due for a gratuity.

2. *African paysheet* (Form Z 289 A (T))
   This records the employee's period of service in days, the rate of pay, the wages received, and the recipient's sign or signature. It is completed in triplicate. The third copy remains as a record in the pay book. The first and second copies are submitted to Headquarters, Salisbury. On them, is also recorded the average cost of rations issued to each individual during the month calculated according to the local ration scale. Hunters are not issued with a meat ration, and meat obtained from hunting operations and distributed as rations is not charged against rations.

Both the African History Sheet and African Paysheet are used and filed in relation to the labour engaged on the various activities of the Branch.

The forms required to be completed as part of the month end return and forms to record other transactions are listed below, according to the various activities carried out in the field. The officer required to complete the forms is indicated:-

a		*Surveys, patrols and test herds*
STFO	i	African history sheet Z 856(R)
STFO	ii	African paysheet Z 289 A(T)
	iii	Blood meal identification T.F.32
	iv	Blood meal summary
	v	Dissection form T.F.52
	vi	Fly patrol summary return T.F.12A
	vii	Game count recording sheet T.F.48
STFO	viii	Livestock and monthly return Tryps. Form 1
STFO	ix	Livestock treatment return Tryps. Form 12
STFO	x	Record of hides from slaughtered cattle T.F.61
b		*Traffic Control*
STFO	i	African history sheet Z 856(R)
STFO	ii	African paysheet Z 289A(T)
STFO	iii	Fly gate summary
STFO/TFO	iv	Gate returns
STFO	v	Traffic register
c		*Hunting operations*
STFO	i	African history sheet Z 856(R)
STFO	ii	African paysheet Z 289A (T)
TFO	iii	Ammunition return T.F.15
STFO	iv	Armed African employees (copies to HQ; D.C; B.S.A.P.; area HQ; self) T.F.41
TFO	v	Daily ammunition working sheet (.303) T.F.94
TFO	vi	Daily ammunition working sheet (other calibres) T.F.95
STFO	vii	Finger print record B.S.A.P.
STFO	viii	Hunter performance record T.F.69
STFO/TFO	ix	Hunter record T.F.22
STFO/TFO	x	Shooting record T.F.16 (G.P.S. 20787)
STFO	xi	Summary of animals destroyed in selective hunting operations T.F.17

STFO xii Summary of animals destroyed on fences T.F.18
STFO xiii Trophies and hides return T.F.56
STFO/TFO xiv Weekly review of hunting operations T.F.60

d *Fence patrols and maintenance. Game fences*
STFO i African history sheet Z 856 (R)
STFO ii African paysheet Z 289 A (T)
STFO/TFO iii Summary of breaks in game fences (for each fence) T.F.20
STFO/TFO iv Weekly report by Fence Patrol Guards T.F.71

e *Fence patrols and maintenance. Cattle fences*
STFO i African history sheet Z 856 (R)
STFO ii African pay sheet Z 289A (T)
STFO iii Summary of breaks in cattle fences (for each fence) T.F.20

f *Fence construction. Game fences*
STFO i African history sheet Z 856 (R)
STFO ii African pay sheet Z 289A (T)
STFO iii Game fence construction unit, Stock and equipment condition report T.F.93

g *Fence construction. Cattle fences*
STFO i African history sheet Z 856 (R)
STFO ii African pay sheet Z 289A (T)

h *Spraying operations*
STFO i African history sheet Z 856 (R)
STFO ii African pay sheet Z 289A (T)
TFO iii Carrier form T.F.38 B
TFO iv DDT consumption record T.F.92
TFO v Favori-Colibri sprayer spares T.F.90
STFO/TFO vi Field form (spray) T.F.36 B
STFO/TFO vii Orders for spraying spares T.F.82
STFO/TFO viii Spraying operations equipment requirements
TFO ix Spraying summary sheet T.F.37
STFO/TFO x Urania sprayer spare parts T.F.89

i *Bush clearing operations*
STFO i African history sheet Z 856 (R)
STFO ii African pay sheet Z 289A (T)

j *Access and airstrip maintenance*
STFO i African history sheet Z 856 (R)
STFO ii African pay sheet Z 289A (T)

k *Access and airstrip development*
STFO i African history sheet Z 856 (R)
STFO ii African pay sheet Z 289A (T)

l *Maintenance of base camp s and laboratories*
STFO i African history sheet Z 856 (R)
STFO ii African pay sheet Z 289A (T)

m *Construction of base camps and laboratories*
STFO i African history sheet Z 856 (R)
STFO ii African pay sheet Z 289A (T)

n *Fuels and lubricants, Issue of*

STFO	i	Fuel and oil issues C.M.E.D. S.20
STFO	ii	C,M.E.D. Petrol oil and lubricants account S.21
TFO	iii	Fuel stock station (direct to C.M.E.D.) T.F.3
o	*Government vehicles, Use of*	
STFO	i	Appointment of heavy vehicle drivers T.F.67A
STFO	ii	Field staff vehicle milage summary T.F.51
STFO/TFO	iii	Government vehicle accident questionnaire Appendix A
STFO	iv	Injury or illness on duty Z 1149
STFO/TFO	v	Vehicle equipment accident report form Z 121 C.M.E.D.
TFO	vi	Vehicle logs. *a* Caravan
		b Land Rovers
		c Lorries
		d Tractors
		e Trailers, light
		f Trailers, tractor
		g Trailers, water
p	*Movable assets, recording of*	
STFO	i	Additions and deletions to movable assets register T.F.58
STFO	ii	Board of Survey report
STFO/TFO	iii	Issue/Receipt voucher
STFO	iv	Movable assets check sheet T.F.64
STFO/TFO	v	Movable assets register
STFO/TFO	vi	Stationary power units record T.F.31
q	*Payment of Staff*	
STFO	i	African history sheet Z 856 (R)
STFO	ii	African pay sheet Z289A(T)
STFO	iii	Deductions from salary Z 324 (T)
STFO	iv	Graded African pay sheet
STFO	v	Imprest account ledger
STFO	vi	Imprest account statement T.F.10
STFO	vii	Salary/Allowance/Pay record change Z 326
STFO/TFO	viii	Short receipt Z 274 (T)
STFO/TFO	ix	Travelling and subsistence claim
r	*Personal activities, Recording of*	
STFO	i	Annual leave T.F.63
STFO	ii	Application for leave
STFO	iii	Check list of month end returns T.F.87
TFO	iv	Daily diary
STFO	v	Deductions from salary
STFO	vi	Monthly report
STFO/TFO	vii	Personal issue of movable assets T.F.68
STFO/TFO	viii	Radio test call T.F.42
STFO/TFO	ix	Report of illness or injury on duty Z 1149
STFO	x	Salary/Allowance/Pay record change Z 326
STFO	xi	Telephone account
STFO/TFO	xii	Travelling and subsistence claim

In addition, where applicable these forms will be completed and submitted:-

STFO	i	Area monthly costing return T.F.96
STFO	ii	Details of duties and expenditure T.F.4
STFO	iii	Return of water consumed from Ministry of Water Development installations
STFO	iv	Summary of monthly returns T.F.54
STFO	v	Water accounts

STFO		vi	Weekly return of commitments made against Freight, Port and Agency vote item T.F.59
	s		*Rations, purchase receipt and issue*
STFO		i	Issue/Receipt voucher
STFO		ii	Ration return T.F.1
STFO		iii	Record of issues/receipts kept in ration store
STFO		iv	Record of hides from slaughtered cattle T.F.61
STFO		v	Requisition book (purchase of rations locally)
STFO		vi	Short receipt (purchase of meat locally)
	t		*Requisitions from Headquarters and other Departments*
STFO		i	Requisition book, interdepartmental
STFO		ii	Stores requisition and issue T.F.8
	u		*Uniforms, Issue of*
STFO		i	African uniform, protective clothing and campkit receipt T.F.26

15. ELEMENTARY CARE OF HEALTH

It is not intended that these notes should provide a reference book on health matters, but they will indicate some essential precautions that the Tsetse Field Officer will be expected to take to maintain his health and that of his family.

15.1 Diet

The normal diet should include proteins, fats, carbohydrates, small but essential quantities of vitamins, and water in some form. Foods rich in protein are animal muscle, milk products, eggs, and seeds of the bean family. Carbohydrates can be supplied in the form of sugar, and starch derived from grain and potatoes. Fats occur in animal fat, eggs, milk and vegetable oils. Usually a varied diet of fresh meat, eggs, butter, green vegetables and fruits will provide an adequate supply of vitamins. Over consumption or under consumption of certain foods can readily result in body disorders. Particular attention should be paid to the intake of fresh vegetables.

Special care must be taken over drinking water. Many avoidable illnesses are caused by careless treatment of water. *All water other than water from boreholes should be boiled and kept clear of contamination before being drunk.* Where filters are provided, they should be kept topped up, and the filter element maintained in a proper state of cleanliness.

15.2 Precautions against transmissible diseases

Personnel working under field conditions are at times exposed to risk of infection by certain diseases, but with proper precautions these risks can be reduced to a minimum.

15.2.1 Alimentary disorders

Failure to boil drinking water or to clean thoroughly fruit or vegetables eaten raw could result in such illnesses as amoebic dysentery and virus or bacterial forms of enteritis.

15.2.2 Bilharzia (Schistosomiasis)

Bilharzia is a disease of humans produced by the presence of a parastic flatworm, usually in the bowel or urinary bladder. The worm has a complicated life history, and occurs in this country as two species. The adults of *Schistosoma haematobium* live in the blood vessels surrounding the urinary bladder, and those of *S.mansoni* in the blood vessels surrounding the intestine. They attach themselves by a pair of well developed suckers to the inner walls of the blood vessels and feed continuously on the blood that surrounds them. After mating, the worms remain for the rest of their lives united, the shorter (12mm) and wider (3mm) male clasping the female within a longitudinal groove along its body. The female lays vast numbers of eggs into the finer blood vessels, each provided with a pointed spine which assists the egg in burrowing its way through the bladder or intestinal wall, from where it is passed out in the urine or faeces. The continued feeding of the worms produces in the infected person an anaemia with feelings of nausea, weakness, lethargy and sometimes psychological disturbances. When the eggs are moving through the wall of the gut or intestine small drops of blood are liberated which can be sufficiently numerous to tinge the urine or faeces red. At this stage the egg has divided up within the shell to form the first larval form.

Where these signs and symptoms are suspected medical advice should be sought immediately, since certain diagnosis depends on the identification of living eggs.

The eggs rapidly die if they do not come into contact with fresh water, but when they do, they quickly hatch and a free swimming larval form emerges. This organism, the *miracidium* lives for two to three days during which time it must find and burrow into the 'foot' of certain small snails which are common in stagnant or slowly moving water.

Within the snail, the miracidium undergoes a process of development and rapid multiplication. The progeny of a single miracidium ultimately emerge from the foot of the snail as hundreds of pre-adult *cercariae*, each provided with two suckers on its head, and a long slender body ending in a forked tail, by means of which it swims about, seeking a human host. If cercariae encounter a human within 24 hours they burrow the head end through the skin of the host and shed their forked tails. They penetrate the skin until they reach a vein, along which they pass to the heart, to the lungs, and then to the liver where mating takes place. Finally the paired adults migrate through the bloodstream to the blood vessels surrounding the bladder or bowel, to the walls of which they attach themselves. The female then proceeds to pass eggs.

If the cercariae fail to find a human within 24 hours, they cease to be infective, but, depending on temperature, they can survive for up to four days.

Their high rate of infection and the personal habits of the indigenous tribesmen of urinating and defaecating into water make it extremely likely that all natural waters are infected. Exposure to untreated natural waters, particularly those of stagnant ponds or slow streams should be avoided where possible. In these situations the snail hosts can usually be found in abundance.

Where contact with suspect water has occurred care should be taken to dry the skin with a towel as soon as possible.

Personnel should receive periodic checks on their physical condition by Government Medical Officers of Health.

15.2.3 Malaria

Malaria is caused by a protozoan blood parasite of a more complex organisation than the trypanosome. It is transmitted by the bite of an infected female mosquito. (Male mosquitoes do not possess biting mouthparts). Only two species of mosquitoes are malaria carriers in Rhodesia, and both belong to the genus *Anopheles*, the adults of which can be recognised by the attitude they assume when resting on a surface. They rest with the proboscis, head, thorax and abdomen held in a straight line, the abdomen pointing away from the surface on which they rest. The gnats, (Culex spp.) in contrast, hold their bodies bent, with the abdomen pointing towards the surface on which they rest. The female mosquito lays its eggs on water, and the larval and pupal stages are entirely aquatic.

One of the malaria carrying mosquitoes, *Anopheles gambiae* lives in situations exposed to strong sunlight. It breeds in standing water in small sandy or rock pools, rain puddles, wheel ruts, animal hoof marks, borrow pits, and isolated pools in road or railway drains. The water in which they thrive may be clear or muddy, contains little or no vegetation, and must be exposed to direct sunshine. This mosquito shows a preference for rain or storm water, and is seldom found in seepages, where the water has a higher mineral content. It does not favour rain water in artificial receptacles, such as cattle watering troughs or discarded buckets or tins.

The other species, *A.funestus*, breeds in slowly running water at the sides of streams and overgrown furrows and ditches where shade is provided by water or land vegetation. The water must be of considerable purity, and the larvae are usually found close to the edges, where the water movement is reduced. This species also occurs in grassy swamps where slow water movements take place. Shade is a necessity, and when absent, although everything else is favourable, breeding will not take place. Mosquitoes can remain active throughout the year in this country below 600 metres above sea level, but elsewhere, during the colder weather, *A.funestus* hibernates as the adult. *A.gambiae* on the other hand, disappears completely from higher lying areas during the cold weather and reinvades from the lower lying areas as the temperatures rise.

The onset of infection, which normally becomes apparent about 10 to 11 days after an infected bite is marked by headaches, nausea, pains in the back, high temperatures and shivering. At this stage, medical advice is needed.

Should an officer working in the field, members of his family or members of his *graded African* staff develop this condition, they must be taken to the nearest hospital, without delay, for expert attention. *Under no circumstances* should a Field Officer attempt to treat sick individuals himself. *This is an instruction issued by the Secretary for Health.*

It is the responsibility of an officer in the field to ensure that the safeguards afforded him are properly utilised. He is provided with a sound mosquito net. He must use it and keep it serviceable. He must also requisition for prophylactic drugs, and must ensure that he, his family and his *graded African* staff take the recommended dose regularly.

The Secretary for Health advises that the recommended prophylactic measure for the prevention of malaria is to take one tablet of Camoquin twice weekly for adults, and half a tablet of Camoquin twice weekly for children.

African labourers must *not* be given prophylactic treatment since, in many cases they have developed a slight immunity which should not be upset by treatment.

If they should develop symptoms of malaria they should be given a *single* dose of two tablets of Camoquin, (see Branch Circular No. 2 of 1974).

It is sometimes necessary to apply a persistent insecticide to the insides of huts and other living quarters. The Department of Health in Pamphlet No. 14 recommends the application of BHC at the rate of 1kg 10 per cent gamma BHC wettable powder in 30 litres of water, applied as a spray at three-monthly intervals. An equivalent application of 75 per cent DDT wettable powder would be 1 kg in 225 litres of water.

15.2.4 Sleeping Sickness

Although field staff generally must live with the tsetse fly, few are exposed to the risk of contracting trypanosomiasis. The incidence of *T.rhodesiense* in Rhodesian tsetse flies is very low and appears to be confined to restricted areas of the Zambesi valley, between the confluence of the Sanyati River and the point where the Msengedzi river enters Mocambique.

It is a feature of the distribution of the disease in this country that whenever it has occurred, both *G.morsitans* and *G.pallidipes* occur, and that it has not been reported where *G. pallidipes* are absent. In several instances infections have been sustained in situations where bushbuck are known to occur, and bushbuck are favoured hosts of *G.pallidipes*. Moreover, the causal agent *T.rhodesiense* has been recorded from only one species of game animal, and that is the bushbuck. There appears to be an association in this country between occurrences of sleeping sickness and the presence of *G. pallidipes.*

The disease is transmitted by the bite of an infected tsetse containing metacyclic forms of *T.rhodesiense* in its proboscis and salivary glands, (see section 11.3.1.c).

The symptoms appear about 10 to 14 days following the infected bite, around which a large sore, or chancre may develop. Trypanosomes may or may not be present within the fluid from the chancre. They do not appear in the general circulation until symptoms appear – headaches, pains in the back and joints and fever. In the early stages of the disease the symptoms resemble those of an attack of malaria, and any feverish condition that does not readily respond to anti-malarial treatment should be reported to the Government Medical Officer of Health as a possible sleeping sickness case. The patient if unable to visit the doctor should be put to bed, kept warm and given plenty to drink (no alcohol), and the doctor's advice must be sought immediately.

If taken in its early stages, the disease is curable, without lasting ill effects.

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