COMMISSION DE COOPERATION TECHNIQUE EN AFRIQUE AU SUD DU SAHARA

Créée en Janvier 1950, la Commission de Coopération Technique en Afrique au Sud du Sahara (C.C.T.A.) a fait l'objet d'une Convention Intergouvernementale signée à Londres le 18 Janvier 1954. Elle se compose, à l'heure actuelle, des Gouvernements suivants : Belgique, Fédération de la Rhodésie et du Nyassaland, République Française et Communauté, Ghana, République de Guinée, Libéria, Portugal, Royaume-Uni, Union de l'Afrique du Sud.

OBJECTIF

Assurer la coopération technique entre les territoires dont les Gouvernements Membres sont responsables en Afrique au Sud du Sahara.

ATTRIBUTIONS

1) Traiter de tout sujet concernant la coopération technique entre les Gouvernements Membres et leurs territoires dans le cadre de la compétence territoriale de la C.C.T.A.

2) Recommander aux Gouvernements Membres toutes mesures tendant à la mise en œuvre de cette coopération.

3) Convoquer les conférences techniques que les Gouvernements Membres ont décidé de tenir.

4) Contrôler du point de vue général et du point de vue financier l'activité des organismes placés sous son égide et présenter aux Gouvernements Membres toutes recommandations y afférentes.

5) Présenter des recommandations aux Gouvernements Membres en vue de la création de nouveaux organismes ou la révision des dispositions existantes pour la coopération technique, dans le cadre de la compétence territoriale de la C.C.T.A.

6) Présenter des recommandations aux Gouvernements Membres en vue de formuler des demandes conjointes d'assistance technique aux organisations internationales.

7) Présenter des avis sur toutes questions concernant la coopération technique que lui soumettront les Gouvernements Membres.

8) Administrer le Fonds Interafricain de la Recherche et la Fondation pour l'Assistance Mutuelle en Afrique au Sud du Sahara.

BUDGET

Alimenté par les contributions des Gouvernements Membres.

ORGANISATION

1) La C.C.T.A. se réunit au moins une fois chaque année. Ses recommandations et conclusions sont portées à la connaissance des Gouvernements Membres en vue de leur adoption à l'unanimité ainsi que de leur mise en œuvre dans les territoires intéressés.

2) Le Conseil Scientifique pour l'Afrique au Sud du Sahara (C.S.A.), Conseiller scientifique de la C.C.T.A., a été créé en novembre 1950, comme suite à la Conférence Scientifique de Johannesburg (1949), en vue de favoriser l'application de la science à la solution des problèmes africains. Il est composé de personnalités éminentes, choisies de telle sorte que les principales disciplines scientifiques importantes au stade actuel du développement de l'Afrique soient représentées. En tant que membres du Conseil ces personnalités n'agissent pas sur instructions de leurs Gouvernements respectifs mais sont responsables individuellement devant le Conseil.

3) Des Bureaux et Comités techniques traitent chacun un aspect particulier de la coopération régionale et interterritoriale en Afrique au Sud du Sahara.

4) Le Secrétariat de la C.C.T.A. et du C.S.A. comprend deux sièges : l'un, jusqu'ici à Londres, est en cours de transfert à Lagos, l'autre se trouve à Bukavu. Il est dirigé par un Secrétaire Général assisté de deux Secrétaires Généraux Adjoints et, à Bukavu, d'un Secrétaire Scientifique et d'un Secrétaire Scientifique Adjoint. Le Secrétaire de la F.A.M.A. est également adjoint au Secrétaire Général.

PUBLICATIONS

Des brochures traitant de problèmes scientifiques et techniques, dont les données sont habituellement rassemblées en Afrique par le C.S.A., sont publiées à Londres. Toute demande d'information devra être adressée au siège de Londres du Secrétariat, à l'attention du fonctionnaire chargé des Publications et de l'Information.

COMMISSION FOR TECHNICAL CO-OPERATION IN AFRICA SOUTH OF THE SAHARA

Established in January, 1950, the Commission for Technical Co-operation in Africa South of the Sahara (C.C.T.A.) was the subject of an Inter-governmental Agreement signed in London on 18 January 1954. It consists now of the following Governments: Belgium, Federation of Rhodesia and Nyasaland, French Republic and Community, Ghana, Republic of Guinea, Liberia, Portugal, Union of South Africa, United Kingdom.

OBJECT

To ensure technical co-operation between territories for which Member Governments are responsible in Africa South of the Sahara.

FUNCTIONS

(1) To concern itself with all matters affecting technical co-operation between the Member Governments and their territories within the territorial scope of C.C.T.A.

(2) To recommend to Member Governments measures for achieving such co-operation.

(3) To convene technical conferences as agreed by Member Governments.

(4) To supervise, from the financial and general points of view, the work of the organisations placed under its ægis and make recommendations thereon to the Member Governments.

(5) To make recommendations to the Member Governments for the setting up of new organisations or the revision of existing arrangements for securing technical co-operation within the territorial scope of C.C.T.A.

(6) To make recommendations to the Member Governments with a view to the formulation of joint requests for technical assistance from international organisations.

(7) To advise Member Governments on any other subject in the field of technical co-operation which the Member Governments may bring to its notice.

(8) To administer the Inter-African Research Fund and the Foundation for Mutual Assistance in Africa South of the Sahara.

FINANCE

Contributions from Member Governments.

ORGANISATION

(1) C.C.T.A. meets at least once a year. Its recommendations and conclusions are submitted to Member Governments for unanimous approval and for implementation in the territories concerned.

(2) The Scientific Council for Africa South of the Sahara (C.S.A.), Scientific Adviser to C.C.T.A., was established in November 1950 following the Johannesburg Scientific Conference (1949) to further the application of science to the solution of African problems. Its members are eminent scientists chosen in such a manner that the main scientific disciplines important at the present stage of the development of Africa shall be represented. As members of the Council they do not receive instructions from Governments but are responsible individually to the Council.

(3) Technical Bureaux and Committees deal with specific aspects of regional and inter-territorial co-operation in Africa South of the Sahara.

(4) The C.C.T.A./C.S.A. Secretariat has two offices, one in London and one in Bukavu. The London office is at present being transferred to Lagos. The Secretariat has at its head a Secretary-General, who is aided in his work by two Assistant Secretaries-General and, at Bukavu, by a Scientific Secretary and an Assistant Scientific Secretary. The Secretary-General is also assisted by the Secretary of F.A.M.A.

PUBLICATIONS

Publications dealing with scientific and technical problems, the data of which are usually collected in Africa by C.S.A., are issued in London. Inquiries should be addressed to the London office of the Secretariat, for the attention of the Publications and Information Officer.

International Scientific Committee for Trypanosomiasis Research

Comité Scientifique International de Recherches sur les Trypanosomiases

SEVENTH MEETING
SEPTIEME REUNION

BRUXELLES

25-30. VIII. 1958

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C.C.T.A.

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Miss P. Stephens . . .	Bi-lingual Secretary. Secrétaire bilingue.

RECOMMENDATIONS

A. FINAL REPORT OF SECTION ON ANIMAL TRYPANOSOMIASIS CHEMOTHERAPY

1. The Committee notes with satisfaction the presentation of several new drugs for the curative and prophylactic treatment of animal trypanosomiasis, together with the improved facilities for controlled testing now available.

2. It is emphasised that trials with new drugs should be conducted to an approved standard design in as many areas as possible, to cover local variations involving the vector, the trypanosome, the host and the ecological conditions.

3. Attention is once more directed to the danger of the development of strains resistant to drugs, following the widespread application in the field, and all veterinary authorities are urged to adopt measures to reduce this risk as far as possible. The procedures reported by Kenya (document I.S.C.T.R. (58) 38) appear to offer a practical approach to this problem.

4. Recent research suggests that the mode of action of trypanocidal drugs may in some instances be closely associated with the immune responses of the host and the trypanosome. Therefore it is strongly RECOMMENDED that research organisations should devote more of their resources and facilities to fundamental immunological studies. This should be correlated where possible with the tolerance shown by n'dama and similar breeds and other domestic animals. Such studies would provide a scientific basis for a policy of disseminating such animals more widely in Africa.

B. REPORT OF SECTION ON HUMAN TRYPANOSOMIASES

1. *Trypanosomiasis* (*T. gambiense*)

(*a*) The Committee CONFIRMS that chemoprophylaxis, where it has been applied, has been successful in considerably reducing the incidence of trypanosomiasis caused by *T. gambiense*.

(*b*) The Committee RECOMMENDS that the use of this method be maintained wherever applicable and appropriate.

(*c*) The Committee RECOGNISES that the factors restricting the use of this method are mainly of an administrative, social and economic nature.

(*d*) The Committee EXPRESSES the hope that investigations be undertaken with a view to determining the mode of action of drugs used in chemoprophylaxis.

(*e*) The Committee STRESSES the control value of the survey and treatment method, whether alone or in conjunction with mass chemoprophylaxis.

(*f*) The Committee CONSIDERS that, owing to insufficient data, it is as yet not possible to lay down with any degree of accuracy general principles of action for the suspension or termination of chemoprophylaxis in a given area.

(*g*) The Committee wishes to EMPHASISE that the success of any campaign of trypanosomiasis control may be gravely prejudiced by unfavourable political conditions, and must therefore be dependent on the active co-operation of the local population and administrative authorities.

2. *Trypanosomiasis* (*T. rhodesiense*)

(*a*) The Committee CONSIDERS that mass chemoprophylaxis against trypanosomiasis caused by *T. rhodesiense* may sometimes be of value in controlling an epidemic outbreak. Otherwise, because the incidence of the disease is normally very low and in widely scattered populations, the method is neither practicable nor economic.

(*b*) Early detection and treatment of the disease are essential and form the basis of the control measures in all territories.

(*c*) The Recommendations in sub-paragraphs (*d*) and (*g*) of para. 1 also apply to *T. rhodesiense*.

3. The Committee AGREES that one of the greatest difficulties in the control of trypanosomiasis arises from the movement of populations, and the existence of a reservoir of infection that is difficult to control is an important factor which contributes to the maintenance of endemic sleeping sickness. The Committee WISHES to direct the attention of Member Governments to the practical importance of the Recommendations of the conference on Medical Co-operation, Leopoldville, 1955, on the medical implications of population movements and to emphasise that careful consideration should be given to means of implementing those Recommendations. The Committee CONSIDERS that where practicable the most effective means are the use of health passports and the pentamidinisation of migrant persons.

4. The Committee CONSIDERS that much could be gained by the application of recent advances in immunology to the study of trypanosomiasis and RECOMMENDS that in view of the immense importance of this subject, all possible support be given to such research.

5. The Committee RECOMMENDS that the study of the epidemiology of African trypanosomiasis be vigorously pursued and that particular attention be directed to epidemiological research on *T. rhodesiense*.

C. REPORT OF SECTION ON ENTOMOLOGY

1. The Committee NOTES the valuable results that have been obtained on the identification of tsetse blood meals collected from both East and West Africa, and CONSIDERS that this work should be greatly extended. It DRAWS ATTENTION to the discrepancies observed between the food preferences thus indicated and the incidence of trypanosome infection found in the wild game and SUGGESTS that these differences require elucidation.

It also RECOMMENDS that research on food preferences should be linked with more detailed studies of the behaviour patterns of both *Glossina* and its host species in relation to their common habitats. The possibility of domestic cattle becoming an alternative host where game destruction is carried out, should not be ignored. The Committee again DRAWS ATTENTION to Recommendation IV of the sixth meeting and believes it would be valuable if selective game destruction experiments could be carried out.

2. The Committe NOTES that the criteria available for the identification of the species of trypanosomes in the tsetse fly are still far from satisfactory and regards it as important that this should be remedied.

3. The Committee RECOMMENDS that the estimation of challenge should be based on standardised criteria that should include the density activity of the tsetse present based on truly representative samples obtained by using cattle as bait, the infection rate of these tsetse and the reactions of a test herd of control cattle.

4. The Committee DRAWS ATTENTION to the need for further studies designed to render more precise our observations on the location of *Glossina* in nature and NOTES the valuable results already achieved in the study of the day-time resting places of tsetse. It is also greatly impressed by the possibilities inherent in the use of glass bead paints for locating tsetse flies at rest at night.

5. The Committee CONSIDERED the question of fly advances and recessions and RECOGNISES this to be an extremely complex one. In view of the evidence that during the last few years extensive fly advances have taken place, it RECOMMENDS that detailed studies be undertaken to elucidate the features which characterise them and the factors which cause them.

6. The Committee NOTES the successful use of discriminative clearing and insecticidal control, but CONSIDERS that these measures could be made more efficient. Were our knowledge of the relation of the tsetse to its habitat more precise these measures could be applied with greater confidence in new situations. It therefore RECOMMENDS that the ecological studies already noted as giving such good results in this direction should be intensified and extended as speedily as possible.

7. The Committee NOTES the success hitherto achieved in the rearing of tsetse flies under laboratory conditions and stresses the fundamental importance of this work, which should be intensified.

D. ADMINISTRATIVE RECOMMENDATIONS

I. THANKS

The Committee EXPRESSES its great gratitude to the Belgian Government for the invitation to hold its seventh meeting at Brussels during the Universal and International Exhibition. It also expresses its thanks for the generous hospitality received and for the excellent facilities afforded for the holding of the working sessions.

II. REPORT OF THE MEETING

The Committee RECOMMENDS that the report of the proceedings of its seventh meeting should be published as soon as possible. As well as an introduction and the list of delegates the publication should include the recommendations of this meeting and also those of the sixth meeting which have not yet been published. All the papers presented to the seventh meeting should be published in full in their original language only. These papers should be grouped in accordance with the heads of the agenda to which they related. i.e.

I Trypanosomiasis
  Animal Trypanosomiasis
  Human Trypanosomiasis
II The tsetse fly
  Biology
  Control.

Before the papers in the publication a statement should make clear that only the authors are responsible for the statements therein.

III. POSSIBILITY OF CO-OPERATION WITH C.C.T.A. BY THE INTERNATIONAL CO-OPERATION ADMINISTRATION OF THE UNITED STATES

1. The Committee NOTES the suggestion contained in Recommendation XV of the ninth Meeting of C.S.A. that the United States International Co-operation Administration might co-operate with C.C.T.A. in further research in the field of trypanosomiasis.

2. The Committee CONSIDERS

(1) That the principle of the acceptance of financial and/or technical aid for research work is for the Commission to decide.

(2) That such aid, if accepted, could profitably be deployed in the field of trypanosomiasis research.

(3) That in such event the Committee itself could most appropriately advise the Commission how any such aid should be utilised.

IV. DRAFT CONSTITUTION FOR I.S.C.T.R.

The Committee NOTES the various comments of Member Governments on the draft I.S.C.T.R. constitution submitted to the eleventh Session of C.C.T.A. as set out in circular letter 2/141 of 11th April 1958, and RECOMMENDS that the final constitution provide as follows :—

(1) Membership

For each meeting of the Committee, each Member Government should appoint not more than three delegates. One of these should be appointed by his Government to be the Head of its delegation for the occasion. Great scientific importance attaches to continuity of this representation.

Moreover, one of these delegates should be appointed to act as liaison officer in the period between meetings.

It should be open to Member Governments to appoint advisers to their delegates at meetings of the Committee.

Invitations to observers from countries and organisations interested in the trypanosomiasis field should be arranged by the Commission itself.

(2) Functions, etc.

The functions of the Committee should be to stimulate the progress, co-ordination and encouragement of research into the problems of tsetse fly and trypanosomiasis in Africa. For the discharge of these functions the Committee holds its regular meetings. In addition it can use between meetings the facilities of B.P.I.T.T. for the dissemination of information.

Responsibility for the preparation of the technical agenda for the next meeting would be vested in the Chairman designate who would perform this task in close consultation with B.P.I.T.T. and the liaison officers of Member Governments whose appointment is recommended in paragraph (1) above. General liaison work could also be carried out through the same channels.

V. RELATIONS BETWEEN I.S.C.T.R. AND B.P.I.T.T.

The Committee RECOMMENDS that the Co-Directors of B.P.I.T.T. should attend the meetings of I.S.C.T.R.

VI. RELATIONS WITH SCIENTIFIC WORKERS ON AMERICAN TRYPANOSOMIASIS

The Committee CONSIDERS that the value of its own work would be increased if closer contact were established with scientists working on American trypanosomiasis.

VII. EIGHTH MEETING OF I.S.C.T.R.

The Committee RECOMMENDS that the date and place of its next meeting be decided by the Commission as soon as possible;

DECIDES that Professeur Neujean shall remain President of the Committee until it next reassembles.

RECOMMANDATIONS

A. RAPPORT FINAL SUR LA CHIMIOTHERAPIE DES TRYPANOSOMIASES ANIMALES

1. Le Comité enregistre avec satisfaction l'apport de plusieurs nouveaux produits pour le traitement et la prophylaxie des trypanosomiases animales, joint à des moyens plus importants pour le contrôle des expériences.

2. Il est souligné que les essais avec de nouveaux produits doivent être conduits suivant un protocole adéquat uniforme dans le plus grand nombre possible de régions pour répondre aux conditions locales variables comprenant le vecteur, le trypanosome, l'hôte et les facteurs écologiques.

3. L'attention est à nouveau attirée sur le danger d'apparition de souches chimio-résistantes, provoqué parfois par l'emploi dans la pratique des produits sur une grande échelle, et toutes les autorités vétérinaires sont alertées pour que des mesures soient prises pour réduire autant que possible ce risque. Les procédés indiqués par le Kenya (document I.S.C.T.R. (58) 38) semblent offrir une solution pratique à ce problème.

4. Les recherches récentes semblent mettre en relief que le mode d'action des produits trypanocides peut, en certains cas, être étroitement associé aux réponses immunologiques de l'hôte et des trypanosomes. Il est, en conséquence, fortement RECOMMANDE que les services de recherches consacrent une plus grande part de leurs ressources et des facilités dont ils disposent aux études immunologiques fondamentales. De telles études devraient être entreprises en tenant compte, là où c'est possible, de la tolérance montrée par les bovins n'dama ou similaires et certaines autres espèces animales domestiques. Ceci fournirait les bases scientifiques pour l'établissement d'un programme d'une plus large diffusion de ces animaux en Afrique.

B. RAPPORT CONCERNANT LES TRYPANOSOMIASES HUMAINES

1. *Trypanosomiase à T. gambiense.*

a) Le Comité CONFIRME que le chimioprophylaxie par les diamidines a donné, partout où elle a été utilisée, d'excellents résultats et a permis de réduire considérablement l'incidence de la trypanosomiase due à *T. gambiense.*

b) Le Comité RECOMMANDE l'emploi de cette méthode partout où elle est applicable et indiquée.

c) Le Comité RECONNAIT que les facteurs limitant l'emploi de cette méthode sont surtout d'ordre administratif, social et économique.

d) Le Comité SOUHAITE que des recherches soient entreprises afin de préciser le mode d'action des produits employés en chimioprophylaxie.

e) Le Comité SOULIGNE la valeur de la méthode du dépistage-traitement soit seule, soit associée à toute opération de chimioprophylaxie de masse.

f) Le Comité CONSIDERE que, faute de données suffisantes, il n'est pas encore possible de définir avec précision une doctrine de valeur générale quant à l'époque à laquelle on peut mettre un terme aux opérations de chimioprophylaxie ou les suspendre dans une zone donnée.

g) Le Comité DESIRE SOULIGNER que le succès de toute campagne de lutte contre la trypanosomiase peut être gravement compromis par des conditions politiques défavorables. Ce succès est étroitement lié à la coopération active des populations locales et des autorités administratives.

2. *Trypanosomiase à T. rhodesiense.*

à) Le Comité CONSIDERE que la chimioprophylaxie de masse contre la trypanosomiase à *T. rhodesiense* peut parfois être utile pour lutter contre une manifestation épidémique de la maladie. En dehors de ce cas, la méthode n'est ni pratique, ni rentable, en raison de la faible incidence habituelle de la maladie et de la dispersion des populations.

b) Le dépistage et le traitement précoces sont essentiels et constituent la base de la lutte dans tous les territoires.

c) Les recommandations des sous-paragraphes *d*) et *g*) de l'alinéa 1 s'appliquent également à la trypanosomiase à *T. rhodesiense.*

3. Le Comité CONSIDERE que l'une des plus grandes difficultés de la lutte contre les trypanosomiases tient à la mobilité des populations et à l'existence d'un " réservoir de virus ", difficilement contrôlable, facteur important du maintien de l'endémie résiduelle.

Le Comité DESIRE attirer l'attention des Gouvernements Membres sur l'importance pratique des recommandations formulées par la Conférence de Coopération Médicale de Léopoldville, 1955, au sujet des conséquences médicales des mouvements de population. Il INSISTE sur le fait que le plus grand soin doit être apporté à rechercher les moyens nécessaires à la mise en œuvre de ces recommandations. Le Comité ESTIME que, là où c'est réalisable, les moyens les plus efficaces sont l'utilisation du passeport sanitaire et la pratique de la pentamidinisation des individus en déplacement.

4. Le Comité ESTIME qu'il y a grand intérêt à appliquer les progrès récents en matière d'immunologie à l'étude des trypanosomes et RECOMMANDE que, en raison de l'importance considérable de la question, tout l'appui possible soit apporté à ces recherches.

5. Le Comité RECOMMANDE que l'étude de l'épidémiologie des trypanosomiases africaines soit poursuivie activement et SOUHAITE que l'étude épidémiologique de la *T. rhodesiense* fasse l'objet d'une attention particulière.

C. RAPPORT DE LA SECTION SUR L'ENTOMOLOGIE

1. Le Comité NOTE les résultats particulièrement intéressants obtenus en ce qui concerne l'identification des repas sanguins de la mouche tsé-tsé observés, tant en Afrique orientale qu'en Afrique occidentale, et CONSIDERE

qu'il y a lieu de développer considérablement les recherches à ce sujet. Il ATTIRE L'ATTENTION sur les discordances constatées entre les préférences alimentaires ainsi révélées et l'incidence de l'infection par trypanosomes observée chez la faune sauvage, et SUGGERE que ces différences soient élucidées. Il RECOMMANDE également que les recherches sur les préférences alimentaires soient liées à des études plus détaillées du comportement des Glossines et des espèces hôtes par rapport à leurs habitats communs. Il ne faut pas perdre de vue la possibilité pour le bétail domestique de devenir hôte secondaire lorsque l'on procède à la destruction de la faune sauvage. Le Comité ATTIRE à nouveau l'ATTENTION sur la recommandation IV de la 6ème session et ESTIME qu'il y aurait intérêt à entreprendre des expériences de destruction sélective du gibier.

2. Le Comité NOTE que les critères disponibles pour l'identification des espèces de trypanosomes chez la mouche tsé-tsé sont encore loin d'être satisfaisants et CONSIDERE qu'il est important de remédier à cet état de choses.

3. Le Comité RECOMMANDE que la détermination du risque d'infection (" challenge ") soit appuyée sur des critères uniformes et fasse intervenir le taux d'activité des mouches présentes, sur la base d'un échantillonnage vraiment représentatif obtenu par l'emploi de bétail-appât, ainsi que le taux d'infection de la tsé-tsé et les réactions d'un troupeau de bétail-témoin.

4. Le Comité ATTIRE L'ATTENTION sur la nécessité de procéder à de plus amples études afin d'obtenir des observations plus précises sur l'emplacement des Glossines dans la nature et NOTE les résultats de valeur déjà observés dans l'étude des gîtes diurnes de la mouche. Il NOTE également avec intérêt les possibilités qu'offre la peinture à base de poussière de verre pour observer les mouches au repos la nuit.

5. Le Comité a étudié la question des avances et des reculs de la tsé-tsé et RECONNAIT qu'il s'agit là d'un problème extrêmement complexe. Considérant qu'au cours des toutes dernières années un certain nombre de progressions importantes des mouches ont été observées, il RECOMMANDE d'entreprendre des études détaillées en vue d'élucider les facteurs qui les caractérisent et ceux qui les provoquent.

6. Le Comité NOTE que le défrichement sélectif et l'emploi des insecticides ont donné des résultats satisfaisants, mais CONSIDERE que ces mesures pourraient être plus efficaces. Si l'on était mieux informé des rapports entre la tsé-tsé et son habitat, ces mesures pourraient être appliquées avec de meilleures chances de succès dans de nouvelles situations. Il RECOMMANDE en conséquence que les études écologiques, qui ont déjà donné de si bons résultats dans ce domaine, soient le plus rapidement possible intensifiées et étendues.

7. Le Comité NOTE les succès réalisées jusqu'à présent dans l'élevage de mouches tsé-tsé dans des conditions de laboratoire, et SOULIGNE l'importance fondamentale de ce travail qu'il y a lieu d'intensifier.

D. RECOMMANDATIONS ADMINISTRATIVES

I. REMERCIEMENTS

Le Comité EXPRIME sa profonde reconnaissance au Gouvernement belge pour l'invitation à tenir sa 7ème réunion à Bruxelles lors de l'Exposition Universelle et Internationale. Il remercie également le Gouvernement belge pour la généreuse hospitalité qu'il y a reçue et pour les excellentes facilités prévues pour la tenue des sessions de travail.

II. RAPPORT DE LA REUNION

Le Comité RECOMMANDE que le rapport des travaux de sa 7ème session soit publié dès que possible. Outre une introduction et la liste des délégués, cette publication devrait comprendre également les recommandations de la 6ème session qui n'ont pas encore été publiées. Toutes les communications présentées à la 7ème session devraient être publiées in extenso, dans leur langue d'origine seulement. Ces documents devraient être groupés sous les titres de l'ordre du jour auxquels ils se rapportent, c'est-à-dire :

I. Trypanosomiases
   Trypanosomiase animale
   Trypanosomiase humaine
II. La mouche tsé-tsé
   Biologie
   Mesures de lutte.

Avant les papiers dans la publication, il doit être constaté que leur publication n'engage que la responsabilité des auteurs.

III. POSSIBILITE DE COLLABORATION ENTRE LA C.C.T.A. ET L'ADMINISTRATION DE COOPERATION INTERNATIONALE DES ETATS-UNIS

1. Le Comité PREND NOTE de la suggestion contenue dans la recommandation XV de la 9ème réunion du C.S.A., selon laquelle l'Administration de Coopération Internationale des Etats-Unis pourrait collaborer avec la C.C.T.A. à de plus amples recherches dans le domaine de la trypanosomiase.

2. Le Comité ESTIME

(1) qu'il incombe à la Commission de prendre une décision de principe en ce qui concerne l'acceptation d'une aide financière et/ou technique pour les travaux de recherches,

(2) que, dans le cas où cette aide serait acceptée, elle pourrait utilement s'appliquer aux travaux de recherches sur la trypanosomiase,

(3) que, dans ce cas, le Comité serait compétent pour conseiller la Commission sur les modalités d'utilisation de cette aide.

IV. PROJET DE STATUTS DU C.S.I.R.T.

Le Comité PREND NOTE des divers commentaires présentés par les Gouvernements Membres sur le projet de statuts du C.S.I.R.T. présenté à la 11ème Session de la C.C.T.A. et reproduit dans la lettre circulaire

2/141 du 11 avril 1958. Il RECOMMANDE que les statuts définitifs prévoient ce qui suit :

(1) Composition du comité

Chaque Gouvernement Membre devrait désigner un maximum de trois délégués pour chaque réunion du Comité. L'un d'eux serait désigné par son Gouvernement comme Chef de Délégation en l'occasion. Il y a un intérêt scientifique considérable à assurer la continuité de cette représentation.

En outre, un de ces délégués devrait être désigné pour agir comme fonctionnaire de liaison dans l'intervalle entre deux sessions.

Les Gouvernements Membres auraient la faculté de désigner des conseillers auprès des délégués aux sessions de ce Comité.

L'envoi d'invitations à des observateurs d'autres Gouvernements ou organismes intéressés aux problèmes de la trypanosomiase serait de la compétence de la Commission elle-même.

(2) Attributions, etc.

Les attributions du Comité devraient être de stimuler le progrès, de coordonner et d'encourager la recherche sur les problèmes de la mouche tsé-tsé et des trypanosomiases en Afrique. Pour l'accomplissement de ces fonctions, le Comité tient ses sessions régulières. En outre, dans l'intervalle entre deux sessions, il peut faire appel aux facilités offertes par le B.P.I.T.T. pour la diffusion d'informations.

Il incomberait au Président élu d'assurer la préparation de l'ordre du jour technique de la prochaine session. Il accomplirait cette tâche en consultation étroite avec le B.P.I.T.T. et les fonctionnaires de liaison des Gouvernements Membres, dont la désignation fait l'objet de l'alinéa 1) ci-dessus. La liaison en général pourrait également être assurée par les mêmes voies.

V. RAPPORTS ENTRE LE C.S.I.R.T. ET LE B.P.I.T.T.

Le Comité RECOMMANDE que les Co-directeurs du B.P.I.T.T. assistent aux sessions du C.S.I.R.T.

VI. RAPPORTS AVEC LES CHERCHEURS SCIENTIFIQUES SUR LA TRYPANOSOMIASE AMERICAINE

Le Comité CONSIDERE que la valeur de ses travaux serait accrue si des contacts plus étroits étaient établis avec les hommes de science travaillant dans le domaine de la trypanosomiase américaine.

VII. 8ème SESSION DU C.S.I.R.T.

Le Comité RECOMMANDE que la Commission prenne une décision dès que possible en ce qui concerne la date et le lieu de la prochaine session du Comité ;

DECIDE que M. le Professeur Neujean demeurera Président du Comité jusqu'à l'overture de la prochaine session.

DOCUMENTS PRESENTED TO THE SEVENTH I.S.C.T.R. MEETING

DOCUMENTS PRESENTES A LA SEPTIEME REUNION DU C.S.I.R.T.

I. TRYPANOSOMIASIS/LA TRYPANOSOMIASE

A. ANIMAL TRYPANOSOMIASIS/LA TRYPANOSOMIASE ANIMALE

RAPPORTEUR'S REPORT/RAPPORT DU RAPPORTEUR

I.S.C.T.R. (58)

15 Animal Trypanosomiasis: Control measures by means of drugs—with Appendix—(Marshall).

SPECIFIC DRUGS/PRODUITS SPECIFIQUES

20 Progress with Suramin Complexes in the treatment of animal trypanosomiasis—(Williamson).

30 Preliminary observations of a new phenanthridinium with chemotherapeutic activity against bovine trypanosomiasis—(Fairclough).

31 Observations on the use of Prothidium in Tanganyika—(Robson).

42* Prophylactic and toxic properties of Prothidium in the Northern Region of Nigeria—(Wilson and Strickland).

GENERAL

13 Chemoprophylaxis: design of trials—(Smith).

24 Possible consequences of widespread chemoprophylaxis against Trypanosomiasis—(Cawdery).

26 Some factors concerned in trypanosome challenge—(Smith).

27 The description of trypanosome strains, especially with regard to tests of virulence and drug resistance—(Cawdery).

28 Methods of estimating blood concentrations of anti-trypanosomal drugs in man and animals—(Cawdery).

32 The immunological approach to problems relating to Trypanosomiasis—(Weitz).

35 Variations in pathogenicity amongst congolense-like trypanosomes in relation to their morphology—(Godfrey).

38 The maintenance of cattle in tsetse infected country. A Summary of four years' experience in Kenya—(Whiteside).

* Note.—Documents 42, 43 and 44 are not published in this volume. They will be found in the C.C.T.A. Publication of the Report of the I.A.C.E.D. Symposium on Animal Trypanosomiasis held at Luanda, Angola, in July 1958. These three documents were first presented to this Symposium.

Les documents 42, 43 et 44 ne figurent pas dans ce volume. Ils paraîtront dans la publication C.C.T.A. consacrée au Colloque de l'I.A.C.D. sur les trypanosomiases animales qui s'est réuni en juillet 1958 à Loanda (Angola). C'est, en effet, à ce colloque que ces trois documents ont été présentés en premier.

ANIMAL TRYPANOSOMIASIS: CONTROL MEASURES BY MEANS OF DRUGS

By R. S. Marshall, Colonial Office, London

There is no doubt that the high cost of completely eradicating the vector of animal trypanosomiasis from enormous tracts of country in Africa and the failure, as yet, to produce a satisfactory and practical method of immunisation has stimulated the continued search for more effective, and preferably cheaper, curative and prophylactic drugs.

Chemotherapy as a method of control has certain disadvantages in a vast and relatively undeveloped continent. Nevertheless it can, and does, reduce the substantial annual losses and will continue to be used until such time as the vector is eradicated or livestock can be protected by some other more convenient means.

While it has not been possible so far to immunise animals satisfactorily nevertheless one cannot disregard entirely the part which immunity response may contribute to the value and efficacy of chemotherapeutic procedures, particularly those which have prophylaxis in view. Indeed, from the very early days of antimony therapy Parkin and Hornby (1930), Parkin (1935) and others have stressed the importance of this factor and premunition has come to be regarded as a characteristic of the disease. Recently a more solid type of immunity following Antrycide prophylaxis (Soltys, 1955) has been described, and some evidence, Soltys (1957), that antibody titres are higher following infection and treatment than with dead trypanosomes alone has been produced. Fromentin (1957) records similar experiments in mice.

It has been recognised for many years and stressed more recently by Fiennes (1950), Lewis (1954) and Edwards *et al.* (1956) that strains of the same species of trypansome may exhibit a very wide range of virulence for their hosts, and whether some of these strains are, in fact, subspecies or separate species is not relevant in the present context. Thus, fulminating infections causing death in about two to three weeks or spontaneous recovery without treatment may occur, with all grades of pathogenicity between these two extremes, and in assessing the value of a curative or prophylactic drug the virulence of the infecting organism or combination of organisms must be known. The importance, therefore, of adequate numbers of untreated controls and a detailed examination of the strains isolated from them, if not previously studied, cannot be over-emphasised. Such examination may, apart from virulence *per se*, determine the existence or otherwise of drug resistance and its nature, an extremely important factor which may influence greatly the result.

These considerations are only a part of what is normally referred to as "challenge". Other factors such as the species of infecting fly, the apparent density of the fly, no matter how assessed, and the infection rates in the fly are equally important.

The situation is even more complicated for, unfortunately, under field conditions in Africa, there are other stress factors, affecting the animal host, which may individually or collectively influence the result. Examples are, intercurrent and possibly dormant disease, the general condition of the animals, the level of nutrition, the type of animal (grade or Zebu) and climatic conditions. Since these can vary widely from region to region it is perhaps not surprising to find that reported results, with the same drug, have varied from place to place and that attempts have been made to achieve a better result by varying the dose level and by other means.

In view, therefore, of the existence of so many variables the true value of a drug cannot be assessed completely on the basis of a few trials and no drug should be accepted for use on an extensive scale in the field until it has been tested, in comparison with drugs of known merit, under the widest possible range of controlled conditions.

The basic aim of safe and prolonged prophylaxis with drugs alone under all conditions has not yet been solved, but ways and means of achieving the best results with different drugs under different conditions are being actively examined, and most of the set-backs have perhaps been due to impatience and use before suitable regimens for different conditions have been accurately assessed.

In *Veterinary Reviews and Annotations*, Volume 3, Part I, April 1957, of the Commonwealth Bureau of Animal Health, Weybridge, published by the Commonwealth Agricultural Bureaux, D. G. Davey reviews the chemotherapy of animal trypanosomiasis. This paper refers to the earlier work and deals in some detail with the results achieved with more recent drugs up to the date of publication. Since the subject has thus been covered adequately so recently, and as a comprehensive bibliography is included, arrangements were made to reprint and translate this review, for the benefit of those who have not had access to the original, and it is attached as an appendix to this paper. I am grateful to both author and publisher for permission to take this action since it enables me to devote more time to developments during the past eighteen months.

A. Curative Drugs

(Where the constitution of a drug is given in Davey's paper this will not be repeated.)

1. Dimidium Bromide

Owing to the undesirable toxicity produced by this drug over a wide area of Africa, its use has largely ceased. In the Rhodesias initial results were good and as not untoward after-effects were recorded, it continued to be used on an increasing scale, up to 48,000 cattle being treated in 1952 in Southern Rhodesia alone. By then, however, it had become obvious that heavy mortality was occurring despite treatment, and when dosage was stopped up, to overcome drug resistance, photosensitisation was recorded in 1954. In 2,326 head inoculated at one Centre 322 deaths were recorded and a large number of severe cases of photosensitisation, all attributed to the drug, were noted. (MacKinnon, 1956.)

2. **Ethidium Bromide** (Boots Pure Drug Company)

To-day this is usually referred to as Homidium bromide, and Homidium chloride (Ethidium "C") sometimes appears under the name "Novidium". As far as toxicity and activity are concerned, there is no significant difference between these two salts — May and Baker (1957).

The apparent advantage of these drugs, the chloride being soluble in cold water, is the complete lack of toxicity at standard dosage 1·0 mg./kg. or indeed with as much as 4 mg./kg.

Davey in his review refers to the Belgian Congo report of relapse to *T. vivax*. MacKinnon (1956) could find no advantage over Dimidium in Southern Rhodesia. On the other hand, Wilson (1958) reports that emphasis has been on Ethidium in Northern Nigeria where over 600,000 animals are treated annually with this drug and Antrycide equally. The success of this drug in Nigeria compared with Rhodesia may well be due to the fact that Dimidium was never used extensively there, since the initial experiments in Nigeria were so unsuccessful that the drug was never released for field trials and no resistant strains therefore existed.

In two field trials in Kenya, Ethidium bromide at 2 mg./kg. has successfully cured Antrycide resistant *T. congolense* and *T. vivax* which appeared under field conditions.

On the other hand, Karib *et al.* (1954) report on a strain of *T. congolense* resistant to Ethidium at 2 mg./kg. as being partially cured with Antrycide methylsulphate at 5 mg./kg.

3. **Antrycide Methylsulphate** (Quinapyramine sulphate. (I.C.I. (Pharmaceuticals) Limited.)

The value of this drug as a curative is now well recognised and several million cattle have been treated with it, with excellent results, generally in *T. congolense* cases, but with slightly less success in *T. vivax* cases. The 1957 Veterinary Department Annual Reports from West, East and Central Africa indicate the popularity of the drug even although "fast" strains appear to be emerging frequently in some areas.

In Southern Rhodesia and in Kenya it has also been used as a prophylactic in low challenge areas with some success. Thus, at a low challenge area in Kenya (1956) Antrycide methylsulphate at two monthly intervals, starting before exposure, gave complete protection for twenty months in Zebu cattle. Eight isolated positive slides only have been recorded during the whole period. In another Kenya area two monthly treatments have protected for six months with no positive slides. This method in low challenge areas has been modified by treating animals only when they become positive. During a period of six months only nine animals out of fifteen became positive, all remaining healthy and putting on weight. The advantage of the method is the saving on drugs, but constant supervision to deal with positives promptly is required. This technique has been tried in a few selected areas in Kenya and the work continues since the economics of treatment regimens are important in Africa.

4. **Berenil** (Farbwerke-Hoechst, A. G.)

Chemically this compound belongs to the diamidine class and is thus similar to pentamidine and stilbamidine. Davey refers to the work carried out with this compound up to 1955 and I am indebted to Whiteside (1957 and 1958) for the following more recent information.

(*a*) About 1,000 cattle exposed to infection and 28% showing positive slides (*T. congolense* and *T. vivax*) were treated with Berenil 3·5 mg./kg. in 7% solution. The first injection was by the intramuscular route, and then subcutaneously every two months. Infection in the herd was completely eliminated at the end of ten months.

(*b*) Various strains of *T. congolense* resistant to normal doses of Ethidium and Dimidium bromide, and a few to Antrycide, were treated in twenty-one inoculated grade steers, with 5 mg./kg. of Berenil in 7% solution subcutaneously. One animal which had relapsed after pro-salt showed scanty trypanosomes on the tenth and twenty-sixth days, but thereafter this animal and all the others remained negative for five months. No reactions were noted on injection and no side effects.

(*c*) Farbwerke-Hoechst reported that Holz in Indonesia had had excellent results in the treatment of *T. evansi* infections in small laboratory animals and horses with Berenil. Whiteside (1957), however, found that Berenil failed to cure *T. evansi* in rats at all doses up to 7 mg./kg.

It is known that this drug has no action on *T. simiae* in pigs.

It would appear from these recent reports that Berenil is a very useful drug indeed against *T. congolense* and *T. vivax* infections and warrants more extensive trial as a curative against a wide range of strains of known virulence. It has many attractive features from the point of view of the Veterinary Officer in the field. It is stable as a dry powder for long periods, up to twelve months or more in tropical climates; it is easily prepared in the field as a 7% solution and can be given either subcutaneously or intramuscularly; it is non-toxic in therapeutic doses with a wide margin of safety, local reactions being absent, or minimal and transient, and no microscopic lesions in internal organs have been demonstrated. Based on the tests by Neitz at Onderstepoort using splenectomised calves it appears to effect a "sterilisation" cure even with 1 mg./kg. The drug is rapidly excreted through the kidneys and, therefore, has no prophylactic properties, but, on the other hand, this fact probably reduces the risk of the emergence of drug fast strains, combined with the fact that a deliberate attempt —Fussgänger (1955)—to produce a fast strain in mice with subtherapeutic doses was unsuccessful after 90 passages. Cross resistance to Berenil has been noted in Kenya by Lyttle and Whiteside (1957) in conjunction with high and deliberately produced resistance to Prothidium and Antrycide but this appears to be an unusual occurrence.

Berenil has thus come to be regarded as an invaluable drug to be kept in reserve for the elimination of strains which have become fast to other drugs. Whether the future use of complexes containing the diamidine molecule will restrict its value in this way still remains to be seen.

5. **Tozocide** (Allen and Hanburys, Limited)

Brief reference is made to this substance by Davey in an addendum to his review. The activity in cattle in Africa was tested in Kenya, and a non-phenanthridinium resistant strain of *T. congolense* was eliminated after single doses down to 0·5 mg./kg. Parallel tests with Antrycide methyl-sulphate at 1 to 4 mg./kg. produced one failure out of five treated at the lowest dosage. In a curative test carried out in Northern Nigeria, Tozocide, at 1 and 2 mg./kg. dose levels, had no effect on the strain of *T. congolense* used.

6. **Compound "528"**

This compound is a cinnoline derivative ($N^1 : N^3$—bis 4′ ammino-cinnolyl—6′) guanidine demethiodile) described by Lourie *et al.* (1951). The substance had a high activity against *T. congolense* and *T. vivax* in cattle in Nigeria by Chandler (1957). The drug had an appreciative curative action against *T. congolense* but had no action on two strains of *T. vivax*. It is unlikely to replace other curative drugs.

7. **M. & B. 4404** (May and Baker, Limited) (1957)

This is one of two new compounds produced by May and Baker for trial in Africa. It has been examined closely in East and West Africa since August, 1957, and shows considerable promise as a curative and possibly also as a prophylactic drug.

It is a soluble salt of a new phenanthridinium derivative and appears to be a combination of Ethidium and a modified form of Berenil. It contains 78·7% of cation.

Initially, toxicity trials were carried out in Kenya—Whiteside (1957–58)—which will be reported in detail later. Local reactions were on the severe side at 5 mg./kg. subcutaneously; less so at this dose level intra-muscularly. There is also a slight systemic reaction at 5 mg./kg.

The minimum curative dose for one strain of *T. congolense* appeared to lie between 0·05 and 0·2 mg./kg. by 1/M injection as compared with Homidium chloride which lies between 0·2 and 0·8 mg./kg.

It was also tested against a *T. vivax* strain (Ngoliba) in comparison with Homidium at precisely the same dose levels. Both drugs gave a hundred per cent cure. This might be a highly sensitive strain.

In a test carried out by the Northern Nigeria Veterinary Department (1957) a dose level of 0·2 mg./kg. and 0·8 mg./kg. cured heavily infected *T. vivax* animals, smears being negative for almost three months.

At the West African Institute for Trypanosomiasis Research, Nigeria (1957) two naturally infected cases were cleared of trypanosomes for about two months at a dosage rate of 0·2 mg./kg.

M. & B. 4404 appears to be a curative drug of some considerable promise, but more extensive trials in comparison with others are required before a final assessment can be made.

8. **Nucleocidin** T. 3018 (Cyanamid Company, Lederle)

Tobie (1957) reports curing 95% of *T. congolense* cases in rats and mice, and 91% *T. equinum* cases in mice with this antibiotic giving three daily doses of 0·15 mg./kg.

As far as treatment in animals other than cattle is concerned, Stephen and Mackenzie (1958) recorded the successful treatment of a *T. congolense* case in a horse with Ethidium bromide at 1 mg./kg. An interesting report also comes from E.A.V.R.O. (1958). Three *T. congolense* cases in horses were treated intramuscularly, one with M. & B. 4404 0·5 mg./kg., one Berenil 7 mg./kg. and one Ethidium bromide 2·5 mg./kg. All reacted severely but were cured. Tobie (1957) treated a *T. equiperdum* case in a horse with 0·025 mg./kg. of Nucleocidin. The animal was depressed for twenty-four hours but thereafter no trypanosomes were detected for seventy-four days.

No information is available on the treatment of trypanosomiasis in camels or dogs with the newer drugs.

B. Prophylactic Drugs

1. **Antrycide Pro-Salt** (Old Formulation = Quinapyramine sulphate 3 parts, quinapyramine chloride 4 parts) (I.C.I. (Pharmaceuticals) Limited).

This prophylactic continues to be used extensively and a considerable body of evidence is now available of its value and its limitations. Not only has it been used as a practical measure of control, e.g. in Uganda (1958), 10,000 cattle being kept in fly areas under two monthly regimens and in Kenya and elsewhere, but it has also been used as the standard of comparison with other prophylactics under controlled conditions.

Davey in his review discusses the regimen problem and more recent work in Kenya corroborates the necessity of assessing the most satisfactory regimen under different conditions of challenge.

There appears to be no doubt now that the " standard " two-monthly regimen (the dose 12 mg./kg. of 23% suspension in water, measured in terms of methylsulphate at 5 mg./kg.) can be safely varied to a three-monthly regimen under light challenge conditions. Under heavy challenge conditions the Kenya workers consider that successful results can be obtained provided a careful check is made constantly and break-through resistant strains eliminated.

Cost of drugs apart, since owners are quite often happy to pay, it is not however a practical proposition to inoculate really large numbers of animals every two months and keep a close check on resistant strains.

Observations have been made in Kenya on the effect of two or three-monthly dosing in low challenge areas for varying periods followed by discontinuation of the drug regimen, with what appears to be promising results. From the experiments reported by Chandler (1958), however, it would appear that while antibodies against the homologous strain of trypanosome could be demonstrated in regularly challenged cattle, the degree of protection against the homologous strain could not be determined, and no noticeable degree of protection existed against the heterologous strain. This, of course, introduces a complication where nomadism still exists. Chandler concluded that the drug alone protected the cattle which, of course, means maintaining drug levels by constant inoculation. To avoid down-grading of carcasses on slaughter, various inoculation sites have been tested. The dewlap is favoured in Kenya and the caudal fold in Tanganyika.

2. **Antrycide Pro-Salt** (New Formulation = Quinapyramine chloride 2 parts, quinapyramine sulphate 3 parts) (I.C.I. (Pharmaceuticals) Limited).

Davey in his review hinted at the possibility of reducing the amount of chloride in the pro-salt mixture and which, *inter alia*, would be slighty cheaper. This, in fact, has now been done and Smith (1958), East African Veterinary Research Organisation, and Whiteside (1958), Kenya, have carried out tests comparing the two formulations. Smith's results indicate that the new formulation is slightly better, while the Kenya results appeared to be about equal. Further comparative tests are indicated as Davey (personal communication) has had a slightly better result with the new formulation also.

3. **Prothidium** (Boots Pure Drug Co., Limited)

The constitution appears in the review by Davey and the drug has been the subject of a large number of trials in East and West Africa, particularly Kenya. Brownlie, Watkins and Woolfe of the Boots Company published a small up-to-date brochure in December, 1957, summarising the reports of laboratory and field trials with this prophylactic drug. These results need not be repeated here.

The recommended dose for this prophylactic is 2 mg./kg., and the serious delayed toxicity following the use of 5 mg./kg. reported from certain areas of Nigeria, but not elsewhere at 5 and higher levels, has not yet been solved.

In spite of this there is no doubt that Prothidium may prove to be a valuable addition to our armoury of prophylactic drugs. The fact that a single 4 mg./kg. dose has protected both 24 grades and 20 Zebus in Kenya for six months under high challenge conditions (*T. congolense*, *T. vivax* and *T. brucei*) indicates the potential, and suggests that a four-monthly regimen might be a possibility, taking precautions to remove resistant strains.

An interesting prophylactic trial Hope-Cawdery and Robson (1958) (in press) has recently been completed in Tanganyika in which Prothidium, Ethidium-Suraminate and Pro-Salt were compared under conditions of high and low challenge. Here the Prothidium dose was 2 mg./kg. and under the low challenge conditions only 3 out of 19 animals became infected in 261 days, the first on the 216th day and the last on the 258th day. As expected under such conditions Pro-Salt every two months protected solidly for the same time. In the high challenge area the first break-through after a single 4 mg./kg. dose of Prothidium was on the 110th day, and the tenth five weeks later, compared with Pro-Salt regimen, first break-through at 31 days, and the twelfth on the 159th day.

Wilson and Strickland (1958) recorded the results in Nigeria with Prothidium, including toxicity.

In neither the Kenya nor Tanganyika trials was any serious toxicity recorded. Quite obviously this prophylactic is worthy of further trial on a larger scale. Optimum dosage and regimen for different areas have still to be determined.

4. **Suramin Complexes** (West African Institute for Trypanosomiasis Research)

These complexes are referred to briefly by Davey in his review, and work on them has been continued by Williamson (1957), Desowitz (1957) at the West African Institute for Trypanosomiasis Research, Nash (1957). Ethidium-suraminate appears to have been the most successful prophylactic, protection for 13 months having been achieved at the 10 mg./kg. level. In comparison a 20 or 40 mg./kg. dose of the Antrycide methyl sulphate-suraminate was required for 5½ months' protection. The serious local toxicity and sloughing at prophylactic dose levels is still a major problem, since loss of " depot " means loss of protection, and Williamson has been working on it for a year. All efforts to overcome it satisfactorily have so far failed. Elimination of toxicity apart from " depot " loss in some cases interfered with prophylaxis. For full details of this work see Nash (1957). Processing of the complex is now being continued in the United Kingdom.

With regard to this toxicity question, it is interesting to record that a Prothidium-Suramin complex prepared in Kenya—Whiteside (1958)—

was shown to be at least four times less toxic than Prothidium alone, but prophylactic trials have still to be carried out.

A toxocide-suraminate has been tested in both Kenya and Tanganyika, the former in low and the latter in high challenge areas, but no appreciable protection was obtained in either case.

Under " Prothidium ", the comparative trial carried out in Tanganyika under high and low challenge was mentioned. Here the Ethidium Suraminate showed no serious toxicity. In the low challenge area the two-dose levels, 5 and 10 mg./kg., showed little difference in the result; the first break-through being on the 140th day in each case, and the last (13/27) on the 258th day with 5 mg./kg. and (8/10) on the 252th day with 10 mg./kg. Under higher challenge at 5 mg./kg. 9/14 were infected in 174 days and at 10 mg./kg. 5/14 in the same period of time.

The results of a comparative prophylactic trial carried out in Uganda (1958) are of considerable interest.

The challenge was natural *G. morsitans* (A D 19) and the infectivity rate (*T. vivax* and *T. congolense*) 13%.

The Ethidium Suraminate group (5 mg./kg.) was protected for 6 to 7 months, only those animals losing the " depot " breaking through.

On the other hand, all the Prothidium animals (2 mg./kg.) and the Antrycide methyl sulphate animals (5 mg./kg.) were positive in three months. In the same area and at the same time Antrycide Pro-Salt (12 mg./kg. every two months) protected solidly for over seven months.

Mention must be made of a prophylactic trial carried out by the Veterinary Department in Sierra Leone—Noble (1957)—on pigs with *T. simiae* and *T. congolense* as challenging trypanosomes. The complex used was Antrycide methyl sulphate/suramin at the two-dose levels 40 mg./kg. and 20 mg./kg. given subcutaneously. The challenge was a natural one in a tsetse area. After six months the result was 7/7 alive at 40 mg./kg., 3/3 alive at 20 mg./kg., and 2/4 of the controls dead from *T. simiae*. This is a follow-up of the work carried out by Watson and Williamson (1958) at the West African Institute for Trypanosomiasis Research on *T. simiae* infection in pigs and reported by Nash (1956).

A suitable regimen for pigs in different challenge conditions has still to be determined.

5. **M. & B. 4427** (May and Baker, Limited)

This is an almost insoluble salt of M. & B. 4404 and was presented for trial as a prophylactic in animal trypanosomiasis. In its anhydrous state it contains approximately 51·8% active cation.

The L D 50 mg./kg. subcutaneously in mice was > 2,000, compared with Homidium Suramin 100. Locally, in rats there was no reaction or lameness, whereas both were noted with pro-salt and Homidium/Suramin. The prophylaxis in rats using *T. congolense* was promising and studies in cattle indicated that the intramuscular route of administration should be used.

The tests in Africa have tended to confirm these findings. Initially, it was considered that the particle size (not greater than 35) was too coarse to permit of sufficiently rapid absorption from the inoculation site and a finer suspension is now being used and compared. Local reactions are modest and quickly resolve, those with the finer suspension being slightly more persistent.

A considerable number of trials have been put in hand following the toxicity tests to determine the prophylactic value of both M. & B. 4427 and M. & B. 4404. Thus, a large scale comparative trial is under way at the East African Veterinary Research Organisation at Sukulu. At the West African Institute for Trypanosomiasis Research, and in Kenya, small scale comparative tests under different challenge have followed the toxicity tests.

It is much too early to assess these drugs as prophylactics, but the effective dose of M. & B. 4404 appears to be rather too close to the toxic level for practical prophylactic purposes, and regimens for M. & B. 4427 will be a matter for future study under the different challenge conditions.

Drug Resistance

It has been impossible to avoid reference to this in considering chemotherapy. Davey mentions the problem in his review and issues a timely warning.

The subject is dealt with exhaustively by Schnitzer and Grunberg (December 1957), and the specific nature of the changes which take place in resistant strains is not yet fully understood.

Now that new prophylactics have been introduced and others are imminent, I need only emphasise the necessity of assessing accurately the dosage fates and regimes for the different types of challenge before extensive field use is contemplated. This is already appreciated and applied in some territories. If protective drugs must be used in high challenge areas where protection periods may be relatively short, then appropriate steps must be taken to remove the animals which are possibly harbouring resistant strains, since retreatment may not be satisfactory at that stage and the herds at risk may all ultimately be exposed to fly transmitted resistant strains.

One problem is the accurate assessment of initial break-through as opposed to observed break-through and the evolution of regimens which will be satisfactory for different areas. C. N. Lyttle and E. F. Whiteside (1957) of the Kenya Veterinary Department have studied the problem closely in connection with the development of suitable regimens for Prothidium. Regimens based on observations have been suggested, and one of these is being subjected to confirmatory tests in the field. Such a procedure may be time consuming, but it would appear from recent results to be essential if the risk of drug fastness is going to be reduced to a minimum.

Prothidium resistant strains appearing during prophylaxis have been closely examined in Kenya and cross-resistance to Antrycide, Homidium and even Berenil has been revealed. The work continues in Kenya and at the East African Trypanosomiasis Research Organisation.

In my opening remarks I outlined the factors which might influence the effective control of trypanosomiasis by means of drugs, and Davey in his comments on the future rightly stated that any new drug to be of real value would have to possess prophylactic properties of a high order. It cannot yet be said that the new drugs which I have mentioned measure up to these requirements in all respects, but the evidence is that they do represent a step in the right direction, in that a safe, more prolonged period of protection is now a distinct possibility, without the need for short interval repetitive inoculation. This applies particularly to the low and medium challenge areas. The problem of the high challenge areas still remains and, as anticipated, it may well be advisable always to reduce the challenge there by other means before introducing cattle under drug protection. Immunisation still does not hold out any immediate prospect of practical application. The more recent observations of Soltys (1957) are relevant.

ACKNOWLEDGMENTS

Having been charged with the responsibility of summarising recent developments in the control of animal trypanosomiasis by means of drugs, and having made use of Davey's paper by reproduction I found, in preparing the paper, that I could not escape reference to work submitted for publication, but not yet published, and indeed to work not yet prepared for publication, or in progress, which has been forwarded to the Chemotherapy Panel in London by the various workers in British Territories in Africa. Some of these workers are attending the meeting and I hope will take some part in the discussion. I wish to acknowledge all such data, which I have mentioned only by way of indicating the trend of current progress in this field.

As a survey of Chemotherapy in Africa this review is necessarily incomplete for I have not been able, through lack of information, to refer to trials that have taken place in several other countries. I should warmly welcome such information before—at or after the meeting in Brussels, so that, in comparison with our own experiments, the merits of the newer drugs may be more truly assessed.

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THE CHEMOTHERAPY OF ANIMAL TRYPANOSOMIASIS WITH PARTICULAR REFERENCE TO THE TRYPANOSOMAL DISEASES OF DOMESTIC ANIMALS IN AFRICA

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INTRODUCTION

Trypanosomes have a notable place in the history of chemotherapy. They featured in the early experimental work on synthetic compounds that was just beginning in the laboratories of Europe at the beginning of this century, and there is reason to suppose that if Thomas, working in Runcorn (Liverpool) in 1904, had not demonstrated the curative action of atoxyl on *Trypanosoma gambiense* in mice, Ehrlich would not have been led to 606 (Salvarsan) for syphilis. Thereafter, as experimental chemotherapy gathered momentum under the great stimulus of Ehrlich, trypanosomes became part, as it were of the laboratories concerned, and they lent their name to some of the early and now historical substances such as Trypan red (1904), Trypan blue (1904) and Trypasafrol (1912).

At first, it was the trypanosomes of man, *T. rhodesiense* and *T. gambiense*, that attracted attention, and one of the early great successes of the new chemotherapy was Bayer 205 (Germanin, Naganol, Suramin, Antrypol, etc.) announced for human trypanosomiasis in 1920, and found to be of use, too, against *T. brucei*, *T. equinum*, *T. equiperdum*, and *T. evansi*. The trypanosomal diseases of cattle in Africa, undoubtedly now the most important of all the diseases caused by trypanosomes, waited until the 'thirties before some attention was focused on them. In Africa itself tartar emetic was being used for treatment, but in Germany and in England the search for other drugs against *T. congolense* was being pursued.

The search was more successful than the immediate results of the original investigations indicated, for all the most modern drugs for animal trypanosomiasis are related to the substances that came to light in the 'thirties. Ethidium is in a direct line of descent from phenanthridinium 897 (Phenidium) synthesised by Morgan and Walls in 1938, and shown to be active against *T. congolense* in mice by Browning in Glasgow in the same year; the discovery of Antrycide owes much to the work of Iensch (1937) that led to Surfen C, and Berenil goes back to the work on the diamidines done by Ewins and his collaborators at Dagenham, by Yorke and his colleagues in Liverpool, by King in the Medical Research Council laboratories in London, and before that to the demonstration of trypanocidal properties in Synthalin (decamethylene-diguanidine hydrochloride) (von Janscó and von Janscó, 1936).

This review will be concerned in detail only with the modern drugs and it is to gain perspective and to pay homage that a very brief history has been given. For a fuller account of the early work the reader is referred to Findlay (1950).

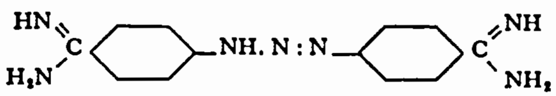
The arrangement of the review needs some comment. I have thought it best to deal with the drugs and their properties first, then very briefly (and consequently, in some measure, dogmatically) with the treatment of the individual diseases, and finally to say something of the problems that remain. The aspects discussed are essentially practical, and for an introduction to the literature concerning the mode of action of the trypanocidal drugs—about which we know very little that helps us to discover others—reference should be made to the reviews by Work and Work (1948), Findlay (1950), von Brand (1951), and Sexton (1953), and the papers by Hawking *et al.* (1937), Hawking (1944), Ormerod (1951*a*, *b*), Sen *et al.* (1954), Hawking and Thurston (1955), etc.

THE DRUGS IN USE AGAINST THE TRYPANOSOMAL DISEASES OF DOMESTIC ANIMALS

Tartar emetic, antimosan and Surfen C are now hardly, if ever, used; and the cinnoline 528 of Lourie *et al.* (1951) was found wanting. Suramin is still widely used for the treatment of *T. evansi* in camels, but its attributes and its defects are now well known and need not be discussed here. We are left with Berenil, the phenanthridinium compounds, Antrycide and certain " complexes " of suramin with these drugs. Other substances have been mentioned in recent papers as active against trypanosomes in small laboratory animals, but no information is yet available concerning their activity in the domestic animals, and so, for reasons of space, they have not been considered.

Berenil*

This substance has the constitution:



Its properties have been described by Fussgänger (1955) and Bauer (1955*a*, *b*). It has a relatively poor action in mice against trypanosomes of the *Brucei* group, and a more marked action against *T. congolense*. The minimum curative dose for the last species is given as 1–2·5 mg./kg. intramuscularly in the dog, and 2·5 mg./kg. subcutaneously in the mouse (in my own experiments more than 5 mg./kg. is necessary to cure the Busimbi, Uganda strain of *T. congolense* in mice).

Reports of experiments with the drug in cattle are few. Bauer (1955*a*) described an experiment in Western Tanganyika in which three groups of

* Marketed by Hoechst of Germany.

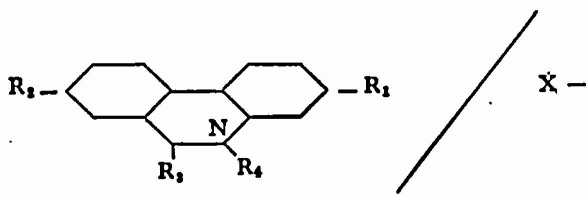
cattle, six beasts in each group, all infected with *T. vivax*, were treated respectively with 1, 2 or 3 mg./kg. intramuscularly. As a result of the experiment the standard dose of 3 mg./kg. intramuscularly was decided upon. This dose was used in Portuguese East Africa to treat 500 cattle, the stock of 12 European farmers. Between 10 and 60% of each herd carried natural infections of *T. vivax* with or without *T. congolense* and *T. brucei*. Trypanosomes were said to have disappeared within 24 to 48 hours, and there were no side effects from the treatment. Subsequent examinations appear to have been limited, but at least four possible relapses with *T. congolense* or *T. vivax* were found amongst 26 animals followed up for six months. In a second paper (1955*b*) Bauer stated that some 800 cattle had been treated for trypanosomiasis with Berenil; 2 or 3 mg./kg. intramuscularly had always given cures, and 1 mg./kg. had been sufficient to cure *T. congolense*.

Milne *et al.* (1955) reported an experiment from Tanganyika in which 20 cattle infected with *T. congolense* were treated with 2 mg./kg., five subcutaneously and 15 intramuscularly. Trypanosomes disappeared from the blood within 5 to 40 hours, and the cattle remained apparently free from infection for 150 days. Re-infection was achieved in all except one animal.

Berenil has only a poor action against *T. simiae* (Bauer, 1955*a*).

The Phenanthridinium Compounds. I

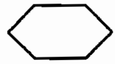
These have the general formula:

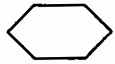


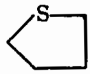
Activity in this type of compound against *T. congolense* was discovered by Browning *et al.* (1938) whose work extended over many years and which culminated in 1943 with the compound 1553 that came to be known as Dimidium bromide. Further studies of the type, particularly since the war, were then made in the laboratories of Burroughs Wellcome and Co. and Boots Pure Drug Co.

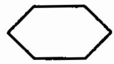
Of the very considerable number of compounds tested in the laboratory nine have been tried against infections in cattle, and of these, six were discarded in their early experimental stages for one reason or another (see, *e.g.* Goodwin and Unsworth, 1952; Goodwin and Chandler, 1952; Burdin and Plowright, 1952*a*, *b*; Burdin, 1953; Wilde and Robson, 1953; Neal and Karib, 1954).

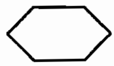
The discarded compounds are :

B. W. & Co. 150.C.47 ($R_1R_2 = NH_2$; $R_3 =$  NH_2 ; $R_4 = CH_3$; $X = Cl$).

B. W. & Co. 676.C.47 ($R_1R_2 = NH_2$; $R_3 =$  NO_2 ; $R_4 = CH_3$; $X = Cl$).

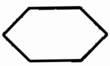
B. W. & Co. 621.C.47 ($R_1R_2 = NH_2$; $R_3 =$  ; $R_4 = CH_3$; $X = Br$).

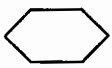
B. W. & Co. 196.C.48 ($R_1 = NH_2$; $R_2 = C_2H_5O$; $R_3 =$  NH_2 ; $R_4 = CH_3$; $X = Cl$).

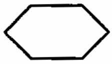
Boots RD 1427 ($R_1R_2 = NH_2$; $R_3 =$  ; $R_4 = C_3H_7$; $X = Br$).

Boots RD 1446 ($R_1R_2 = NH_2$; $R_3 =$  ; $R_4 = CH_2.CH.CH_2$; $X = Br$).

The three that progressed and came to be used more widely are :

Phenidium chloride or phenanthridinium 897 ($R_1 = H$; $R_2 = NH_2$; $R_3 =$  NH_2 ; $R_4 = CH_3$; $X = Cl$).

Dimidium bromide or phenanthridinium 1553 ($R_1R_2 = NH_2$; $R_3 =$  ; $R_4 = CH_3$; $X = Br$).

Ethidium bromide or *Boots RD 1572* ($R_1R_2 = NH_2$; $R_3 =$  ; $R_4 = C_2H_5$; $X = Br$).

Phenidium chloride

This was one of the two substances described when the phenanthridinium compounds were first announced as " a new type of trypanocidal agent " (Browning *et al.*, 1938). It was tried against *T. congolense* in cattle in Africa by Hornby *et al.* (1943) and by Carmichael and Bell (1944*a*). In the experiments of Hornby and his colleagues the only animal treated with 4 mg./kg. subcutaneously relapsed ; it also had a large swelling at the site of injection which persisted for the two months before it was killed. Of 20 given 2 mg./kg. intramuscularly 14 were cured, one was doubtfully cured and five relapsed. The intramuscular injection led to some local reaction and some slight lameness. Carmichael and Bell were led to prefer intravenous treatment, partly because they thought it more efficacious, partly because of the local reactions following intramuscular treatment. Doses greater than 3 mg./kg. intravenously were dangerous and 2 mg./kg. cured only about half the animals.

Phenidium chloride has very obvious drawbacks to modern eyes, and so it is not without interest to recall that 12 years ago Carmichael and Bell

(1944*a*) could conclude that the drug "must ... be given a high place among the trypanocides tried against this very intractable infection".

Phenidium had a relatively short life. There is a curious lag between the time of its announcement in England (1938) and its trial in Africa (1943) and because of this Dimidium bromide, not discovered until 1943, appears to follow hard on its heels into Africa.

Dimidium bromide

Dimidium bromide was first tried in Uganda against *T. congolense* (Carmichael and Bell, 1944*b*; Bell, 1945), and the results were most promising. They indicated that the new drug had a relatively wide margin of safety, that a dose of 1 mg./kg. subcutaneously was sufficient to cure *T. congolense*, and that injection of the drug by this route caused relatively little irritation whilst intramuscular injection produced a painful swelling and led to marked lameness. The initial field trials with the drug in Uganda in 1945 proved these conclusions to be far too optimistic. In the first, of 187 cattle treated with 2 mg./kg. subcutaneously "nearly all developed symptoms of photosensitisation some six weeks after administration of the drug, and 41 subsequently died. In addition, severe local reactions at the site of injection were of frequent occurrence, resulting in sloughing of areas of skin up to 12 inches or more in diameter". (Randall and Beveridge, 1946.) Because of these mishaps the dose was reduced to 1 mg./kg. and the injections made intramuscularly in the next trial. No toxic effects were observed and it was estimated that, using this dose, the relapse rate with *T. congolense* infections probably did not exceed 5% (Randall and Beveridge, 1946).

Further experimental work confirmed in general the conclusions drawn from the use of Dimidium in the field in Uganda (Barnett, 1946; Randall and Laws, 1947; Randall and Beveridge, 1947; Wilson, 1948*a*, *b*; Wilde, 1949). All workers were agreed that so-called photosensitisation was a serious hazard in the use of the drug; that 1 mg./kg. was about the highest reasonably safe dose; that the intramuscular route was probably to be preferred because of the sometimes severe local reaction after subcutaneous administration; and that 1 mg./kg. intramuscularly cured the majority but not all cases of *T. congolense*.

The standard treatment with Dimidium bromide, then, came to be 1 mg./kg. intramuscularly, but some territories, *e.g.* Kenya and Southern Rhodesia, used doses up to 1·5 mg./kg. and in Southern Rhodesia the intravenous route was preferred even though it led to the veins becoming partly occluded. Delayed toxicity has always been a fear with those who used the drug, understandably in view of its potential severity (see, *e.g.* Evans, 1948; Thorold and Plowright, 1952) but nevertheless Dimidium has been of very considerable use in Africa as the annual reports of the

Veterinary Departments of such countries as the Republic of the Sudan, Kenya, Nigeria, the Rhodesias, etc., emphasise again and again.

One point will have struck the reader, and that is how little attention was given to *T. vivax* in the experimental studies done with Dimidium. Everyone knew that *T. vivax* was important, but few attempted to work with it (in later trials with Ethidium and Antrycide—see below—*T. vivax* was not neglected). The accumulated results from the field, however, finally served to show that this species appeared to be as susceptible as *T. congolense* and there are a few experiments, *e.g.* Mornet and Mahou (1949) to confirm this. For the rest, the prophylactic action of Dimidium is very little (annual report of the Veterinary Department, Nigeria, 1947, p. 20) and its action against *T. simiae* is poor (Wilson, 1948*a*). The toxicity of the drug is discussed further below.

Ethidium*

Ethidium bromide was announced in 1952 by Watkins and Woolfe who claimed that in mice it was somewhat less toxic than Dimidium bromide, and 10 times as active against *T. congolense*, 20 times as active against *T. brucei*, 50 times as active against *T. gambiense*, and 11 times as active against *T. rhodesiense*. The reader will have noticed that the chemical difference between Dimidium bromide and Ethidium bromide is slight, merely the difference that in one the quaternising group is methyl (CH_3) and in the other is ethyl (C_2H_5). The difference in biological properties is therefore remarkable ; it is equally remarkable that 14 years went by before the attributes of the ethyl quaternisation group were discovered.

Experiments have been done in various parts of Africa with Ethidium bromide, and Table 1 is an attempt to summarise the therapeutic results achieved.

In the actual experiments summarised in Table 1 various doses extending over quite a wide range were tried, of course, and on the basis of all the work the manufacturers recommend 1 mg./kg. for routine use which clearly allows latitude with some strains. It is advised, however, that the dose be given intramuscularly, because all the workers who gave it subcutaneously describe the development of a sometimes large swelling at the site of injection with occasional necrosis of the skin. Also, an alternative salt is offered. The initial work was done with the bromide which requires boiling water to bring it into solution whereas the chloride (called Ethidium "C") is soluble in cold water. Like Dimidium bromide, Ethidium is relatively rapid in action, and with effective treatment trypanosomes disappear from the blood within 48 hours.

The promise of Ethidium so apparent in the experimental work is not reflected in a recent report from the Belgian Congo where Thienpont and Hérin (1955), working in Astrida, state that eight relapses occurred amongst

* Marketed by Boots Pure Drug Co., England.

Table 1.—Action of Ethidium bromide against *T. congolense* and *T. vivax* in cattle

Territory	Species	Route	Probable Minimum Curative Dose[1] mg./kg.	No. of cattle on which result is based	Reference
Sudan .	*T. vivax*[2]	s/c	0·25	6	Ford *et al.* (1953*a*)
Sudan .	*T. congolense*	s/c	0·5–1	7 at 0·5 6 at 1	Ford *et al.* (1953*b*)
Kenya .	*T. congolense*	s/c	0·5	3	Wilson and Fairclough (1953)
Tanganyika	*T. congolense*	s/c	0·3–0·9 (?)[3]	8 at 0·3 8 at 0·9	Wilde and Robson (1953)
Nigeria .	*T. vivax* (Syringe passaged)	s/c	1 (Expt. I) 0·1 (Expt. II)	5 2	Unsworth (1954*a*)
Nigeria .	*T. vivax* (fly-passaged)	s/c	0·5–1	7 at 0·5 9 at 1	Unsworth (1954*b*)

[1] Where two doses are quoted a relapse recurred at the lower.
[2] A debilitating but not a virulent strain.
[3] Of a group of 8 bovines treated with 0·3 mg./kg. 7 were cured and 1 relapsed; an identical result was achieved with 0·9 mg./kg. and possibly a mistake was made or a re-infection occurred.

47 cattle infected with *T. vivax* which were treated with 1 mg./kg. subcutaneously of the bromide.

The Toxicity of the Phenanthridinium Compounds

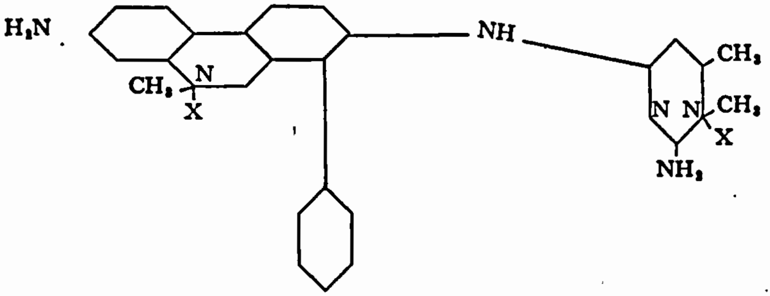
The delayed toxicity which sometimes follows the injection of Dimidium bromide, the symptoms of which so closely resemble photosensitisation, has now been reported from most parts of Africa (see, *e.g.* Randall and Beveridge, 1947; Stewart, 1947; Evans, 1948; Wilde, 1949; Thorold and Plowright, 1952). At first it was thought to be associated with high doses (2 mg./kg.) but more extended use of the drug showed that it could follow the standard treatment with 1 mg./kg. The general picture is always the same. About six weeks after treatment a proportion of the treated cattle begin to lose condition and may deteriorate rapidly, exhibiting lachrymation and skin lesions. An early symptom may be hyperaemia of the subepithelial tissues of the muzzle and droplets of plasma may be exuded (Plowright *et al.*, 1952). Animals that are mildly affected show " signs of sensitivity and irritation of the muzzle and of the skin at the face and ears, together with slight lachrymation " (Thorold and Plowright, 1952). Animals more severely affected may exhibit " intense irritation and hypersensitivity of the skin—usually of non-pigmented parts exposed to direct sunlight—accompanied by oedematous swellings of the muzzle, face, backs of the ears, base of the horns and dewlap, followed by serious exudation with hardening and cracking of the skin over these areas ". Strips of " boarded skin " may peel off the back, flanks and udder exposing a raw granulating surface. The teats may become necrotic and drop off, and the ears may be left raw and misshapen. When the skin over the back and flanks finally hardens the gait is affected and the animals walk stiffly (Thorold and Plowright, 1952).

The fact that Dimidium may produce this alarming effect seems undoubtedly due to the toxic action of the drug on the liver (Bell, 1947; Wilde, 1949; Plowright *et al.*, 1952; Burdin and Plowright, 1952*a*, *b*), but what the factors are which may exacerbate the liver lesions and why the lesions may lead to the syndrome of photosensitisation remain unknown. Delayed toxicity is not an invariable accompaniment of the use of Dimidium bromide at 1 mg./kg., and no one has yet been able to pinpoint the all-important factor linking the sporadic occurrences. It has occurred at high altitudes in Kenya and at low altitudes in Ghana and the Republic of the Sudan; it has been associated with poor grazing in the Republic of the Sudan and in Ghana (Evans, 1948; Stewart, 1947), and with good grazing in Kenya (Thorold and Plowright, 1952) and it has been seen in zebus, mixed zebu and grade crosses, low-grade and high-grade cattle. Evans thought that cattle in good condition were the most severely troubled, whilst Thorold and Plowright pointed out that the only high-grade cattle to be severely affected in the outbreak they witnessed was a Friesian herd in poor condition after an outbreak of foot and mouth disease.

A comparative study of the toxicity of the phenanthridinium compounds, with particular reference to their effect on the liver, has been done at the Kenya Veterinary Laboratory in Kabete (Plowright *et al.*, 1952; Burdin and Plowright, 1952*a*, *b*; Burdin *et al.*, 1952; Burdin, 1953). The liver lesion produced by Dimidium is characteristic and takes the form of a periportal fatty infiltration together with the accumulation of a golden brown pigment, probably bilirubin, in the hepatic and Kupffer cells. It is associated with a loss in weight and condition, a positive direct van den Bergh reaction, a clinically observable jaundice in some cases and an elevated plasma level of alkaline phosphatase. The liver lesion is produced sometimes by 1 mg./kg. and regularly at 2 mg./kg. or more, but symptoms of photosensitisation are not invariably present. A similar lesion is obtained with some related compounds (*e.g.* 150.C.47) but not with Phenidium at doses up to 4 mg./kg. The absence of any apparent effect on the liver by Ethidium at this relatively high dose has led to the hope that "photosensitisation" will not be a problem bedevilling its use. Confirmation that Ethidium is less toxic for cattle than Dimidium is given by Unsworth (1945*a*), Ford *et al.* (1954) and Wilson (1954). Unsworth (1954*a*) noticed an unexplained rise in temperature (2°–3·6° F.) in a proportion of his *unifected* cattle 24–96 hours after they were injected with Ethidium.

The Phenanthridinium Compounds. II

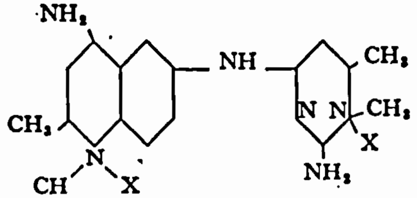
In a preliminary communication Watkins and Woolfe (1956) described a substance referred to as R.D. 2801 (now called Prothidium) which is built on the Antrycide plan (see below), but which has a phenanthridinium nucleus in place of the quinoline nucleus of Antrycide linked to the pyrimidine moiety. It has the constitution :



Considerable prophylactic properties are claimed for it (2 mg./kg. has given protection for approximately six months—personal communication from Dr. G. Woolfe—), but trials are still in progress and details are not available.

Antrycide*

This drug was described by Curd and Davey (1949, 1950) and has the constitution :



(X = Cl, Antrycide chloride, or CH_3SO_4, Antrycide methylsulphate).

It has a wider range of action against the various species of trypanosomes than most drugs and is active against the *Brucei* group, *T. congolense*, *T. equinum*, *T. equiperdum*, *T. evansi*, *T. simiae* and *T. vivax*, but most active against *T. congolense*. Apart from the intrinsic value of the substance itself, its discovery has emphasised two important facts. First, the early experiments were done with two salts, the readily soluble methylsulphate and the sparingly soluble chloride. After subcutaneous or intramuscular injection the former is quickly absorbed whilst the latter is held at the site of injection and only slowly seeps into the transport systems of the body. It was thought, and shown to be true, that the methylsulphate would be better for curative and the chloride for prophylactic purposes. The concept of what may be called " depot prophylaxis " is potentially applicable to any drug if a salt or complex that is only slowly absorbed can be made, and this is really what Williamson and Desowitz (1956) have done in their work on

* Marketed by Imperial Chemical Industries, Limited, Pharmaceuticals Division, England.

combinations of Bayer 205 with Ethidium, Berenil, Antrycide, etc. (see below).

Secondly, although the prophylactic properties of Antrycide are far from all that can be desired they have served to show that chemoprophylaxis of cattle trypanosomiasis in Africa can play a very important part in the development of that continent.

Antrycide as a curative drug. I

Initial field experiments (Davey, 1950) were concerned with the treatment of *T. congolense* and *T. vivax*. It was shown that 0·5 mg./kg. subcutaneously (all treatments with Antrycide mentioned in this review were made subcutaneously unless otherwise stated), of the methylsulphate cured all of 6 cattle infected with a Uganda (Mubende) strain of *T. congolense*, 1 mg./kg. cured all of 7 cattle infected with a Southern Sudan strain and all of 9 infected by the bite of tsetse fly with a Kenya (Mariakani) strain. With a second Kenya strain (T. 90 of the Kabete laboratory) 2 mg./kg. cured 10 of 11 animals. Experiments with *T. vivax* were more limited, but 1 mg./kg. cured 5 of 6, and 5 mg./kg. cured all of 5 cattle infected by the bite of tsetse fly with a virulent Kenya strain, and in Uganda, using a much less virulent strain, all of 6 cattle were probably cured with 5 mg./kg. On the basis of these results 5 mg./kg. was suggested as the dose to be tried in the field in cattle which might be infected with *T. congolense* and *T. vivax*.

Confirmation of its efficacy came from the Republic of the Sudan (Evans, 1950), Portuguese East Africa (Da Cruz Ferreira and Tendeiro, 1950), Italian Somaliland (Pellegrini and Bonelli, 1951), the Belgian Congo (Schoenaers, 1950 ; Andrianne, 1952) and particularly from Uganda where, since 1950, more than three-quarters of a million cattle have been treated (annual reports of the Veterinary Department 1950, 1951, 1952, etc.). It was used, too, in Nigeria, Northern Rhodesia, Kenya, etc., and no serious criticisms of its therapeutic effect were made (annual reports of the Veterinary Departments, 1951 *et seq.*, and of the West African Institute for Trypanosomiasis Research, 1952 *et seq.*). Summing up, the recommended field dose is almost certain to cure *T. congolense*, and most cases of *T. vivax*.

T. congolense infections have also been cured in dogs and horses with 3–5 mg./kg. (Pellegrini and Bonelli, 1951 ; personal observations), and *T. vivax* in horses with 5 mg./kg. (personal communications).

Antrycide as a curative drug. II.

The laboratory experiments in small animals (Curd and Davey, 1950) had shown that Antrycide possesses a very marked action against such other species of trypanosomes as *T. evansi*, *T. equinum*, etc., and the methylsulphate was therefore tried against them in the field. Camels infected with *T. evansi* have been cured with 5 mg./kg. in the Republic of the Sudan (personal communication from Mr. J. T. R. Evans), in Italian Somaliland

(Pellegrini and Bonelli, 1951) and in Iran (Rafyi and Maghami, 1953). The same species has been shown to be susceptible to Antrycide in horses and dogs in Indo-China (Chary and Bocquet, 1955), but repeated treatments were used. In India, 5 mg./kg. cured *T. evansi* in horses, and 3 mg./kg. was completely satisfactory in cattle (Ray *et al.*, 1953). Turton (1953) eradicated an outbreak of *T. brucei* in a group of horses at Accra with 5 mg./kg. repeated once more after 4 days. Zottner (1952), working in Morocco, regarded 5 mg./kg. as completely effective against dourine (*T. equiperdum*). *T. simiae* was cured in three pigs with 5, 4 and 3 mg./kg. respectively in Uganda by Wilson (1949*b*), but in Nigeria Unsworth (1952) failed to achieve complete cure of this infection with 5 mg./kg., relapses occurring three to four weeks after treatment.

Antrycide as a prophylactic drug. I

The first field experiments with Antrycide (Davey, 1950) were also concerned to show that practical use could be made of the prophylactic properties of the chloride for protecting cattle in tsetse areas. They demonstrated that (*a*) a single dose prevented animals from acquiring infection with trypanosomes for some months ; (*b*) better protection was afforded against *T. congolense* than *T. vivax* ; and (*c*) the very important point that trypanosomes " breaking through " the waning concentration of drug towards the end of the prophylactic period could emerge resistant to the drug, and therefore the important corollary that, in practice, re-treatment must be made soon enough to prevent the emergence of break-through strains.

The methylsulphate, because of its conversion in part to the chloride in the subcutaneous spaces, was also shown to have some prophylactic properties, and the salt has actually been used sometimes for prophylaxis. For example, in Northern Rhodesia (annual reports of the Veterinary Department, 1952, 1953) some cattle have been kept in a fly belt for as long as 30 months free from trypanosomes by the injection of 5 mg./kg. methylsulphate every two months.

As a result of the first field trial it was recommended that for prophylactic purposes Antrycide should be used in the form of a mixture containing three parts by weight of the methylsulphate and four parts by weight of the chloride, a mixture called Antrycide prosalt. The chloride is there to give protection and the methylsulphate to eradicate trypanosomes that might be present at the time of treatment. The dose is measured in terms of the methylsulphate at 5 mg./kg.

The field work in Africa was continued by Fiennes (1953*a*, *b*) and Unsworth and Chandler (1952). Information is contained also in various annual reports written in Africa since 1950, particularly those of the Veterinary Departments of Uganda, Kenya and the Republic of the Sudan, and of the West African Institute for Trypanosomiasis Research. It would take too long to trace in detail the history of Antrycide through all the investigations, and I have therefore tried to summarise what seems important in the following conclusions. In framing them I have been helped considerably by conversations and discussions from time to time with workers in Africa.

(i) The period which may be allowed between treatments, if the cattle are to be kept completely free from trypanosomes, is dependent on the density of the tsetse fly population. If the " challenge " to the drug is anything but light the period between treatments must not exceed two months, and if the challenge by *T. vivax* is heavy some infections usually appear after a time even with this frequency of treatment. Unfortunately, there is no universal agreement upon what constitutes " light ", " medium " and " heavy " challenges. The first quantitative work on the subject was done by the Kenya Veterinary Department, whose members have rendered a great service by always measuring fly density and natural incidence of trypanosomiasis in their experimental areas and correlating their prophylactic results with it. The density is expressed as the apparent density (AD), which is the number of tsetse flies caught per 10,000 yards of patrol, using a standardised catching technique. In the case of the tsetse fly *Glossina pallidipes* an AD less than 10 allows the area to be described as offering a light challenge, and one greater than 40 a heavy challenge. Under light challenge, prophylaxis with Antrycide prosalt at two-monthly intervals gives near-perfect results and it is possible that the interval could be increased a little or the amount of chloride in the mixture reduced. Indeed, in an area with an AD less than 3, the prosalt at three-monthly intervals has given complete prophylaxis (personal communication from Kenya Veterinary Department). Under medium challenge, treatment every two months still gives excellent results, but it would be dangerous to increase the period, and at AD's approaching 40 some infections may appear after about a year's exposure. Under very heavy challenge *T. vivax* or, much more rarely, *T. congolense* may break through after a variable period of four to eight months, depending on the actual fly density.

Dr. E. F. Whiteside, who has emphasised for some years the important part played by the nature of the challenge in determining the efficacy of prophylaxis (it is apparent, too, in the different results obtained by Unsworth and Chandler in a " palpalis area " and a " morsitans area ") thinks the drug is soaked up, as it were, if large numbers of trypanosomes are injected (personal communication) and I have some evidence that this may be part of the explanation. In experiments in mice and rats (unpublished observations) I have been able to show that the magnitude of the curative dose of certain drugs for *T. rhodesiense* is determined by the number of trypanosomes present at the time of treatment. In other words, the more trypanosomes there are present, the more drug is required to cure.

The magnitude of the challenge is clearly an important factor, and knowledge of it helps to explain why laboratory results in cattle are better than the results sometimes obtained in tsetse areas, and why there is outstanding success in some areas and relative failure in others. One might go so far as to say that all workers contemplating the occupation of tsetse country by cattle should first measure the density of flies present, even if roughly, because they will thereby be much more able to weigh the chances of success.

(ii) *T. vivax* breaks through sooner than *T. congolense* (*T. brucei* may also break through as early as *T. vivax* but probably rarely matters in cattle), and better protection can therefore be expected in a predominantly *congolense* area than in a predominantly *vivax* one.

(iii) The species of tsetse fly does not seem to influence the results, except in so far as different species are differently attracted to cattle (which affects the challenge) and to man (which affects the AD observed).

Antrycide as a prophylactic drug. II. Some uses in cattle.

(i) In French West Africa, Ghana, Nigeria and the coastal area of Kenya, the cattle-raising areas of the north are separated from the markets of the south by tsetse belts. It was the habit in the past to force-march the cattle past the danger with, of course, a resulting loss of condition made worse, sometimes, by infection with trypanosomes. The benefits to be derived from protecting the cattle with Antrycide have been demonstrated by Mornet *et al.* (1951, 1952), Unsworth and Birkett (1952) and workers in Kenya (annual report Veterinary Department, 1954).

(ii) In Uganda (Western Ankole) injections with Antrycide prosalt every two months are used to protect cattle taken into a tsetse area to resettle it. The cattle (more than 7,500) have now been there for almost two years and are flourishing (personal communication from the Uganda Veterinary Department).

In Kenya an apparently successful experiment has been described of taking cattle from the normal grazing grounds during the wet season and putting them in tsetse areas, so allowing the grazing a chance to recover. The cattle were kept in the tsetse area under the protection of Antrycide (annual reports of Department of Veterinary Services, Kenya, 1953, 1954). The same reports speak of a ranch being maintained in a tsetse area with the help of Antrycide. Cattle for special purposes, *e.g.* milking herds and working oxen have also been kept in tsetse areas in the Republic of the Sudan (annual reports of the Veterinary Department, 1951–53).

Antrycide as a prophylactic drug. III

Zottner (1952) considered that two doses of Antrycide prosalt should keep horses completely free from dourine (the breeding season is March to June) in Morocco. Ray *et al.* (1953) and Ramanujachari and Alwar

(1955) suggested that the drug should be of service in protecting cattle and other animals against surra in India.

Other observations on Antrycide

"The blood of Antrycide-treated cattle drawn up by tsetses at frequent intervals does not destroy *T. vivax* which has established itself in flies; nor does it affect development of the trypanosome to the mature, infective stage; not even after 18–19 meals over a period of 41 days, which is believed to be longer than the life of a tsetse in nature" (Lewis, 1949). Similar conclusions were drawn by Roubaud (1952).

The toxicity of Antrycide

The chloride when injected subcutaneously or intramuscularly is virtually without general toxicity because it is so poorly soluble and seems to be absorbed only as a solution. It is of equal toxicity with the methylsulphate when given intravenously (Curd and Davey, 1950). It probably causes some local irritation when given subcutaneously, and the methylsulphate certainly does, but less than the phenanthridinium compounds. When the two salts are used together as the prosalt of the chief local trouble is the "lump" of unabsorbed material which may persist when the small oedematous swelling caused by irritation has subsided. The risk of a lump is lessened if the injection site is massaged at the time of treatment, and sometimes it is dispersed by the movement of the animal. Most people prefer to make the injection in cattle behind the shoulder, but workers in Kenya have pointed out the advantages of making it into the dewlap where the risk of an unsightly blemish is minimal, and the damage to meat or hide is negligible.

The maximum amount of the methylsuphate by itself or as it is contained in the prosalt which should be given to any species of animal subcutaneously or intramuscularly is 5 mg./kg. Even at this dosage a proportion of animals exhibit symptoms—increased salivation, sweating, uncontrolled tremors, etc.—suggesting stimulation of the parasympathetic system. The symptoms may be very marked in horses, which should be treated with great care. Climate seems to have an influence. I treated two horses in the relative cool of Kabete, and six (with Mr. T. W. Groves) in England and observed only slight side effects, but much more severe reactions have been described in Nigeria. A similar contrast occurs with cattle. Mr. W. T. Harrow and I dosed ten cows in England with 20–25 mg./kg. only and one died; the same dose in Africa might easily have killed them all. Under such conditions of strain as very poor health, over-heating, fright or undue exercise, 5–7·5 mg./kg. may kill cattle (Davey, 1950; Goodwin and Unsworth, 1952). Death under these circumstances does not usually occur until 10 days to 3 weeks later. The symptoms and lesions are characteristic and similar to those produced by doses of 10–15 mg./kg. which may kill without superimposed strain (Wilson, 1949*a*; Garner, 1950; Burdin and Plowright, 1952*b*; Andrianne, 1952). They include a haemorrhagic gastro-enteritis with or without zebra markings of the large intestine, pulmonary oedema, excess fluid in the thoracic and pericardial cavities, and evidence of serious damage to the kidneys.

The risk of accidents is, of course, more during the hurly-burly of mass treatments than during the treatment of a few individual cases and the general recommendation, following a lead given by Uganda, for the treatment of cattle in the field is now 4·5 mg./kg. (2 ml. of a 10% solution per 100 lb. body weight).

Intravenously, 5·9 mg./kg. killed one bovine within 5 minutes, and 5 mg./kg. given slowly caused severe shock in another (Shone, 1954).

COMPLEXES OF SURAMIN WITH THE PHENANTHRIDINIUM COMPOUNDS AND WITH ANTRYCIDE

It was pointed out above that the concept of "depot prophylaxis" is potentially possible with any trypanocidal drug if a poorly absorbed salt or complex can be made. Williamson and Desowtiz (1956) have made such complexes of certain drugs with suramin. Suramin is exceptional amongst drugs in being acidic and it will combine with basic substances such as Pentamidine, Berenil, the phenanthridinium compounds, Antrycide, etc., to form relatively insoluble complexes. Williamson and Desowitz have shown that certain of these complexes, particularly the complex of suramin with Ethidium and to a lesser extent with Antrycide, have marked prophylactic properties against fly-transmitted *T. congolense* and *T. vivax* when given to cattle subcutaneously. More than 7 months' protection was obtained with the Ethidium complexes in these preliminary experiments and clearly the results of field experiments will be awaited with great interest.

DRUG RESISTANCE

It is relatively easy, particularly in the larger animals, to make trypanosomes resistant to the drugs by under-treatment. Unfortunately, all the substances mentioned above, except Berenil, share some common factor which makes for cross-resistance amongst them. Sometimes the cross-resistance appears incomplete, but this may be more apparent than real. For example, few workers would care to use more than 1·5 mg./kg. of Dimidium routinely and this is about the minimum curative dose for some strains of *T. congolense*. Now Antrycide will cure several, if not most strains of *T. congolense* at 1 mg./kg., and the advised field dose of 5 mg./kg. might therefore easily cure a strain of *T. congolense* partially resistant to Dimidium even if cross-resistance occurs, whereas the same cross-resistance would preclude the use of Dimidium (and possibly even of Ethidium at 1 mg./kg.) against a strain partially resistant to Antrycide. In any event, cross-resistance does exist, and care should therefore be taken in the use of all the drugs. Drug-resistance has not yet proved a problem of any magnitude, perhaps because care has been taken, and Unsworth (1954*c*) was able to say: " In spite of the extensive use of the drug in the field (*i.e.* Antrycide in Nigeria) . . . there is as yet little reliable evidence that such has led to the creation of Antrycide-fast strains of trypanosomes". The same statement could equally well be made of Antrycide in Uganda. Nevertheless, strains resistant to Dimidium have been picked up in the field because the recommended dose of this drug did not always cure (see, *e.g.* Wilson, 1950), which is indicative that the hazard ought not to be forgotten.

Drug-resistance can develop from inadequate prophylaxis as well as from inadequate treatment. As was remarked above, trypanosomes breaking through the waning concentration of Antrycide towards the end of its effective period may emerge with resistance to the drug. This will almost surely be true, too, of the newer prophylactic drugs if they come to be used, and so again, if prophylaxis is attempted, every effort should be made to make it complete. Examples of drug-resistance, and how it is developed, will be found in the work of Wilson (1949*a*, 1950, 1953), Davey (1950), Fiennes (1953*a*), and in the annual reports for 1953 and 1954 of the Veterinary Department Kenya.

SOME RECOMMENDATIONS REGARDING THE USE OF THE DRUGS

The treatment of cattle trypanosomiasis

A possibly important point which bears on this subject must first be mentioned. It is so-called cryptic trypanosomiasis in which a cryptic focus of parasites is said to exist in cattle under certain conditions, and is supposed to be refractory, or more refractory, to treatment (Fiennes, 1950, 1952, 1953*a*, *b*). One gets the impression that something analogous to the leishmanial form of *T. cruzi* was sometimes suspected to be present, though no unequivocal evidence is given. Trypanosomes, mostly in a state of lysis, have been described in the capillaries of the heart and kidney (Fiennes, 1952); but is not the description " cryptic focus "—implying a precise and localised reservoir of parasites that are protected by their station, or by virtue of being different from the blood form—too suggestive without further evidence ?

From a chemotherapeutic viewpoint it is important to know whether trypanosomes in sites other than the circulating blood are different or are sheltered from the action of most drugs as they would be, for example, if they were in the nervous system. We do not know all the details of the pathology of trypanosomiasis in cattle that we should, but the weight of evidence from the field does not suggest that chemotherapy is fighting any mysteries. The curative doses of all the drugs now used were first worked out using infections only a few days old and they are being successfully used against much older ones. Actually, Randall and Laws (1947) produced evidence that Dimidium is possibly more effective in infections of long standing (up to 117 days) than in those existing for only a very short time before treatment is made. And again, if prophylaxis with Antrycide does not keep an animal entirely free from infection, but makes for a cryptic infection, how can one explain the results of, for example, Unsworth and Chandler (1952) who took such pains to demonstrate infection in cattle kept for almost a year in tsetse areas, and who failed; and how can one explain so many results now being achieved year by year in Africa?

Incomplete treatment can suppress an infection, and imperfect prophylaxis could lead to a similar effect, but are the resulting chronic infections (forgetting drug-resistance) *qualitatively* different from those we may call acute or semi-acute? If they are not (and there is little evidence to the contrary) then existing drugs should be satisfactory. In any event, one hopes that workers in the field will bear the problem in mind and record any unusual results they may obtain.

Regarding the modern treatments of *T. congolense* and *T. vivax* in cattle the choice appears to lie between Ethidium and Antrycide methylsulphate. If Berenil has advantages, more work is required to demonstrate them. It should be remembered, however, that Berenil may be of value for treatment of cases resistant to Ethidium and Antrycide. Individual cases in cattle may be treated according to the species present; for the purpose of mass treatment it should always be assumed that both *T. congolense* and *T. vivax* are present.

T. congolense and *T. vivax* in other hosts

Ethidium does not appear to have been tried in hosts other than cattle. Antrycide has been used to cure *T. congolense* in horses and dogs (3 mg./kg. should be ample) and *T. vivax* in horses (5 mg./kg.).

T. simiae in pigs

Unless Ethidium is better than Dimidium the drug of choice is Antrycide, and this may not be completely effective as a single-dose treatment.

T. evansi, T. equinum and *T. equiperdum* in horses

Antrycide is less toxic than suramin for horses and the treatment is simpler. The full dose of 5 mg./kg. need not be used, except possibly for *T. equiperdum*.

T. evansi in cattle

Antrycide (3 mg./kg.) has given very good results in India.

T. evansi in camels

Both suramin (better tolerated by camels than by most domestic animals) and Antrycide are effective; the choice seems to be an individual one.

Prophylaxis

Antrycide as the prosalt is the only drug which has received extended use for this purpose. It can be used to protect animals against *T. congolense*, *T. vivax*, *T. evansi* (and probably *T. equinum*) and *T. equiperdum*.

THE FUTURE

The search for new drugs continues. From a curative point of view all that can be done is to find something which will not bring about cross-resistance with existing drugs, and with which there will be good latitude between the curative dose and the dose producing undesirable side effects. The task is not an easy one because the modern drugs are good, very good when one considers what is asked of them, particularly that they should cure in a single dose.

But a new drug, even a wonder drug, will not now contribute much to the development of Africa unless it has, or can be given, prophylactic properties of a high order. The development of Africa demands that the rule of the tsetse fly be broken, that people and domestic animals shall occupy tsetse country, and in the battle chemoprophylaxis can play a big part. Antrycide is already helping much, but anyone called upon to inject thousands of cattle every two months knows its major defect only too well, and so the promise of longer duration of prophylaxis given by R.D. 2801, and the complexes of Williamson and Desowitz, is most encouraging.

Promise of perhaps even greater import has come from another quarter. Soltys (1955) describes an experiment in which 18 cattle were kept in a tsetse area for 28 months under the protection of Antrycide prosalt given every two months. The challenge was mainly from *T. congolense* transmitted chiefly by *Glossina austeni.* At the end of this time they were divided into three groups with six animals per group. Group I continued to receive the drug for a further 18 months and stayed in the tsetse area. Group II also stayed in the area, but drug treatment was discontinued. Group III was taken to Kabete, the drug treatment discontinued, and the animals kept there for 10 months under fly-proof conditions before being transferred back to the tsetse area where they were still not given drug treatment and where they stayed for 8 months. None of these animals developed trypanosomiasis (five controls, introduced at the same time as Group III, contracted *T. congolense* within 2–3 weeks) and none could be infected even artificially.

The immunity developed by the animals, particularly striking in those of Groups II and III, is clearly a solid immunity, and not " the kind usually called premunition; where the condition of resistance is accompanied by or even dependent on the survival of the parasite ", (Hornby, 1949).

Fiennes (1953*b*) used Antrycide to aid the development of apparently effective premunition in calves born and reared in tsetse country, but as Hornby (1949) pointed out, research on premunition finds qualified support because the animal remains a reservoir of infection. The results obtained by Soltys, if confirmed, are clearly of much greater practical significance and it is most important that his experiments should be repeated. This is being done in East Africa (annual report of the East African Tsetse and Trypanosomiasis Research Organisation, 1954–55) and in the Republic of the Sudan (personal communication).

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I am indebted to my colleague Mr. J. T. Edwards who has allowed me to use his translations of some of the foreign literature, and whose index to the literature in general has helped me to check mine.

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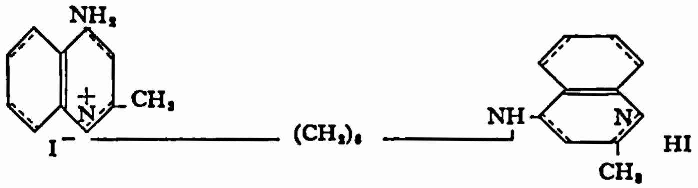
ADDENDUM

Tozocide

Since this review was written and while it was in the hands of the editor, a new substance called Tozocide has been described (Austin *et al.*, 1957). It has the constitution:



and is the hydriodide of 6′ (4-quinaldylamino) hexyl-4-amino quinaldinium iodide. Like Antrycide, it owes something to the work of Iensch (1937), but it is unusual, as a trypanocidal compound, because of the position of the linkage between the two ring systems.

Laboratory work with infections in mice has shown that Tozocide is more active than Antrycide against *T. congolense* and *T. vivax*, and that it has some prophylactic properties (Austin *et al.*, 1957). Preliminary tests in Kenya have indicated that activity is also obtained in cattle, but details are not available (personal communication from Dr. H. O. J. Collier).

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PROGRESS WITH SURAMIN COMPLEXES IN THE TREATMENT OF ANIMAL TRYPANOSOMIASIS (JUNE 1958)

By Dr. J. Williamson, West African Institute for Trypanosomiasis Research, Vom, Nigeria.

At the Third Meeting of the I.S.C.T.R. in 1951, the late Dr. E. M. Lourie indicated the therapeutic and prophylactic possibilities of his discovery that suramin and pentamidine could combine to form an insoluble complex. This principle has been extended to the formation of suramin complexes with drugs used in the treatment of cattle trypanosomiasis (Williamson and Desowitz, 1956; Williamson, 1957), and several of these complexes have been shown to have remarkable prophylactic activity in Zebu cattle challenged experimentally with heavily infected tsetse. The results of initial experiments with these complexes, in both cattle and pigs, were reported on at the Sixth Meeting of the I.S.C.T.R. in 1956, and some of the more recent developments are now outlined here.

Attention has been concentrated on the most active and economically practicable complexes for cattle, i.e. those with ethidium, prothidium and RD 2902 (products of Boots Pure Drug Co., Ltd.). The prophylactic activities of these three complexes, against a predominantly *Trypanosoma vivax* challenge, are compared in Table I, which summarises the first experiments in cattle made by Dr. R. S. Desowitz.

Table I.

Treatment	Dose (mg./kg.)	No. of Cattle	Prophylaxis (days)	
			Mean	Range
Ethidium bromide	5	4	107	54—147
Ethidium-suramin complex	5 10	2 3	228 591	216—239 385—727
Prothidium	1 2	3 4	76 172	74—79 144—200
Prothidium-suramin complex	2 5 10	4 3 3	71 153 307	60—87 136—176 285—330
RD 2902-suramin complex	10 20	3 2	327 450	280—257 (one died after 285 days protection)

A striking feature is the ability of the ethidium-suramin complex at a dose of 10 mg./kg. to protect cattle against a heavy fly challenge for periods well over a year. The table demonstrates the considerable increase in the amount of the drug which can be given safely in the complex form, and also the marked accession of prophylactic activity with complex formation.

All treatments in this first trial were given subcutaneously in the shoulder. When a larger scale trial of the ethidium complex was later undertaken by Dr. L. E. Stephen, 24 animals were injected subcutaneously in the neck at doses of 5, 7·5 and 10 mg./kg. As in the first trial, initial œdematous swellings occurred at the injection site, but although these subsided in the first trial, they did not do so in the second ; in 22 out of the 24 beasts treated, the swelling necrosed and sloughed or ruptured, in a period of 3 to 4 months, and a considerable amount of the drug depot was lost.

A corresponding decrease in prophylactic activity ensued. Twelve beasts in which complete sloughing occurred about 2½ months after treatment, were protected only for approximately 4½ months. In 2 beasts, the swellings did not burst or slough, and in these, the expected long prophylaxis was obtained ; one broke through at 309 days, and the other at 481 days after treatment. No signs of general toxicity occurred among the 21 adult cattle treated with the ethidium complex. Despite swellings, sloughs and bursts, weight gains after the first month were parallel to those of untreated controls. There was, however, evidence of a deleterious effect on the 3 calves used.

If the ethidium complex could be made to stay in the animal's tissues without causing local or general toxicity, it would probably fulfil its promise of being the most active prophylactic drug for cattle trypanosomiasis yet devised. However, the problems associated with the local toxic reaction have so far proved largely intractable, and it may be that the ethidium complex will have to be discarded in favour of others which are less active but more easily tolerated.

Over the last eighteen months, Dr. L. E. Stephen and myself have investigated possible causes of the local reactions which follow subcutaneous injection of the ethidium-suramin complex. We surmised originally that as ethidium bromide alone is known to produce similar reactions when given subcutaneously, the reactions to the complex might have resulted from the presence of free ethidium bromide. The formation of the complex is governed by simple rules of chemical combination, and under defined optimal conditions, free ethidium bromide should be absent or present only as traces. A number of possible sources of free ethidium were checked, the most important of which transpired to be the hydration, under tropical humidity conditions, of commercial so-called " anhydrous " preparations of suramin. These were found to contain up to 15 to 20% moisture, which was sufficient to upset the chemical combining relations of the complex and give appreciable amounts of free uncombined ethidium in the final preparation ; however, extensive experiments in sheep and cattle showed that this factor alone was not responsible for the toxic local reaction.

The identical biological and chromatographic behaviour of a number of different batch samples of ethidium bromide eliminated batch variation as another possible cause of toxicity. The local reactions observed in Dr. Stephen's trial were not due to his having changed the injection site from shoulder to neck, nor to his having slightly reduced the injection volume. In fact, it was found later that by the use of more concentrated complex preparations, made with the more soluble ethidium chloride, local reactions were decreased, but not eliminated. Some further diminution of the reaction resulted from injection in the dewlap after a prior injection of hyaluronidase, but none of these methods completely prevented necrosis.

Intramuscular injection promised well for a time, as the complex given to sheep by this route caused a negligible tissue reaction, and in cattle, only 1 out of 33 developed skin necrosis. Unfortunately, later examination of these cattle showed that they had developed a severe reaction in the muscle tissue at the injection site, accompanied in a number of cases by weight loss and death, particularly at the 10 mg./kg. dose level. In one experiment, weight loss occurred in 4 animals out of 12 at the 5 mg./kg. dose level, and of these four, 2 subsequently died. At the 10 mg/kg. dose level, out of 12 animals, 7 lost weight and of these, 6 died.

This weight loss reaction, which was often considerable (up to 30% of body weight in 2½ months), is in striking contrast to the result after subcutaneous injection. It seemed as if we had driven the local reaction so far into the tissues that, instead of causing damage externally in the skin without otherwise affecting the animal's wellbeing, the drug was so confined that the toxic effects were generalised.

Despite the regular use of a comprehensive battery of haematological and clinical pathological examinations, and careful and extensive post-mortem investigation, we have so far been unable to find any constant feature, sympton or lesion, other than cachexia, which would account for the toxicity observed.

One hopeful venture which promised well initially was the use of lyophilised ethidium-suramin complex as a means of producing a highly concentrated preparation in a small injection volume. The complex was freeze-dried by our colleagues in the Department of Federal Veterinary Research in Vom, and the product was a fluffy red powder which reconstis tuted readily to any desired volume in water. This preparation gave les-severe reactions after intramuscular injection, and weight loss occurred only in two out of six beasts at the higher dose rate ; unfortunately, however, we found that the prophylactic period with this lyophilised material was considerably reduced.

So far, considering only those animals which did not lose their drug depot after treatment and excluding animals treated with freeze-dried material, the overall prophylactic results from our experiments with the ethidium-suramin complex are as shown in Table II.

Table II.

Dose mgm. per kgm.	Route	Protection period (days)
10	S.C. (shoulder)	385, 662, 727
5	,, ,,	216, 239
10	,, (neck)	309
7·5	,, ,,	481
10	,, ,,	159
10	,, ,,	131
10	I.M. ,,	105
10	,, ,,	>275, >229, >229,
5	,, ,,	143, 181, 207
		207, 237

Of 11 beasts treated with more than 5 mgm. per kgm., 8 were protected for more than 200 days and of these, 5 for more than 300 days. Of 7 beasts treated with 5 mgm. per kgm., 5 were protected for more than 200 days. No satisfactory explanation can be given for the short prophylactic periods (105, 131 and 159 days) observed in 3 animals treated at 10 mgm. per kgm. but we believe this may be due to the introduction of drug fast strains.

Excluding the 3 animals in which the prophylaxis was not determined to completion, an overall average protection period for 7 animals treated at 10, and one at 7·5 mgm. per kgm., is 370 days (range 105–727 days). For the 5 mgm. per kgm. dose, the overall average protection period is 204 days (range 143–239 days, 7 animals).

We hope by further investigation of methods of formulation and presentation, to overcome the difficulties attendant on ethidium complex treatment. We have some indications that the suramin complex of prothidium and of RD 2902, though less active prophylactically, may be better tolerated, but our experiments are not sufficiently advanced to justify the drawing of firm conclusions. The testing process is laborious and takes considerable time, and no doubt new suramin complexes will appear from time to time, for the combination principle is extensible to any active cattle trypanocide with one or more cationic centres. Our own results so far, and those we have gleaned from other sources where this type of compound has been tested, confirm us in our belief that further investigations to decrease toxic side-effects are well warranted.

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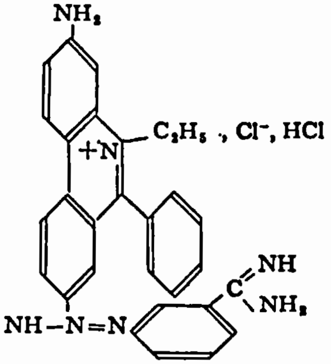
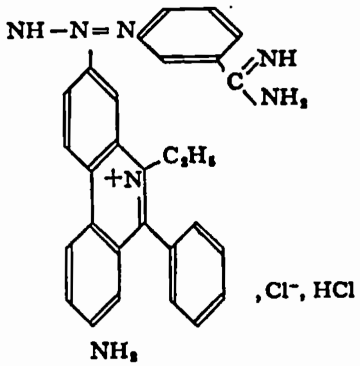
PRELIMINARY OBSERVATIONS OF A NEW PHENANTHRIDINIUM WITH CHEMOTHERAPEUTIC ACTIVITY AGAINST BOVINE TRYPANOSOMIASIS

By R. FAIRCLOUGH, Veterinary Department, Kenya.

The trials described were the first tests in Africa of M. & B. 4404.

This new trypanocidal drug, for which the common name metamidium chloride has recently been suggested, consists of a mixture of two isomeric phenanthridinium salts, 7-(*m*-amidinophenyldiazoamino)-2-amino-10-ethylphenanthridinium chloride hydrochloride (I) and 2-(*m*-amidinophenyldiazoamino)-7-amino-10-ethylphenanthridinium chloride hydrochloride (II).





(I) (II)

One of these isomers is purple and the other red. Both isomers are approximately equally toxic to mice and both have high trypanocidal activity. Quantitatively M. & B. 4404 consists of 55% of the purple isomer and 45% of the red isomer. A preliminary report on the chemistry and the laboratory evaluation of M. & B. 4404 is being published (Washbourn, K., Wragg, W. R., Brown, K. N. and Hill, J., *Nature*, 1958, in the press).

M. & B. 4427, an almost insoluble salt of the same phenanthridinium derivative, was also provided for trial. Lower toxicity and a longer period of prophylaxis had been found in laboratory animals and better local tolerance in cattle was claimed by the makers.

BOVINE TOXICITY TRIALS

Groups each of four steers were used to compare three dosage levels of M. & B. 4404 with one high dosage level of M. & B. 4427. Similar groups given dimidium bromide at a dosage level known to be toxic, antrycide methyl sulphate at 50% over dosage, and an uninoculated control group were included. All drugs were inoculated subcutaneously into the dewlap, the site normally used for such substances in Kenya. Treatments are tabled as follows:

Group	(*a*)	M. & B. 4404 1·0 mg./kg. as a 4% w/v solution.
„	(*b*)	„ „ 5·0 „ „ „ „ „ „
„	(*c*)	„ „ 10·0 „ „ „ „ „ „
„	(*d*)	dimidium bromide 5·0 mg./kg. as a 2% solution.
„	(*e*)	M. & B. 4427 10·0 mg./kg. as a 4% w/v suspension.
„	(*f*)	Antrycide methyl sulphate 7·5 mg./kg.
„	(*g*)	uninoculated controls.

Biochemical, histological and other observations were made by the methods described by Plowright *et al.* (1952) and Burdin (1953) in their work on the toxicity of other phenanthridinium compounds. These were commenced before inoculation and continued until 90 days post inoculation. Severe local swellings were caused by M. & B. 4404 at 5·0 and 10·0 mg./kg. and by dimidium bromide at 5·0 mg./kg. Insignificant reactions occurred with M. & B. 4404 at 1·0 mg./kg. and the other drugs used. Swellings were recorded by photographs. Bodyweight losses in groups (*b*), (*c*) and (*d*) occurred at the two higher dosage levels of M. & B. 4404 and with dimidium bromide. Group (*b*) lost a maximum average of 105 lb. up to the sixty-fourth day p.i., group (*c*) 225 lb. up to the fifty-third day and group (*d*) 100 lb. up to the fifty-fourth day. Slight losses in weight occurred during the three days following inoculation of M. & B. 4404 at 1·0 mg./kg. and Antrycide methyl sulphate with subsequent unchecked gains.

Transient rises in blood bilirubin and urea levels indicated delayed toxicity in groups (*b*), (*c*) and (*d*). Elevation of serum alkaline phosphatase and periportal fatty changes in liver biopsy specimens were also detected during the same period in animals which had received 10·0 mg./kg. M. & B. 4404 and dimidium. One animal died in each of these groups and necropsy confirmed the *in vivo* detection of liver damage.

M. & B. 4404 at 10·0 mg./kg. was therefore shown to produce a delayed toxicity syndrome similar in severity to that caused by dimidium bromide at 5·0 mg./kg. Some evidence for delayed toxicity after administration of 5·0 mg./kg. M. & B. 4404 was also adduced but the drug appeared to be completely non-toxic at 1·0 mg./kg.

THERAPEUTIC TRIALS

A small preliminary experiment showed that M. & B. 4404 and Homidium bromide were both active at 0·1 mg./kg against a locally isolated strain of *T. congolense* (Kibwezi) in cattle.

Twenty-eight steers were infected with a strain of *T. congolense* (Buswale) of normal drug sensitivity. The therapeutic activity of M. & B. 4404 and Homidium chloride were compared at 0·05, 0·2 and 0·8 mg./kg. using groups of four animals at each dosage level of each drug. A further group of four was left uninoculated. Both drugs failed to eliminate trypanosomes from blood smears at 0·05 mg./kg. and Homidium also failed at 0·2 mg./kg. The blood of all other treated animals remained clear of trypanosomes during the ensuing three months' observation. Chronic infection persisted in the controls. In a parallel trial with steers infected by *T. vivax* (Ngoliba strain) and treated at the same dosages, trypanosomes were eliminated from blood and gland smears by both drugs at all levels. The control group died. M. & B. 4404 was therefore shown to have therapeutic activity greater than that of Homidium against a strain of *T. congolense* in cattle; high activity against a strain of *T. vivax* was also apparent but no differences from Homidium were demonstrable at the dosages used.

PROPHYLACTIC EXPERIMENTS

The survivors of the toxicity trials were needle challenged by *T. congolense* (Buswale strain) with 10 cc. of infected bovine blood injected by the intravenous route at thirteen and nineteen weeks post inoculation of drugs, and thereafter at weekly intervals. Somewhat equivocal results indicated some residual prophylactic activity as may be seen from the accompanying table.

Drug	Dosage	No. 20	Infected at weeks post inoculation					
			21	22	23	24	25	26
M. & B. 4404	1·0 mg./kg.	4/4	—	—	—	—	—	—
M. & B. 4404	5·0 mg./kg.	0/4	3/4	3/4	3/4	4/4	—	—
M. & B. 4404	10·0 mg./kg.	1/3	1/3	1/3	1/3	1/3	1/3	3/3
M. & B. 4427	10·0 mg./kg.	2/4	4/4	—	—	—	—	—
Dimidium Bromide	5·0 mg./kg.	3/3	—	—	—	—	—	—
Antrycide	7·5 mg./kg.	1/4	2/4	3/4	3/4	3/4	3/4	4/4

M.& B. 4427 at 5·0 mg./kg. failed to cure nine of these break-throughs and antrycide methylsulphate at normal dosage was eventually used to clear them.

In a small trial, animals were inoculated with M. & B. 4404 and M. & B. 4427 intramuscularly in the neck. Some swelling occurred with dosages up to 10·0 mg./kg. but local reactions quickly resolved and appeared to cause little discomfort, although at the higher dosages some animals had stiff necks for four or five days and others stopped grazing for a while but picked up again later.

Subsequent needle challenge by *T. congolense* (Buswale) after a month, then at weekly intervals, again showed some variable prophylactic effect of the drug particularly at high dosage levels. Results are given:

Drug	Dosage	Infection
M.& B. 4404	1·0 mg./kg.	2/2 at 6 weeks p.i.
M.& B. 4404	2·0 mg./kg.	1/2 at 6 weeks, 2/2 at 7 weeks p.i.
M.& B. 4404	5·0 mg./kg.	1/2 at 26 weeks, 2/2 at 28 weeks p.i.
M.& B. 4427	5·0 mg./kg.	1/2 at 6 weeks, 2/2 at 12 weeks p.i.
M.& B. 4427	10·0 mg./kg.	1/2 at 7 weeks, 2/2 at 26 weeks p.i.

Field trials are in progress designed to assess more accurately the prophylactic activity of M. & B. 4404 against natural challenge.

THERAPEUTIC TRIALS AGAINST DRUG-RESISTANT STRAINS

An omniresistant strain of *T. congolense* developed at Kabete and found to be resistant to at least normal therapeutic doses of antrycide, berenil, prothidium, homidium and stibophen has been cured for at least three months as judged by the disappearance of trypanosomes from blood and gland smears with M. & B. 4404 at 4·0 or 5·0 mg./kg. but not at 2·0 mg./kg.

Against other multi-resistant strains with narrower spectra of drug resistance M. & B. 4404 at 2·0 mg./kg. was effective.

It is suggested that the substance could be used to cure drug resistant strains appearing during drug prophylaxis regimes.

SUMMARY

1. M. & B. 4404 was shown to have therapeutic activity in cattle at low dosage against strains of *T. congolense* and *T. vivax.*

2. The drug caused delayed hepatoxic effects and serious local swellings after subcutaneous inoculation at 10·0 mg./kg. Some toxicity at 5·0 mg./kg. was apparent but administration at 1·0 mg./kg. was not followed by detectable systemic ill effects and local tolerance was good.

3. Preliminary therapeutic trials against resistant strains of *T. congolense* showed promising results.

4. M. & B. 4427 was well tolerated at 10·0 mg./kg.

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OBSERVATIONS ON THE USE OF PROTHIDIUM IN TANGANYIKA TERRITORY

By John Robson, B.Sc., M.R.C.V.S., Veterinary Research Laboratory, Mpwapwa, Tanganyika Territory.

The first trial on Prothidium carried out in Tanganyika was a laboratory trial (Robson and Milne, 1957), and this took the form of needle challenge with *Trypanosoma congolense*, two, four, six and seven months after the inoculation with Prothidium. Under this challenge two out of four animals given 1 mg./kg., and none out of six animals given 2 mg./kg., broke down at the sixth month. At seven months, one out of two given 1 mg./kg., and one out of six given 2 mg./kg., broke down. The administration of the drug appeared to lengthen the incubation period of the trypanosomes as judged by the daily examination of thick blood smears in cases where breakdowns occurred.

Further preliminary investigations were carried out on uninfected oxen. (Robson, 1958, 1).

A 3% solution was prepared and one ox received the drug at a dosage level of 10 mg./kg. (68 ml.) in the dewlap. A swelling seven inches in diameter developed and the point of this swelling sloughed one month after the inoculation. The animal lost a considerable amount of body weight, which it was beginning to recover when it died, 10 weeks after inoculation. The only lesion seen on post-mortem examination was pneumonia. Another ox received 5 mg./kg. of 3% solution in the dewlap. A local swelling developed but caused no inconvenience to the animal which lost some weight but regained the loss in eight weeks.

A 10% solution was prepared and inoculated immediately into two oxen at 10 mg./kg. Fairly large swellings developed in the dewlap but no sloughing took place. One of these beasts lost a considerable amount of weight, falling from 511 lb. to 343 lb. in eight weeks, and did not regain its original weight in 21 weeks. The other lost a lot of weight and showed progressive weakness and lassitude but was beginning to recover when it collapsed and died, nine weeks after inoculation. The post-mortem examination showed some serious exudate and fibrinous deposits in the pleural and peritoneal cavities. The lungs were œdematous, especially in the dependent parts and between the lobules. There was fluid in the smaller bronchioles and congestion and early pneumonia elsewhere. The pericardium showed fibrinous deposits and there were necrotic areas in the epicardium with fibrinous deposits overlaying. There was extensive fatty degeneration of the myocardium but the coronary fat was firm. The liver was very congested, fatty and very friable. The spleen was congested and soft, and the kidneys showed fatty degeneration and atrophy of the medulla.

Three groups of adult slaughter stock were inoculated with Prothidium in September 1956 (Markham, 1957) as follows:

Number of cattle	Prothidium dosage rate
99	2 mg./kg.
45	4 mg./kg.
26	6 mg./kg.

One-half in each group were inoculated intramuscularly into the rump, and one-half subcutaneously into the dewlap. Some of the reactions in the dewlap were large, the dewlap being described as " like a well filled brief case ". The local reactions were greater in the larger doses. The doses (by volume) were kept constant for each administration, the concentrations being altered.

The cattle were then kept in very light tsetse bush (*Glossina pallidipes*), weekly thick blood smears being examined and the first breakdowns appeared as follows:

Prothidium dosage rate	Time before first breakdown
2 mg./kg.	6 months 10 days
4 mg./kg.	7 months 7 days
6 mg./kg.	7 months 27 days

The protective period appeared to be increased with the dosage but not in proportion to the dose of Prothidium used. No toxic effects were noted.

A further 150 head of immature cattle were divided into three groups and given Prothidium at 2, 4 and 6 mg./kg., all inoculations being given into the caudal fold. (Markham, 1957.) The concentrations of Prothidium were varied to give a constant dose of 2 ml. per 100 lb. liveweight, i.e. 5, 10 and 15% solutions were used.

There were no breakdowns after 2½ months in very light fly. Local reactions were greatest amongst those given the higher dosages and an abscess formed on one animal which had received 4 mg./kg. and abscesses on four of those which had received 6 mg./kg. Reactions were recorded as follows:

Description of reaction 10 days after inoculation	Number of animals showing reactions in various groups		
	2 mg./kg.	4 mg./kg.	6 mg./kg.
Large swelling . .	3	13	11
Small swelling . .	14	17	20
No swelling . .	33	20	19

Large Swelling = Size approx. 4" × 1½" × 1"
Small Swelling = Size approx. 1½" in diameter and round similar to reaction following Antrycide Prosalt.

No sign of systemic toxicity was noted in any group.

Prothidium as a 4% solution was used in a field trial (Robson and Cawdery, 1958) in an area of very heavy tsetse in doses of 2 and 4 mg./kg., inoculations being into the dewlap. The challenge to which these cattle were subjected was an A.D. (apparent density = number of male tsetse per 10,000 yards of flyround) *G. swynnertoni* 177 and *G. pallidipes* 34 with an infection rate of 2·44% and 3·05% respectively. It was calculated that 0·071 infected flies would feed on each animal each day. Under these circumstances at 2 mg./kg. the earliest breakdown was 47 days, 11 out of 14 animals having broken down in 108 days. At 4 mg./kg., the first breakdown was at day 110, 10 out of 14 animals having broken in 174 days. Under the same conditions, 8 out of 28 animals given Antrycide Prosalt at 11·7 mg./kg. broke down in 57 days, the first at 31 days. The local reactions noted in this trial are recorded below.

Drug	Dosages rate mg./kg.	Days after inoculation 2: Type of Reaction: Severe	Mod.	Mild	9: Type of Reaction: Severe	Mod.	Mild	No. of animals in group
Prothidium	2	1	6	7	2	6	6	14
	4	6	2	6	3	8	3	14

Severe reaction = more than 6" in diameter and very prominent.
Moderate „ = approx. 2–6" „ „ not very prominent.
Mild „ = less than 2" „ „ and hardly noticeable without palpation.

There was one death in the 4 mg./kg. group on day 31, but the post-mortem examination revealed only slight congestion of the lungs.

In another field trial (Robson, 1958, 2), in an area of light tsetse, A.D. *G. morsitans* 1·5, Prothidium was used at a dosage level of 2 mg./kg. and three out of twenty animals became infected in 261 days, the first at 216 days and the third at 258 days.

Forty adult dry cows averaging 750 lb. were given Prothidium in 10% solution (Robson, 1958, 1) at a dosage rate of 4 mg./kg. into the dewlap. Extremely large localised swellings developed, some so big that the animals could hardly move and had to be kept indoors for five days before they could go out to graze. At the end of the third month four swellings burst and red stained fluid and a plug of red stained necrotic tissue escaped. The animals showed no sign of general toxicity and all calved and came into milk normally.

In an area of coastal fly belt with an A.D. *G. pallidipes* 28 and *G. brevipalpis* 5, with an occasional *G. austeni*, 100 head of immatures were inoculated with Prothidium as a 3% solution at a dosage rate of 2 mg./kg.; one broke through at 28 days and two more at 56 days. In some areas the

69 immatures were given Prothidium at 3 mg./kg. and the first breakdown was at 35 days and the next at 42 days. This trial is continuing.

SUMMARY

Observations on the use of Prothidium in Tanganyika are recorded. Prothidium has been used at dosage levels of 1, 2, 3, 4, 6 and 10 mg./kg. in 607 cattle and systemic toxicity has only been recorded in these cattle treated with 10 mg./kg. Local reactions have been noted in all cases, being most severe in the higher dosage level groups. The prophylactic effect given by Prothidium has been found to vary from long prophylaxis with low dosage in light fly, through poor prophylaxis with low dosage in medium fly to very good prophylaxis with moderate doses in heavy fly.

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CHEMOPROPHYLAXIS—DESIGN OF TRIALS

By I. M. SMITH, East African Trypanosomiasis Research Organisation, Uganda

Work on the chemoprophylaxis against bovine trypanosomiasis recently carried out and perhaps not yet widely available has produced anomalies and conflicts of evidence. As one example, and there are others, Prothidium at a dose of 2 mg./kg. (Boots Pure Drug Co., Ltd.) reported by Robson and Milne (1957) and by Whiteside and Lyttle (1957) as having given prophylaxis markedly superior to Antrycide Prosalt (Imperial Chemical Pharmaceuticals, Ltd.) has been found by others, e.g. Smith (1958) and Tennant (1958) to have an effect not significantly superior to that of the standard Antrycide Prosalt. Much of the variation recorded can be attributed, no doubt, to differences in the experimental areas, including the trypanosome challenge, the cattle, vagaries in the different batches of the drug used and so on, but much of its seems inherent in the nature of the work also.

As chemoprophylaxis improves by the production of more effective agents, it seems that anomalies in reported results are likely to increase rather than decrease. It seems wise to accept that undue haste in carrying out experimental work to get quick answers in this field will be deleterious in the end. I believe that when a new agent is produced it should be examined initially for local and general toxicity by two or three interested laboratories independently. It seems clear that variations in susceptibility by the types of indigenous African cattle can be expected to occur. Thereafter initial experiments with small groups of cattle under well defined and preferably standard conditions should be carried out at as many centres as possible. Here the recent development of methods of storing strains of trypanosomes might play an important role. With modern techniques of analysis answers can be obtained as quickly as the controls break down under challenge. Moreover it is possible with some of these sequential methods to decide in advance the degree of superiority required in a new product. In mentioning small groups this should not be construed as implying that I mean two or three animals; it is my opinion that less than ten per group may lead to misconceptions but the methods of analysis do not, as yet, permit the prediction of the numbers needed to get a decision. The variability in the time of break down of cattle under chemoprophylaxis is pronounced and so only reasonably sized groups can be expected to produce reliable comparisons unless the difference between the new drug and the standard drug is startling.

Collation of the data from these widespread initial experiments would indicate the wisdom of proceeding with field experimentation. Here large groups are certainly necessary to obtain, among other things, an idea of the " breakthrough " times. My evidence at present is that breakthroughs are normally distributed but this applies to an area of very heavy challenge and I cannot speak of other areas or lower challenges. If breakthrough times are normally distributed or can be put in a form which will lead to normality it is an easy matter to determine the design necessary for the next and final step, namely the development of regimes of chemoprophylaxis later to be employed in the cattle population at large. By this method large-scale field work can, I feel, be undertaken with good chance of producing results which can be rapidly employed. There is no reason, except caution with regard to drug fastness, to forbid the use of the most conservative regime in the experiment in the field generally after it is reasonably believed that the results warrant the procedure. If, for example, it were known that a drug given at intervals of four months was continuously protecting after a year or more, then one could begin to use it in the field. If later from the results of the experiment it were clear that a five-monthly regime, say, was also efficacious there would be no difficulty in lengthening the interval between injections in the field. It might also appear that at six months there was some danger, so that any regime adopted for cautious field use from such an experiment would require rigid adherence. It must be granted that the initial expense of such work is likely to be more than in the past but the saving in the end may prove measurably greater. It should be considered here, however, that if trouble arises in the field, decreasing the interval between injections is unlikely to be of much value.

It is clear from past experimentation, including my own, that widespread repetition of the two types of field work I have mentioned is necessary. It is not usually possible for any one laboratory to cope with all the factors and work involved in such trials, and there seems to be a basis here for regional co-operation. I am thinking primarily of breeds or types of cattle, species of tsetse, areas of low and high trypanosome challenge and so on. Much has been said of the desirability of avoiding unnecessary duplication of work and while there is some substance in this statement, a good deal depends on the meaning of "unnecessary". The sound basis of agricultural and indeed other experimentation depends on replication and repetition. I do not believe that chemoprophylaxis in bovine trypanosomiasis falls outside this category and I feel that repetition and duplication of trials by independent investigators is not only desirable but essential.

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POSSIBLE CONSEQUENCES OF WIDESPREAD CHEMOPROPHYLAXIS AGAINST TRYPANOSOMIASIS

By M. J. H. Cawdery, East African Trypanosomiasis Research Organisation, Tororo, Uganda

In East Africa satisfactory resettlement of tsetse-infested land is difficult to obtain unless the inhabitants have cattle with them early in the process. Chemoprophylaxis against bovine trypanosomiasis is likely, therefore, to play a most important role in reclamation. Drug resistant strains, however, may arise from its use and these can be considered broadly from two aspects:

A. The Trypanosomes

The appearance of drug resistant strain could result from either (*a*) selection, in the face of the drug, of resistant forms (either species, or strains within species, or even individuals within a strain) or (*b*) by the physiological adaptation of the organisms in the presence of the drug.

The mode of the action of the drugs is not known; whether they can afford absolute protection, i.e. prevent the establishment of any organisms in the host or are merely suppressant, keeping an established infection latent. In this situation it is difficult to know which mechanism is likely to be more important in the genesis of drug resistant strains. There is no doubt, however, that trypanosomes which are insusceptible to the usual doses of both therapeutic and prophylactic drugs appear in cattle under prophylaxis. The full effect of cyclical transmission on drug resistance is not known, but that trypanosomes can retain their drug resistance is established.

B. The Cattle

The reaction of the cattle will play an important part in the development of drug resistance. The natural resistance of the cattle, together with the effect of the drug and antibody effects, will combine to decide if an infection is to become patent. Some of the resulting infections would probably be cured at the next treatment but a certain number would appear again, and as time progresses, would probably appear nearer to the time of the previous treatment, thus giving a greater chance for tsetse to feed on the animal and become infected with trypanosomes which have been in contact with the drug. Also, drug resistant trypanosomes may occur in cattle without marked deleterious effect and these animals presumably offer a dangerous reservoir for the dissemination of resistant parasites.

Plans for prevention of the appearance of drug resistant strains in the field must be considered before starting a campaign. Certain measures which may help are:

(*a*) Routine examination of say 10% cattle before each treatment. If positives occur, all should be examined and those positive removed, or preferably, slaughtered. This is difficult under East African conditions.

(*b*) Alternation of drugs. Whiteside (Personal communication) has used Ethidium bromide after a regime of Antrycide Prosalt in which the trypanosomes were regularly breaking through the drug. After treatment with Ethidium bromide the cattle were protected for about six months without further treatment. It is suggested that alternate treatments of two or more drugs, of different chemical groups, might help at least to delay the appearance of drug resistance.

(*c*) A powerful anti-trypanosomal drug should be kept in reserve to deal with resistant trypanosomes. Ideally it should be used only outside tsetse areas, so that there would be no chance of resistance to it occurring in the field, but this will rarely be possible.

In conclusion one should consider one possible long-term consequence of widespread chemoprophylaxis—that the development of productive breeds of cattle naturally resistant to the disease may be delayed. And, moreover, attention may be diverted from what appears likely to be a productive line of research, viz. the study of the natural mechanisms of resistance and immunity to protozoal parasites.

SOME FACTORS CONCERNED IN TRYPANOSOME CHALLENGE

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The trypanosome challenge may be defined as the number of infective bites from a tsetse which a host receives in unit time. That the estimation of the trypanosome challenge is of importance is indicated by the work of Whiteside (1955; Annual Report Dept. of Veterinary Services, Kenya; Nairobi, Government Printer). He found that the greater the challenge the shorter the period of prophylaxis obtained in cattle injected with a prophylactic drug. This phenomenon has not been confirmed for other drugs but accumulating evidence suggests that it does also occur. Whiteside has been led by his studies to the concept, the index of trypanosome challenge, which he has defined as the value of the product of the number of non-teneral male and female tsetse per 10,000 yards (called by him the Apparent Density) and their infection rate; he has shown that the index can be used to plan a regime of prophylaxis for cattle in any given area, but he has observed that the method is not infallible.

At E.A.T.R.O. we are interested in developing methods which will refine the method of estimating the trypanosome challenge. It seems to us that there are several factors to consider.

A. The Tsetse

1. Population Density

In the broadest sense the density of the population of *Glossina* in an area is probably the most important factor.

The general age of the population must also be important. The older a tsetse is, the more likely is it to be infected. Clearly an old though comparatively small population is just as dangerous as a large, young one. Seasonal effects also exist in this connection. Broadly speaking, trypanosomiasis does tend to show seasonal fluctuations but it does not follow that these are necessarily related to fluctuation in the density of tsetse.

The secondary sex ratio of a tsetse population is held to be about one male to two females, and this sex structure is supposed to arise because of the essentially sedentary existence of the females whose length of life is approximately double that of males. If this is so one would reasonably expect that females are the more important sex pathogenically. Nevertheless dissection studies suggest that males are more frequently infected than females. Clearly this problem requires resolution.

2. The Hunger Cycle of the Population

That this quantity varies with climatic conditions seems well established. Clearly a population of a given size which feeds say twice as frequently as another of the same size is likely to be the more dangerous because not only is an animal bitten more frequently but also the tsetse have a greater chance of becoming infected. This feature must be modified, however, by the fact that the unfavourable conditions (whatever they may be) which force the insect to feed more frequently are also inimical to its survival.

3. The Habits of the Tsetse Species

The various species of tsetse are, it seems, differentially attracted to different hosts. In this feature lies a major objection to the use of the Apparent Density to estimate trypanosome challenge. Apparent Density is a quantity derived from catches made by humans along some predetermined path. Prima facie it would not appear that the numbers of tsetse caught in this way are necessarily related to the numbers which might be attracted to some other species of host, and we have evidence that, in fact, the numbers of tsetse caught on a flyround do not bear any simple relationship to the numbers which can be caught off a host animal. The number caught on the flyround cannot be related to the numbers caught off a bait animal in a way which can be given a biological meaning.

The disposition of the tsetse throughout their general habitat must also be a factor in determining the attack on animals.

The times of activity of the insect may well be important also. For example, in our experimental areas in the wet season *G. pallidipes* is most active in the early morning and late evening. Were cattle, for example, not present when these comparatively large numbers of flies were active one can easily see that the challenge would be very much less. Various factors might arise from these times of activity. For example, it is possible that young flies tend to feed in the morning and old ones in the evening, or vice versa.

4. The Various Species of Tsetse

Some species of tsetse may be more efficient transmitters of the disease than others for various reasons.

B. The Trypanosome

1. Differences between Species

It has long been held for example that in the main *Trypanosoma brucei* is less pathogenic for cattle than *T. congolense* and *T. vivax*. It is quite feasible that infections of *T. brucei* could be so mild as to pass unnoticed, the disease being fairly quickly thrown off. In East Africa, at any rate, *T. vivax* seems to be much less pathogenic than *T. congolense*.

2. Differences between Strains

While on the whole the specific differences in pathogenicity are certainly valid it is also clear that there is wide variation in the pathogenicity of strains within species, and it may be that the more virulent a strain the less effective is chemotherapy or rather chemoprophylaxis.

3. The Lability of Trypanosomes

The organism seems to possess the ability to vary widely in response to adverse conditions, features exemplified by its immunological reactions. Trypanosomes seem to be able to adapt themselves rapidly to drugs especially when dosage is inadequate. Clearly therefore a strain which is fast to a given prophylactic drug and which is transmitted by tsetse would produce the effect of rapid failure of prophylaxis in an area in which the trypanosome challenge is *per se* not particularly great. Also some drugs are not particularly effective against some species of trypanosomes.

4. Infection Rate as Measured by Tsetse Dissection

We are obtaining evidence that the dissection of tsetse does not lead to a correct estimate of the infection rate. Infections with the *T. brucei* group have been believed to occur in less than 0·1% of the general tsetse population, but we find that animals exposed to *G. pallidipes* in our experimental areas are very frequently and rapidly infected with *T. brucei* group, although out of about 4,000 flies dissected only one fly had a salivary gland infection.

C. The Host

1. Differential Resistance to Infection

Various breeds and types of cattle in Africa show widely differing susceptibility to the disease. Thus there are the well-known N'Dama, of West Africa, in which the organism can establish itself with difficulty only and can be quickly eliminated. On the other hand there are animals of European derivation in which the disease is readily established, runs a rapid course and terminates fatally. Between these extremes are many gradations.

2. The Habits of the Host

Animals which feed at night are unlikely to suffer attack from tsetse if it is true that the latter are in general active diurnally. Again, animals which tend to concentrate may be more frequently attacked than those which are dispersed, though this feature must be governed by the tendencies of the tsetse to concentrate and disperse. The fact that cattle are usually compelled by their herdsmen to graze in a tightly bunched throng probably predisposes to the mechanical transmission of the disease not only by tsetse but by other biting species of fly. In a tightly bunched herd disturbance of a feeding tsetse seems more likely to occur, but in our experience *G. pallidipes* at any rate feeds so rapidly that it is not usually disturbed, but if disturbed before blood has been ingested the fly immediately returns, often to the same animal.

3. Other Factors

While we have mentioned those features which seem the more important there are doubtless many factors involved, some of which seem relatively unimportant and others which have not been recognised.

THE DESCRIPTION OF TRYPANOSOMES TRAINS, ESPECIALLY WITH REGARD TO TESTS OF VIRULENCE AND DRUG RESISTANCE

By M. J. H. Cawdery, East African Trypanosomiasis Research Organisation, Tororo, Uganda.

Comparison of trypanosome behaviour is rendered difficult by the lack of standardisation in descriptions of strains. Hence, it is important that strains are described in a standard form. It is proposed to suggest a system for this purpose.

VIRULENCE

A definition is required to establish the meaning of this term. If it is considered to the time taken to kill, it includes at least three variables:

Infectivity.
Rate of multiplication.
Lethal effect.

At the present time the usual measure of virulence is the mean length of life of infected animals. This is inadequate, and it is considered that at least two other data should be given:

The prepatent period.
The infective dose.

In determining the mean length of life, prepatent period and infective dose of newly isolated strains, the conditions to standardise are:

1. The number of syringe passages in rats or mice since the original host. This can be standardised by freezing the trypanosomes by the method of Polge and Soltys (1957; Preservation of trypanosomes in the frozen state; *Trans. Roy. Soc. trop. Med. Hyg.*, 51, 519–526) at a certain passage, preferably early. All work should be done using organisms from the frozen stock.

2. Animals; mice of standard age—35–42 days is suggested—(for species other than those of the *T. vivax* group) should be used.

3. Route of inoculation; intraperitoneal is suggested as a standard.

4. Inoculum. It is important to decide which of the two methods should be used, or even whether both should be used. One method is to use a fixed number of trypanosomes which is presumed capable of infecting all test animals with all strains; 500,000 *T. brucei* group were used as the infective dose by Robertson and Baker (in press; Human trypanosomiasis in south-east Uganda. 1. A study of the epidemiology and present virulence of the disease; *Trans. Roy. Soc. trop. Med. Hyg.*). Another method, which

appears preferable, is to give an inoculum based on the infectivity tests for the individual strain, e.g. a low multiple of the ED50.

Another point to consider regarding the inoculum is, in relation to all three data, the variation of the trypanosomes when inoculated. For example, it is not known whether variations in the representation of slender and stumpy forms of the polymorphic trypanosomes affect the estimates. Again, in other species the parasites occurring during the rise of the infection may not be equivalent to those occurring during its fall. The volume and composition of the inoculum may also be important; Ashcroft (personal communication) believes that the proportion of blood may be important.

DRUG RESISTANCE

At present the only way of measuring the drug resistance of a strain of trypanosomes is by determining the CD50. Standardisation of animals and route of inoculation, as discussed above for virulence tests, is indicated. Further conditions to be standardised are:

1. Route of treatment; SC, as usually used at E.A.T.R.O., is suggested.
2. Time of treatment. It has been usual practice to treat when the parasitaemia is low, e.g. 1–10 trypanosomes per high power ($\frac{1}{8}''$) field, but this requires consideration. With recently isolated strains of *T. congolense* it has been found that the prepatent period is very variable and for this reason animals have been treated when first positive. This, however, is not very satisfactory and it may be better to treat on a particular day, discarding animals not positive or which have more than ten trypanosomes per high power field.
3. Drug concentrations and compositions.
4. Criterion of cure. The absence of trypanosomes in twenty high power fields of a wet film for a stipulated time is usually used. Large subinoculations of blood from treated to susceptible animals at a fixed date after treatment might be used to detect subpatent infections.
5. In each test it is necessary as controls to have a standard strain and standard drug. As a standard strain it is suggested that an old-established laboratory strain is used. Such a strain usually shows less variation than a newly isolated one. The standard drug used will depend on circumstances and the species of trypanosome being tested. It is suggested that, as far as possible, the standard should consist of the drug in normal therapeutic use for the species of trypanosome concerned.

To recognise acquired or natural drug resistance during field use of drugs, or in experiment, strains should be isolated before the regime or experiment is started, and preserved in the frozen state.

METHODS OF ESTIMATING BLOOD CONCENTRATIONS OF ANTI-TRYPANOSOMAL DRUGS IN MAN AND ANIMALS

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Tororo, Uganda

There are three main difficulties in the estimation of the concentration of these drugs in plasma:

(1) the very low concentrations present, even with soluble drugs such as Antrycide methylsulphate and suramin, B.P.;

(2) the plasma proteins interfering with the technique or linking with the drug;

(3) the rapid metabolism of the drug.

Several methods may be discussed:

(1) Colorimetry

Colorimetric techniques depend on the drugs combining with dyes. The techniques have been used with success by Gage, Rose and Scott (1948; The estimation of suramin in plasma; *Biochem. J.*, **42**, 574). Spinks (1950*a*; Determination of Antrycide; *Biochem. J.*, **47**, 299–306) had, however, little success in the estimation of Antrycide methylsulphate. The present author has also found them unsatisfactory for the estimation of Ethidium (unpublished data).

(2) Fluorimetry

Spinks (1950*a*) has described an indirect fluorimetric technique for Antrycide methylsulphate using "yellowish" eosin. This technique measures quantities as small as 20 μg./litre. Only about 77% of the drug added to plasma *in vitro* is detected by the test, the remainder possibly being precipitated with the plasma protein—probably the albumin fraction. The test is very specific as regards allied drugs or breakdown products and can be used for tissues other than blood.

(3) Spectrophotometry

No work on the estimation of blood concentration of these drugs by this method has come to my notice.

(4) Isotopic Tracers

Radioactive isotopes offer considerable advantages over the classical methods for estimation of drug levels in blood and other biological materials, particularly in sensitivity.

There are, however, two main possible difficulties:

(*a*) Non-specificity. No distinction can be made between the drug itself, and its active or non-active derivatives. A considerable amount of biochemical work would have to be done to determine the anti-trypanosomal activities of the various fractions.

(*b*) With prophylactic anti-trypanosome drugs the local irradiation effects must be considered. The amount of radioactive principle in the dose must be small enough not to cause deleterious results. There is a " depot " formed at the site of inoculation, and also secondary " depot " sites. With Antrycide these latter are in the liver and kidney (Spinks, 1950*b*). Irradiation effect in these organs could affect the metabolism, detoxification and excretion of the drug. However, if the amount of radioactive principle at the site of inoculation is not harmful it is unlikely that toxic doses of irradiation will be received by the tissues of the liver and kidneys, unless there is a definite concentration within these tissues, and/or these tissues are very much more susceptible to irradiation than subcutaneous and muscular tissues. The concentrations of the radioactive principle in the blood may not be of sufficient magnitude to detect when this condition has been fulfilled.

The use of stable isotopes is also possible.

(5) **Biological**

This would have to be based on the effect of plasma or serum from a a treated animal on an indicator system. The indicator system suggested is an old laboratory strain of trypanosome, highly sensitive to drugs. A standard technique, based on the use of frozen strains, is recommended.

The effect of the drug would be measured either by metabolic activity, or animal inoculation tests.

THE IMMUNOLOGICAL APPROACH TO PROBLEMS RELATING TO TRYPANOSOMIASIS

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Trypanosomiasis is so wide a subject that it offers considerable opportunities to students of all branches of biological science to contribute towards the solution of the many problems involved. Many of the contributions to be made at this meeting illustrate the complexity of the research done by various workers in their own specialised fields, but the assessment of the value of such contributions in relation to the main problem may not always be clear. It is the purpose of this communication to interpret the way in which the immunological approach to the study of the tsetse fly and trypanosomiasis has helped to advance our knowledge of such problems and to indicate how immunological methods could be applied to future studies.

Traditionally the tendency of the immunologist was to find the means of prevention of a disease and, in fact, this approach has been attempted in the past by many workers, unfortunately without great success. It is not surprising that such an empirical approach to a complex problem met with failure, because little attempt had been made to study the basic knowledge which is so essential for the proper understanding of the process of immunity and protection. Modern immunology is perhaps less concerned with protective mechanism than with the accurate study of the process of immunity, i.e. the response of the host to external antigens as also the response of the parasites to the host's defensive mechanisms. These studies have given rise to a wealth of immunological methods which have, in many cases, greatly facilitated the approach to problems of diverse nature. Thus, the studies of earlier workers on trypanosome infections and related problems may often deserve revision in the light of modern techniques and knowledge.

IMMUNOLOGICAL METHODS FOR IDENTIFICATION OF BLOOD MEALS OF TSETSE FLIES

The immunological approach to problems related to trypanosomiasis in the field is exemplified by the advances made recently in the methods for the identification of blood meals of tsetse flies. Although as long ago as 1904 Nuttall (1) paved the way for the use of the precipitin test for identification purposes by showing that the serum antigens of animals were immunologically related in accordance with the zoological relationships, it was not until the last few years that this approach was undertaken seriously. Yet many noble attempts have been made by other means to find out objectively the feeding habits of *Glossina*.

Prates (1928) and later Symes and McMahon (1937) made the first real attempt to identify the blood meals of *G. swynnertoni* and *G. palpalis* by the precipitin test. The results they obtained are hardly unequivocal and this was due largely to the lack of specificity and sensitivity of the antisera used. A thorough investigation of the relationships of the antigens present in the sera of different mammals showed that the relationships were not so simple as was indicated by the work of Nuttall (Weitz, 1952). These findings showed the limitations of the precipitin test as a tool for the identification of blood meals of tsetse flies which have, as their possible hosts, very large numbers of animals so closely related to each other that they cannot be distinguished by this test. It was, therefore, necessary to find a test which would distinguish the sera of these related animals satisfactorily and the "inhibition of agglutination" test was devised for the purpose. Boyden (1951) had used a method of tanning red blood cells and sensitising them with extracts of *M. tuberculosis*. In a similar way, tanned erythrocytes can be coated with serum protein and thus used as indicators of the presence of homologous antibody. This reaction can be inhibited specifically by known serum proteins and also by the blood meals of insects containing these. The procedure thus formed a convenient method of identification. The validity of the results obtained by this new test was thoroughly investigated and it is normally correct within about one to five per cent. Most of the errors which occur may be ascribed to insufficient feeds or to mechanical errors (Weitz, 1956).

At last objective and reliable results were obtained from identification tests of large numbers of blood meals from different species of tsetse fly (Weitz and Jackson, 1955; Weitz and Glasgow, 1956). The results, which on the whole were unexpected, yielded a new understanding of the feeding habits and consequently of the biology of the fly and of the disease which it carries. Perhaps this work has evoked more new problems than it has solved. The results have shown firstly that all possible hosts are not equally favoured by tsetse, and secondly that different species of tsetse flies have predilections for different host animals. Some examples of these findings are contributed to this meeting as separate communications. Such problems as the significance and nature of food preferences of tsetse flies, the problems of control of the fly by the selective elimination of preferred hosts, the pattern of trypanosome infection of wild game in relation to feeding habits, are but some of the avenues opened by these findings and which require the fullest investigation.

THE IMMUNOLOGICAL MANIFESTATIONS OF TRYPANOSOMIASIS

As it is not the purpose of this communication to make a complete review of the work on the immunology of trypanosomes or of the disease they cause, it will be more useful to pinpoint certain aspects of the problems and to discuss the significance of the immunological findings.

ANTIBODY MANIFESTATION

Many ingenious techniques to demonstrate the presence of antibody following antigenic stimulation with trypanosomes have been used. Some methods are entirely empirical, others are only relatively qualitative and only few are really quantitative.

(i) Protective Antibody : Laboratory Studies

The earliest attempts made were nearly always concerned with the protection of susceptible animals against a challenge, but unfortunately little indication was given of the heterogeneity of the strains used. The early workers (Laveran and Mesnil, 1901 ; Mesnil, 1901 ; Mesnil and Rigenbach, 1911 ; Mesnil and Blanchard, 1916 ; Mesnil and Briment, 1909) showed that the serum of infected animals acquired protective properties against reinfection and their studies suggested that the protective antibodies elicited were specific enough to differentiate two strains of *T. brucei* and *T. evansi.* They suggested that the protective substance was fixed to trypanosomes in such a way as to make them susceptible to phagocytosis. Protection against challenge with heterogeneous strains of trypanosomes is, to a large extent, empirical and, in any case, difficult to measure quantitatively. Few studies of this kind have been made since this time except for the more recent work of Soltys (1957) who again used the passive protection test to demonstrate antibody formation. The interesting suggestion made by Soltys (1957) that strains, after passage through rabbits, developed a protective mechanism against immune bodies, is worthy of further investigation. Although the experiments described are suggestive of a protective mechanism of the parasite against its host, there is no real evidence of the reproducibility of this work or, indeed, of the mechanisms involved, and the work should be repeated with other strains or species of trypanosomes, and the nature of this apparent resistance to antibody should be thoroughly investigated before any conclusions are reached. Similar phenomena, using *T. gambiense,* had already been shown by Inoki *et al.* (1952). These workers produced a series of " relapsed strains " which were claimed to be immunologically distinct, by treating mice with human serum, and further immunological variants could be produced by further passage and treatment with human serum. Moreover, the original strain characteristics could be regained by treatment of relapsed strains with human serum. It may be suggested that the reason for these rather confusing results may be an inadequate knowledge of the real antigenic characters of strains used in such experiments. The picture must remain obscure unless work of this kind is carried out from singly isolated trypanosomes, as Lourie and O'Connor (1936, 1937) showed that clones isolated in this fashion gave rise to immunologically distinct strains of *T. rhodesiense* in mice. Otherwise the possibility of naturally selected variants being responsible for such results cannot be excluded.

(ii) Protective Mechanism in the Natural Disease

Protection in the field is often associated with a state of " premunition ", i.e. a co-existence of trypanosomes of apparently low pathogenicity with antibody in the serum. Perhaps, as Soltys (1957) suggests, these strains may have acquired a tolerance to the antibodies. Resistance to natural infection appears to be a rather different problem from that encountered in laboratory animals. Fulton and Lourie (1946) showed that in mice, drug fast strains are usually infective to mice immunised against the parent strain and suggest that reinfection either with homologous or heterologous strains depends on the stability of the antigenic constituents of the trypanosomes. In their own words, " the antigenic lability of trypanosome antigens largely accounts for the difficulty of successfully immunising men or beasts against trypanosomiasis in the field ". In the absence of any measurement of " antigenic lability " it is difficult to interpret the meaning of these remarks. Hornby (1941) recognised the difficulty of artificially immunising cattle and has adequately reviewed the evidence to that date. Nevertheless, immunity exists in nature. The survival of game in trypanosome endemic areas confirms that immunity in the field is not necessarily unobtainable. Perhaps a study of the nature of the resistance of game animals or, more particularly, baboons which are resistant to artificial infection with polymorphic trypanosomes, may be a valuable field of investigation. The presence of " natural " antibodies in cotton tail rats demonstrated by Terry (1957) is an example of the kind of studies which should be carried out with resistant species of animals.

The observations of Desowitz (1956) show that *in vitro*, when *T. vivax* is mixed with the serum of N'Dama cattle which had been challenged with this trypanosome, there is a marked reduction of the respiration rate of *T. vivax*. Although this breed of cattle is particularly tolerant to trypanosome infection, no such inhibitory effect occurred with serum from unchallenged cattle. This elegant and useful method of assay appears to be related to antibody titre as indicated by dilution studies and by the progressive increase in the respiratory rates as the interval after the challenge of the cattle increased. It is not quite clear on what basis it is claimed that this response is a more accurate quantitative method of assay of " antibody " content than for instance the complement fixation test, agglutination test or inhibition test. Although Desowitz mentions that trypanosomes are lysed in such sera, to accept such a claim demands a new interpretation of the meaning of the word " antibody ". The differences of respiratory rates between trypanosomes passaged cyclically and those passaged by syringe indicate that variations of this kind can be evoked by complex mechanisms other than antibody (Jenkins and Grainge, 1956).

(iii) *In vitro* Manifestations of Antibody

The main objects of most of the studies have been to devise reliable means for the diagnosis of trypanosomiasis in the field, or to study the taxonomy and serological relationships of trypanosomes by the systematic serotyping of strains or species. In either case results have proved to be alarmingly contradictory and these can be discussed conveniently in relation to both objects, as they are obviously interdependent.

(*a*) The Complement Fixation Test

This test has proved of some value in the diagnosis of the disease in man (Schoenaers *et al.*, 1953). For the execution of the test it has been found that the most suitable antigens have been obtained from *T. equiperdum* which combines with complement fixing antibodies against *T. gambiense* and *T. rhodesiense*. In fact, it is a more sensitive antigen for the diagnosis of the disease in man with *T. gambiense* and *T. rhodesiense* than for the diagnosis of dourine in horses (Rhodain *et al.*, 1941). Complement fixing antibodies are, it would appear, quite non-specific on this basis, and may of be little value in the distinction of trypanosome strains or species, although they may prove to be of some value for the diagnosis of this disease as a group.

(*b*) Platelet Adhesion Phenomenon

The voluminous literature on the specificity or otherwise of this test is most confusing. The manifestly elaborate nature of this test is probably responsible for the contradictory findings.

(iv) Red Cell Adhesion Test

This test is evidently similar to the above test but is much neater in its execution. Duke and Wallace (1930) found that it failed to distinguish between *T. gambiense* and *T. rhodesiense*. The test was more clearly defined by Wallace and Wormall (1931) who described an antibody-like substance called " adhesin " which, in the presence of complement, will fix human red blood cells to a suspension of trypanosomes. Unfortunately the specificity of this promising test has never been established.

(v) Agglutination Test

Soltys (1957) has described the absence of cross-reactions with three species of trypanosomes. From this work it appears that here would lie a useful method for the classification of trypanosome species. The agglutination test has characteristically poor sensitivity and in view of this, non-apparent similarities between strains or species would not be evoked. That does not alter the possibility of its usefulness in the distinction of trypanosome species, although it would be erroneous to conclude, on this basis, that the different species of trypanosomes have no common antigen ; they are merely not detected by such tests.

DISCUSSION

If the pattern of the antigenic structure of different strains of trypanosomes under specified conditions is to be clearly understood, the tests used must be extremely sensitive. This is all the more important when it is realised how poor trypanosomes are as a source of antigen. Whole trypanosome homogenates yield, in terms of antibody response, extremely poor amounts of antigen. This, of course, may be simply due to the method by which trypanosomes are obtained for such work, which is mostly by infecting laboratory animals and removing the trypanosomes from the serum by centrifuging. Another difficulty is that such methods invariably yield trypanosome homogenates which are, in fact, contaminated with the serum of the animal of origin. The picture of antibody formation is complicated when such homogenates are injected into animals so that reactions in the serum of injected animals are confused by the presence of homologous antibodies against the serum of the donor hosts. This is a real difficulty when working with dead trypanosomes. To avoid such difficulty it is simpler to use living strains, but studies which have used living strains suffer from the severe disadvantage that very little has been done to ensure that the strains themselves are homogeneous. Once inoculated into animals the pattern of antibody formation will depend on the changes which may occur in the parasites as a reaction to their new environment.

It therefore appears most important that this work should be carried out with clones, as Lourie and O'Connor (1937) have already demonstrated immunological differences between different clones. It is open to discussion how much the variation in the results of workers who have used live trypanosomes in the study of antibody to this parasite is influenced by the process of natural selection of suitable strains within the host. This is particularly evident when lapsed strains are produced by treating animals with suitable drugs.

These considerations make it obvious that to obtain a clear picture of the mode of action of trypanosome antigens, it is most important to acquire some knowledge of the serotypes of antigens which are involved, their nature and their metabolism in the host. A thoroughly systematic approach by modern immunological techniques is bound to yield results of some considerable importance. The identity of different antigens can be established in given strains, and once antigens have been isolated, it should be possible to observe the presence of such antigen, or its alterations in different strains or in different species under varying environmental conditions. For this purpose, it is most important not to be limited to a method of assay of any particular kind, but to take into consideration the numerous tests which have been discussed, and it would not be surprising if results of such studies on the antigenicity of trypanosomes show that the antigens of these parasites are, in fact, more closely related to each other than appears at present. Once a clear picture of the antigenic constitution of trypanosomes has been obtained, the path is then clear for studies in the field relating to the many problems involved. Such studies would also help very considerably investigations related to drug sensitive and resistant strains, as up to date there has been no real evidence that antigenic changes occur in these circumstances. This knowledge would also be of great value to the systematic study of taxonomy of trypanosomes and it may be that they will yield trypanosome classifications which do not necessarily correspond to those established on a morphological or ecological basis, but which may prove more useful for the observation of changes from parent strains.

The problem in the field which so far has proved to be very unyielding is the discovery of a reservoir host of *T. rhodiense*. Many attempts have been made to isolate this particular organism from wild game, but so far have not yielded any definite results. The main reason is probably that our conception of *T. rhodesiense* as a distinct species of either *T. gambiense* (Willett, 1956) or *T. brucei* is based mainly on the ecology of these trypanosomes. *T. rhodesiense* is only recognised as such when recovered from man and because of its capacity to infect man. If the trypanosome is recovered from game, it fails to infect man and by definition is then called *T. brucei* (Willett, 1956). While it is generally recognised that *T. rhodesiense* is an adaptation of a wild species, it remains to be seen if there will be any differences in the antigenic constitution of the polymorphic trypanosomes when these can be examined systematically by antigenic analysis. It is worth while examining this problem from the immunological point of view because if such differences exist it should be possible to follow the biology of the disease and its animal hosts by the study of antibody patterns resulting from their infection with such different trypanosomes. Indeed, a survey of trypanosomiasis in wild game would yield more accurate information from the identification of antibodies as indicators of present or past infection with trypanosomes, than by the laborious and inevitably chancy search for the organism by direct examination or by isolation in laboratory animals (Ashcroft, 1958).

If antigenic differences between species of trypanosomes can be demonstrated they would thus afford a useful tool to help towards the solution of many such problems. However, in the light of our present knowledge, it is difficult to evaluate the expected results and it may be optimistic to postulate that similar patterns to the ones obtained with bacteria and viruses will necessarily apply to trypanosomes. The most apparent obstacles to the success of such studies are the difficulty of collecting sufficient quantities of antigenic material by the growth of organisms in animals, and the poor antibody response in animals produced by the injection of trypanosome antigens obtained from such homogenates. Nothing is known about the chemical nature of the antigenic components of trypanosomes, and it is quite possible that the antigens may not be protein in nature. Glucosides or polysaccharides are known to be very poor antibody-producing antigens, although they readily combine *in vitro.* The antibody-forming properties of such substances can be enhanced by artificial conjugation with inert proteins and it may well be necessary to prepare conjugated antigens of this kind from trypanosomes in order to obtain an antibody response which will yield antisera suitable for such studies. It may be found that this may well be why animals are seldom if ever immune to reinfection after recovery from trypanosomiasis.

Modern immunological techniques with the help of biophysical and biochemical analytical methods should yield the answer to many of these problems if they are approached systematically. In the past too much attention has been given to the observation of phenomena and artefacts, the basis of which were not clearly understood, and too much haste was shown in applying such tests to field problems. If any measure of success is to be expected it would seem necessary to study the fundamental basis of such observations before the application to problems in the field can be of much value.

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VARIATIONS IN PATHOGENICITY AMONGST *CONGOLENSE*-LIKE TRYPANOSOMES IN RELATION TO THEIR MORPHOLOGY

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The maintenance by cyclical transmission of *Trypanosoma congolense* has proved a difficult problem in these laboratories. The experience of the author and his predecessors was that animals (dogs, sheep and cattle) infected with *T. congolense* did not usually exhibit clinical symptoms, parasitaemia was invariably low and the trypanosomes quickly disappeared from the blood. It was difficult to infect tsetse flies, and also difficult to infect rats by blood inoculation.

In 1957, a *congolense*-like trypanosome was isolated from a dog and gave a very different picture from that described above. This new organism when cyclically transmitted produced a heavy parasitaemia in dogs and goats, and always proved fatal. In adult sheep, the initial parasitaemia was moderate to heavy but, after a series of relapses, about one-fifth of the animals died and the remainder recovered: four lambs, however, all died after being infected. White rats were easily infected by blood inoculation and always died after periods of high parasitaemia. Insufficient work has been done to reach firm conclusions on the virulence of this trypanosome to cattle. An adult ox was infected by the bite of a single tsetse fly and during the first three months trypanosomes were often numerous in the peripheral blood, but they were only seen occasionally during the following three months, before disappearing completely. During the initial period of high parasitaemia, the ox was undoubtedly sick but later seemed to make a complete recovery. Recently, a calf has been infected and, since the end of the incubation period, trypanosomes have appeared in the blood on each of thirty-five days; weight has been lost and the general condition of the calf has deteriorated.

The picture is also very different when it comes to infecting tsetse flies. Fairbairn recorded experimental infection rates of 3·6 and 3·1% for for *T. congolense* in *G. palpalis* and in *G. morsitans* respectively (W.A.I.T.R. Ann. Rep., 1954); but, with this newly isolated organism, 73 flies were positive out of the 554 *G. morsitans* which survived at the end of the experiments, giving an infection rate of 13·2%.

The clinical aspects of the disease caused by this trypanosome and its development in the tsetse fly have to be investigated further, but it is certain that this organism is much more virulent than the strains of *T. congolense* previously encountered; there is evidence, which will be discussed later, that it may be *T. dimorphon*.

As part of a morphological study, measurements were made of this virulent trypanosome for comparison with those from normal mild strains.

A sample from the results obtained to date is given in Table I; one hundred trypanosomes were measured from each host.

These figures show that trypanosomes of the severe strain are significantly longer than those from the same species of host infected with a mild strain.

No comparative measurements have been made between trypanosomes of the severe and of the mild strains in sheep, since in the mild infections so far encountered too few trypanosomes appeared in the peripheral blood for a significant number of measurements to be made. However, Table II gives a sample of the mean lengths of trypanosomes of the severe strain maintained by cyclical transmission in the laboratory, and others from sheep, which eventually died, after being infected by wild flies. One hundred trypanosomes were measured from each host.

Despite their different origins, there are no significant differences between the mean lengths of trypanosomes from the various severe strains; hence, they are probably of the same species or strain. This is confirmed by other morphological characteristics which are described below.

The mild strain was found to consist of short trypanosomes having no free flagellum, a poorly defined undulating membrane and a kinetoplast close to the rounded posterior end; this description fits that of typical *T. congolense.*

A few similar forms were seen in the severe strains; however, there were also many long forms without free flagella but having a distinct undulating membrane and a kinetoplast lying some distance from a pointed posterior end. Some of the trypanosomes were intermediate between the long form and the typical *T. congolense* form.

The morphological differences in structure between the two types of trypanosome are still the subject of detailed study, but the general characteristics described here differentiate the species or strains, particularly when considered in conjunction with the biometric studies.

Laveran and Mesnil (1912) described a trypanosome similar to *T. congolense* but differing in that long forms were present; this trypanosome was named *T. dimorphon.* These authors reported that some of the long forms had a pointed posterior end whilst others had a rounded posterior end and that the latter corresponded to types intermediate between the true long and the true short forms. Since this description fits, to some degree, that of our severe *congolense*-like trypanosome, it is possible that it is *T. dimorphon*; however, forms longer than 21μ have not been found, whereas Laveran and Mesnil encountered forms stated to be 25μ in length. Hoare (1956) is of the opinion that *T. dimorphon* may be a distinct species, but he suggests that its status should be verified. Until such a verification has been completed by Dr. C. A. Hoare on the original slides made by Laveran and Mesnil, it cannot be stated whether our severe *congolense*-like trypanosome is *T. dimorphon*, or simply a severe strain of *T. congolense* in which an elongated form is predominant. In the meantime, an extensive investigation is being carried out in Nigeria to ascertain whether there are other *congolense*-like trypanosomes, and to determine the economic importance and distribution of our severe strain.

Table I.—Comparison of the Mean Lengths of *Congolense*-like Trypanosomes in Relation to the Severity of the Disease

Severe infections: *T. dimorphon* (?)				Mild infections: *T. congolense*			
Host	Mean Length (μ)	Standard Error of Mean	Range (μ)	Host	Mean Length (μ)	Standard Error of Mean	Range (μ)
Dog 17	15·13	±0·165	11–18	Dog 2	13·48	±0·135	10–17
Dog 1	15·06	±0·180	10–18	Dog 33	13·30	±0·130	10–16
Dog 5	15·68	±0·197	11–21				
Ox 643[1]	14·62	±0·154	11–19	Ox 861	12·53	±0·140	9–16
Ox 643[1]	14·56	±0·162	10–19	Ox 627[2]	13·05	±0·169	9–17

[1] Measured on different days.
[2] Severity of disease uncertain since the infection later became mixed with *T. vivax*.

Table II.—Mean Lengths of Trypanosomes from Severe Strains in Sheep

Severe strain maintained cyclically in Laboratory				Severe strain transmitted by wild flies			
Host	Mean Length (μ)	Standard Error of Mean	Range (μ)	Host	Mean Length (μ)	Standard Error of Mean	Range (μ)
Sheep 194	14·51	±0·153	11–18	Sheep 510	14·79	±0·165	11–19
Sheep 198	14·57	±0·130	10–18	Sheep 537	15·00	±0·184	10–19
Sheep 264	14·91	±0·177	11–18				

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THE MAINTENANCE OF CATTLE IN TSETSE-INFESTED COUNTRY

A Summary of Four Years' Experience in Kenya

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INTRODUCTION

Cattle are maintained in tsetse-infested country chiefly by means of drugs. The use of drugs is an example of the principle of " direct attack on the parasite ". Such direct attack has long been a possible way of controlling animal trypanosomiasis, but little could be done about it until a series of strikingly effective drugs appeared after the war (Davey, 1957). The potentialities of efficient chemotherapy were quickly realised everywhere. In Kenya the pioneer work was done by S. G. Wilson in 1948–51 and by Fiennes (1953). The series of investigations and practical schemes summarised here began in 1954.

Although at present chemotherapy is the main weapon of direct attack on trypanosomes, two other applications of the same principle should not be lost sight of. They are the immunisation of cattle and the selective breeding of resistant types. Both receive further mention below.

This paper deals only incidentally with experimental results. It is mainly concerned with their practical application—which, in Kenya, has closely followed the discoveries made in the course of laboratory and field experiments.

ADVANTAGES OF BEING ABLE TO KEEP CATTLE IN TSETSE AREAS

The chief advantage is economic. It is nearly always cheaper to use drugs than to clear bush, i.e. to kill the trypanosome than to kill the tsetse fly. This consideration especially applies when the land is fit only for cattle ranching. On the other hand, chemotherapy alone achieves nothing permanent; the land is used but it is not reclaimed from the tsetse fly and not essentially improved. Chemotherapy is therefore most beneficially employed in conjunction with other measures. A list of the uses to which it has been put in Kenya follows.

(*a*) Permanent or temporary ranching in fly-belts sometimes with partial clearing to bring the incidence of trypanosomiasis down to a level controllable with drugs.

(*b*) Early introduction of stock into tsetse reclamation schemes, leading to better land usage.

(*c*) The control of trypanosomiasis on the fly-infested margins of reclamation schemes. This was previously possible only by means of expensive barrier clearings.

(*d*) The control of sporadic trypanosomiasis due to any or all of the following causes: mechanical transmission; seasonal fly dispersal; flies carried by vehicles; scattered tsetse foci.

(*e*) Protection of animals passing through fly-belts.

(*f*) Aid in the stopping of fly advances: stock need no longer be evacuated while the necessary clearing operations take place, nor need people retire in the face of tsetse encroachment.

PROBLEMS POSED BY THE USE OF CHEMOTHERAPY

It is well known that a given drug regime—for instance two-monthly Antrycide Prosalt—is sometimes successful in protecting cattle and sometimes not. That is an unsatisfactory state of affairs from the practical point of view. One wants to know beforehand whether any situation is completely amenable to chemotherapeutic measures, or only temporarily amenable, or whether they are ruled out without some kind of supplementary action. In order to acquire such knowledge it is necessary to discover the factors responsible for success or failure and to devise convenient means of assessing them. That is the first problem posed by chemotherapy.

When this particular problem was investigated in Kenya it was discovered that regimes involving treatment at longer intervals, or with the cheaper curative drugs, gave adequate protection in certain circumstances. Thus (economics being all-important) another problem is to find means of assessing the cheapest regime that will suffice in a given situation.

While some progress has been made, our understanding is still far from perfect. All the precautions we can take at present do not suffice to avoid an occasional failure to protect the cattle from trypanosomiasis. What to do when that happens forms the third main problem of chemotherapy, for it is common experience that the infected cattle harbour trypanosomes resistant to the drug being used, and sometimes others as well.

GENERAL PRINCIPLES IN PRACTICAL CHEMOTHERAPY

The large-scale use of chemotherapy against animal trypanosomiasis is still an evolving technique, and it is perhaps too early to talk of general principles. Nevertheless, the problems just discussed have led to a particular method of approach being adopted in Kenya. It attempts to take into account a number of factors found relevant to every situation, and is roughly as follows. (Numbers in brackets refer to later paragraphs expanding the subjects mentioned.)

When chemotherapy is to be used for any of the purposes reviewed earlier, the first necessity is an initial survey to determine the trypanosome challenge (1) and accessory factors (1) which together form the obstacle to be overcome. These, considered in conjunction with the nature of the protection required (short-term, long-term, etc.) enable a decision to be made as to the choice of drug or drugs (2, 3) the regime (4), and the organisation needed for administering it (4). At the same time the possibility—or even certainty—of an eventual failure of protection (5, 7) is taken into account, and measures for dealing with it are planned (6). Finally, an appropriate scale of supervision with periodical checks is arranged (which need not be described here).

(1) Trypansome Challenge and Accessory Factors

Investigations into the factors influencing the protection afforded by drugs have shown that they can be divided into two groups: those concerned with the trypanosome (trypanosome **challenge**), and those concerned with the host, in this case cattle (**accessory factors**). The trypanosome challenge can be divided into **intensity of infection** on the one hand and **characteristics of the trypanosome** on the other. Intensity of infection is almost synonymous with the number of infective bites per unit time, and depends on at least five factors which are mentioned in the list below. The important characteristics of the trypanosome are such things as the species, virulence, susceptibility to drugs, etc.

Accessory factors can also be divided into two groups: those concerned with **innate resistance** of the cattle to trypanosomiasis on the one hand and those **modifying resistance** on the other. A number of accessory factors classified under these two heads appears below.

The list that follows includes all the factors at present known or reasonably suspected to influence the success of chemotherapeutic measures, and the items numbered are those that ought to be taken into account during a preliminary survey. Some can be numerically measured in various ways (e.g. 1 to 4), others can only be descriptively noted at present (e.g. 10 to 13). The influence of some (e.g. intensity of infection) is known with a small degree of precision for some species of fly; the influence of others (e.g. innate resistance of cattle) is at present only beginning to be explored.

TRYPANOSOME CHALLENGE

a. **Intensity of Infection**

(1) Species of fly.
(2) Numbers of fly.
(3) Disposition to feed on cattle.
(4) Infection rate of fly.
(5) Mechanical transmission.

b. **Trypanosome Characteristics**

(6) Species.
(7) Virulence or pathogenicity.
(8) Susceptibility to drugs.
(9) Liability to become drug-fast.

ACCESSORY FACTORS

a. **Susceptibility of Cattle**

(10) Breed.
(11) Type and sex (bull, bullock, etc.).
(12) Place of origin.
(13) Previous history.

b. **Factors Modifying Susceptibility**

(14) General condition of cattle.
(15) Pregnancy and lactation.
(16) Intercurrent, dormant or chronic disease.
(17) Conditions of grazing and watering.
(18) Climatic conditions.

It is not possible within the limits of this paper to describe either how these factors are measured or noted or what distinguishes a " low " from a " high " degree of any of them.

(2) Categories of Drugs

The customary and arbitrary division into " curatives " and " prophylactics " is becoming less rigid. It would be more correct to speak of the curative or prophylactic **use** of drugs. Thus, Berenil, a " curative ", is being successfully used in Kenya as a prophylactic, while Antrycide Prosalt, a " prophylactic ", is needed in certain circumstances as a curative. Further, there is recent evidence that Metathidium (M. & B. 4404) acts as a curative at low dosages and as a prophylactic at high dosages.

In addition to these two functional categories a third has been found valuable in Kenya. Drugs which cure infections resistant to other drugs have been called " sanatives ". The same drugs are involved; it is a distinction of use. Thus Ethidium is a sanative for Antrycide-resistant *T. vivax*, Berenil for Ethidium-resistant *T. congolense*, and so on. With some reservations almost any drug can be used as either a curative or a prophylactic or a sanative. It helps to think of them in this way when planning a protective regime.

(3) The Main Drugs Tested in Kenya and the Dosages Used

Dimidium bromide[1]	1·5	mg./kg. (curative)
Ethidium (Boots) or Novidium (M.& B.)	1	mg./kg. (curative)
	2	mg./kg. (sanative)
Prothidium (Boots)	1	mg./kg. (curative)
	2	mg./kg. or 4 mg./kg. (prophylactic)
	2	mg./kg. (sanative)
Antrycide sulphate (I.C.I.)	5	mg./kg. (curative, prophylactic, sanative)
Antrycide Prosalt (I.C.I.)	12	mg./kg. (prophylactic)
	12	mg./kg. + Berenil 5 mg./kg. (sanative)
Berenil (Hoechst)	3·5	mg./kg. (curative, prophylactic)
	5	mg./kg. or 7 mg./kg. (sanative)
Metathidium (M.& B.) (4404)	0·2	mg./kg. (curative)
	1	mg./kg. or 3 mg./kg. (prophylactic)
	2	mg./kg. or 4 mg./kg. (sanative)

[1] Dimidium bromide is gradually being abandoned in favour of the homidiums.

(4) Systems of Treatment and Drug Regimes

Three main methods have been used in the field in Kenya. They are (*a*) treatment on demand, (*b*) treatment when positive, (*c*) treatment at regular intervals. The main difference between (*a*) and (*b*) is that microscopic diagnosis is confined to the latter.

(*a*) **Treatment on demand** is carried out by African veterinary staff. Owners bring their sick cattle and pay for curative drugs administered on the spot, there being no diagnosis beyond what the owner and the Veterinary Scout can manage between them. This system is satisfactory only in areas of very low incidence. The dangers are underdosing and sudden rises in incidence, both of which lead to drug-fastness. It is best to use a single curative over large areas, so as to avoid producing resistance to several at the same time (which makes the choice of sanative difficult). If appreciable resistance does develop a different drug is introduced throughout the area.

(*b*) **Treatment when positive** (i.e. when blood or gland smears reveal infection) demands a microscopist and a fixed or mobile treatment centre, to which animals are brought, examined and given a curative if found infected. This system has proved satisfactory where the annual incidence does not greatly exceed 100%. It is economic only where large numbers of cattle can be dealt with by the treatment centre. Cases of resistance are more easily detected than with system (*a*).

(*c*) Various types of **treatment at regular intervals** have been used under different conditions in Kenya, with the following results.

Two-monthly Antrycide sulphate. Successful only in low trypanosome challenge, where three-monthly Prosalt is equally good, less trouble, but more expensive.

Two-monthly Berenil. Successful so far (one year) in low to medium trypanosome challenge.

Three-monthly Antrycide Prosalt. Successful in low trypanosome challenge only, unless accessory factors are favourable.

Two-monthly Antricyde Prosalt. Successful in medium trypanosome challenge but fails after 4–8 months in high trypanosome challenge.

One-monthly Antrycide Prosalt and sulphate alternately. Used once in high trypanosome challenge to demonstrate that raising the amount of drug lengthens the period of protection. Not economic.

Four-monthly Prothidium (2 mg./kg.). Successful so far (one year) in low to medium trypanosome challenge.

Three-monthly Metathidium (1 mg./kg. or 3 mg./kg.). Under trial in low to medium trypanosome challenge.

(5) Failure of Protection

The following regimes have failed to protect under Kenya conditions, the criterion of failure being 10% or more confirmed infections during the regime.

In medium trypanosome challenge:	Three-monthly Prosalt after 4–8 months.
	Two-monthly Antrycide sulphate similarly.
	Antrycide sulphate when positive (resistant infections appeared).
In high trypanosome challenge:	Two-monthly Prosalt after 4–8 months.
	Prothidium 2 mg./kg. after six months.
	Prothidium 4 mg./kg. after seven months.
	Antrycide sulphate when positive (resistant infections appeared).

" Failure " of this type does not necessarily mean that the regime has no practical value. On the contrary, to take two examples: two-monthly Prosalt in high trypanosome challenge has been used many times to give six months' temporary grazing (6), and Antrycide sulphate—when positive—has been used to maintain cattle in high trypanosome challenge for nearly two years, during which time twelve calves have been born and reared. This is done by means of sanatives (6).

When failures occurred the cattle concerned were almost invariably found to harbour trypanosomes resistant to the drug used. (Fly transmission of such strains has, however, only once been observed out of many trials.) At one time it seemed that *T. vivax* was particularly prone to develop resistance to certain drugs and *T. congolense* to others. But later experience has shown that no prediction is possible as to which species will give trouble.

(6) Control of Resistant Infections

This can be achieved by a suitable choice of sanative. Much work has been done on this problem in Kenya, where opinion at present is that before a drug can safely be used in the field the corresponding sanative should be found.

After sanative treatment the cattle can sometimes be left in fly-bush on the original regime and sometimes not; it depends on various factors which are slowly being recognised by trial and error. In some cases the treatment is so effective that regimes known to produce resistance can confidently be used. An example is Antrycide Prosalt administered every two months to cattle in a high trypanosome challenge: at the end of six months 20–40% of them are invariably found to have infections resistant to Prosalt. Nevertheless, large numbers of cattle have been furnished with temporary grazing under such conditions. They receive sanative treatment with Ethidium or Berenil after six or seven months in the tsetse area and are then withdrawn—healthy, free from trypanosomiasis and showing normal live-weight increase.

The choice of sanative is sometimes complicated by cross-resistance. For example, strains relapsing through Prothidium are at first partially cross-resistant to Ethidium and Antrycide. It is also complicated by the degree of resistance developed. For example, strains persistently relapsing through Prothidium are completely cross-resistant to Ethidium and Antricyde and partially to Berenil as well. There are also specific differences in cross-resistance. For example, *T. congolense* relapsing through Antricyde is (in Kenya) usually cross-resistant to Ethidium, but *T. vivax* is not.

The resistance-spectrum of relapse infections from field and laboratory trials has received much study that is still continuing. The results are complicated and cannot be summarised here. At present a sanative is known for low or high resistance to every existing drug except Metamidium (regarding which a sanative for low resistance only is known); but trypanosomes change their characteristics in a surprising way, and some successful treatments may yet fail when tested under a wider range of conditions.

(7) Causes of Failure of Protection

The basic cause appears to be the development of drug-fast strains (without which chemotherapy would be a simple matter). At least, failure is nearly always associated with this phenomenon. Drug-fast strains seem to develop in three ways, of which two are obvious and the third merits attention: (*a*) underdosing, (*b*) infection at waning drug-concentration, (*c*) a high intensity of infection.

It now seems well established by trials in many parts of East Africa that a given drug level (i.e. frequency of treatment) is able to withstand a certain intensity of infection but not more. We have found that the converse also applies: a higher drug level (more frequent treatment) withstands a greater intensity of infection than a lower one. These phenomena appear to be new, and merit further research. Indeed, the whole subject of why drugs fail needs further research.

ARTIFICIAL IMMUNITY

A temporary solid immunity to a high intensity of infection has been demonstrated several times after a regime of two-monthly Antrycide Prosalt in high or medium trypanosome challenge, with or without a final sanative. This confirms the observation of Soltys (1954). It could, however, be due merely to the combined effect of several Prosalt depots: that is to say, it could be no more than normal but rather lengthy prophylaxis, and such a possibility is made more likely by the fact that the immunity observed by Soltys was not strain-specific.

The point has been investigated in Kenya by employing an immunising regime consisting solely of curatives (Antrycide and Ethidium). The regime lasted seven months, was in a high trypanosome challenge, and was repeated in three batches of cattle. In every case a temporary immunity of 5–12 months' duration appeared. Since in several cattle it followed as little as two Antrycide treatments and one Ethidium treatment a depot effect can be ruled out. The immunity is probably an antibody response to alternate infection and cure. It is possible that a similar response accounts for the prophylactic effect of regular treatment with curative drugs.

The cattle referred to have, in seven months following the initial immune period, shown a significantly lower incidence of infection than untreated controls. A residual immunity of lesser degree seems to have developed. A similar residual immunity of up to eighteen months' duration has been observed after Prosalt regimes.

These results are interesting but at present artificially induced immunity is too little understood to be used on a large scale in protecting cattle from trypanosomiasis. On the other hand once established it is astonishingly effective, and in some trials has solidly withstood very high trypanosome challenges indeed (*G. pallidipes* A.D.s in the region of 300). It is therefore receiving further study in Kenya.

INHERITED IMMUNITY AND SELECTIVE BREEDING

Up to now in our experiments just over a dozen calves have been born to cows being maintained in fly-infested country. None has died of trypanosomiasis. There is some evidence that they are less susceptible to trypanosomiasis than their dams (but control calves introduced at birth have yet to be observed). The evidence is briefly as follows. Sixteen cows undergoing an immunising regime with curatives sustained eighty-four overt infections between them in their first thirty weeks of exposure. When immune they produced a number of calves, of which five have now lived more than thirty weeks, sustaining fifteen overt infections between them. Thus the dams averaged 5·25 infections per head and the calves 3·0 infections per head in equal periods, a difference that is highly significant ($P<0 \cdot 001$). Selective breeding from cattle under regular Prosalt protection is being investigated in a different area. This, however, is long-term research.

THE FUTURE

There seems little doubt that chemotherapy is likely to become as important as anti-tsetse measures in the future control of animal trypanosomiasis. The basic principles—assessment of the challenge, adjustment of the regime to it, and the use of sanatives—are beginning to be understood. But most of the work so far has been empirical, and there is need for more fundamental research. What part artificial immunity or selective breeding can play in trypanosomiasis control only the future can show. But at present they seem promising.

ACKNOWLEDGMENTS

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This paper is presented by kind permission of the Director of Veterinary Services, Kenya.

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POSSIBLE UNDESIRABLE CONSEQUENCES OF WIDESPREAD CHEMOPROPHYLAXIS AGAINST BOVINE TRYPANOSOMIASIS —THE UPSET OF ESTABLISHED SOCIAL PATTERNS AND LAND USE

By V. N. Scott, East African Trypanosomiasis Research Organisation, Tororo, Uganda.

The established social patterns and land use of many tribes in East Africa has been influenced by the ability or inability to maintain cattle in a state of health. Tribal life amongst nomadic pastoralists such as the Masai in Kenya and the Hima in Western Uganda is completely dependent on the relative absence of the killing diseases in their herds and an availability of pasture and water over a wide area. More settled peoples, for example the Wasukuma in Tanganyika, practise a cattle/cotton economy and, according to the population pressure both in respect to human beings and cattle, extend their activities where conditions are most favourable. Even more settled conditions obtain in the Buganda Province of Uganda where the system of " mailo " land ownership gives the owner a security of tenure which encourages enclosure and the development of mixed farms in which soil fertility is maintained by the close integration of crops and cattle. The Banyoro in contrast provide an example of a one-time cattle-owning people whose economy is now based on the cultivation of cotton and tobacco; successive rinderpest epizootics in the past followed by depopulation and the advance of tsetse decimated the cattle population and restricted the survivors to a few circumscribed areas; the social pattern of the tribe became adjusted accordingly.

To most Africans the possession of cattle constitutes an end in itself. Irrespective of their economic worth and in excess of the nutritional, social and cash requirements of the owners, numbers are accumulated. Unless an adequate off take is assured, various degrees of overstocking result and this is usually followed by land erosion and its attendant evils. In the past killing diseases such as rinderpest, anthrax and pleuropneumonia resulted in a mortality " off take " which maintained cattle numbers at a low level. This restraint, however, no longer applies as control of these epizootics by widespread prophylaxis and other means has now been more or less achieved. Many of the cattle areas in East Africa are demarcated by a peripheral incidence of trypanosomiasis; in the absence of effective prophylaxis against the disease, occupation by cattle of the marginal tsetse areas is hazardous and occupation of fly-infested areas is not practicable. Trypanosomiasis restricts the land available for grazing and militates against the free movement of cattle from one area to another; it also prevents the exploitation of cattle or cattle/crop economies in areas of high soil fertility. It may well be that widespread prophylaxis against bovine trypanosomiasis, either by chemoprophylactic or biological means, will be possible within the foreseeable future and, irrespective of the presence of the tsetse vector, cattle will be maintained economically and in health over wide areas meanwhile denied to domestic stock by the incidence of the disease.

The solution to one problem invariably creates other problems. Undesirable consequences might result if the nomadic pastoralists extended their peripatetic activities and encroached on other tribal areas, if the cotton/cattle economy of the cultivators became unbalanced, more dispersed and lost its pressure, if the Buganda kept more cattle than their enclosed farms could maintain, if the Banyoro gave up cotton and tobacco cultivation and reverted to their traditional role of cattle keepers. Some of these suppositions may be hypothetical, there may be others which have not been mentioned. It does appear, however, that widespread chemoprophylaxis against bovine trypanosomiasis may result in several upsetting conditions unless stock numbers are controlled and an economic " off take " of cattle assured.

DOCUMENTS PRESENTED TO THE SEVENTH I.S.C.T.R. MEETING

DOCUMENTS PRESENTES A LA SEPTIEME REUNION DU C.S.I.R.T.

I. TRYPANOSOMIASIS/LA TRYPANOSOMIASE

B. Human Trypanosomiasis/La Trypanosomiase humaine

I.S.C.T.R. (58)

47 Report on the Chemoprophylaxis of *T. rhodesiense* sleeping sickness—(de Andrade Silva).

45 Rapport sur la Chimioprophylaxie de la Trypanosomiase à *T. gambiense*—(Demarchi).

21 The use of Chemoprophylaxis in the control of Trypanosomiasis in Northern Nigeria, with particular reference to the Diamidines—(Hay).

12 The characteristics of strains of trypanosomes isolated from persons infected with human trypanosomiasis in East Africa—(Robertson and Lomax).

14 Nouvelles observations au cours d'infections expérimentales par mélange de souches de trypanosomes polymorphes—(Vaucel et Fromentin).

19 The effect of different types of man-fly contact upon the distribution of *T. gambiense* sleeping sickness in Nigeria—(Nash).

23 The local reaction in man at the site of a fly transmitted infection of *Trypanosoma rhodesiense*—(Godfrey).

39 L'évolution de la trypanosome humaine dans les pays d'Afrique au cours des dix dernières années—(van Oye).

48 La trypanosomiase résiduelle en Afrique Occidentale Française—(Nodenot).

REPORT ON THE CHEMOPROPHYLAXIS OF *T. RHODESIENSE* SLEEPING SICKNESS

By M. A. de Andrade Silva (Director, Missao de Combate às Tripanosomiases — Mozambique)

During the previous meeting held in Salisbury, 1956, a resolution was passed to report, at the present meeting, the results obtained by chemical prophylaxis against Rhodesian trypanosomiasis, and it was decided that the Portuguese Government should appoint a rapporteur.

The present paper complies with the above-mentioned recommendation.

The scanty information received from the various territories where the disease is known to exist, does not enable us to say much on the subject.

Such as it is I am giving you data and references received.

BECHUANALAND

The Medical Department informs us of the very low incidence of this disease (four to seven cases yearly) and that no chemoprophylactic measures take place.

FEDERATION OF RHODESIA AND NYASALAND

Chemoprophylaxis is not in use in this country. Only twenty-four cases were reported in 1957 in a population of nearly seven and a half million people.

KENYA

In this country no chemoprophylactic measures against *T. rhodesiense* sleeping sickness are carried out.

MOZAMBIQUE

In this country we rely mostly upon the early detection and treatment of cases for the control of sleeping sickness.

However, during a serious epidemic outbreak in the area of Mocimboa da Praia we tried Pentamidine, as prophylactic, at the dose of 5 mg./kg. body weight.

The campaign was reported to this Committee during the Salisbury meeting (de Andrade Silva *et al.*, 1956).

According to our census the population of the area was 16,946 inhabitants.

The first injection was given, from April to October 1954, to 11,869, people. Infants, young children and old people were not injected and remained as controls (5,077).

Pentamidine injections were repeated every six months.

A second injection was given to 7,952 people from October 1954 to April 1955. The third injection was given to 5,165 people from April to October 1955. The last injection of Pentamidine was given again to 4,092 people from October 1955 to April 1956.

Of fifty-three new cases diagnosed during the application of Pentamidine, forty-seven were found amongst the "controls" and only six cases among those injected.

Of these six cases one had received only one Pentamidine injection three months before diagnosis, and another case had one injection two months before diagnosis. Both had serious C.S.F. changes and we presume they had been already infected before Pentamidine administration.

The third case had one injection seven months before diagnosis.

In the other three cases Pentamidine, being given regularly, undoubtedly failed as prophylactic.

Table I shows the new cases per month and the results obtained.

Until 1948 we injected people more exposed to infection such as hunters, surveyors, game wardens, and so on, with Bayer 205 at the dose of 1 gr. to adults. The injection was repeated every three months. One European became infected within three months: he had been injected seventy-three days before diagnosis. It was his first contact with the tsetse-fly. From 1948 onwards Pentamidine is used instead of Bayer 205 for individual protection.

RUANDA-URUNDI

In this territory *T. rhodesiense* sleeping sickness appeared for the first time, in 1954, in the area of Muhinga, that is in the eastern portion of the country adjacent to Tanganyika.

Marneffe (1955) reports the diagnosis, in March 1954, of ninety-seven cases amongst a population of 7,228 inhabitants.

A second census was carried out in the same area, in June 1954, after which chemoprophylaxis was launched.

Pentamidine, at the dose of 5 mg./kg., was given to 65% of the population, i.e. to 5,015 people and Moranyl, at the dose of 1 gr. per adult, was given to the remaining 35% (2,213 people).

In November of the same year two new cases were diagnosed amongst the people who had been injected. One patient had received Moranyl seventy-one days previously but on the date the disease was diagnosed the C.S.F. already presented great alterations. For this reason it was concluded that this patient already carried trypanosomiasis when injected.

The other patient had been injected with Pentamidine 139 days previously. As the C.S.F. was normal when the disease was diagnosed, he concludes that the disease was caught during the surmised period of protection conferred by the drug.

The injections were repeated.

Marneffe does not mention the interval between injections of either of the two drugs.

Recently we were informed that the disease appeared also, in 1955 and 1956, in other areas of Ruanda-Urundi: in 1955 in the Kigali sector and in 1956 in that of Ruyigi-Rutana.

During 1956, 22,641 injections of Bayer 205 (Moranyl) were applied in the following areas:

Kigali sector	5,953
Muhinga sector:	
(a) Niakisozi	11,403
(b) Kinazi	3,970
Ruyigi-North sector	1,135
Total	22,461

The prophylactic campaign started in March.

The interval between injections was four months. Only adults and adolescents received injections.

No reasons are given why Pentamidine was put aside.

Amongst the new cases which were diagnosed in 1956, one patient had received Bayer 205 injections regularly.

During 1957, 30,011 injections of Bayer 205 (Moranyl, Antrypol) were given as follows:

Sector	To Residents	To Travellers	Total
Kigali	7,145	55	7,200
Muhinga	15,568	3,966	19,534
Ruyigi-North	3,148	129	3,277
Totals	25,861	4,150	30,011

Only adults and adolescents were injected. Eleven new cases were diagnosed, three of which had been regularly receiving Bayer 205.

In Table II we can follow the results obtained by the chemical prophylaxis.

TANGANYIKA

According to a letter from the East African Trypanosomiasis Research Organisation no prophylactic measures take place in this territory against Rhodesian trypanosomiasis.

UGANDA

To control *T. rhodesiense* sleeping sickness the Medical Department rely entirely upon the early detection and treatment of cases. It is feared that the use of prophylactic drugs would cause a serious degree of resistance.

Table I

New Cases of Sleeping Sickness in Mocimboa da Praia Area (Mozambique) from 1953 up to 1956

1953	1954												
	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Total
104	10	15	34	3	1	1	3	2	4	3	3	–	78

1955												
J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Total
3	3	2	2	3	1	1	3	2	–	1	4	25

1956												
J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Total
1	2	3	3	2	2	2	–	–	–	1	1	17

N.B.—Pentamidine started in April 1954 and injections were repeated every six months during two years

Table II

New Cases of Rhodesian Trypanosomiasis in Ruanda-Urundi

	1954	1955	1956												
			J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Total
Kigali sector															
(*a*) Bugesera North	–	5	–	–	–	–	3	–	1	–	–	–	–	–	4
(*b*) Bugesera South	–	15	2	3	–	1	1	3	–	–	–	1	1	–	12
Muhinga sector															
(*a*) Nyakisozi	–	56	35	12	24	20	2	–	4	2	3	3	–	1	106
(*b*) Kinazi	97	1	2	–	2	1	–	–	–	–	1	1	–	1	8
	97	77	39	15	26	22	6	3	5	2	4	5	1	2	130

	1957												
	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Total
Kigali sector													
(*a*) Bugesera North	–	–	–	–	–	–	–	1	–	–	–	–	1
(*b*) Bugesera South	–	–	–	1	–	–	–	–	–	–	–	–	1
Muhinga sector													
(*a*) Nyakisozi	–	–	1	1	1	2	–	–	3	–	1	1	10
(*b*) Kinazi	–	–	–	–	–	–	–	–	–	–	1	–	1
	–	–	1	2	1	2	–	1	3	–	2	1	13

N.B.—In Kinazi area Pentamidine and Bayer 205 were used in mass prophylaxis in 1954 and 1955. From June 1956 onwards Bayer 205 was the only drug in use.

In Nyakisozi area chimioprophylaxis with Bayer 205 started March 1956.

In Kigali sector prophylaxis with Bayer 205 started in April 1955.

DISCUSSION

From the data of Mozambique and Ruanda-Urundi we can say that in areas where the disease presented itself in the epidemic form, chemoprophylaxis was of great help, the incidence coming down quickly as a result.

Of the two drugs, Bayer 205 and Pentamidine, it is difficult to say which is the better for the prophylaxis of *T. rhodesiense* sleeping sickness. Both were used with similar results.

It is too early to come to definite conclusions as we have little experience as yet in this field of investigation. So far we do not know exactly how chemical protection works against trypanosomiasis. It seems to depend mainly on the dose of the drugs used. Also it is important to know for how long drugs are retained in the body and there is no accurate accessible method to determine the small residual quantities of Pentamidine and Bayer 205 present in the tissues.

There must be individual differences in the elimination of drugs and, consequently, in their retention. This may explain why these drugs fail as prophylactics in some individuals and do not in others.

From the information at out disposal mass chemoprophylaxis with both Pentamidine and Bayer 205 gave quick and spectacular results in the epidemic form of *T. rhodesiense* sleeping sickness.

In the usual low endemic form of *T. rhodesiense* sleeping sickness, which is quite similar to the residual Gambian trypanosomiasis, mass chemoprophylaxis has no chance and it would prove too expensive.

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RAPPORT SUR LA CHIMIOPROPHYLAXIE DE LA TRYPANOSOMIASE A *T. GAMBIENSE*

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Le complexe pathogène de la maladie du sommeil causée par *T. gambiense* ne repose que sur deux pivots : l'homme, malade et réservoir, et la glossine vectrice. Les mesures prophylactiques, en présence d'une telle chaîne épidémiologique, peuvent donc se rapporter à trois méthodes :

— La stérilisation de l'homme malade, " réservoir de virus ". C'est ce que recherchait la méthode de dépistage-traitement, codifiée et mise en application extensive, dans les territoires français, par Jamot.

— La destruction des glossines, avec toutes les difficultés inhérentes à la lutte contre des insectes ailés exophiles répandus sur 10 millions de km^2 environ (Buxton), lutte étroitement dépendante de l'écologie des mouches, de leurs possibilités de migration et des facteurs économiques locaux.

— Enfin la protection des sujets sains.

Cette dernière méthode a, au cours de ces douze dernières années, obtenu des résultats spectaculaires que nous présentons dans ce rapport, pour satisfaire à la recommandation D5 de la 6ème réunion du C.S.I.R.T. (Salisbury, 1956).

1° LA CHIMIOPROPHYLAXIE

Tous les essais d'immunisation biologique de l'homme contre *T. gambiense* se sont, jusqu'à présent, soldés par des échecs. On s'adressa donc à la chimioprophylaxie, telle qu'elle fut définie, dès 1929, par Launoy :

" Une méthode qui, introduisant dans l'organisme sain une quantité relativement faible d'un produit chimique défini, provoque chez cet organisme un état réfractaire tel qu'il soit à l'abri pendant de longs mois contre une infection déterminée. Autrement dit, il faut exiger de la prophylaxie chimique les caractéristiques qui sont celles de l'immunisation biologique par l'emploi des vaccins : injection de très petites quantités de produit actif, réactions organiques négligeables, immunisation certaine en milieu épidémique et endémique, longue durée de l'immunisation."

De nombreux essais avaient déjà été tentés avec les produits trypanocides connus, mais, comme l'avaient montré Mesnil et Brimont, l'élimination rapide des arsenicaux ne permettait pas d'obtenir une action préventive nette. La technique dite de doppel-injektion de Koch, reprise ensuite par Jamot avec des doses plus faibles, ne laissait espérer que la stérilisation partielle de malades ayant échappé au dépistage.

Le Bayer 205 (Moranyl, Suramine), dont l'apparition avait suscité des espérances, ne conférait qu'une courte protection (2 à 3 mois) malgré les fortes doses administrées. Ce n'est qu'avec les diamidines que l'on parvint à réaliser une véritable chimioprophylaxie.

Nous ne nous étendrons pas sur l'historique de la découverte de ces trypanocides. Bornons-nous à rappeler qu'à la suite des travaux de N. et H. Jancso sur la synthaline en 1935, Ewins synthétisa, peu avant la guerre, divers dérivés de la guanidine dont l'un en particulier, le M.B. 800 ou diamidinodiphénoxypentane, se révéla, à la suite d'essais expérimentaux ou cliniques, doué d'une action curative (King, Lourie et Yorke 1937, McLetchie 1940) ou préventive (Launoy et Lagodsky 1940).

Les premiers essais de prophylaxie humaine en Afrique, effectués par van Hoof, Henrard et Peel, en 1944, se révélèrent très encourageants: appliquée à tous les sujets menacés, la méthode semblait devoir supprimer à la fois l'infection et la transmission. En effet, van Hoof, Lewillon, Henrard, Peel et Rodjestvensky (1946) montraient que l'action préventive des diamidines aromatiques s'étendait sur une période de 6 mois.

Depuis, quelques essais furent tentés avec d'autres produits, mais aucun ne permit de détrôner les diamidines dans la réalisation de l'action de masse requise par l'extension de la maladie.

Nous étudierons tout d'abord l'étendue de cette application avant de passer en revue ses techniques et ses résultats.

2° GEOGRAPHIE DES ZONES TRAITEES

Si on ne trouve de trypanosomiase humaine que là où existent des glossines, l'inverse n'est cependant pas vrai, et la carte montre de vastes zones où les glossines peuvent être présentes et où il n'y a pas de maladie du sommeil.

Ces " zones libres " ne doivent pas tant cette absence au manque d'apport du trypanosome qu'à un manque de contact étroit entre l'homme et la tsé-tsé. On sait que les modalités du contact homme-mouche dépendent de circonstances climatiques, entomologiques, biogéographiques ou sociales ou enfin biologiques.

Selon le type climatique de la région considérée, les tropismes des glossines présentes, les habitudes économiques ou sociales des populations humaines et la qualité de la souche de trypanosomes en cause, la trypanosomiase présentera un aspect épidémiologique très particulier, nécessitant une technique de lutte appropriée.

Afin d'avoir des renseignements directs sur les méthodes pratiquées en diverses régions d'Afrique, nous avons adressé un questionnaire aux Services responsables de la lutte contre la maladie du sommeil dans les Territoires suivants: A.O.F., Angola, Cameroun, Congo Belge, Gambie, Ghana, Guinée Portugaise, Libéria, Nigéria, Sierra Leone, Togo.

Nous reproduisons, en annexe de ce rapport, le texte de ce questionnaire ainsi que les réponses qui nous ont été fournies par l'A.O.F., l'Angola, le Cameroun, le Congo Belge, la Gambie, la Nigéria et le Togo. Nous prions nos correspondants de trouver ici l'expression de notre gratitude. En ce qui concerne l'A.E.F., nous avons pu, grâce au Médecin-Colonel Beaudiment, avoir accès aux Archives du Service des Grandes Endémies, dont nous avons utilisé les rapports.

Ces réponses permettent de définir l'idée d'ensemble de la progression suivie dans l'application de la chimioprophylaxie.

a) Délimitation des zones infectées

Toute mesure de lutte doit être précédée d'une parfaite délimitation géographique de la maladie. On se souvient, d'ailleurs, que, dans ses recommandations faisant suite à la réunion de Lourenço Marques en 1952, le Comité préconisait le processus suivant:

— Examen complet de la population.

— Diagnostic préliminaire approfondi de tous les malades, y compris l'analyse systématique du sang de tous les sujets examinés.

— Application de la prophylaxie à tous, à l'exception des inaptes pour raison médicale.

— Définition des zones à traiter basée sur des considérations épidémiologiques et géographiques exactes.

C'est, à peu de choses près, la méthode utilisée dans les divers Territoires.

L'opération comporte toujours deux temps, dépistage-chimioprophylaxie, qui peuvent être accomplis par la même équipe ou par deux équipes qui se suivent, mais il semble actuellement que le premier procédé soit le plus généralement adopté.

La composition des équipes de prospection et prophylaxie varie selon les pays. Certains préfèrent utiliser des équipes massives capables de faire un grand nombre d'examens et d'injections à la fois. C'est ainsi que l'équipe mobile type, en Angola, comporte une cinquantaine de personnes transportées dans quatre camions de 4.500 kg. De telles équipes peuvent examiner 800 lames de sang ou de suc ganglionnaire par jour, ce qui suppose la possibilité de réaliser des rassemblements très importants.

Etant donnée la faible densité habituelle de population en Afrique, la plupart des autres territoires préfèrent mettre sur pied des équipes plus restreintes ne comportant au maximum qu'une dizaine de personnes, soit: 1 médecin ou agent technique expérimenté, 4 à 6 microscopistes et aides infirmiers, 1 manœuvre, 1 agent recenseur et 1 chauffeur. En certains endroits, le travail de prospection peut être assez facilement réalisé par un personnel restreint, lorsqu'il s'agit de surveiller des collectivités de travailleurs, chez lesquels les problèmes administratifs de rassemblement sont réduits au minimum et où le travail peut être effectué en plusieurs séances.

Quoi qu'il en soit, les principes d'action demeurent immuables: ce sont ceux que Jamot préconisait en 1920, et ils sont appliqués dans tous les territoires:

— Il est nécessaire d'opérer dans une zone bien délimitée. Partout le découpage en secteurs pouvant être visités dans le courant de l'année par une ou plusieurs équipes a montré son utilité.

— Il est capital d'obtenir un indice de présence le plus possible voisin de 100%.

— Enfin, le dépistage doit être à la fois clinique et biologique et comporter, avec l'examen des sujets présentés, l'examen systématique du sang en goutte épaisse et la recherche des trypanosomes dans le suc ganglionnaire et le L.C.R. des suspects. En outre, le L.C.R. de ces suspects sera soumis aux examens cytologiques et chimiques d'usage.

L'examen systématique de la goutte épaisse semble généralisé dans les pays où la lutte contre la maladie du sommeil est menée avec vigueur. Cependant, actuellement en A.E.F., dans les zones où la trypanosomiase ne semble pas avoir donné de signes d'activité depuis quelques années, on se contente d'examiner le quart ou la moitié des prélèvements. Si aucun trypanosomé n'est ainsi dépisté, le reste des prélèvements est rejeté. On doit souligner que l'aspect épidémiologique de la maladie dans la région considérée influe directement sur la technique de dépistage (Vaucel et Jonchère 1953): dans la plupart des zones d'endémie le diagnostic de certitude se fait après triage clinique par la ponction ganglionnaire suivie d'examen à l'état frais du suc recueilli. Selon McLetchie (1948), en Nigéria, chez 30% des malades présentant des trypanosomes dans les ganglions, l'examen du sang est négatif. Par contre, Akwei (1952) a décrit au Ghana des formes sans adénopathies où seul le sang renfermait des trypanosomes. Il en était de même du "Type Fuero" de maladie décrit par Harding et Hutchinson, en Sierra Leone. Du point de vue dépistage, les formes à tendances épidémiques doivent être recherchées par l'examen du sang.

Selon ce dépistage, les indices épidémiologiques habituels ICN (indice de contamination nouvelle) et IVC (indice de virus en circulation = parasite index) seront établis (C.S.I.R.T. 1948).

D'autre part, l'étude des résultats trouvés dans la région permet de classer la répartition géographique dans l'une des catégories de Lotte ou de Saunders: riveraine, linéaire, focale, en nappe, rurale, régionale, suburbaine.

b) **Décision d'application de la chimioprophylaxie**

Lorsque l'incidence de la maladie, sa répartition géographique, son aspect épidémiologique et les caractères de la population sont connus, une décision doit être prise concernant l'opportunité de l'application de la chimioprophylaxie et ses modalités.

Il semble que 3 facteurs principaux puissent guider les responsables:

— la densité de l'infestation humaine,
— les risques d'extension,
— les possibilités administratives.

— La densité de l'infestation humaine est le plus souvent liée aux modalités du contact homme-mouche, mais on la mesure grâce à l'évaluation des indices épidémiologiques obtenus à la suite des opérations de dépistage. Il ne semble pas, en l'occurrence, qu'un accord soit intervenu concernant le chiffre critique à partir duquel l'application de la chimioprophylaxie soit rendue nécessaire. Il y a 10 ans, dans la plupart des foyers, l'ICN était supérieur à 1 et certains chefs de service, en A.E.F. par exemple, pensaient que toute localité présentant un ICN supérieur à 1 devait être traitée. Il en est encore ainsi en A.O.F., mais nous verrons plus loin les modifications que les résultats obtenus ont permis d'apporter à ce principe.

— Les risques d'extension sont fonction de la situation géographique de la localité étudiée. Là encore interviennent les modalités du contact homme-mouche qui peut être, selon Nash, "étroit personnel" ou "étroit impersonnel". Il est bien évident qu'une opération menée en un point situé sur une grande voie de communication présente un caractère d'urgence plus marqué que lorsqu'il s'agit d'une localité isolée en un endroit peu accessible. D'autre part, lorsque plusieurs villages d'une même zone sont infestés, même si certains ne présentent qu'un faible taux, la zone entière doit être soumise à la chimioprophylaxie. Ainsi donc, les conditions épidémiologiques de possibilité de transmission priment, dans une certaine mesure, la densité de l'infestation. En effet, si Jamot préconisait une prospection centrifuge des foyers "à la recherche du zéro absolu", la chimioprophylaxie doit être appliquée dans la totalité de l'aire ainsi définie, en débordant même assez largement ses limites.

— Les possibilités administratives viennent malheureusement apporter une restriction à ces principes. Comme nous le verrons lorsque nous étudierons la technique d'application, les conditions socio-économiques amènent le plus souvent les autorités à limiter un effort qui risque d'être rendu inopérant par les difficultés rencontrées dans son application. Le souci d'efficience a pu amener certains services de lutte à renoncer à traiter certaines régions où des contingences, telles que les difficultés d'accès et surtout le nomadisme des populations, risquaient d'amener à un échec.

Ainsi donc, dans l'exposé qui va suivre sur les zones traitées dans les divers pays où sévit la Maladie du Sommeil à *T. gambiense*, les différences de tactiques ont pour causes : soit les conditions épidémiologiques, soit les conditions socio-économiques.

c) Les zones traitées dans les divers pays

A.E.F.

Dans ce groupe de territoires, étendu sur plus de 3.000 km. du Nord au Sud, la limite Nord de la Maladie du Sommeil est située au Tchad, entre 9 et 10° de lat. N.

Au-dessous de cette limite, dans une région de savane soudanienne puis guinéenne, elle sévit dans l'angle Sud-Ouest de ce territoire, dans les vallées du Logone et du Chari.

La presque totalité des trois autres territoires (Oubangui-Chari, Moyen-Congo et Gabon), zone de forêt équatoriale ou de savane arbustive, est infectée en nappes, de répartitions variables. C'est là, pour reprendre l'expression de Sice, " le terroir d'élection " envahi par la trypanosomiase humaine lors de sa grande diffusion africaine de 1895–1897.

Au moment de l'instauration de la chimioprophylaxie, en 1946, et quoique la lutte y fût menée avec opiniâtreté depuis 1906 à l'aide des méthodes de dépistage-traitement ainsi que de prophylaxie agronomique, 3 foyers principaux de trypanosomiase étaient l'objet de préoccupations du S.G.H.M.P. qui venait d'être créé (Kernevez et Chassain 1951).

1° — Un foyer Moyen-Congo-Gabon, situé au-dessous de l'Equateur, traversant les régions congolaises et gabonaise, d'Est en Ouest, de la Likouala à la mer et s'étendant du Nord au Sud de la frontière camerounaise au Cabinda (Sud-Ouest) et au Congo (Sud-Est), ce dernier fleuve formant alors la frontière, zone dite du " couloir " entre le Congo Français (Brazzaville) et le Congo Belge (Léopoldville).

Couverte de forêt humide, ou de steppe arbustive sur les plateaux avec toujours cependant des îlots forestiers ou des forêts galeries dans les vallées, cette zone est le domaine de *G. palpalis.* On y trouvait des IVC (parasite-index) de 7% (Gamboma) 5,7% (Maribou) 5,9 (Kellé) et 5,4% (Makoua), et même des ICN de 31,25% (Bokaba) et 11,53 (Léfini) dans certains postes à bois du " couloir ". (Raynal.)

2° — Un foyer situé au-dessus de l'Equateur, comprenant l'important secteur de Nola (entre le bassin de la Sangha et celui de la Kadéi), où l'IVC atteignait 16,5%.

3° — Un foyer septentrional touchant le Tchad par le Logone et s'étendant vers le Sud jusqu'au bassin de l'Oubangui, dans la région de Bambari et Mobaye. L'épidémie y faisait place à l'endémie, sauf dans certaines zones comme Moundou, où l'ICN dépassait 3%. 10 secteurs du Service d'Hygiène et de Prophylaxie couvraient ces zones; ils furent ensuite portés à 15, dans lesquels 30 équipes mobiles polyvalentes s'occupent du dépistage, du traitement et des injections prophylactiques.

Ces équipes, toujours itinérantes, suivent le plan de campagne établi chaque année.

2.731.193 habitants sont recensés dans les secteurs couverts par leurs prospections.

La chimioprophylaxie par injections biannuelles fut appliquée dans tous les secteurs, tout d'abord sur le principe de la chimioprophylaxie totale dans les premiers foyers traités où les indices parasitaires étaient élevés, en couvrant largement les zones infectées. Les villages isolés où l'ICN atteignait 1% étaient traités, et si plusieurs villages de la même zone étaient dans ce cas, on traitait tout le district.

Avec l'extension donnée à la méthode (Lotte-Richet), la chimioprophylaxie fut appliquée de façon plus souple.

On pratiqua une prophylaxie sélective et limitée dans l'espace aux foyers à systématisation caractérisée : riveraine, linéaire, focale.

Dans le cas contraire cependant, la méthode fut appliquée plus largement à la population des zones géographiquement ou ethniquement homogènes — parfois encore à des districts entiers où l'IVC (parasite-index) était supérieur à 1.

C'est ainsi qu'en 1954 M. Richet distinguait :

1. Des zones de type épidémique comme le foyer oubanguien de Bimbo.
2. Des zones endémiques historiques capables de réveils épidémiques (Nola, la vallée du Niari, la région de Bossembele).
3. Des zones à endémicité constante traversées par de nouveaux pérégrinants — par exemple le couloir congolais.
4. Des zones à endémicité résiduelle comme le cours de l'Alima.
5. Des foyers actifs très limités, isolés par des zones saines.
6. Des foyers très faiblement endémiques où l'on ne peut cependant liquider totalement le réservoir de virus par l'action du dépistage-traitement.

Les progrès accomplis permettent actuellement de n'appliquer la méthode que dans les villages où 1 trypanosomé a été dépisté, ainsi qu'aux villages voisins qui peuvent être en relation et présenter un contact commun avec les mêmes gîtes à glossines (point d'eau commun).

De même, la méthode est appliquée à la population permanente des zones de passage où une importante population mouvante est observée.

Depuis 1946, 2.787.810 lomidinisations ont été pratiquées.

Actuellement, le nombre d'injections va diminuant, les foyers étant de mieux en mieux circonscrits : pour 2.337.633 personnes visitées en 1957, seulement 193.233 ont reçu des injections prophylactiques, dont 32.947 deux fois au cours de l'année.

A.O.F.

En 1939, 175.934 cas de maladie du sommeil avaient été dépistés dans les 31 secteurs spéciaux et les 43 secteurs annexes de l'A.O.F., sur une population de 8.226.496 habitants soumis au dépistage systématique.

La chimioprophylaxie fut commencée en 1946 (Brun-Buisson 1947, Le Rouzic 1949) et vint compléter les mesures de dépistage-traitement et de prophylaxie agronomique déjà entreprises.

Il est difficile, dans un territoire aussi vaste, de donner en détail la répartition géographique de la maladie. Contentons-nous de dire que les régions les plus atteintes correspondaient à la bande de savane guinéenne et soudanienne, entrecoupée d'îlots forestiers et de galeries forestières, qui va de la Casamance au Dahomey, soit : la Casamance, le Fouta Djalon et les zones avoisinantes de Guinée, les vallées des fleuves de Côte d'Ivoire, les pays Lobi et Mossi de Haute-Volta, la région Nord du Dahomey.

Les premiers essais eurent lieu en décembre 1946, dans la forêt de Guinée et Casamance, où l'ICN était supérieur à 5%.

Depuis, la méthode fut appliquée en divers cantons du Sénégal, de Guinée, de Côte d'Ivoire, de Haute-Volta, du Soudan et du Dahomey, partout où la situation épidémiologique paraissait précaire. (Jonchère 1951).

Dès le début sélective, la chimioprophylaxie est encore maintenant appliquée dans des régions très limitées, cantons ou villages :

— soit en raison des facilités offertes pour traiter une population de travailleurs réunis sur un chantier et exposés à la trypanosomiase, comme en Casamance (Personnel de la C.G.O.T. près de Sédhiou),

— soit en raison des risques d'extension encourus dans des zones forestières aux populations mal fixées, ou de la systématisation épidémiologique de la maladie comme en Guinée, le long de la frontière du Libéria et dans le massif du Fouta Djalon ; en Côte d'Ivoire, le long du Cavaly (frontière du Libéria) et du Lobo, (près du Ghana) ; en Haute-Volta, le long de la Léraba, dans le canton de Toumana ; au Soudan, dans la région de Segou et Bamako, le long du Niger.

Les mêmes équipes mobiles assurent la prospection et les séances d'injections prophylactiques. Le plan de campagne tient compte des résultats de la prospection (examen systématique du sang en goutte épaisse), les villages dans lesquels l'ICN atteint ou dépasse 1% étant traités, ainsi que les endroits les plus exposés des frontières ou des cours d'eau fréquentés par de nombreux voyageurs.

Angola

La zone contrôlée par les services de lutte contre la Maladie du Sommeil en Angola englobe les districts administratifs du Congo, de Cuanza Norte et de Luanda, entre la frontière Nord et le 10° lat. Sud environ.

Des prospections périodiques sont faites, par des équipes mobiles, dans les districts de Cabinda, Malange et Cuanza Sul.

Ce vaste territoire est constitué géographiquement par une zone littorale, pénétrant jusqu'à 150 km. de la Côte, de faible altitude inférieure à 400 m., zone de steppe entrecoupée de galeries forestières le long des fleuves ; la pluviosité y est inférieure à 700 mm. par an.

— une zone de plateau, à des altitudes de 400 à 1.200 mètres, à pluviosité supérieure à 1.000 mm. par an, à végétation de savane sur les hauteurs et de forêt dans les vallées.

Il est parcouru par de nombreux cours d'eau appartenant aux bassins hydrographiques des fleuves Congo, M'bridge, Loge, Dande et Cuanza.

La chimioprophylaxie y est appliquée depuis 1949, et s'étend à toute la population des districts de Cuanza Norte, Luanda et Congo, à l'exception des zones où l'on n'observe aucun cas autochtone de la maladie.

Cinq équipes mobiles assurent le dépistage et l'application des injections chimioprophylactiques et sont en tournée 11 mois dans l'année.

Toute la population de la zone endémique est observée au moins une fois par an par les équipes mobiles. De plus, les chefs de secteurs sanitaires recherchent tous les 3 mois les trypanosomés de leur secteur. La chimioprophylaxie est appliquée sur le mode sélectif, dans les zones où des cas autochtones ont été dépistés.

Cependant, il existe encore une large zone où elle est appliquée sur le mode total : il s'agit des secteurs de la frontière Luso-Belge, où l'extrême mobilité des populations, de part et d'autre, rend leur contrôle extrêmement difficile (Cardoso de Albuquerque). C'est là que s'accroche le foyer endémique le plus intense de toute la province. Or, en 1949, l'indice de virus en circulation global, pour les trois districts infectés, était de 4,77%.

Cameroun

Le territoire entier du Cameroun est soumis au contrôle de la trypanosomiase. Celui-ci est effectué par des équipes polyvalentes du S.H.M.P., constituées sur le mode décrit pour les Territoires d'A.E.F. et d'A.O.F.

La trypanosomiase existe sous forme de cas sporadiques dans presque toute la zone Sud du Cameroun, zone forestière limitée au Nord par le plateau de l'Adamaoua. Ce plateau, ainsi que la zone Nord du Pays, est pratiquement indemne, à l'exception d'un foyer tenace situé le long du Logone et du Chari, en aval de Logone Birni. Ce foyer est difficilement contrôlable pour les mêmes raisons que celles évoquées plus haut ; population frontalière instable, difficile à saisir et à recenser, constituée de tribus nomades de pasteurs, de colporteurs circulant entre l'A.E.F. et la Nigéria, de pêcheurs Kotokos résidants saisonniers.

La chimioprophylaxie fut appliquée sur le mode sélectif dans les diverses zones contaminées :

1. Les rives du Logone et du Chari, bordées de végétation arbustive propice à l'existence de G. *tachinoides*.
2. Le pays Tikar s'étendant à l'intersection des régions de l'Adamaoua, de Mbam et de Foumban. Dans cette plaine, les forêts galeries, le long du Mbam et de ses affluents, constituent des gîtes actifs.
3. La zone montagneuse du pays Bamileké présente deux foyers de petite taille : la vallée du Noun autour de Bati et de Bamindjing, et une zone située au Nord de la subdivision de Bafang.
4. La subdivision de Mbang à la frontière de Cameroun britannique.
5. La zone côtière à l'estuaire du fleuve Vouri.
6. La région de Nyong et Sanaga, où se trouvent des cas disséminés.
7. La subdivision de Campo sur le littoral.
8. Le foyer M'Bimou, correspondant au très grave foyer de Nola en Oubangui (A.E.F.).

9. Enfin le foyer du Haut-Nyong, historique, où Jamot avait trouvé autrefois des indices de l'ordre de 90%.

Les considérations déterminant l'application de la chimioprophylaxie portaient sur le taux des IVC (inférieur ou égal à 0,5%) et sur les conditions épidémiologiques locales.

Actuellement deux foyers sont encore protégés par la lomidinisation:
— celui des rives du Logone et du Chari
— celui de l'estuaire du Vouri.

Quoique les indices y soient généralement inférieurs à 0,5%, la prophylaxie est maintenue en raison des possibilités d'apports constants de trypanosomés dans une population aussi mouvante.

En outre, des postes-filtres appliquent les injections préventives aux immigrants saisonniers tels que les pêcheurs Massa du Logone et du Chari (cf. Feyte).

En 1957, sur une population visitée de 657.715 sujets, 20.358 injections préventives ont été pratiquées.

Congo Belge

On trouve au Congo Belge de larges zones infectées de trypanosomiase qui comprennent — en gros — la totalité de la province de Léopoldville, du Kasaï et du Katanga, la moitié Ouest de la province de l'Equateur, et une zone voisine de la frontière du Soudan, dans la province Orientale. Enfin, une enclave du Ruanda-Urundi.

Nous avons déjà rappelé que les premiers essais de chimioprophylaxie par les diamidines aromatiques dans la nature avaient été réalisés au Congo Belge par Van Hoof et ses collaborateurs, de 1940 à 1944, dans la zone d'assistance du FOREAMI, en province de Léopoldville.

Dans l'ensemble du pays, les villages menacés sont classés sur des bases parasitologiques: recherche de trypanosomes dans le sang, les ganglions et éventuellement le LCR.

La méthode sélective est généralement appliquée dans l'ensemble du pays.

C'est ainsi qu'en 1949, Scaillet et Haddad notaient, à l'occasion d'une campagne effectuée dans le Secteur des Cataractes, que la pentamidine était administrée dans tous les villages où le taux d'infection dépassait 1%.

Actuellement même, on admet que le point critique n'est atteint que lorsque l'ICN s'élève à 2%.

Cependant, depuis 1949, la chimiopropnylaxie est appliquée à des secteurs administratifs entiers dans la zone occupée par la section d'assistance du FOREAMI.

De 1945 à 1947, 3.637.868 injections préventives ont été pratiquées.

Nigéria

La zone de Nigéria où sévit la trypanosomiase humaine est située entre le 7° et le 12° degré de lat. Nord, avec une extension vers le Nord, le long du système orographique de l'Hadejia, dans la province de Kano, et une extension vers le Sud, dans la province d'Ogoja, en région orientale.

A l'origine, il semble qu'il n'existait qu'une distribution riveraine de la maladie le long des rives du Niger et de la Bénoué. Cette région à climat stable, à humidité constante, sans saisons extrêmes, présentait un état épidémiologique pratiquement constant, parmi une population soumise à un contact largement impersonnel avec la Tsé-Tsé.

Mais la pénétration européenne, là comme dans toute la partie de l'Afrique qui nous occupe, allait, en favorisant les échanges, élargir l'expansion de la maladie.

Les limites septentrionales de la maladie sont liées aux conditions de climat, avec une saison froide et très sèche déterminant des concentrations saisonnières des mouches et un état épidémiologique sporadique et irrégulier dans la population humaine.

Les limites occidentales et orientales ont pour cause l'amenuisement de la population dans ces contrées. En outre, les mouvements de populations suivent un axe Nord-Sud plutôt que Est-Ouest.

Vers le Sud, le facteur limitant est moins facile à définir.

La trypanosomiase à *T. gambiense* s'étend donc au Nigéria sur une vaste région de quelque 390.000 km.², donnant asile à 9 millions d'habitants.

Deux types de répartitions s'y observent :

— répartition riveraine, sur le système orographique du Niger et de la Bénoué,

— répartition focale ailleurs, avec, au Nord, un aspect épidémiologique particulier, lié aux variations climatiques saisonnières.

La chimioprophylaxie y est appliquée sur le mode sélectif et la décision d'application dépend tantôt de facteurs administratifs, comme chez les travailleurs des mines d'étain du plateau méridional, protégés depuis 1946 par des injections bi-annuelles de pentamidine ; tantôt de facteurs épidémiologiques, comme dans les zones de Ndzorov, Kambe, Mbasaan et Abinsi (division de TIV, province de la Bénoué), où la répartition focale de la maladie permet d'agir dans des îlots séparés les uns des autres par des zones saines.

Au **Togo**, comme en **Gambie**, la chimioprophylaxie n'est pas appliquée. Dans le premier de ces territoires, la décision de ne pas utiliser cette méthode est liée à la faible endémicité de la trypanosomiase dans le bassin de l'Oti, seule région infectée, située au Nord du 8° parallèle et comprenant les circonscriptions de Dapango, Mango, Lama-Kara, Sokodé et Bassari.

Nous n'avons pu obtenir de renseignements sur les autres territoires intéressés par la maladie du sommeil à *T. gambiense*.

3° LA TECHNIQUE DE CHIMIOPROPHYLAXIE

A. PRINCIPE DE BASE

Comme on le voit par ce bref survol des conditions de lutte dans les divers territoires, à part quelques exceptions, la chimioprophylaxie n'est, en général, pas appliquée à des secteurs administratifs entiers, mais plutôt sur le mode sélectif en se limitant à certaines communautés.

3 raisons justifient cette façon de procéder:

— des raisons épidémiologiques,
— des raisons financières,
— des raisons administratives.

— Nous ne reviendrons pas sur les raisons épidémiologiques dont nous avons déjà dit quelques mots ci-dessus.

— Les raisons financières sont faciles à comprendre : il est fort coûteux de lancer de nombreuses équipes dans la nature et il est peut-être inutile de gaspiller de l'argent et du temps pour un résultat problématique.

— Les raisons administratives interfèrent à la fois avec les possibilités de dépistage, d'une part, et d'application de la chimioprophylaxie, d'autre part.

Assez complexes, elles relèvent des conditions de travail, des conditions de discipline et des mœurs de la population.

a) **Les conditions de travail** apportent aux autorités médicales des facilités plus ou moins grandes de réunir la population avec une plus grande chance d'obtenir un indice de présence voisin de 100%. C'est ainsi que, partout où existent des sociétés fixes occupant une grande quantité de travailleurs, il est facile, lorsque ceux-ci sont exposés à la Maladie du Sommeil, de les réunir, de les recenser et de les traiter.

Dans la vallée du Niari, où l'on trouve de nombreuses exploitations importantes, l'indice de virus en circulation, qui était de 2,7% en 1946, a pu être ramené à des chiffres situés entre 0,002 et 0,006% uniquement dus à la population flottante. Le Docteur Hay nous apporte un autre exemple du rôle de ce facteur social, en citant les travailleurs des mines d'étain, faciles à atteindre, chez lesquels la chimioprophylaxie fut parfaitement couronnée de succès.

En outre, il arrive parfois que la direction de certaines grandes compagnies provoque elle-même la décision d'appliquer la chimioprophylaxie à son personnel. Un exemple nous est donné par la Compagnie des Oléagineux Tropicaux en Casamance.

b) **Les conditions de discipline,** qui interviennent déjà dans le précédent facteur, représentent la contribution des autorités administratives à l'action médicale.

En effet, la décision d'application de la chimioprophylaxie fait, en général, établir à l'avance un plan de campagne: il est nécessaire alors d'obtenir l'accord des autorités, de prévoir des centres de rassemblement facilement accessibles aux équipes mobiles et pas trop éloignés des villages à traiter.

Le regroupement des villages le long des axes routiers a, en certains endroits, facilité le travail des équipes mobiles, mais il est encore des régions dont l'accès est difficile. Récemment encore, dans la région de la Likouala, en forêt inondée, un agent sanitaire devait faire en saison sèche un détour de 800 km. pour aller effectuer sa tournée.

L'organisation des tournées et des rassemblements ne peut se faire avec efficacité que dans des régions socialement structurées où l'autorité des Chefs de villages, de terres ou de districts est forte et reconnue.

Il est également indispensable d'opérer sur une population parfaitement recensée. Si l'action prophylactique de la lomidine peut éventuellement s'accommoder de quelques défections, comme l'a montré Fairbairn (Procès-verbal de la Réunion du C.S.I.R.T. de Pretoria, 1954, p. XVII), il n'en est pas de même du dépistage qui doit être effectué sur la totalité de la population pour être valable. C'est ainsi qu'en 1952, il fut nécessaire en Oubangui d'arrêter prospection et lomidinisation dans les districts de Bossangoa et de Bouca, l'indice de présence étant tombé au-dessous de 70%.

Aussi une certaine propagande est-elle nécessaire afin d'inciter la population à venir en totalité aux rassemblements organisés. Cette propagande doit être soit directe, soit indirecte. C'est à ce dernier aspect qu'appartient l'exemption d'impôts consentie, en territoire français, à tout trypanosomé en traitement. Nous envisagerons l'effet de propagande dû aux résultats mêmes de la prophylaxie en étudiant ces résultats.

c) **Les mœurs des populations** constituent un facteur capital de succès ou d'échec des opérations de prophylaxie, et l'on doit être à même d'en prévoir à l'avance les incidences.

— Il n'est certes pas opportun d'entreprendre une campagne de prophylaxie au moment où les travaux de culture, de pêche ou de chasse absorbent toute l'activité des populations.

— D'autre part, nous avons vu, au cours des pages qui précèdent, l'importance des habitudes de migrations des populations dans l'épidémiologie de la maladie du sommeil. Ces habitudes constituent une grave entrave à l'application des mesures préventives dirigées vers l'homme. Deux procédés ont été employés en pareil cas, opposés dans leur principe, mais pouvant être conjoints :

— D'une part, la pratique d'injections prophylactiques à la partie fixe de la population, pour éviter que l'apport de malades ne crée un foyer : en 1955, dans la région de Bozoum (Oubangui), un pêcheur trypanosomé, venu s'installer dans cette zone où l'endémie semblait jugulée et qui n'était plus lomidinisée depuis plus d'un an, fut à l'origine d'un foyer de 49 cas.

— D'autre part, l'établissement de postes-filtres sur les voies de migration, destinés à examiner les immigrants, à trier et traiter les trypanosomés et à protéger les autres par des injections préventives.

Le comportement psychologique des populations interfère d'une façon très marquée sur les chances de succès du travail entrepris : la peur de la maladie ou au contraire son mépris, les divers impératifs de la religion, de la sorcellerie et des croyances locales sont des facteurs qu'il serait imprudent de négliger.

B. L'APPLICATION SUR LE TERRAIN

Nous avons déjà donné des indications sur la composition des équipes et noté que le plan de campagne de chacune d'elles était communiqué aux autorités administratives chargées des rassemblements. Théoriquement, dans les territoires français, un agent de l'administration devrait accompagner les équipes.

Le protocole des séances de dépistage-prophylaxie comporte en A.E.F.:

— l'examen de tous les sujets,

— l'examen systématique du sang en goutte épaisse,

— la pesée sur balance romaine pour fixer la dose à injecter.

En Nigéria, les sujets ne sont pas pesés, mais on applique un schéma de dosage calculé selon l'âge et le sexe.

Seuls sont dispensés des injections les sujets fiévreux ou en mauvais état général, les très jeunes enfants, les vieillards et les femmes enceintes de plus de 5 mois.

Après les injections de diamidines aromatiques, on prescrit un repos d'une heure en position couchée, tête basse.

C. LES PRODUITS UTILISES

De nombreux essais ont été pratiqués avec différents produits, tels que le Bayer 205 (Moranyl ou Suramine) (Congo Belge, Ruanda-Urundi, Nigéria, Sierra Leone, etc.), la propamidine (Congo Belge), le Msb essayé au laboratoire par Rollo, Williamson et Lourie (1949).

Les produits chimioprophylactiques de valeur doivent leur action à la lenteur de leur élimination.

Pour le Moranyl et la Pentamidine, ces produits ont tendance à se fixer sur les grosses molécules des protéines sanguines, retenues par le filtre rénal. Dans le cas du Msb, l'action prophylactique est due à la taille de ce corps stibié, polymérisé (Friedheim).

Les résultats furent assez satisfaisants, mais partout on donna la préférence à la Pentamidine, d'un emploi plus facile et plus sûr.

Le p.p. Diamidino-Diphenoxy-Pentane est désigné, tantôt sous le nom de " Pentamidine " (May and Baker ou UCB), tantôt sous le nom de " Lomidine " (Specia). Les sels diffèrent : dichlorhydrate, diiséthionate ou dimethane sulfonate, mais de toute façon les doses utilisées sont calculées sur le poids de base.

On injecte généralement, à des intervalles de 6 mois, 4 milligrammes de base par kilo de poids, par voie intramusculaire, avec un plafond de 300 mg.

Le produit est présenté, soit sous forme de poudre, soit sous forme de solution prête à l'emploi, mais il est souvent préférable d'employer la seconde forme (en flacons à bouchon perforable), pour éviter toute faute d'asepsie au moment de la mise en solution du produit présenté en poudre.

En ce qui concerne la Lomidine, ses solutions sont titrées à 4% : on injecte autant de ml. que le poids du sujet comporte de tranches de 10 kg. Cependant en A.E.F., on ne dépasse pas la dose de 5 ml. (200 mg. de base).

Nous avons déjà signalé, dans le paragraphe B du chapitre III, les contre-indications et les précautions générales à prendre après injection.

Des essais pratiqués dans le but d'administrer les diamidines par voie orale (Trinquier 1947, Launoy et Jeanpierre 1947, Beaudiment, Brochen et Peuziat 1949, Raynal 1949) n'ont pas permis d'obtenir des résultats assez satisfaisants pour utiliser cette méthode dans un but prophylactique.

Guimaraes et Lourie (1951) avaient montré que la suramine diminuait la toxicité de la pentamidine chez la souris. A la suite de cette étude préliminaire, Cosar, Ducrot, Gaillot et Baget (1954), dans les laboratoires de Recherches de la Société Rhône-Poulenc, avaient obtenu un sel de suramine/pentamidine, le 4.891 RP.

J. Schneider et G. Montezin (1954), étudiant le coefficient chimiothérapeutique de ce corps, le trouvèrent digne d'intérêt et constatèrent que son action préventive était supérieure à celle de ses composants et durait plus longtemps.

Malheureusement ce corps, mal toléré par les tissus humains, donne des accidents de non-résorption et des réactions douloureuses, parfois même de nécrose aseptique au lieu d'injection.

Son emploi, essayé au Cameroun, en 1954, fut assez rapidement stoppé (Beaudiment). L'idée cependant n'était pas abandonnée, et actuellement, on pratique en A.E.F. l'injection simultanée de Moranyl par voie intraveineuse (1 cg. par kg. de poids, avec plafond à 0,50 g.) et de Lomidine intramusculaire (Beaudiment et Zozol 1952).

Si cette technique demande un travail accru aux équipes chargées de l'appliquer, la prolongation de la prévention qui dépasserait 9 mois (permettant de n'effectuer qu'une tournée dans l'année et de dépasser la durée de vie des glossines, coupant ainsi à coup sûr le cycle épidémiologique) et la réduction des incidents lipothymiques justifieraient son emploi. Cependant tous les auteurs ne sont pas d'accord sur l'augmentation de la durée de protection apportée par ce procédé (Nodenot cf. annexe).

D. ACCIDENTS ET INCIDENTS

a) Généraux

Les incidents de déséquilibre vagosympathique liés à l'injection de Diamidines sont assez fréquents, quoique le plus souvent sans gravité. C'est ainsi que des malaises avec sueurs profuses, sialorrhée et nausées sont signalés dans des proportions allant de 1 à 75%. Ils sont aggravés souvent par l'état de fatigue de l'individu (danses, longues étapes pour se rendre au lieu de rassemblement, etc.) et tout ce qui peut favoriser l'hypotension.

Il arrive que l'on observe des troubles plus marqués : vomissements — tachycardie violente — chutes tensionnelles pouvant aller jusqu'à la lipothymie — coliques abdominales — douleurs utérines ayant pu provoquer des avortements ou l'accouchement chez des gestantes à terme. (A vrai dire, ces derniers accidents ont été observés avec la Stilbamidine, mais non avec la Pentamidine).

Les statistiques rapportent des proportions allant de 0,8 à 5% d'accidents de cet ordre.

Saleun et Chassain, utilisant, il est vrai, la voie intraveineuse, ont trouvé les pourcentages suivants sur 1.616 injections :

	%
Hypotension simple	66,7
Tachycardie	49,1
Refroidissement des extrêmités	59,7
Lipothymie	0,2
Syncope	0,06
Nausées	2,5
Vomissements	0,5
Céphalées	7,3
Vertiges	0,1

Rarement il s'agit de syncopes graves (1‰) pouvant même entraîner la mort. De tels cas furent cependant signalés, en particulier au Cameroun (1954 et 1957), au Congo Belge (1948–1950–1953) et en A.E.F. (1956). En 1957, sur 226.180 injections, on observa en A.E.F. 35 accidents généraux notables dont 1 mortel, soit 0,0004% de mortalité pour 0,015% d'accidents généraux.

Parmi les causes favorisantes, Beaudiment, Cauvin et Leproux (I.S.C.T.R. (54) 16), qui ont observé que ces accidents généraux étaient plus fréquents sur les grands axes de communication et près des grands centres que dans la brousse, relèvent :

> "— un facteur de pusillanimité et d'émotivité plus marqué dans ces populations ;
>
> — l'absorption de nourriture avant l'injection, traduction d'un état d'esprit moins enclin à la discipline ;
>
> — l'absorption abusive de boissons alcoolisées, dont la consommation prend un essor extraordinaire au contact des grands centres."

a) **Accidents locaux**

Ces accidents sont de trois ordres :

— accidents de non résorption,
— accidents nerveux,
— accidents septiques.

— Il y a peu à dire des premiers qui surviennent parfois en série, sans que l'on puisse relever l'anomalie dans le lot de produit utilisé.

— Les accidents nerveux sont en général des troubles moteurs et trophiques du membre inférieur. Comme on les observe plutôt chez les enfants, il semble qu'ils soient dus à une faute de technique, le produit étant injecté trop près de l'emergence du sciatique. Cependant, dans certains cas, l'utilisation d'un lot trop vieux de Lomidine a pu être incriminée (Ravisse. Rapp. ann. A.E.F. 1952).

En général, ces atteintes sciatiques rétrocèdent sous l'influence du traitement (vitamine du groupe B et strychnine).

— Les accidents septiques peuvent être fort graves, mais il n'y a rien là de très spécial à la lomidinisation : toute campagne de prophylaxie de masse par injections, dans les conditions de la brousse africaine, est à la merci d'accidents de ce genre, dus, soit à des fautes de technique de la part des agents vaccinateurs, soit à des manœuvres intempestives de la part des sujets recevant les injections.

Au Gabon, en 1952, 62 abcès gangréneux, causant 14 décès par toxiinfection, furent observés à N'Koltang (Richet I.S.C.T.R. (54) 6).

L'instruction judiciaire très poussée permit de penser que les victimes de ces accidents en étaient les responsables. En effet, ces sujets avaient appliqué, au point d'injection, un emplâtre de boue liquide d'excréments et de banane écrasée, utilisé couramment dans la région comme anti-phlogistique.

En 1954, au Cameroun, dans la Subdivision de Yokadouma, 284 abcès gangréneux provoquèrent 23 décès. Leur cause fut trouvée dans l'eau, utilisée pour préparer extemporanément la solution de Lomidine et dont la stérilisation avait été défectueuse.

Le risque de tels accidents est sérieusement amoindri par l'emploi de solutions stériles toutes préparées.

De même, on doit signaler 54 accidents, dont 13 décès, survenus en 1950 à Bomboma au Congo Belge. La pentamidine incriminée ne présentait pas d'anomalie de toxicité expérimentale, et l'origine des accidents semble avoir été extérieure au produit même.

Enfin, le problème du déclenchement d'une poliomyélite-maladie par les injections prophylactiques fut étudié devant le C.S.I.R.T. en 1954 par le Médecin-Général Richet. Il semble qu'il en soit de la lomidine comme des injections vaccinales anticoquelucheuses par exemple, mais aucun fait nouveau ne semble avoir été versé au débat depuis 4 ans.

E. METHODES UTILISEES POUR PREVENIR CES ACCIDENTS

Nous ne nous étendrons pas sur la prévention des accidents nerveux ou septiques. L'amélioration de l'entraînement du personnel des équipes mobiles et l'éducation sanitaire des populations doivent éviter leur répétition.

Insistons cependant sur l'importance de ces mesures, de tels accidents ayant des répercussions psychologiques catastrophiques sur la bonne marche de la lutte anti-sommeilleuse. Les accidents signalés au Gabon en

1952 durent faire interrompre les séances de lomidinisation dans ce secteur jusqu'en 1955, alors que la situation épidémiologique se détériorait.

Contre les accidents généraux, on doit mettre en œuvre les précautions déjà signalées :

On dispensera de l'injection les fiévreux, les sujets en mauvais état général, les très jeunes enfants dont le poids n'atteint pas 8 kilogs, les vieillards et les femmes enceintes. En ce qui concerne ces dernières, certains écartent de la lomidinisation les femmes enceintes avant le 5ème mois et au voisinage du terme. D'autres ne font jouer cette mesure qu'au-delà du 5ème mois. En réalité, la lomidine n'est pas vraiment abortive et de telles mesures sont plutôt d'ordre psychologique (Raynal 1949).

Tous les auteurs insistent sur la nécessité de pratiquer les injections chez des sujets à jeun — en particulier n'ayant pas absorbé d'alcool. On a, en effet, remarqué l'incidence plus forte des lipothymies chez les gens bien nourris ayant mangé avant l'injection (gardes) et nous avons déjà signalé le rôle favorisant de l'alcool.

Les séances seront proscrites aux heures les plus chaudes de la journée. Les injections seront poussées très lentement, en s'assurant bien que la pointe de l'aiguille n'est pas dans un vaisseau.

Enfin, on prescrira le repos obligatoire, en position couchée, tête basse, à l'ombre, pendant au moins 1 heure après l'injection.

En raison de l'hypotension déterminée par les diamidines, tous les médecins appliquant cette chimioprophylaxie connaissent la nécessité de garder à portée de la main une solution d'adrénaline.

En A.E.F., on fait absorber systématiquement à tout sujet lomidinisé, un morceau de sucre imprégné de 2 à 3 gouttes d'adrénaline à 1‰. On aurait pu penser que cette distribution aurait servi de propagande au moins en ce qui concerne les enfants. Il n'en est rien, car ils manifestent, au Moyen-Congo, une certaine répulsion pour le sucre! Mais le procédé est maintenu en vigueur, car il semble avoir fait diminuer l'incidence des accidents lipothymiques.

Mise à part l'hypotension, l'origine des divers accidents a été recherchée dans deux voies différentes.

On sait que les diamidines, dérivées de diguanidines hypoglycémiantes, interfèrent avec le mécanisme de la glycorégulation — l'emploi prolongé de lomidine a même pu faire apparaître des troubles de ce système (Collomb, Miletto et Levron 1956, Claisse et coll. 1950, Serre et Mirouze 1951). Certains des troubles observés seraient sous la dépendance de modifications brutales du taux de la glycémie : hypoglycémie précédée ou non d'une courte phase d'hyperglycémie (Gasq et Lapeysonnie 1949).

Duron, en 1954, trouvait que, dans l'heure qui suit l'injection, 82% des sujets étaient hypoglycémiques, 6% hyperglycémiques et 12% n'accusaient pas de modification du taux de glucose sanguin.

En effet, certains accidents comateux ont pu être maîtrisés par une injection intraveineuse de solution glucosée à 30% (Richet 1954 — Rapport Annuel SGHMP. A.E.F).

Une autre explication donnée est que la pentamidine libérerait des quantités excessives d'histamine dans la circulation sanguine (C.S.I.R.T. (1954) procès-verbal n° 49, p. XVII).

Sans entrer dans le débat, notons que dans le but de prévenir les accidents, on utilise en A.E.F. l'association Moranyl (voie IV), Lomidine (IM). En effet, cette association, en dehors de l'action préventive plus durable que certains auteurs lui accordent, diminue assez nettement le nombre des accidents généraux de choc observés à la suite de l'injection de pentamidine seule. Elle permet de tolérer des doses élevées de pentamidine qui, injectées seules, déclencheraient des accidents toxiques (Neujean et Evens 1958). Ailleurs, il est recommandé, par exemple au Cameroun — où l'association n'est pas employée systématiquement — de faire une injection intraveineuse de Moranyl, à raison de 1 cg. par kg. (max. 0g,50) en cas de choc syncopal. Selon certains auteurs, le Moranyl limiterait la libération d'histamine par la pentamidine.

Au Cameroun, on administre préventivement 1 comprimé de Phénergan. Les chefs des services de prophylaxie de ces territoires se déclarent satisfaits de ces méthodes.

4° LES RESULTATS OBTENUS

L'effort de chimioprophylaxie, commencé dès la fin de la période d'expérimentation, en 1946, s'est poursuivi jusqu'à maintenant sans relâche dans la plus grande part des territoires infectés par *T. gambiense*.

Un nombre impressionnant d'injections a été pratiqué: citons à titre d'exemple:

4.433.177	en Angola	de 1949 à 1957
3.637.868	au Congo Belge	de 1945 à 1957
2.787.810	en A.E.F.	de 1946 à 1957
834.996	au Cameroun	de 1946 à 1957

On peut considérer que dans le cours de ces dernières années, environ 1.500.000 sujets étaient protégés chaque année.

Mais la situation évolue et en 1956 ou en 1957, par exemple, on a dû dans l'ensemble pratiquer moins de lomidinisations qu'en 1953, car les progrès obtenus permettent d'obtenir une meilleure délimitation des foyers.

Nous étudierons donc à la fois les résultats obtenus et l'évolution des campagnes entreprises.

A. LA CHUTE DES INDICES EPIDEMIOLOGIQUES

De nombreuses publications sont venues, depuis 1946, exposer les résultats spectaculaires obtenus au cours des premières campagnes fragmentaires effectuées. (Van Hoof et coll. 1944–46–47, Eeraerts 1947, Saleun et Chassain 1946, Brun-Buisson et coll. 1947, etc...).

Rappelons par exemple le cas du foyer historique de Nola, dans la vallée de la haute Sangha à la limite de l'Oubangui et du Cameroun (Le Gac 1951).

Des poussées épidémiques avaient dépeuplé le pays en 1906–1911, 1919–1924. En 1933, l'ICN était encore de 25%. Les efforts de lutte menés par la seule méthode de dépistage-traitement, (la population étant trop décimée pour entreprendre une prophylaxie agronomique anti-glossines) n'avaient pu abaisser l'indice parasitaire au-dessous de 16,5 en 1937. Cependant, un nouvel effort en 1945 permettait d'amener l'ICN à 4,2, alors que dans la Terre M Bimou voisine, il était encore à 12%.

En 1946, commençait à cet endroit l'expérience de lomidinisation menée par Choumara sous la direction du Médecin-Général Raynal et du Médecin-Colonel Lotte. En 1947, l'IVC était tombé à 2,2 et l'ICN à 1,7%. Il était à 0 en 1954.

Un tel exemple, s'il est spectaculaire, n'est une exception que par les indices étonnamment élevés qu'il présentait avant l'ère de la chimioprophylaxie.

La fonte des indices est un phénomène général qui peut être observé partout où la méthode a été appliquée.

En A.E.F.

Les indices globaux ont décru régulièrement depuis 1946 (de 0,72 à 0,03 pour l'ICN et de 0,81 à 0,02 pour l'IVC) quoique le nombre de sujets visités ait cru progressivement avec la création de nombreux secteurs.

Tableau I. (A.E.F.)

Année	Population examinée	Injections de Lomidine	Nouveaux tryp. dépistés	ICN	IVC
1946	386.031	261	2.691	0,72	0,81
1947	743.723	4.429	4.560	0,62	0,69
1948	637.504	41.565	3.556	0,63	0,62
1949	670.220	80.751	2.144	0,35	0,35
1950	854.293	90.208	3.621	0,39	0,40
1951	1.148.688	258.282	4.802	0,42	0,42
1952	1.197.818	405.738	3.080	0,27	0,27
1953	1.149.725	489.507	1.911	0,16	0,16
1954	1.810.388	470.683	1.566	0,10	0,11
1955	1.901.834	378.685	1.590	0,08	0,07
1956	2.462.987	341.521	784	0,03	0,03
1957	2.337.633	226.180	705	0,03	0,02

On peut constater que le dépistage s'est amplifié considérablement; le nombre de trypanosomés dépistés s'est accru à mesure que l'action s'étendait en superficie, puis, sous l'influence de la prophylaxie appliquée: traitement des malades et chimioprophylaxie, il a décru notablement alors que les indices s'effondraient. Dans cette période de 1946 à 1957, 97.754 trypanosomés avaient été dépistés sur lesquels 44.070 ont pu être déclarés guéris, 19.671 étaient décédés, 23.884 avaient disparu et 10.129 étaient encore sous surveillance.

Mais les chiffres globaux ne donnent peut-être pas une idée suffisamment nette des résultats obtenus, en raison des différences qui existent entre les diverses localités, selon la situation épidémiologique et selon l'intensité de l'attaque menée par les services de prophylaxie.

Nous prendrons quelques exemples d'opérations couronnées de succès qui sont indiqués dans le tableau II ci-dessous (Détail des campagnes de lomidinisation dans certains districts d'A.E.F.).

Ce tableau est extrait du rapport annuel 1954 du SGHMP d'A.E.F. (Dr. Richet).

Tableau II. Détail des campagnes de lomidinisation dans certains districts d'A.E.F.

Région traitée District Zone	Début des injections		Nombre de campagnes	Arrêt des campagnes	
	Année	ICN		Année	ICN
Brazzaville couloir Nord	1948/1	2,09	10	1954/1	0
„ C.R. de M'Bé	1948/1	2,3	3	1950/1	0
Madingou Kayes	1947/1	2,5	7	1954/2	0
„ Est	1949/1	0,74	5	1954/2	0
Mouyoundzi centre	1952	0,02	2	1953/2	0
Divenie route du Gabon	1948/1	6,5	6	1952/2	0
Kimongo zone Nord	1947/2	4	8	1952/1	0
Batangafo zone 1.	1950/1	1,06	4	1952/1	0

Nous n'avons pris dans ces exemples que des zones où les campagnes purent être arrêtées, l'ICN étant tombé à 0. Mais on doit savoir qu'il est des régions où les campagnes sont encore continuées, des indices résiduels étant encore observés. C'est ainsi que dans la région de l'Ogooue Ivindo, dans le district de Makokou, la lomidinisation, commencée en 1953/2 alors que l'ICN était 7,36 put faire tomber l'indice à 0,2 après 3 campagnes, mais qu'il subsiste des villages infectés qui doivent encore être lomidinisés. Et cette situation se rencontre dans la majorité des districts: le feu couve sous la cendre.

A.O.F.

Partout où la chimioprophylaxie fut appliquée, on observe une réduction des indices:

En Guinée, dans une zone frontière et dans le massif du Fouta Djalon, où la répartition de l'endémie est focale, on observait:

en 1944	ICN = 0,49%	IVC = 0,48%
en 1957	ICN = 0,09%	IVC = 0,071%

En Côte d'Ivoire, dans une région où la répartition est riveraine :

1944	ICN = 1,90%	IVC = 2,25%
1957	ICN = 0,194%	IVC = 0,193%

En Haute-Volta (répartition riveraine) :

1944	ICN = 2,06%	IVC = 1,96%
1957	ICN = 0,02%	IVC = 0,01%

Angola

Les chiffres globaux des résultats obtenus, dans les districts de Congo, Cuanza Norte et Luanda, comparés avec les injections pratiquées, sont présentés dans le tableau ci-dessous :

Tableau III. (Angola)

Année	Nombre d'injections	IVC	Pourcentage de présence aux séances
		%	%
1949	125.200	4,77	99,5
1950	365.038	1,02	99,2
1951	460.059	0,24	96
1952	581.428	0,12	93,8
1953	503.015	0,04	92,1
1954	634.340	0,03	100
1955	555.298	0,03	95
1956	556.439	0,04	92,7
1957	752.360	0,02	91,7

Cameroun

Au Cameroun, sur une population totale évaluée à 2.997.000 en 1948, à 3.187.621 en 1957, le dépistage de la trypanosomiase a permis d'observer, depuis le début des opérations de chimioprophylaxie en 1948 une diminution presque constante des nouveaux cas, quoique le chiffre de population visitée, resté à peu près égal jusqu'en 1956, ait doublé en 1957.

Tableau IV. (Cameroun)

Année	Population visitée	Nouveaux trypanosomés dépistés	Nombre d'injections préventives
1947			21.867
1948	332.200	4.340	15.028
1949	259.857	3.627	14.512
1950	279.483	3.045	38.525
1951	362.886	1.430	6.393
1952	382.276	744	189.056
1953	461.012	1.125	247.167
1954	320.284	552	235.676
1955	245.689	668	54.296
1956	450.328	367	92.118
1957	657.715	359	20.358

Le détail des opérations indique encore mieux les résultats obtenus, quoique nous ne puissions indiquer le nombre d'opérations de chimioprophylaxie effectuées dans chaque secteur.

Tableau V. (Cameroun)

Régions Subdivisions	Evolution des ICN (le chiffre du début des opérations est en caractères gras)									
	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957
Boumba-Ngoko										
Yokadouma .	**8,21**	0,07	1,55	—	0	—	0	—	—	0
Haut Nyong										
Messana . .	**2,74**	0,12	—	0,045	0,1	—	—	—	—	0,02
Abong Mbang .	—	**1,29**	0,36	—	0,06	—	—	—	—	0
Bamileké										
Bafang . .	—	**2,28**	—	1,35	0,02	—	0,12	0,4	—	0,05
M'Bam										
Bafia . . .	—	2,37	**1,27**	0,35	—	0,13	—	0,13	—	0,04
Nyong et Sanaga										
Yaoundé . .	0,52	0,68	**0,43**	0,1	0,12	0,1	—	—	—	0,03
Saa . . .	0,39	—	—	**0,3**	0,12	—	—	—	—	0,1
Logone-Chari	—									
Sult. Koussery .	—	—	**2,1**	0,53	0,16	—	—	—	—	0,63
Sult. Logone Birni	—	—	**1,6**	2,56	0,45	—	—	—	—	0,22
Sult. Goulfei .	—	—	0,3	0,6	**0,86**	—	—	—	—	0,3
Mungo										
Mbanga . .	—	1,15	—	**0,8**	—	0,4	0,07	0,2	—	0,1
Bamoun . .										
Pays Tikar . .	—	—	—	**0,37**	0,12	—	0,37	0,2	—	0,4
N'Kam										
Yabassi . .	—	—	0,04	—	**0,12**	0,17	—	—	—	0,08
Kribi										
Campo . .	0,25	—	—	—	—	—	2	**1,3**	0,45	0
Vouri										
Estuaire du fleuve	—	0,12	—	0,2	0,18	0,1	0,24	0,17	**0,24**	0

Congo Belge

Partout au Congo Belge, on assiste également à la régression marquée des indices.

Nous reproduisons ci-dessous un extrait du tableau d'évolution des indices de contamination nouvelle. L'évolution des IVC est également donnée dans le document — reproduit en annexe.

Tableau VI. (Congo Belge)

Province Secteur	Evolution des ICN		
	1944	1955	1957
P. Léopoldville			
Mayumbe	0,09	0,0063	0,0062
Cataractes	0,64	0,054	0,034
M M K K	0,51	0,05	0,04
Luozi	0,31	0,025	0,054
Inongo	0,07	0,001	0,008
Mushie	0,41	0,06	0,042
Foreami	0,22	0,03	0,03
P. Katanga	0,49	0,01	0,006
P. Orientale			
Dungu	0,07	0,03	0,01
Ango	0,15	0,005	0,005
Niangara	0,07	0,04	0,009
Aba	0,05	0,009	0,01
P. Equateur	0,299 (en 1946)	0,035	0,028
Ruanda-Urundi	0,62	0,007	0,002

Nigéria

Nous avons vu qu'en Nigéria la chimioprophylaxie avait été appliquée chez les travailleurs des mines d'étain. 6.048 de ceux-ci reçurent en 1956 de la pentamidine.

McLetchie, dans le rapport annuel 1948 du Service de la Maladie du Sommeil, expose que les sujets travaillant dans les deux principales zones minières (Divisions de Wamba et Jemaa de la Province du Plateau) étaient au nombre de 3.500 à 4.000 entre 1945 et 1948. En 1945, la pentamidine ne fut utilisée que dans quelques camps seulement et il y eut 170 nouveaux cas. Puis, l'application de la chimioprophylaxie s'accroissant, le nombre de nouveaux cas diminua: 161 en 1946, 85 en 1947 et 14 en 1948.

Les injections semestrielles continuèrent à être pratiquées et l'on n'observa plus un cas depuis dans les collectivités traitées.

En ce qui concerne la campagne de la Bénoué en 1956, 16.951 sujets reçurent les injections prophylactiques.

L'ICN, dans ces régions, était de 1,38% avant la campagne. En 1957, 1 an après la 1ère inoculation, il était tombé à 0,21% et en 1958 il était à 0,06%.

B. VALEUR DE LA METHODE

La lecture de ces divers documents appelle quelques commentaires ; tout d'abord on peut constater que si une amélioration très nette est obtenue localement dans chaque zone soumise à la chimioprophylaxie, amélioration pouvant aller jusqu'à la suppression totale de l'endémie, il reste dans chaque territoire une trypanosomiase résiduelle globale et les indices, quoique spectaculairement réduits, demeurent encore entre 0,002 et 0,2%.

La première question qui vient à l'esprit est la suivante : l'application de la méthode de chimioprophylaxie semble avoir coïncidé avec une augmentation très nette de l'effort de dépistage, qui s'accompagne de la mise en traitement des trypanosomés découverts. Le dépistage-traitement appliqué seul aurait-il obtenu les mêmes résultats ? Il ne le semble pas.

D'une part, partout où on a dû s'attaquer à un foyer bien défini (cf. Nola ci-dessus), le seul contrôle des malades n'a pu enrayer totalement le développement de l'endémie entre les passages des équipes chargées de ce contrôle.

En effet, une seule partie du réservoir de virus avait été supprimée. Pendant cette période, les glossines restées infectées continuaient à distribuer leurs trypanosomes et rien ne venait enrayer l'infestation de l'homme sain.

D'autre part, il n'est peut-être pas exact que l'augmentation des examens de population soit, dans tous les territoires, contemporaine de la chimioprophylaxie. En A.O.F., avant l'application de cette méthode, l'indice de contamination nouvelle était encore de 2,7% en 1937, alors que plus de 3 millions de personnes étaient sous contrôle annuel. En A.E.F., dans la zone du " Couloir ", prospectée et traitée régulièrement, l'indice restait entre 2,09 et 2,68% depuis 1936. A la première série de lomidine, il tombait à 0,8% pour la première fois depuis le début des contrôles. McLetchie en 1948 notait que de 1931 à 1945, quoique plus de 500.000 personnes aient été examinées chaque année en Nigéria, le taux de morbidité moyen par trypanosomiase qui s'était élevé à 20,5% en 1935 n'avait pu être abaissé au-dessous de 1,2%. En 1946, les taux d'infection étaient encore, selon les localités, entre 2 et 12%.

Dans son étude sur la trypanosomiase en Afrique Occidentale Britannique, Davey (1948) souligne que la seule méthode de dépistage-traitement ne peut parvenir à l'éradication de la maladie.

Au Congo Belge, il semble que les meilleurs résultats obtenus dans une zone limitée n'aient pu parvenir à abaisser l'ICN qu'à 0,48% (Acres 1950) en utilisant la seule méthode de dépistage-traitement.

Cependant, on doit reconnaître que le Togo, où l'endémie a toujours été faible, est parvenu à abaisser encore celle-ci jusqu'à un ICN de 0,042 sans le secours de la chimioprophylaxie (cf. annexe).

Une seconde manière d'évaluer la valeur de la méthode consiste à recherchet le nombre de sujets ayant reçu la pentamidine et qui ont cependant pu être infectés. C'est là une question qui fut omise dans le questionnaire diffusé, mais à en juger par les chiffres obtenus en A.E.F., le pourcentage de ces échecs semble minime.

Ainsi le tableau VII réunit tout ce qui peut être porte au passif de la méthode: réinfections et accidents, au cours des années 1955–1956 et 1957.

Tableau VII. (A.E.F.)

Année	Nombre de personnes ayant reçu de la lomidine à titre prophylactique	Nouveaux trypanosomés dépistés		Accidents graves	
		Moins de 6 mois après lomidinisation	Plus de 6 mois après lomidinisation	Nombre	Décès
1955	1 fois : 154.683 2 fois : 112.001	1	2	15	0
1956	1 fois : 130.907 2 fois : 105.307	7	25	80	2
1957	1 fois : 160.286 2 fois : 32.947	3	24	35	1
Total	696.131	11	51	130	3

Ainsi donc, en 3 ans, moins de 0,0016% des personnes ayant reçu l'injection préventive dans les 6 mois précédents ont été trouvées infectées à la prospection suivante. On doit donc reconnaître que ce qui avait été observé d'abord au laboratoire, puis sur de petites collectivités, se confirme lorsqu'on étudie l'ensemble des opérations chimioprophylactiques réalisées dans un grand territoire.

L'amélioration observée peut donc bien être portée à l'actif de la chimioprophylaxie.

C. INFLUENCE DE LA CHIMIOPROPHYLAXIE SUR LE CYCLE EXTRINSEQUE DES TRYPANOSOMES

En outre, comme l'ont signalé divers auteurs (Jonchère 1951, Fairbairn, 1954), l'action des diamidines ne se borne pas à protéger l'individu ayant reçu l'injection. Par la réduction du réservoir de virus qu'elle entraîne dans la collectivité traitée, elle contribue à assainir la région et à diminuer l'incidence de la trypanosomiase chez les sujets pouvant entrer en contact avec les mêmes glossines.

" Dans une région déterminée, écrit Jonchère, alors que le nombre des nouveaux malades chez les sujets protégés est réduit de 16 fois

(0,97/0,06), il est simultanément réduit de plus de moitié $\left(\frac{0,97}{0,45}\right)$ chez les témoins non protégés, de telle sorte que la protection des 5/7 de la population $\left(\frac{36.060}{48.268}\right)$ réduit de 6 fois $\left(\frac{0,97}{0,16}\right)$ les pourcentages d'infestation de l'ensemble de cette population."

Certains ont même pensé que la pentamidine absorbée par des glossines, lors de la piqûre de sujets soumis à la chimioprophylaxie, pouvait exercer une action dysgonique sur les trypanosomes qu'elles hébergeaient à ce moment. L'hypothèse est séduisante, mais on sait que Roubaud (1952) a prouvé que cette action dysgonique n'existait pas pour l'antrycide et nous n'avons pu trouver, dans la littérature, la trace d'expériences de ce genre menées avec les diamidines.

Aucun document très précis ne nous permet de nous faire une idée d'ensemble sur la réduction du taux d'infestation des glossines depuis l'application de la chimioprophylaxie. Cette réduction doit logiquement être sensible. Au Cameroun, l'examen systématique des *Gl. palpalis palpalis* capturées aux environs de Yaoundé n'a montré que 0,11% d'infections salivaires pour 6,27% d'infections intestinales, dans cette région où certains villages sont soumis à la chimioprophylaxie. Da Cruz Ferreira et ses collaborateurs ont observé en Guinée Portugaise une réduction de l'infestation des glossines dans une zone pentamidinisée.

Cependant, pour parvenir à supprimer l'infection des glossines, il serait nécessaire de supprimer totalement le réservoir de virus humain. Or, nous avons déjà insisté sur les dangers des migrations humaines. Il suffit qu'un trypanosomé vienne s'installer dans un secteur assaini pour qu'un nouveau foyer se constitue: rappelons qu'en 1954, un pêcher trypanosomé venu s'installer dans une localité du district de Bozoum fut à l'origine d'un foyer de 49 cas, alors que le district était indemne auparavant.

Si nous ne craignons pas de nous répéter sur ce point, c'est qu'il nous amène à poser une grave question: **Peut-on contrôler la trypanosomiase sans contrôler son vecteur?**

Il est bien probable, à la lumière des faits connus, qu'on ne peut pas éradiquer totalement et définitivement la trypanosomiase sans supprimer la glossine. Dans les localités isolées en contact avec une population glossinienne également limitée dans l'espace, on peut probablement rompre le cycle, mais plus le contact est impersonnel, moins on a de chances d'éradiquer la maladie par cette méthode.

Cependant les résultats obtenus par les seules méthodes s'adressant au maillon humain de la chaîne épidémiologique sont assez encourageants pour que l'on persiste dans cette voie: une attaque des glossines sur toute leur aire de répartition demanderait des moyens matériels et financiers hors de proportion avec les possibilités existantes. Encore ne serait-on pas sûr de pouvoir en venir à bout, surtout dans les secteurs forestiers. Il suffit de considérer les moyens mis en œuvre, en 1947, par Du Toit au Zoulouland (et *Gl. pallidipes* est probablement plus vulnérable, du fait de son écologie, que ne peut l'être *Gl. palpalis*). De plus, il serait nécessaire de mener l'action avec ensemble sur toute l'immense zone contaminée, sinon les populations de glossines, capables elles aussi de migrations, se reconstitueraient.

Certes, on peut objecter que les moyens mis en œuvre pour la chimioprophylaxie ne sont pas négligeables. Nous n'avons pas étudié l'aspect financier de la question, mais il est certain que l'immense armature sanitaire mise en œuvre pour lutter contre la Maladie du Sommeil est terriblement coûteuse. Cependant, elle présente l'avantage de ne pas être univalente. D'autres grandes endémies redoutables en Afrique bénéficient de son activité et elle ne tomberait pas en désuétude du jour où la trypanosomiase aurait été rayée des préoccupations médicales.

Par ailleurs, selon les conditions épidémiologiques et écologiques locales, la seule attaque de la maladie chez l'homme parvient parfois à établir une situation rendant la zone impropre à la multiplication des glossines. Nous étudierons cet aspect en considérant l'influence de la prophylaxie sur les conditions démographiques.

D. INFLUENCE DE LA CHIMIOPROPHYLAXIE SUR LA DEMOGRAPHIE LOCALE

On connaît l'influence de la trypanosomiase sur la démographie. Davey (1948) a rapporté que la maladie du sommeil causait une sérieuse dépopulation — soit par les exodes qu'elle provoquait, exodes dirigés des vallées vers les crêtes où les conditions d'agriculture étaient moins favorables — soit par son incidence même : " Il a été estimé qu'une incidence de 50% extermine la population, 13% dépeuple rapidement, 6% permet une démographie stationnaire et 3% permet une légère ascension de la courbe." (Analyse par Corson in *Trop. Dis. Bull.* 1949. 46 : 221.)

La réduction des indices obtenus grâce à la méthode aurait dû avoir pour résultat une augmentation de la démographie.

Et cette observation devrait être à double sens : en effet, on ne peut juger avec précision de la situation que dans les zones où la population est bien fixée, solidement structurée socialement et ce sont justement les zones où les opérations de prophylaxie peuvent être menées avec le plus de rigueur. En réalité, l'action sanitaire forme un tout et il n'est pas possible de séparer, dans l'amélioration démographique, ce qui revient à la lutte contre la trypanosomiase et ce qui revient à la lutte contre les autres causes de dénatalité.

Citons cependant les chiffres fournis par l'Angola : les indices d'évolution démographique, dans la zone chimioprophylactisée, sont passés de 0,77% en 1949 à 1,56% en 1953 et 2,03% en 1956.

Par contre, si l'on a peu de renseignements sur l'influence de la prophylaxie anti-sommeilleuse sur la démographie, on doit souligner l'influence de cette dernière sur la situation épidémiologique.

Le plateau Koukouya, qui fait partie des plateaux Batékés au Nord de Brazzaville, groupe actuellement sur 450 km.² environ 12.000 habitants, soit environ 27 habitants au km.² (Bastiani 1957). Cette entité rurale bien délimitée, à caractère ethnique et économique remarquable, était très atteinte de trypanosomiase jusqu'en 1949. A cette époque, l'ICN était de 7,35%. Huit lomidinisations parvinrent à supprimer l'endémie et cette situation se maintient depuis 1954, car l'activité agronomique régnant dans ce secteur entretient les débrousaillements nécessaires et contribue à éloigner les glossines.

Mais était-il nécessaire d'apporter encore cette preuve ? Il semble que l'accord soit fait sur cette idée : la trypanosomiase ne sera éradiquée que le jour où une population nombreuse et active occupera tout le terrain et rendra, par ses défrichages, les conditions de vie intenables aux glossines ! La pression démographique est un élément positif de la lutte anti sommeilleuse. Encore faut-il commencer par effacer la maladie humaine, pour permettre aux populations d'être actives et stables. Et la chimioprophylaxie par les diamidines a permis de rompre ce cercle vicieux.

E. INFLUENCE PSYCHOLOGIQUE DES CAMPAGNES CHIMIOPROPHYLACTIQUES

Cette influence est réciproque : la psychologie des populations influe également sur le déroulement et le succès ou l'insuccès des campagnes entreprises.

La maladie du sommeil était une affection terrifiante et bien connue. Une méthode destinée à protéger l'homme ne pouvait que susciter l'intérêt, surtout si le même médicament avait une action curative nette : " La rapidité avec laquelle plusieurs cas avancés et presque moribonds se sont rétablis a évidemment fait une forte impression sur la population locale " (Lourie 1940 cité in Muraz 1954).

Mais la chimioprophylaxie à elle seule suffisait à obtenir l'adhésion de la population : " Cette méthode jouit maintenant dans la région d'une très grande popularité, les indigènes eux-mêmes sollicitent son application " (Jonchère 1951).

Il en est encore ainsi en Angola : " Les injections de la Santé ", écrit le Dr. Cardoso de Albuquerque, ont toujours été bien reçues partout, et quand on fait cesser la pentamidinisation, il arrive parfois que les populations manifestent du mécontentement ".

Il suffit d'ailleurs de lire les pourcentages de présences pour s'assurer de la popularité de ces campagnes (cf. ci-dessus).

— Mais les quelques accidents observés, pour rares qu'ils soient, et

2) Dans le district de Cocobeach, l'opération est arrêtée après 1 lomidinisation au 2ème semestre 1952 (ICN = 0,31).

Une courbe voisine de la précédente est observée :
1953/1 ICN = 0,10 1953/2 = 0,08 1954/1 = 0,05 et en 1954/2 l'ICN remonte à 0,25.

3) District de Kango — arrêt après 4 lomidinisations.

1952/2 ICN = 0,11
1953/1 = 0,07 1953/2 = 0,12
1954/1 ICN = 0,24 1954/2 ICN = 0,24

4) District de Batangafo — en 1952/1 l'ICN était amené à 0 après 4 lomidinisations — arrêt des opérations et la situation se maintient en 1953 et 1952, et brusquement en 1955/1 l'ICN passe à 0,5.

5) District de Bouca, la situation est identique à la précédente ; en 1955/1 l'ICN monte à 0,63.

Ainsi donc, une situation améliorée peut se maintenir pendant 1 an 1/2 et l'amélioration s'accuser encore éventuellement. Mais la prospection doit être constamment tenue à jour afin de pouvoir intervenir dès la reprise de l'endémie.

LA CHIMIOPROPHYLAXIE ET LA MEDECINE INDIVIDUELLE

Tout ce que nous venons d'exposer démontre que la méthode chimioprophylactique fait diminuer l'endémie. C'est là le point de vue de l'hygiéniste et il est incontestable que l'action de masse se révèle favorable. Mais nous devons également rechercher l'action individuelle de la méthode et poser les questions suivantes :

A. L'action préventive est-elle suffisamment sûre pour présenter une valeur de prophylaxie individuelle ?

Et quel est le devenir des sujets lomidinisés ?

B. Quelle est l'action des diamidines sur l'organisme ?

C. Enfin une résistance à la pentamidine peut-elle se créer ?

A. L'action préventive est-elle sûre?

Nous avons déjà dit que le pourcentage de sujets trouvés infectés moins de 6 mois après l'injection de lomidine était extrêmement faible : 0,0016%. Cela pourrait signifier que l'on a 99,9984 chances sur 100 d'être protégé contre une infection dans les 6 mois à venir par une injection de lomidine.

En réalité, tous les sujets ayant reçu l'injection n'ont pas été piqués par une glossine infestante. D'autre part, beaucoup de sujets ainsi infectés malgré l'injection préventive sont à la phase de polarisation cérébrale, voire même d'encéphalite démyélinisante.

Deux explications en sont données :

Certains pensent que la lomidine pourrait favoriser le neurotropisme du trypanosome, et déclencher chez lui une réaction de défense le rendant plus résistant aux autres thérapeutiques. Ce point de vue a été exposé devant le C.S.I.R.T. en 1954 par le Médecin-Général Richet.

D'autres y voient surtout un échec du dépistage. L'infection contractée antérieurement à l'injection préventive n'aurait pas été décelée, l'inoculation unique de lomidine n'aurait pas pu stériliser tous les parasites, l'infection aurait continué à évoluer et n'aurait été dépistée qu'à un stade avancé.

Il n'est pas encore possible de conclure mais il semble que plusieurs cas peuvent se présenter.

D'une part, la chimioprophylaxie elle-même peut être en défaut et la fausse sécurité apportée servir de masque au début de la maladie. Le Docteur Saugrain nous a rapporté le cas d'une fillette examinée à Madagascar pour état fébrile et adénopathie et envoyée au laboratoire pour hémogramme, ponction ganglionnaire et recherche de cellules leucosiques. Ce n'est qu'après la découverte fortuite de trypanosomes dans le suc ganglionnaire que les parents expliquèrent qu'ils arrivaient d'Afrique mais ne pensaient pas à la trypanosomiase " parce que l'enfant avait reçu quelques mois auparavant une injection de lomidine ".

D'autre part, il est également possible que le dépistage initial ait été en défaut. Le malade n'est alors reconnu qu'à la prospection suivante, lorsque la maladie a eu le temps d'évoluer, et le temps d'évolution de la trypanosomiase est trop sujet à variations d'un individu à l'autre pour qu'on en puisse tirer des conclusions concernant l'action du médicament sur les affinités du parasite.

En 1952, dans le secteur IX d'A.E.F., 17 nouveaux trypanosomés furent trouvés chez les sujets lomidinisés 6 mois auparavant : 10 étaient en première période et furent considérés comme des échecs de la prévention — 7 étaient en " 2ème période " et furent considérés comme des échecs de dépistage. Mais le nombre même de ces échecs, comparé à leur rareté habituelle, fait demander si une mauvaise qualité du produit injecté ne pouvait pas être incriminée.

L'hypothèse d'un dépistage en défaut peut cependant être maintenue, car on connaît les phases de latence, si troublantes, qui marquent l'évolution de la maladie du sommeil.

Beaucoup plus graves, dans les conclusions qu'ils appellent, sont les cas " d'infection cryptique " qui ont été signalés.

McLetchie, en 1948, signale deux cas présentant des anomalies du LCR et considérés comme des trypanosomiases dans lesquelles on ne pouvait mettre en évidence de trypanosomes.

En 1951, Jonchère signale l'apparition, " chez quelques sujets protégés, de symptômes absolument superposables à ceux que l'on rencontre chez les trypanosomés en deuxième période, mais sans qu'il soit possible de mettre l'agent causal en évidence... Pourtant il s'agit bien de trypanosomés, car ces ' suspects cliniques ' sont rapidement améliorés par les traitements habituels de la deuxième période ".

En 1954, Richet signale que " le nombre des suspects cliniques est plus important qu'auparavant ", et actuellement, on rencontre toujours des cas aussi troublants.

Malheureusement, nous n'avons pas pu retrouver l'exacte proportion de " suspects cliniques " avant et après le début des opérations de chimioprophylaxie.

Expérimentalement, il ne nous a pas été possible de mettre en évidence la persistance des trypanosomes, chez des cobayes infectés, traités avec une dose unique minima curative de lomidine.

B. Quelle est l'action des diamidines sur l'organisme ?

Par cette question nous n'entendons pas rechercher toutes les actions physiologiques de ces produits. Nous en avons déjà parlé à propos des accidents. Mais nous voudrions connaître ce qui, dans ces actions, peut prêter à confusion avec les perturbations apportées par une infection trypanosomienne — en particulier dans les protéines de l'organisme.

L'étude des dossiers de 86 sujets traités par la lomidine à l'Institut Pasteur de Brazzaville nous a montré une fois (fiche n° 4852) une élévation transitoire de l'albuminorachie, qui, à la fin d'une série de 8 injections de lomidine, monta de 0,22 à 0,60, pour redescendre 3 mois après à 0,35 sans thérapeutique ; puis, aux visites trimestrielles suivantes, le taux d'albumine dans le liquide céphalorachidien remontait à 0,40, retombait à 0,24, et ce ne fut qu'un an après qu'il revenait à 0,22, toujours sans autre série thérapeutique, et s'y maintenait, alors que l'infection parasitaire semblait jugulée.

En même temps que l'albuminorachie, le nombre de lymphocytes s'était élevé à 7 par $mm.^3$, puis était redescendu après 3 mois à 3, puis 2.

Quelles conclusions faut-il en tirer? L'injection unique de lomidine est-elle capable de perturber aussi le taux des protéines du LCR? Fragilise-t-elle les défenses méningées ?

Nous n'avons malheureusement pas encore pu développer nos recherches sur ce point, mais nous nous proposons de poursuivre cette étude, tant en ce qui concerne le LCR que les protéines sanguines.

C. La dernière question a poser est de la plus haute importance :

Une résistance à la pentamidine peut-elle se créer ?

La question a été souvent examinée. Launoy (1947), par l'administration de doses trop faibles pour prévenir ou guérir l'infection, n'est pas parvenu à obtenir une souche de trypanosomes chimiorésistante à l'action ultérieure des diamidines, alors qu'il est possible de réaliser cette résistance avec les autres produits trypanocides.

Cependant, Henrard et Peel (1950) ont observé des signes de résistance à la pentamidine sur des souches provenant de malades traités et on connaît des cas cliniques où la pentamidine fut inopérante. Une très grave crainte se fit jour à Nola, en 1948, en présence de deux rechutes lymphatico-sanguines chez d'anciens malades qui, par erreur, avaient reçu, un an avant, l'injection prophylactique de lomidine. Des cures ultérieures de lomidine ne stoppèrent pas l'évolution. (Raynal 1949.) Mais ce n'était que des cas d'espèce, puisque la chimioprophylaxie dans le secteur continua à remporter des succès marqués, et c'est pourquoi nous n'abordons ce problème que sur le plan individuel.

On comprend néanmoins l'angoisse que peut faire naître une telle hypothèse : nous ne disposons pas encore de produits à la fois très actifs et suffisamment atoxiques pour remplacer les diamidines, en chimioprophylaxie, le jour où celles-ci seraient mises en échec par une adaptation biologique d'un parasite dont on connaît la remarquable plasticité.

CONCLUSIONS

Si le principe de la chimioprophylaxie a été posé il y a 30 ans, ce n'est que depuis un peu plus de 20 ans qu'on possède le moyen de la réaliser dans la maladie du sommeil et 12 ans qu'on la pratique couramment en Afrique. Les conditions épidémiologiques de la trypanosomiase à *T. gambiense* sont telles que les autres moyens de lutte, répondant aux hypothèses de Koch ou de Ross s'étaient révélés le plus souvent insuffisants ou pratiquement irréalisables : le " dépistage-traitement " ne parvenait qu'en des territoires limités à tarir le réservoir de virus, et la lutte anti-glossines demandait un effort trop gigantesque pour être entreprise sur toute la zone de répartition de ces insectes vecteurs.

La méthode de chimioprophylaxie par les diamidines aromatiques a permis d'obtenir des succès spectaculaires :

— par l'éradication de certains foyers privilégiés,
— par la diminution des indices d'infestation,
— par le rétrécissement de la zone infestée.

Cependant, il serait imprudent de méconnaître la persistance d'indices liminaires qui prouvent bien que la maladie du sommeil n'est pas encore rayée de la nosologie médicale.

Certes, l'application de cette méthode n'a pas reçu partout la même extension. Cela tient à des différences dans les conditions épidémiologiques et socio-économiques, et à leurs incidences administratives et financières.

Mais même là où elle fut appliquée avec la plus grande envergure, il subsiste des foyers résiduels. La transmission continue à être assurée et la moindre négligence dans la surveillance pourrait entraîner de fâcheux réveils. Plus que jamais discipline, coordination et centralisation sont nécessaires.

C'est justement alors que l'endémie, si elle n'est pas éteinte, est considérablement atténuée, que la prophylaxie rencontre les premiers symptômes du plus grave des écueils : l'atténuation de l'adhésion populaire. Rien n'est plus indispensable à la réalisation d'une technique, qui mobilise les masses, que la coopèration de ces masses mêmes et il faut souhaiter que des facteurs psychologiques ne viennent pas abattre ce mur dressé contre l'un des plus redoutables agents de dénatalité et de mort de l'Afrique Occidentale et Centrale.

La chimioprophylaxie présente une certaine sécurité puisqu'un arrêt momentané n'en fait pas perdre aussitôt le bénéfice. C'est pourquoi l'action doit être de plus en plus sélective pour gagner en efficience.

Enfin, à côté du problème de masse, la médecine individuelle se fait de plus en plus jour.

Le devenir des sujets pentamidinisés est un problème qui vient s'ajouter à tous ceux que pose cette maladie au déroulement encore mystérieux, capable de latences et de guérisons spontanées, ou au contraire d'évolutions accélérées, maladie parasitaire dans laquelle le parasite peut disparaître sans que l'évolution en soit arrêtée, maladie irréversible dans sa phase terminale sans qu'on sache où commence son irréversibilité.

Dans l'histoire de la trypanosomiase humaine, déjà longue de 155 années, la chimioprophylaxie marque un palier prometteur, mais il est possible qu'il reste devant nous autant de degrés à gravir qu'il en a déjà été dépassés, pour atteindre notre but final : l'éradication de la maladie du sommeil.

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QUESTIONNAIRE

concernant la chimioprophylaxie de la Trypanosomiase à *T. gambiense*

1. **Géographie des zones surveillées du point de vue de la Trypanosomiase à *T. gambiense***
2. **Technique de la chimioprophylaxie**

a) Principe de base. Appliquez-vous la chimioprophylaxie à des secteurs administratifs entiers ou faites-vous une chimioprophylaxie sélective uniquement chez les habitants de villages menacés ?

b) Dans la deuxième éventualité, comment classez-vous les villages menacés ?

— sur des bases parasitologiques (recherche du trypanosome dans le sang, les ganglions, le L.C.R.)

— ou sur des bases épidémiologiques (écologie des glossines, lieux de " close personal contact ", etc...) ?

c) Aspect administratif des rassemblements de population pour dépistage et injections prophylactiques. Pourcentage de présence des populations dans les divers villages. Comment les équipes sont-elles distribuées ?

d) Produits utilisés couramment pour la chimioprophylaxie, posologie, mode et rythme d'application — utilisez-vous l'association Pentamidine-Moranyl pour prolonger l'action prophylactique ?

e) Accidents — incidents (pourcentage). Prévention de ces inconvénients.

f) Statistique numérique des injections pratiquées. Le dépistage peut-il être toujours maintenu à jour ?

3. **Résultats obtenus**

a) Evolution des taux des indices de virus en circulation et de contamination nouvelle dans les zones considérées, (indices en 1944 — en 1955 — en 1957).

b) Evolution de la tactique de chimioprophylaxie en fonction des améliorations observées (cf. 2-*a*).

c) Influence de la chimioprophylaxie sur le cycle épidémiologique extrinsèque (captures de glossines et pourcentages d'infestation avant — et depuis la Pentamidine).

d) Influence psychologique sur les populations. Les injections prophylactiques sont-elles bien acceptées ?

e) Influence démographique des résultats obtenus.

4. **Essais divers**

Avez-vous essayé la chimioprophylaxie avec d'autres produits modernes — avec quels résultats ?

5. **Bibliographie** des publications portant sur ce sujet dans les territoires sous votre contrôle.

REPONSE DU SERVICE DES GRANDES ENDEMIES DE L'A.O.F.

Méd. Col. NODENOT

La Chimioprophylaxie est appliquée de façon systématique dans certaines régions très limitées, cantons ou même villages.

En **Côte d'Ivoire,** le long du Cavally qui fait la frontière avec le Libéria, et le long du Lobo, affluent du Sassandra, près du Ghana, 96.732 personnes ont reçu la lomidine préventive à la dose de 0,004 mg./kg., dont 1.742 deux fois. Il n'a pu être procédé partout à la deuxième injection, car le temps nous a manqué par le fait d'une grève des infirmiers qui a duré plus de 4 mois.

Les I.C.N. et I.V.C. moyens de ces divers cantons traités ont été :

— en 1944 de 1,90 et 2,25
— en 1955 de 0,16 et 0,13
— en 1957 de 0,194 et 0,193.

En **Guinée**, la lomidinisation préventive a été faite dans 8 villages le long de la frontière du Libéria et dans le massif du Fouta Djalon où l'endémie a été particulièrement active. 16.442 personnes ont été ainsi protégées.

Les I.C.N. et I.V.C. moyens ont été :

— en 1944 de 0,49 et 0,48
— en 1955 de 0,12 et 0,12
— en 1957 de 0,09 et 0,071.

En **Haute-Volta**, 18.216 personnes ont été lomidinisées, dont 886 deux fois, le long de la Léraba, dans le canton de Toumana.

Les I.C.N. et I.V.C. sont passés de :

— 1944 de 2,06 et 1,96 à
— 1955 de 0,09 et 0,09 et
— 1957 de 0,02 et 0,01.

En plus, au **Sénégal**, le Personnel de la C.G.O.T. (Cie Générale des Oléagineux Tropicaux) près de Sédhiou, Haute-Casamance, a été lomidinisé sur la demande de ses dirigeants. L'évolution des indices n'est pas encore connue chez les 1.409 personnes ainsi protégées.

Au **Soudan**, dans la région de Ségou et de Bamako, le long du Niger, 36.125 personnes ont été lomidinisées.

Cette prophylaxie chimique est faite par les équipes de prospection. Toute séance de lomidinisation préventive est précédée d'un examen systématique du sang en goutte épaisse colorée. L'administration du médicament préventif est décidée soit au moment de la prospection, quand l'I.C.N. atteint ou dépasse 1 p. 100 dans le village ou le canton rassemblé, soit à l'avance dans les endroits particulèrement exposés des frontières ou cours d'eau où abondent les glossines et où passent des émigrants nombreux.

Le plan des prospections et des lomidinisations est fait chaque année en accord avec l'administration et, quelques semaines à l'avance, les chefs de cantons et de villages sont prévenus de la date exacte à laquelle passera l'équipe et des lieux de rassemblement. Ceux-ci sont choisis dans des villages assez importants pour que les infirmiers puissent y acheter leur nourriture et se loger si nécessaire, et suffisamment rapprochés pour que les habitants de la région environnante n'aient jamais à faire plus de 10 km. Malgré toutes ces mesures, le pourcentage de la population aux prospections est très variable. Encore satisfaisant, puisqu'il reste aux environs de 75%, dans les villages de la brousse en Haute-Volta, Soudan, Côte d'Ivoire et Nord Dahomey, il diminue beaucoup partout ailleurs, pour devenir ridicule dans les villes ou agglomérations importantes. Lorsqu'une population ne se présente pas au médecin ou à l'équipe dans une proportion au moins égale à 75%, on ne peut avoir aucun renseignement épidémiologique sûr, d'autant plus que ce sont les malades qui, en règle générale, restent chez eux. . La proportion de plus en plus importante de trypanosomés trouvée en période nerveuse s'explique davantage par cet absentéisme que par une " décapitation " de la maladie du sommeil due à l'injection stérilisante, mais non curatrice, d'une dose unique de diamidine. Ce refus de plus en plus fréquent de venir aux prospections se voit surtout dans les zones où l'administration est impuissante ou peu active. Il est temps de trouver des moyens de faciliter le travail de nos équipes, car l'I.V.C. moyen de l'A.O.F. est passé de 0,07 en 1956 à 0,09 en 1957. C'est la première fois, depuis 1939, qu'il remonte.

L'indice de contamination des glossines a été fait, en 1953, à Bamako où une seule *palpalis* a été trouvée infectée sur 53 échantillons. Dans la brousse, il n'a pas été procédé à cette opération à cause de la variété des trypanosomes du type *brucei* qui peuvent les contaminer, ce qui fait qu'on n'est jamais sûr d'avoir affaire à du *gambiense* par simple examen microscopique à l'état frais.

En règle générale, la chimioprophylaxie est bien acceptée dans les régions où nous la faisons, à condition que l'injection protectrice ne se renouvelle pas. Un exemple typique est fourni par le canton de Dima dans la subdivision de Nouna au Secteur Spécial n° 6 en Haute-Volta. Au mois de septembre 1956, les habitants du village de Sogdiankoli et du village de Samé venaient à la prospection au nombre de 261 sur 322 recensés, soit 81% de présence; on dépistait 13 malades, dont 2 en période nerveuse, soit 4% d'I.C.N. à l'examen du suc ganglionnaire et de la goutte épaisse colorée systématique. Lomidinisation préventive a été faite à la dose habituelle de 0,004 g./kg. En mars 1957, quand on revient pour la deuxième injection, on ne voit plus que 164 villageois, soit 51%. Mais il y avait un assez grand nombre de gens qui ne s'étaient pas présentés à la première séance, et on trouve encore dans les mêmes conditions 8 nouveaux trypanosomés, dont 2 en deuxième période. Tous les gens présents et indemnes ont été lomidinisés. Un troisième séance de lomidinisation préventive fut faite en décembre et on ne voit plus que 10 individus parmi lesquels on trouve encore 1 N.T. en 1ère période. Les 9 autres furent lomidinisés. Les gens commencent bien à venir quand ils sentent le danger proche, mais ne se dérangent plus quand ils pensent n'avoir plus rien à craindre dans l'immédiat.

Pour la chimioprophylaxie, nous nous en tenons à la Lomidine. Des essais de protection par l'association moranyl-diamidine ne nous ont pas donné de résultats supérieurs. En 1954, la population des villages de Laro, Dima, Nahouya et Karoba, en Haute-Volta, a été choisie pour un essai comparatif de protection par la lomidine seule et l'association moranyl-lomidine.

Les tableaux suivants donnent les résultats :

Tableau 1.

Villages	Février 1953 Population		A.T.	N.T.	I.C.N.	I.V.C.	I.C.T.
	recensée	visitée					
Laro	355	391	13	14	3,3	3,5	6,9
Dima	64	54	0	3	5,5	5,5	5,5
Nahouya	220	272	3	6	2,2	2,2	3,6
Karoba	344	327	0	5	1,5	1,5	1,5

Lomidinisation en mars 1953 : 780 sujets protégés
Contrôle en janvier 1954

Tableau 2.

Population visitée dans ces 4 villages	A.T. +	A.T.O.	N.T. +
773	0	34	2

Du 26 au 31 décembre 1954, les opérations de protection ont été refaites avec : **lomidine** : 0,004 g./kg. pour les 2 villages de Nahouya et Karoba.

Moranyl 0,02 g./kg. plafond 1 gr. + lomidine 0,004 g./kg, dans les villages de Laro et Dima, dans les conditions suivantes :

Tableau 3.

Prophylaxie par :	Villages	Population		A.T.	N.T.	Protégée	Exemptée causes diverses
		Recensée	Visitée				
Lomidine seule	Nahouya	220	213	9	0	210	11
	Karoba	344	212	5	1	207	5
		564	425			417	
Lomidine + Moranyl	Laro	355	377	17	0	356	21
	Dima	64	49	6	1	48	
		419	426			404	

Tableau 4.

Prophylaxie par:	Villages	Population					Prot. revus	N.T. +	
		Recensée	Visitée Déc. 1954	Visitée Avril 1955	Protégée Déc. 1954	Protégée Avril 1955		Prot.	Non prot.
Lomidine seule	Nahouya	220	213	209	202	3	193	0	1(a)
	Karoba	344	212	214	207	4	204	0	0
		564	425	423	409	7	397	0	1
Moranyl + Lomidine	Laro	355	377	414	356	23	339	0	1(b)
	Dima	64	49	59	48	4	42	0	0
		419	426	473	404	27	381	0	1

a)—1ère période
b)—2ème période

Tableau 5.

Prophylaxie par :	Villages	Population visitée				Protégée		Protégée Revus	N.T. +	
		Recensée	Déc. 1954	Avril 1955	Juillet 1955	Déc. 1954	Avril 1955		Prot.	Non prot.
Lomidine seule	Nahouya	220	213	209	213	202	3	196	0	0
	Karoba	344	212	214	214	207	4	204	0	0
		564	425	423	427	409	7	400	0	0
Moranyl + Lomidine	Laro	355	377	414	402	356	23	360	0	0
	Dima	64	49	59	55	48	4	46	0	0
		419	426	473	457	404	27	406	0	0

Tableau 6.

Prophylaxie par :	Villages	Population				N.T	
		Recensée	Visitée	Protégée	Visitée et protégée Août 1955	Protégée	Non protégée
Lomidine seule	Nahouya	220	206	205	196	0	0
	Karoba	344	214	211	203	0	0
		564	420	416	399	0	0
Moranyl + Lomidine	Laro	355	402	379	363	0	0
	Dima	64	55	52	47	0	0
		419	457	431	410	0	0

Tableau 7.

Prophylaxie par :	Villages	Population				N.T.	
		Recensée	Visitée	Protégée	Protégée et visitée Sept. 1955	Protégeé	Non protégée
Lomidine seule	Nahouya	220	192	205	190	0	0
	Karoba	344	174	211	163	0	0
		564	366	416	353	0	0
Moranyl + Lomidine	Laro	355	377	379	367	0	0
	Dima	64	40	52	34	0	0
		419	417	431	401	0	0

Tableau 8.

Prophylaxie par :	Villages	Population				Protégée et visitée	N.T.	
		Précédemment	Recensée 1955	Visitée	Protégée		Protégée	Non protégée
Lomidine seule	Nahouya	220	330	196	205	179	0	0
	Karoba	340	470	226	211	178	0	0
		560	806	422	416	357	0	0
Moranyl + Lomidine	Laro	355	499	466	379	356	0	0
	Dima	64	55	57	52	38	0	0
		419	564	523	431	394	0	0

REPONSE DES SERVICES DE LUTTE CONTRE LA MALADIE DU SOMMEIL DE L'ANGOLA

Dr. Cardosa de Albuquerque

1° Géographie des zones surveillées du point de vue de la Trypanosomiase à *T. gambiense.*

La zone contrôlée par les Services de Prophylaxie et Combat de la Maladie du Sommeil en Angola englobe les aires des Districts Administratifs du Congo, Cuanza Norte et Luanda, entre la frontière Nord et le parallèle 10° Sud environ.

Dans les Districts de Cabinda, Malange et Cuanza Sul des prospections périodiques ont été faites par les équipes mobiles. La chimioprophylaxie, dans ces régions, a eu lieu seulement quand il y avait des cas autochtones de maladie. Dans cette vaste région, il y a à considérer deux zones distinctes :

a) Une zone littorale, qui s'étend depuis la côte jusqu'à quelque 150 kilomètres à l'intérieur du pays, avec des altitudes ne dépassant pas 350–400 mètres, de faible pluviosité, inférieure à 700 millimètres par an, et une végétation caractéristique de steppes de graminées, entrecoupées de galeries forestières le long des fleuves de la région.

b) Une zone de plateau, avec des altitudes variant de 400 à 1.200 mètres, de pluviosité supérieure à 1.000 millimètres par an, et une végétation de savanes sur les hauteurs du type " Durierbosa ", et de forêts le long des rivières et dans les vallées du type " Laurisilva ".

Toute la région est traversée par de nombreux cours d'eau, faisant partie des bassins hydrographiques des fleuves Zaïre, M'Bridge, Loge, Dande et Cuanza, leurs affluents et sous-affluents.

Les températures moyennes annuelles oscillent entre 20° minimum et 24° maximum.

2° Technique de la Chimioprophylaxie

a) Pratiquée depuis 1949 à certains endroits, elle a été étendue depuis 1952 à toute la population de la zone correspondant aux districts administratifs de Cuanza Norte, Luanda et Congo, à l'exception des aires où il n'y a eu aucun cas autochtone de la maladie.

b) Le dépistage des malades et l'application des injections prophylactiques de la pentamidine sont faites par les 5 équipes mobiles existantes, dont chacune est constituée par :

1 médecin,
2 infirmiers,
21 microscopistes,
10 agents sanitaires,
1 chef des services administratifs,
3 chauffeurs,
10 ou 12 aides indigènes.

Chacune des équipes mobiles est auto-transportée par 4 camions de 4.500 tonnes, dont un aménagé pour le transport du personnel, disposant du matériel de campagne et de laboratoire, pour observer 819 lames de sang en goutte épaisse ou de suc ganglionnaire par jour, prélevées sur tous les indigènes qui se présentent aux rassemblements des populations prévenues d'avance par les autorités administratives. Toutes les équipes mobiles travaillent sur le terrain 11 mois par an selon des plans établis au préalable par l'Inspection du Service et d'accord avec les médecins-chefs de chaque équipe.

c) Ainsi, toute la population de la zone endémique est observée, au moins une fois chaque année, par les équipes mobiles et pentamidinisée dans les aires où ont été dépistés des cas autochtones de trypanosomiase. Dans les secteurs de la frontière Luso-Belge, on fait la pentamidinisation en masse de toute la population, indépendamment des cas nouveaux dépistés.

En plus de cette prospection dite " en profondeur ", faite par les équipes mobiles, chacun des chefs de secteur sanitaire observe tous les trois mois la population de l'aire à sa charge, en faisant l'examen du suc ganglionnaire à l'état frais des porteurs d'adénopathies cervicales, et l'examen complet, le L.C.R. inclus, de tous les malades sous contrôle en voie de conduire la thérapeutique ou les donner comme guéris selon le criterium adopté.

d) Le seul produit utilisé a été jusqu'à présent, la Pentamidine May and Baker sous la forme de di-iséthionate en solution aqueuse à 5% en injection 5 mg./kg. La pentamidinisation est pratiquée suivant le rythme bi-annuel, mais exceptionnellement, et pour des raisons locales ou matérielles, il s'est écoulé parfois, entre deux injections, une durée de 7, 8 et même 12 mois.

Devant l'inocuité de la méthode, les contre-indications sont très réduites et on considère seulement celles relevant d'un état général précaire. On n'a jamais fait l'association pentamidine-moranyl.

e) Les accidents observés sont très rares et sans gravité. Ils sont surtout des lipothymies et des vomissements sans conséquences désagréables.

Le pourcentage des accidents observés à la suite des injections prophylactiques de la pentamidine n'a jamais excédé 0,01%.

f) Les injections prophylactiques de pentamidine pratiquées ont été les suivantes :

1949 . . .	125.200	1953 . . .	503.015
1950 . . .	365.038	1954 . . .	634.340
1951 . . .	460.059	1955 . . .	555.298
1952 . . .	581.428	1956 . . .	556.439
1957	752.360		

Le dépistage des malades est toujours maintenu à jour dans la région surveillée par les secteurs sanitaires, qui font l'examen de la population tous les trois mois et également celui des individus en transit.

Dans les aires où l'endémie est presque inexistante, on fait la prospection de la population une fois par an, par une des équipes mobiles.

3° Résultats obtenus

a) Les incidences de virus en circulation dans la zone surveillée, soit les districts administratifs de Congo, Cuanza Norte et Luanda, ont été les suivants :

	%		%
1949 . . .	4,77	1953 . . .	0,04
1950 . . .	1,02	1954 . . .	0,03
1951 . . .	0,24	1955 . . .	0,03
1952 . . .	0,12	1956 . . .	0,04
1957	0,02%		

On voit qu'après la chute spectaculaire des indices dans les premières années, l'endémie résiduelle se maintient, surtout à proximité de la frontière où l'extrême mobilité des populations d'un côté et de l'autre, rend son contrôle extrêmement difficile.

b) Comme nous l'avons déjà mentionné, la pentamidinisation est faite dans tous les secteurs où nous avons vérifié des cas autochtones de la maladie, après l'observation de toute la population.

Dans les villages pentamidinisés et où aucun cas autochtone de la maladie n'a été dépisté pendant trois prospections consécutives, on arrête la pentamidinisation, mais la population est maintenue en surveillance, avec des examens annuels de sang en goutte épaisse de tous les individus et du suc ganglionnaire des porteurs d'adénopathies cervicales.

Dans les régions de la frontière on fait la pentamidinisation de masse à toute la population. D'ailleurs, c'est là que s'accroche le foyer endémique le plus intense de toute la Province.

c) Nous n'avons pas d'éléments exacts en ce qui concerne l'influence de la chimioprophylaxie sur l'infestation des glossines. Des travaux à ce sujet sont en cours à l'Institut de l'Investigation Médicale de l'Angola dont les résultats seront publiés dès que possible.

d) La collaboration des populations indigènes a été la plus complète, comme on peut le voir par le pourcentage de présences aux rassemblements effectués.

Les pourcentages de présences ont été les suivants :

	%		%
1948 . . .	99,5	1953 . . .	92,1
1950 . . .	99,2	1954 . . .	100
1951 . . .	96	1955 . . .	95
1952 . . .	93,8	1956 . . .	92,7
1957 . . .	91,7%		

Les " injections de santé ", comme sont appelées les injections de pentamidine, ont toujours été bien reçues partout et quand on fait cesser la pentamidinisation, dans les conditions déjà mentionneés, il arrive parfois que les populations manifestent du mécontentement.

e) Les indices d'évolution démographique dans la zone surveillée ont été les suivants :

	%
1949 . . .	0,77
1953 . . .	1,56
1956 . . .	2,03

4° Essais divers.

Nous n'avons pas essayé jusqu'à présent d'autres produits pour la chimioprophylaxie de la Trypanosomiase à *T. gambiense.*

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REPONSE DU
SERVICE D'HYGIENE MOBILE ET DE PROPHYLAXIE
DU CAMEROUN

Méd. Col. FEYTE

1° **Géographie des zones surveillées** du point de vue de la Trypanosomiase à *T. gambiense.*

Pratiquement tout le Territoire du Cameroun est soumis au contrôle de la Trypanosomiase. Celui-ci est réalisé par les équipes de prospection polyvalentes du S.H.M.P., qui, selon l'importance locale de l'endémie sommeilleuse, effectuent des prospections tous les six mois, tous les ans, ou tous les deux ans.

Actuellement, sous forme de cas sporadiques, la Trypanosomiase existe dans presque toute la zone Sud du Cameroun, dont la bordure septentrionale est figurée par le contrefort du plateau de l'Adamaoua. Le plateau lui-même et la partie Nord du pays en sont pratiquement indemnes, à l'exception d'un foyer tenace et difficilement contrôlable qui se maintient le long des rives du Logone, puis du Chari, en aval de Logone-Birni.

Au cours de ces dernières années, la lutte contre la Trypanosomiase humaine a été intensifiée dans les zones où nos prospections avaient détecté des indices endémo-épidémiques. La chimioprophylaxie à base des diamidines aromatiques a été un des éléments de la lutte et s'est affirmée comme étant une arme d'une efficacité majeure.

C'est ainsi que, du Nord au Sud du Cameroun, ont été soumises à cette méthode les zones décrites ci-dessous :

1. Les rives camerounaises du Logone et du Chari, dans les Sultanats du Goulfeï, de Kousseri et de Logone-Birni. Bordées par une végétation arbustive, propice à l'existence de Glossina tachinoïdes, dont l'aire d'extension se superpose, au cours de l'année, avec la zone d'inondation, elles représentent au Cameroun un des plus anciens foyers de Maladie du Sommeil.

Dès 1925, le Dr. Jamot fut chargé de le réduire. Il l'inventoria, précisa ses limites et les taux de contamination. Il inaugura les campagnes prophylactiques qui se proposaient de stériliser le réservoir de virus humain. Son œuvre fut poursuivie par le Dr. Montestruc et entretenue jusqu'à nos jours. Malgré les efforts persévérants dont elle fut l'objet, il subsiste encore dans cette zone une endémie qui ne demande qu'à s'intensifier lorsque la lutte se relâchera. Ce demi-échec s'explique par la difficulté que l'on rencontre à contrôler la population de cette zone qui, à part une minorité sédentaire, est constituée par des éléments instables: tribus nomades de pasteurs se déplaçant à la recherche de pâturages (Arabes, Bornouans), colporteurs circulant entre l'A.E.F. et la Nigéria (Haoussas), résidants saisonniers (pêcheurs Kotokos et Massas qui descendent le Logone pour une campagne de pêche).

2. Le pays Tikar se développe sur les subdivisions de Banyo (Région de l'Adamaoua), de Yoko (Région de Mbam), de Fomban (Région Bamoum). Il est constitué par une plaine drainée par le Mbam et par son affluent la Mapée. Le long des fleuves et de leurs affluents s'allongent des forêts galeries où existent des conditions climatiques analogues à celles de la forêt du Sud-Cameroun.

3. Dans la zone montagneuse du pays Bamiléké. Il existe deux foyers d'étendue restreinte:

a) Dans la subdivision de Bouda, l'endémie sommeilleuse se maintient dans la vallée du Noun, auprès des Centres de Bati et de Bamindjing.

b) On relève chaque année quelques cas au Nord de la Subdivision de Bafang.

4. La région de Nyong et Sanaga. Il persiste des cas sporadiques, disséminés dans les subdivisions de Saa, Okala et Obala, où sévissaient, il y a encore quelques années, d'importants foyers de Maladie du Sommeil.

5. La zone côtière de la région du Vouri et plus particulièrement l'estuaire du fleuve Vouri. Là encore, une partie importante de la population est constituée par des éléments étrangers qui se renouvellent sans cesse, et plus particulièrement, par des pêcheurs provenant des territoires voisins qui s'installent pour de brèves périodes sur ces côtes poissonneuses.

6. Dans la subdivision de Mbang (Région du Mungo) sévissait un foyer de trypanosomiase dans la zone des bananeraies de Ndjombé, qui confine au Cameroun Britannique. Les campagnes de chimioprophylaxie sont parvenues à le réduire, mais une surveillance vigilante s'impose du fait de l'apport de nombreux trypanosomés provenant du territoire voisin.

7. Sur le littoral, dans la subdivision de Campo, les campagnes de lomidinisation ont blanchi rapidement une zone dans laquelle, autour des centres de Campo et d'Ikoko, on recensait depuis plusieurs années des indices alarmants.

8. Le foyer Mbimou, au Nord-Est de la subdivision Yokadouma, s'est constitué dans le prolongement de la zone voisine de Nola (Oubangui) où depuis longtemps la trypanosomiase sévissait à l'état épidémique. Les résultats obtenus par six années de chimioprophylaxie ont été extrêmement favorables, puisque l'indice de la contamination se maintient à zéro depuis 1 an et demi.

9. La Trypanosomiase qui, pendant fort longtemps, s'est maintenue à l'état endémo-épidémique au Sud de Bafia (pays Balamba et Yambetta), ne se manifeste plus que par de rares cas disséminés.

2° Technique de la chimioprophylaxie

Principe de base déterminant l'application de la chimioprophylaxie

Les zones de chimioprophylaxie ont été déterminées par des considérations portant sur les taux des indices de virus circulant (I.V.C. supérieur ou égal à 0,5%) et sur les conditions épidémiologiques de possibilité de transmission.

Actuellement, il subsiste deux foyers protégés par la lomidinisation préventive :

— celui des rives du Logone et du Chari, de part et d'autre de Fort-Foureau; les I.V.C. de la dernière année se situent entre 0,2% et 0,6%.

— et celui de l'estuaire du Vouri où, lors de la prospection d'août 1957, aucun trypanosomé ne fut dépisté.

Malgré ces indices, la chimioprophylaxie est maintenue dans ces deux zones, en raison des conditions épidémiologiques qui sont particulièrement propices à susciter une réapparition de l'endémie, si ce n'est à une nouvelle flambée épidémique.

Malgré tous les efforts apportés à réaliser une chimioprophylaxie de masse, nous ne parvenons, en ces points, à atteindre que la fraction stable de la population. L'autre partie étant constituée par des éléments étrangers, qui représentent un apport possible et constant de réservoir de virus, nous estimons nécessaire de protéger sans interruption la population permanente de cette région.

Pour être efficace, la limite de la zone d'application de la chimioprophylaxie doit déborder largement les limites du foyer de trypanosomiase. Elle doit constituer autour de celui-ci une ceinture dans la zone où les indices de virus circulant sont nuls. Ainsi est créée une zone de sécurité s'opposant à l'extension périphérique de la trypanosomiase.

La chimioprophylaxie est utilisée à titre de protection des individus qui, venant de zones indemnes, pénètrent dans une région contaminée, dans laquelle, au cours de leur séjour, leur activité les exposera à contracter la trypanosomiase. Tel est le cas des rives du Logone et du Chari, où viennent s'installer, pendant quelques mois de la saison sèche, des pêcheurs de race Massa. A leur intention, des postes-filtres, où sont effectuées les injections préventives, ont été installés en amont du Logone, à Yagoua et à Pouss.

Aspect administratif des rassemblements de population

Les campagnes de chimioprophylaxie sont réalisées par les équipes de prospection des Secteurs S.H.M.P. Elles sont prévues dans leurs plans de travail. Quelques semaines avant qu'une d'entre elles débute, les autorités administratives en sont prévenues et reçoivent le programme selon lequel elle se déroulera. A leur tour, elles agissent auprès des chefs autochtones, qui sont chargés d'assurer, aux dates fixées, les rassemblements des populations.

Dans chaque centre l'opération est pratiquée en deux temps :

1) dépistage des nouveaux trypanosomés,

2) pratique de l'injection préventive de Lomidine aux individus reconnus non atteints.

Le pourcentage de présence est en moyenne de 80%. Souvent il dépasse ce taux dans les régions dont les populations sont stables. Par contre, il lui est très inférieur dans les zones où existe une importante population itinérante (Logone-Chari, estuaire du Vouri).

La chimioprophylaxie est réalisée au moyen d'injections semestrielles de pp. Diamidino-Diphenoxy-Pentane. Le produit utilisé est la Lomidine, fabriquée par Spécia, qui nous est livrée en solution à 4%, dans des flacons à bouchon perforable. Cette présentation assure le maximum de garanties d'asepsie.

La posologie pour chaque injection est établie à 4 mmgr. de Lomidine par kg. de poids ; ce qui correspond à 4 ctgr, c'est-à-dire à 1 cc. de la solution, pour 10 kg. de poids.

L'association Pentamidine-Moranyl a été employée au Cameroun. L'intérêt qu'on lui attribuait résidait dans la prévention des accidents causés par l'injection de Pentamidine et dans l'allongement de la durée de la chimio-protection. Son utilisation fut supprimée en juillet 1954, en raison des difficultés qu'offraient ces injections de produits associés et des réactions douloureuses, parfois inflammatoires, que suscitait le mélange médicamenteux.

La pénétration de la Lomidine dans l'organisme déclenche chez certains individus, particulièrement sensibles, des réactions de déséquilibre vago-sympathique. On a pu noter, selon l'importance de ces manifestations ;

— *a*) de simples malaises avec nausées, sueurs, vertiges, qui sont habituellement fugaces. Tels sont les troubles le plus souvent observés.

— *b*) des vomissements avec état lipothymique.

— *c*) exceptionnellement des syncopes. Des cas mortels ont été enregistrés. Ces incidents relèvent concurremment de l'action hypotensive de la Lomidine et de l'état de fatigue de l'individu (danses, longues étapes pour se rendre au Centre, libations abondantes).

D'autre part, on a constaté des incidents d'ordre infectieux liés à des fautes d'asepsie ou favorisés par l'action locale du choc que détermine le produit.

Nous rapporterons deux ordres d'incidents, qui furent particulièrement graves.

En novembre 1954, dans la subdivision de Yokadouma, par suite de l'utilisation d'une solution de Lomidine, faite extemporanément, avec une eau dont la stérilisation était défectueuse, il apparut de nombreux cas de gangrène gazeuse, provoquant 23 décès et atteignant plus ou moins gravement 284 malades.

En août 1957, lors de la chimioprophylaxie pratiquée dans la zone des bananeraies de Djoumbé (Subdivision de Banga), il y eut deux cas de syncopes mortelles, dont le début suivit immédiatement l'injection de Lomidine. La mort survint dans la seconde 1/2 heure. Il s'agissait de deux jeunes gens, venus de la région de Nkam pour travailler comme manœuvres dans les bananeraies. Les autopsies ne purent être effectuées. On suppose que, malgré l'heure matinale de la séance de chimioprophylaxie, ces deux manœuvres avaient absorbé des quantités assez importantes d'alcool pour les sensibiliser à l'égard du produit injecté.

Les recommandations suivantes sont observées par les équipes qui effectuent des opérations de Lomidinisation :

— pratiquer l'injection sur des individus à jeun — plus particulièrement quant à l'alcool;

— les séances doivent être proscrites pendant les heures les plus chaudes de la journée;

— injecter lentement la Lomidine après s'être assuré que l'extrêmité de l'aiguille ne se trouve pas dans la lumière d'un vaisseau;

— faire reposer les individus lomidinisés, à l'ombre, durant une heure après l'injection.

Les mesures suivantes sont appliquées, lors de l'apparition d'accidents hypotensifs :

— administration de toni-cardiaques (camphre, spartéine ou abaïne), dans le cas d'un syndrome bénin;

— si les incidents s'avèrent graves, ou s'il s'agit de syncope, une injection intraveineuse de Moranyl devra être pratiquée, à raison de 1 ctgr. par kg. (avec plafond de 0 gr. 50).

Nous employons avec d'excellents résultats l'administration préventive, " per os ", de comprimés de produits anti-histaminique (Phénergan). Grâce à cette méthode, les rares incidents que nous observons sont très bénins.

La statistique s'effectue pour chaque groupement de population lors du dépistage de la trypanosomiase, puis au moment de la séance d'injections chimioprophylactiques.

Le tableau ci-joint rapporte l'évolution des campagnes de chimioprophylaxie auxquelles ont été soumises plusieurs zones à trypanosomiase du Cameroun.

Influence de la Chimioprophylaxie sur le cycle extrinsèque.

Depuis la mise en pratique de la chimioprophylaxie, les recherches entomologiques ont montré parmi les glossines contrôlées la très faible proportion de celles qui sont infectées par les trypanosomes.

L'examen systématique de *Gl. palpalis*, capturées en 1957 aux environs de Yaoundé, a confirmé les constatations faites les années précédentes. Alors que les infestations trypaniques salivaires persistent à être rares (2 fois sur 1 720 glossines disséquées, soit 0,11 % des cas), les infestations intestinales restent fréquentes (6,27 % des glossines disséquées). Les possibilités de transmission sont faibles dans la zone périphérique de Yaoundé, qui possède de pareils indices.

Dans l'ensemble, la chimioprophylaxie par la Lomidine est bien acceptée par les populations. Mais si son application se prolonge, celles-ci, qui oublient rapidement le danger que représentait la Maladie du Sommeil, deviennent indifférentes envers elle, et l'on constate que les pourcentages de présence devant les équipes de traitement s'amenuisent rapidement.

Pour conclure, nous soulignerons la valeur de la chimioprophylaxie par la Pentamidine, qui est venue compléter et étayer l'action prophylactique qui jusqu'en 1947 visait seulement, dans le cycle d'évolution du trypanosome, à stériliser l'homme contaminé.

Presque partout au Cameroun, les indices sont tombés à des taux très faibles, qui relèvent de la " Surveillance Médicale ".

Chimioprophylaxie de la Trypanosomiase en 1957

Régions	Population recensée	Population visitée	Population lomidinisée	Tryp. parmi lomidinisés		Indice virus circulant %	Nombre de campagnes antérieures
				+6 mois − 1 an	− 6 mois		
Logone et Chari Sultanat de Goulfei Janvier 1957 Juillet 1957	7.718 8.153	5.704 4.053	5.699 4.017	0 0	0 0	0,1 0,24	11
Bamileke Subd. de Bouda Bamindjing et Bat Mai 1957	2.942	2.142	2.125	0	0	0	9
Mungo Subd. de Banga Centre de Djombé Février 1957 Août 1957	3.753 3.753	4.256 3.073	4.223 3.073	0 0	0 0	0,1 0	2
Kribi Subd. de Campo Campo et Ypoko	696	465	447	0	0	0	3
Vouri Monoka	1.070	785	772	0	0	0	5

Lomidinisations

	Régions	Nombre d'injections	Population visitée
1945		21.867	—
1947		—	533.159
1948	Haut-Nyong, Boumba-Ngoko	15.028	332.200
1949	Bamileké . . . . Haut-Nyong . . . . Boumba-Ngoko	— 11.312 3.200	259.857
1950	Logone-Chari . . . . Boumba-Ngoko . . . . Nyong et Sanaga . . . . Mbam	13.500 — — 25.025	279.483
1951	Bamoun . . . . Adamaoua. . . . . Logone-Chari . . . . Mbam . . . . Nyong et Sanaga	— 5.383 1.010 — —	362.886
1952	Bamileké, Bamoun, Adamaoua, Nyong et Sanaga, Vouri, Haut-Nyong, Logone-Chari, Mbam, Boumba-Ngoko, Mungo	189.056	382.276
1953	Bamileké, Haut-Nyong, Nyong et Sanaga, Bamoun, Adamaoua, Vouri, Mungo, Logone-Chari, Boumba-Ngoko, Mbam	247.167	461.012
1954	Logone-Chari, Bamoun, Adamaoua, Bamileké, Mungo, Vouri, Mbam, Nyong et Sanaga, Haut-Nyong, Boumba-Ngoko, Lom et Kadei. . .	235.676	320.284
1955	Kribi, Bamileké, Bamoun, Adamaoua . . .	54.296	245.689
1956	Nyong et Sanaga, Kribi, Vouri, Mungo, Bamileké, Bamoun	92.118	450.328
1957	Bamileké, Vouri, Kribi, Mungo, Logone, Chari .	20.358	657.715

Trypanosomiase humaine au Cameroun au cours des années 1948 à 1957

Années	Population du pays	Population visitée	Nouveaux Trypanosomés dépistés
1948	2.997.000	332.200	4.340
1949	2.997.000	259.857	3.627
1950	2.997.000	279.483	3.045
1951	2.997.000	362.886	1.430
1952	3.065.000	382.276	744
1953	Un peu plus de 3 millions	461.012	1.125
1954	Un peu plus de 3 millions	320.284	552
1955	Un peu plus de 3 millions	245.689	668
1956	3.187.621	450.328	367
1957	3.187.621	657.715	359

Evolution du taux des indices de trypanosomiase dans les zones soumises à la chimioprophylaxie

Régions et Subdivisions	1947		1948		1949		1950		1951		1952		1953		1954		1955		1956		1957	
	ICN	ICV	ICN	ICV	ICN	ICV	ICN	ICV	ICN	ICV	ICN	ICV	ICN	ICV	ICN	ICV	ICN	ICV	ICN	ICV	ICN	ICV
Bamiléké Bafang					**2,28**	**2,26**			1,35	1,35	0,02				0,12		0,04				0,05	0,05
Bamoun Pays Tikar	0,67								**0,37**	**0,39**	0,12				0,37		0,2				0,4	0,2
Haut-Nyong																						
Ensemble de la région													0,19		0,14		0,2					
Messana	2,2	2,2	**2,74**	**2,81**	0,12	0,13			0,045	0,05	0,1	0,1									0,02	0,02
Abong Mbang					**1,29**	**1,32**	0,30				0,06	0,06									0	0
Boumba-Ngoko Yokadouma			**8,21**	**8,25**	0,07	0,11	1,55				0	0			0						0	0
Mbam Bafia					2,37	2,32	**1,27**	**1,27**	0,35	0,35			0,13				0,13				0,04	0,04
Logone-Chari																						
Ensemble région	0,4	0,5	0,81	0,82							0,2	0,2	0,75		0,3		0,4					
Sultanat Koussery							**2,1**	**2,1**	0,53		0,16	0,8									0,63	0,62
Sultanat Legone-Bimi							**1,6**	**1,6**	2,56		0,45	0,38									0,22	0,21
Sultanat Goulfei							0,3	0,3	0,6		**0,86**	**0,86**									0,3	0,3
Mungo Moanga	0,7				1,15	1,15			**0,8**	**0,8**			0,4	0,4	0,07		0,2				0,1	0,1
Nyong et Sanaga																						
Yaoundé	1,40		0,52	0,52	0,68	0,72	**0,43**	**0,45**	0,1	0,1	0,12	0,12	0,1								0,03	0,03
Saa			0,39	0,41					**0,3**	**0,3**	0,12	0,12									0,1	0,1
Vouri																						
Estuaire du fleuve					0,12	0,12			0,2	0,2	0,18	0,18	0,1		0,24		0,17		**0,24**	**0,24**	0	0
Kribi Campo			0,25	0.25											2	2	**1,3**	**1,3**	0,45	0,45	0	0
Nkam Yabassi							0.04				**0,12**	**0,12**	0,17	0,17							0,08	0,08

En caractères gras = début de la chimioprophylaxie.

REPONSE DES SERVICES MEDICAUX DU CONGO BELGE

Dr. C. Dricot

1° **Géographie des zones surveillées** du point de vue de la Trypanosomiase à *T. gambiense.*

Ces zones sont indiquées sur la carte annexée.

2° **Technique de la chimioprophylaxie**

a) **Principe de base :**

La méthode employée est celle de la chimioprophylaxie sélective, utilisée uniquement chez les habitants de villages menacés.

Dans la zone occupée par la Section d'Assistance du Foreami en Province de Léopoldville, par contre, la chimioprophylaxie est plus étendue : sélective au début (1940), elle est appliquée depuis 1949 à des secteurs administratifs entiers. Cette nouvelle formule de protection beaucoup plus efficace consiste à protéger, en même temps que le foyer, une vaste région indemne adossée à des limites naturelles.

b) Les villages menacés sont classés sur des bases parasitologiques : recherche de trypanosome dans le sang, les ganglions, éventuellement dans le L.C.R.

c) La population, pour les opérations de dépistage et les injections prophylactiques, est rassemblée par villages.

Ces rassemblements, qui ont lieu semestriellement ou annuellement selon les contingences locales, sont organisés de façon à ne pas imposer aux habitants un déplacement de plus de 12 km.

Le pourcentage de présence des populations varie selon les régions de 80% à 95%.

L'équipe type est composée de :

1 agent sanitaire
2 à 3 microscopistes
2 aides-infirmiers, chargés des injections.

Elle peut être fortement renforcée lorsqu'il s'agit de campagnes plus étendues, par exemple :

en 1952–1954, lors d'une campagne de pentamidinisation dans le Territoire de Banningville, la composition de l'équipe était la suivante :

1 médecin et 2 agents sanitaires,
1 clerc,
6 plantons,
7 aides-infirmiers : 2 pour les injections
5 pour la microscopie
10 élèves aides-infirmiers,
2 chauffeurs.

Cette équipe a permis d'examiner et injecter environ 350 indigènes par jour.

d) **Produits utilisés pour la chimioprophylaxie**

Pentamidine May and Baker
Pentamidine U.C.B.
Lomidine Spécia.

La posologie est de 3,5 à 5 mg. par kilo de poids corporel (le plus généralement 4 mg.).

Le produit est injecté par voie intramusculaire chez le sujet à jeun. Le rythme des injections est de 1 tous les 6 mois, pendant une période de 2 à 3 ans.

Le Bayer 205 et l'Antrypol ont été utilisés en Province de l'Equateur à la dose de 1,5 gr. chez l'adulte, les injections étant trimestrielles, semestrielles ou annuelles.

La Stilbamidine a été utilisée dans cette même province en 1949, puis remplacée par la Pentamidine.

L'association Pentamidine-Moranyl n'est pas employée pour obtenir une prolongation de l'effet prophylactique.

e) **Accidents**

1 décès est signalé en terriroire de Kasongo.

1 décès en Province du Katanga (l'autopsie n'a rien révélé).

Au Ruanda-Urundi, sur un total de 333.547 injections, 3 décès furent observés en 1951–1952 :

1 décès de cause inconnue,

1 décès survenu une heure et demie après l'injection, le sujet ayant présenté préalablement une syncope résistant à l'administration d'adrénaline,

1 décès également après syncope.

En Province du Kasaï, une femme à état général déficient est décédée, suite à l'injection prophylactique.

En Province de l'Equateur : les injections provoquèrent 4 décès en 1948, dont 1 après syncope, 1 autre survenant moins d'une minute après l'injection.

En 1950, à Bomboma, 13 personnes succombèrent et 41 furent atteintes d'une invalidité de degré variable, allant de la douleur persistante à l'endroit de l'injection jusqu'à la paralysie avec atrophie musculaire.

L'étude de la Pentamidine incriminée montra que le produit était conforme aux normes de toxicité.

En 1953, à Bomboma également, 2 enfants en bas âge moururent, 4 jours après l'injection, après avoir présenté de la prostation puis un état comateux.

Incidents

Ils ont consisté en :

douleurs de type sciatique et paralysies transitoires, attribuées à une faute de technique,

nausées et vomissements,

chutes tensionnelles légères, avec frissons, cédant à l'administration d'adrénaline,

coliques abdominales,

douleurs et contractions utérines, ayant parfois provoqué l'accouchement chez des femmes à terme, ou l'avortement.

Ces divers incidents sont très peu fréquents, généralement bénins et n'ont guère donné lieu à l'établissement de données statistiques.

En Ruanda-Urundi, on signale 43 incidents, de gravité très réduite, sur un total de 333.547 injections, soit 0,01 %.

En Province de l'Equateur, on signale des accidents bénins, de nature syncopale, dans la proportion de 1 à 5%.

Note. — En Urundi, il a été observé des cas de non-résorption de la Pentamidine avec nécrose limitée à l'endroit de l'injection, formation d'une collection liquide aseptique faite de sang extravasé. Il y avait parfois élimination du produit injecté au moment de l'ouverture de cette collection. La pentamidinisation a dû être supprimée pour certains sujets, surtout des femmes, qui présentaient ces phénomènes lors de chaque injection (allergie?)

Des cas identiques sont signalés en Province de l'Equateur.

Prévention

On insiste sur la nécessité de pratiquer l'injection chez le sujet à jeun à qui l'on conseillera, ensuite, de s'étendre à l'ombre 1 à 2 heures.

Seront exemptés de l'injection prophylactique les enfants dont le poids n'atteint pas 8 kg., les femmes enceintes (pendant les 5 premiers mois et à l'approche du terme) et les personnes à état général non satisfaisant.

f) Statistique numérique des injections pratiquées

Provinces	*Période considérée*	*Nombre d'injections*
Kasaï . .	1953 à 1957	114.437
Léopoldville .	1945 à 1957	1.681.578
Katanga . .	1951 à 1957	41.447
Orientale . .	1955 à 1957	182.772
Kivu . .	1956 à 1957	26.082
Ruanda-Urundi	1946 à 1957	1.591.552

Le dépistage peut très généralement être tenu à jour sauf circonstances exceptionnelles, par exemple insuffisance numérique passagère du personnel.

3° Résultats obtenus

a) Evolution des taux des indices de virus en circulation

P. Léopoldville	*1944*	*1955*	*1957*
Mayumbe . .	0,41	0,041	0,005
Cataractes . .	1,25	0,29	0,047
MMKK . .	1,65	0,23	0,066
Luozi . . .	0,78	0,094	0,056
Inongo . .	—	0,06	0,071
Mushie . .	2,03	0,14	0,042
Oshwe . .	—	0,064	0,007
Kasangulu . .	—	0,24	0,094
P. Equateur . .	0,72	0,21	0,17

Evolution des taux des indices de contamination nouvelle

P. Léopoldville	*1944*	*1955*	*1957*
Mayumbe . .	0,09	0,0063	0,0062
Cataractes . .	0,64	0,054	0,034
MMKK . .	0,51	0,05	0,04
Luozi . . .	0,31	0,025	0,054
Inongo . .	0,07	0,001	0,008
Mushie . .	0,41	0,06	0,042
Oshwe . .	—	0,02	0,01
Kasangulu . .	—	0,078	0,03
Foreami . . .	0,22	0,03	0,03
P. Katanga . .	0,49	0,01	0,006
P. Orientale			
Poko . . .	—	0,11	0,004
Dungu. . .	0,07	0,03	0,01
Ango . .	0,15	0,005	0,005
Niangara . .	0,07	0,04	0,009
Aba . . .	0,05	0,009	0,01
P. Equateur . .	0,299 (en 1946)	0,035	0,028
Ruanda-Urundi .	0,62	0,007	0,002

b) Evolution de la tactique de la chimioprophylaxie en fonction des améliorations observées

Sauf en zone Foreami, où les conditions de travail sont particulières et permettent d'assurer la pentamidinisation régulière et systématique de secteurs administratifs étendus, c'est la méthode de prophylaxie sélective qui est actuellement d'application sur l'ensemble du territoire.

La régression de l'endémie a été considérable, mais il n'est évidemment pas possible d'envisager, dans l'état actuel de nos moyens, une éradication complète de la maladie.

Ce sont les opérations périodiques d'examen de la population et de dépistage des cas, qui doivent fournir les critères parasitologiques qui conditionneront la reprise éventuelle de la chimioprophylaxie.

On estime que le point critique est atteint lorsque l'indice de néo-contamination atteint le taux de 2% : il implique la nécessité de commencer ou de reprendre la pentamidinisation. Celle-ci est considérée comme souhaitable lorsque le taux est de 1 à 2%.

c) **Influence de la chimioprophylaxie sur le cycle épidémiologique extrinsèque**

Aucun renseignement n'est fourni à ce sujet.

d) **Influence psychologique sur les populations**

L'effet psychologique a été excellent dans certains cas lors de l'organisation d'une campagne de chimioprophylaxie dans les régions particulièrement menacées.

Ailleurs, les réactions ont été nulles.

On note que lorsque la campagne se prolonge (plus de 4 injections), la population se lasse et devient rétive.

e) **Influence démographique des résultats obtenus**

Il n'est pas possible d'attribuer à la chimioprophylaxie de la trypanosomiase une part déterminante dans les améliorations de la situation démographique où elle a été appliquée.

La difficulté de ces études, les longues périodes d'observation qu'elles requièrent et la fréquence de campagnes simultanées dirigées contre d'autres maladies (notamment le paludisme) rendent toute conclusion aléatoire.

4° Essais divers

Aucun autre produit moderne n'a été utilisé ou essayé pour la chimioprophylaxie.

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REPLY FROM THE SLEEPING SICKNESS SERVICE, NORTHERN NIGERIAN MEDICAL DEPT.

Dr. I. K. Hay

1. Geography

The area concerned in Nigeria lies between latitude 7° N. and latitude 12° N., with an extension of the northern boundary associated with the River Hadejia system in Kano Province, and an extension of the southern limit into Ogoja Province of the Eastern Region.

The epidemiological picture within this vast endemic zone has altered throughout the years. Originally there existed only a **riverine endemic zone** along the banks of the Niger-Benue waterway: in this zone the situation was fairly stable due to the equable climatic conditions, with a constantly maintained high level of humidity: there were no extreme dry-season conditions, and dry-season concentration of fly was probably not marked. " Population densities were adequate for transmission but insufficient to provide the free supply of alternative mammalian hosts, so that man-fly contact was **largely impersonal** though often prolonged, as amongst the fishing communities and traders using these highways." (Duggan, 1952.)

Expansion of the disease came with the Pax britannica in 1900. The northern limit of spread is determined largely by climatic conditions—a severe cold, dry season when humidity falls to near zero, resulting in epidemiological (and entomological) conditions entirely different from the stable perennial transmission which exists in the riverine zone: here there are marked dry-season fly concentration and a type of disease and of man-fly contact pertains, which because of its more sporadic and irregular nature lends itself more easily to control by mass survey and treatment.

The eastern and western geographical limits of the endemic zone are determined largely by the thinning out of the population in the eastern and western parts of the country. Also population movements have always been more marked in a north–south than in an east–west direction.

The limiting factors to the south of the endemic zone are much less clear and have not yet been definitely determined, although there are several theories both epidemiological and entomological. The spread of Trypanosomiasis and of *G. tachinoides* below its natural southern limit into northern Ogoja is probably due to many unknown factors involving both host and vector.

To sum up: " the endemic zone of Trypanosomiasis (*T. gambiense*) in Nigeria is a vast area some 152,000 square miles in extent, and containing over 9,000,000 people, limited in the north by climatic conditions; in the east and west by population density, and in the south by various conditions, not yet fully understood, involving both vector and host." This zone has a hard core of low-grade but constant transmission associated with the riverine areas of the Niger-Benue waterways, from which the disease has spread, mainly northwards, into the savannah regions where a different and typical epidemiological picture is presented, influenced by the marked seasonal climatic and vegetational variations which exist there in contra-distinction to the perennially equable humid climate of the riverine area.

2. Technique of Chemoprophylaxis

(*a*) Basic principles

Chemoprophylaxis is not applied on the basis of entire administrative areas but **selectively**: this selection is not necessarily based on the degree of infection in any area, but on two factors:

1. The epidemiological features of the area.
2. The administrative possibilities of carrying out regular comprehensive, bi-annual or annual inoculation for an indefinite period.

(*b*) To illustrate the epidemiological and administrative factors concerned it would be best to give examples of how Chemoprophylaxis against Trypanosomiasis has been applied here:

1. Workers in the tin mines of southern Plateau have been protected by the **bi-annual inoculation** of Pentamidine Isethiamate since 1946 and no single case of Sleeping Sickness has occurred since then in the areas so protected. All these workers in the many mining companies have permits to work in a Sleeping Sickness area, and nominal rolls are available. It is therefore comparatively easy to keep a record of inoculations, and "Pentamidinisation" is complete and regular. In other words chemoprophylaxis works successfully because of the administrative situation.

2. In the Ndzorov, Kambe, Mbasaan and Abinsi areas of Tiv Division of Benue Province there has existed a hard core of high infection surrounded by areas of fairly low incidence, and there is little doubt that from this heavily infected area Sleeping Sickness has been spreading out in all directions. This area has been subjected to Pentamidine prophylaxis, annually for the last three years, and the incidence of infection has been greatly reduced. This is the epidemiological approach, applied in accordance with Lotte's fifth category, namely—"active limited foci isolated by healthy areas".

Another factor, in accordance with basic principles, which determined the use of chemoprophylaxis in this situation, was the impracticability, for economic and administrative reasons, of tsetse control measures.

(*c*) **Administrative aspects** (In this question " dépistage " is taken to mean " investigation ").

As regards chemoprophylaxis to mine-workers and other controlled bodies of labour there is little administrative difficulty: with the co-operation of the management the men are assembled and thereafter it is simply a matter of enumeration, examination, documentation and inoculation.

In a civilian population which cannot be vigorously disciplined in this country the campaign is more difficult. Much propaganda is required first—the co-operation of the local authorities, both Government and native Authority is necessary, a census is taken, based on local household by household tax returns, followed by examination, recording and inoculation.

The percentage attendance may vary from 65 to 100 per cent according to various factors, such as the strength of the local Chief, how accustomed the people have become to survey methods, the time of the year the campaign is carried out (farming, fishing, etc.), to what degree the local people consider Sleeping Sickness a menace to health, and very important, the local religion, Moslem, Christian or pagan.

The campaign in Tiv Division of Benue Province has been greatly complicated by such factors as crop failures, witchcraft and wanderlust.

(*d*) **Drugs used**

The only chemoprophylactic agent used at present here is Pentamidine Isethiamate, given intramuscularly based on a dose of 4 mg. per kg. of Pentamidine base at 6–12 monthly intervals. Injectees are not weighed, but a scheme of dosage according to age and sex is employed. Moranyl is not used in conjunction with Pentamidine.

(*e*) **Reactions**

No accurate figures are available for the incidence of reactions, but given intramuscularly in the above dosage, they are of rare occurrence, and the drug has been found perfectly safe for use by Medical Auxiliaries in the field.

During inoculation campaigns Adrenaline is always to hand for immediate use in case of emergency.

(*f*) **Statistics**

In 1956 a total of 6,048 mine labourers and other workers were given prophylactic Pentamidine.

In the Benue campaign in 1956 a total of 16,951 people was injected.

3. **Results obtained**

(*a*) Already answered as regards the minefields—nil cases since the introduction of Pentamidine prophylaxis in 1946.

Benue prophylactic campaign:

1956—1·38% (246 cases). Before Pentamidine.
1957—0·21% (32 cases). 1 year after 1st inoculation.
1958—0·06% (9 cases). 2 years after 1st inoculation.

(*b*) Already described.

(*c*) No marked psychological effect has been observed. The injections are as readily accepted as any other injection, simply because it is an injection.

(*d*) The use of Pentamidine prophylaxis in this country has not been on a sufficiently large scale to have exerted any demographic influence. It may be remarked here that the factors which preclude the more general use of this method of control in Nigeria include:

1. The vast area and large populations concerned, involving an enormous and annually (or bi-annually) repeated administrative effort, quite impossible with the available staff and money.
2. The greatly varying conditions existing in different parts of the country.
3. The impracticability and undesirability of subjecting the population to the disciplinary measures required.
4. The possibility of creating a resistant strain of Trypanosome, with disastrous results.
5. The doubt, which must still remain, of the possibility of the control of the disease, without the control of the vector, which could be achieved by this method, even were all administrative, economic and political reasons overcome.

4. Other Drugs

Antrypol (Suramin) was used for a short time in 1936, but abandoned because of the danger of serious reactions.

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REPONSE DU SERVICE D'HYGIENE MOBILE ET DE PROPHYLAXIE DE LA REPUBLIQUE DU TOGO

Méd. Col. Paravisini

1. Au Togo, seule la région nord du Territoire, située au-dessus du 8ème parallèle, est intéressée par la trypanosomiase.

Cette région comprend les circonscriptions administratives de Dapango, Mango, Lama-Kara, Sokodé et Bassari. Elle est irriguée par de nombreux cours d'eau coulant d'est en ouest pour se jeter dans l'Oti qui, après avoir lui-même traversé le pays en diagonale, le délimite sur un certain parcours, d'avec le Ghana et se jette dans la Volta.

Au point de vue prophylaxie, elle est divisée en 3 secteurs comportant chacun une équipe de prospection.

Equipe n° 1 pour le secteur Mango Dapango (Dr. Sauvet).
Equipe n° 2 pour le secteur Lama-Kara Pagouda (Dr. Raoux).
Equipe n° 3 pour le secteur Sokodé Bassari (Dr. Coudert).

Chaque équipe, contrôlée par un médecin qui assume en même temps les fonctions de Médecin-Chef de l'Assistance Médicale, est dirigée par un agent technique ou infirmier ancien et compétent. Elle comprend :

3 infirmiers,
4 à 8 microscopistes,
1 agent d'hygiène,
1 manœuvre,
1 agent recenseur,
1 chauffeur.

2. La faible endémicité de la trypanosomiase au Togo, où elle décroît régulièrement depuis une dizaine d'années, n'a pas justifié la mise en œuvre de la chimioprophylaxie. Les malades dépistés sont dirigés sur les hypnoseries de Mango, Dapango, Pagouda et Sokodé où ils sont mis en traitement.

3. Incidence de la trypanosomiase

Secteurs	Contamination nouvelle			Virus circulant		
	1944	1955	1957	1944	1955	1957
Mango . Dapango .	0,25	0,057	0,023	0,25	0,060	0,050
Lama-Kara Pagouda .	0,05	0,074	0,066	0,05	0,082	0,066
Sokodé . Bassari .	0,16	0,051	0,024	0,16	0,051	0,024
Ensemble .		0,06	0,042		0,06	0,045

NOTA

La réponse des Services du Congo Belge comprenait une carte.

Celle du S.G.M.H.P. du Cameroun comprenait 3 cartes, 1 graphique et 1 tableau.

Il ne nous a pas été possible de reproduire ces documents, et nous nous en excusons auprès de nos lecteurs.

THE USE OF CHEMOPROPHYLAXIS IN THE CONTROL OF TRYPANOSOMIASIS IN NORTHERN NIGERIA, WITH PARTICULAR REFERENCE TO THE DIAMIDINES

By Dr. I. K. HAY, Northern Nigeria Sleeping Sickness Service

This paper is an attempt to collate and assess the part which chemoprophylaxis plays in the control of Trypanosomiasis in a country in which for epidemiological, sociological, economic, administrative and geographical reasons there can be no single universal approach to the control of the disease, the method of attack in each area being influenced by one or more of these factors.

I would like to start by giving an account of the general epidemiological picture of Trypanosomiasis in Northern Nigeria. The endemic area concerned lies mainly in the Northern Region, between latitude 70° N. and 120° N. with an extension of the northern boundary of the endemic zone associated with the vast Hadejia river system in Kano Province, and an extension of the southern limit into Ogoja Province of the Eastern Region. The epidemiological situation within this large endemic zone, some 152,000 square miles in extent, and containing over 9,000,000 people, all of whom, to a greater or lesser degree, depending on their local circumstances, may be considered as being at risk, is one which has altered throughout the years.

Originally there existed almost certainly only a riverine endemic zone along the banks of the Niger-Benue waterway; in this area the situation remained fairly stable because of the equable climatic conditions, with a constantly maintained high level of humidity: there were no extreme dry-seasons conditions, and dry-season concentration of tsetse fly was probably not marked. The degree of man-fly contact was therefore fairly constant from season to season throughout the year, and from year to year. Duggan (1952) summed up the epidemiological situation in these stable riverine areas when he said—"Population densities were adequate for transmission but insufficient to provide the free supply of alternative mammalian hosts, so that man-fly contact was largely impersonal though often prolonged, as amongst the fishing communities and traders using these highways."

Expansion of the disease from this riverine focus came with the increase in population movement and the opening up of overland trade routes, following the Pax Britannica in 1900. The northern limit of spread is determined largely by climatic conditions—a severe, cold, dry season when relative humidity falls to a very low level, resulting in epidemiological and entomological conditions entirely different from the stable perennial transmission which exists in the riverine zone: here, in the savannah regions, there is marked dry-season fly concentration, and a type of disease, and of man-fly contact, exists which because of its more sporadic and irregular nature is amenable to control by the routine method of mass survey and treatment.

The eastern and western geographical limits of spread are determined largely by the thinning-out of the population in the eastern and western parts of the country; also, population movements have always been more marked in a north–south than in an east–west direction.

The factors limiting the spread of Trypanosomiasis to the south of the endemic zone are much less clear and have not yet been fully determined, although there are several theories, both epidemiological and entomological. The spread of Trypanosomiasis and of *G. tachinoides* below the natural southern limit into Ogoja Province of the Eastern Region is probably due to many factors involving both host and vector.

To sum up the above:—The endemic zone of Trypanosomiasis in Nigeria, containing 9,000,000 people living in 152,000 square miles, is a vast area, limited in the north by climatic conditions, in the east and west by population density and in the south by various conditions involving both host and vector. This zone has a hard core of fairly low grade but constant transmission associated with the riverine areas of the Niger-Benue waterways, from which the disease has spread, mainly northwards, where a different epidemiological picture is presented, influenced by the marked seasonal climatic and vegetational variations which pertain there in contradistinction to the perennially equable humid climate of the riverine areas.

Before passing on to an account of the use of chemoprophylaxis in Northern Nigeria, I would like to discuss some of the various factors which govern, and to a large extent limit, the chemoprophylactic approach to Trypanosomiasis control in this country:—

SOCIOLOGICAL FACTORS

The two epidemiological situations described correspond approximately with the two principal sociological structures of the country. In the northern savannah regions the population consists predominantly of the Hausa and Fulani peoples with the addition of many smaller and relatively unorganised pagan tribes and a smattering of Christians who are mainly immigrants from the southern areas, engaged in commerce and government service. The religion, and certainly the religion of the "ruling classes", with whom one must co-operate when planning control measures, is principally Muslim: the people are a proud, independent and conservative race, and any procedure which involves measures of regimentation and what perhaps might be termed "interference with the liberty of the subject", must be approached with the utmost caution. This is as it should be, and any attempt, except in the most urgent circumstances, to disregard these social and religious tenets would be morally wrong and indeed would almost certainly be doomed to failure if pressed without willing consent. On the other hand, once any such measure is accepted by the rulers the co-operation of the public is assured.

In the riverine zone, which comprises, as far as trypanosomiasis is concerned, the Provinces of Benue, Plateau and Niger, the sociological picture is entirely different: the people are either Christian or pagan, they are more individually independent, " westernised ", politically minded, and local authorities are smaller and less autocratic and powerful—and, on the whole, financially poorer. Once again formidable obstacles exist which operate against regimentation of the public and subjection of the people to what would be considered an unnecessary health measure. With the social structure here the annually repeated organisation of such a campaign, even given its willing acceptance by the public, would be an almost impossible task and satisfactory attendances could not be guaranteed. The heaviest infection in this riverine zone exists amongst the Tiv people of Benue Province, the " cradle " of Trypanosomiasis in Northern Nigeria, and although a prophylactic campaign is at present being carried out amongst a small group of these people, considerable difficulty has been encountered because of the social structure of the Tiv, who are divided into numerous small " clans ", and who are extremely migratory in their habits, which migration is often quite unpredictable, being influenced by such socio-economic factors as crop failures, witchcraft and wanderlust.

Other factors to be taken into consideration and which are liable to complicate any campaign of this nature are, briefly, Fishing, Farming and Fasting, which occupations occupy a considerable time every year and during which attendances at any health campaign or survey will inevitably be disappointing.

ECONOMIC FACTORS

These are obvious. To protect the population at risk, several million injections would be required annually involving the use of an enormous quantity of whatever prophylactic agent was adopted and the employment of a very large technical and administrative staff engaged on prophylactic campaigns to the exclusion of all other work: in addition the large area involved would necessitate heavy transport and travelling expenses. Trypanosomiasis control is a function of central government in Northern Nigeria, and the costs of such a programme, continued for an indefinite period, as a recurrent cost, would be quite beyond the financial resources available and, indeed, unjustifiable, in proportion to other medical and health requirements.

The view held by McLetchie (1948) was that when Trypanosomiasis had been brought to a low endemic level, the expenditure on such measures of control must be balanced against the benefits accruing, and against the effect on the public health compared with that of a variety of other endemic diseases.

ADMINISTRATIVE FACTORS

I do not know what proportion of a population exposed to the risk of contracting Trypanosomiasis it is necessary to protect to ensure a high measure of control of the disease—but it must be not less than 70 per cent. But to obtain a degree of protection sufficient to effect a significant reduction in incidence in a population of some 20,000 it has been found necessary, in the present prophylactic campaign in Benue Province, to divert almost all Sleeping Sickness Service staff from their normal duties from the whole of the Benue area, and indeed to draw additional staff from other areas for a period of six weeks. To carry out an annual campaign to protect the entire population of the Nigerian endemic zone would be an administrative exercise quite beyond the present staff resources of the Service.

GEOGRAPHICAL FACTORS

Again these are obvious, and tie up with the administrative and economic factors—the enormous distances to be covered with the present staff position and financial resources prohibit the adoption of universal chemoprophylaxis against Trypanosomiasis.

DRUG RESISTANCE

As regards the danger of drug resistance, and here I am considering the diamidines, there is, I think, little likelihood of this occurring, although Henrard and Peel (1950) claimed to have isolated a Pentamidine-resistant strain of *T. gambiense* transmissible by *G. palpalis* from a patient who had received both prophylactic and therapeutic Pentamidine. The possibility, however, must be borne in mind, when large-scale measures are considered.

A final factor, which must be taken into consideration, is the doubt which must always remain under such conditions as pertain in Northern Nigeria of the control of the disease *without* the control of the vector, which could be achieved by this method, were all administrative, economic and sociological difficulties overcome.

From what I have said the impression may have been gained that I am not much in favour of chemoprophylaxis as a Trypanosomiasis control method. This is not so: it is a most valuable weapon. What I do say, however, is that in the circumstances which exist in a country such as Northern Nigeria its application must be on a purely *ad hoc* basis and in accordance with certain basic principles which have been summed up very adequately by Lotte (1952), who postulates six different categories of endemicity and their response to chemoprophylaxis, namely:

(1) Epidemic foci.

(2) Highly endemic foci, with a tendency to epidemic outbreaks.

(3) Constant endemicity, with a large floating population.

(4) Residual endemicity untouched by continual survey and treatment.

(5) Active limited foci isolated by healthy areas.

(6) Low but ineradicable endemicity of the order of 1·0 to 0·1%.

In the Nigerian situation chemoprophylaxis is most applicable in categories (1) and (5), i.e. epidemic foci, and active limited foci isolated by healthy areas, and chemoprophylaxis has been successful in both these circumstances. Lotte's sixth category, low but ineradicable endemicity of the order of 1·0 to 0·1% appears to fit the Nigerian picture fairly accurately—the over-all incidence for the whole Northern Region being in the neighbourhood of 0·20 to 0·15%, and although in theory this category responds readily to chemoprophylaxis its application is precluded by the size of the area and population concerned. Categories (3) and (4), particularly category (3), i.e. constant endemicity with a large floating population, require a prolonged campaign continued regularly over a period of many years.

CHEMOPROPHYLAXIS IN NORTHERN NIGERIA

I would like now to say something about the way in which this method of Trypanosomiasis control has been, and is being, employed in Nigeria.

In 1936 Suramin was given a trial as a prophylactic agent, but although it was undoubtedly an effective prophylactic, the fairly frequent occurrence of severe reactions (collapse) after a dose of 1 gr., resulted in this drug being abandoned (Lester 1938) and nothing more need be said about it.

In the tin-mines of Plateau, Bauchi and Benue Provinces of Northern Nigeria the relatively high incidence of Trypanosomiasis amongst mines labourers, as compared with the surrounding population, had been the cause of considerable concern for some years. Attempts at control by survey and treatment were not eminently successful, and moving, as they did and still do, from camp to camp in the mining area and mingling with the general public, infected labourers were a constant menace and a very potent source of spread. In 1944, therefore, after the Suramin trials were abandoned, a trial of prophylactic Pentamidine in 199 mines labourers was carried out. Nine to twelve months later re-examination of 123 of these labourers revealed no cases of Trypanosomiasis amongst them as compared with a 1·1% incidence in over 600 controls. This was sufficient justification to warrant expansion of the scheme and consequently, in 1945, a further 600 labourers were given prophylatic Pentamidine and in three years the incidence of Trypanosomiasis had fallen from about 10% to about 0·36%. Unfortunately, perhaps, certain tsetse control measures were also taken, which somewhat obscured the issue, but there can be little doubt, in view of subsequent findings, that the chemoprophylactic measures played an important part in this significant result.

These measures were expanded, with the co-operation of the mines management and the help of legislation, to cover several thousand labourers. In 1948, 3,243 mines labourers who had been given prophylactic Pentamidine were examined and closely questioned and lumbar puncture was performed in 105 of them: of six cases showing altered cerebro-spinal fluid, four proved to have had Sleeping Sickness two to three years previously and two appeared to be true cryptic infections (Gall, 1954). Since then until the present, at routine examination in the field, no definite gland positive case of Trypanosomiasis has been discovered amongst these labourers who are protected by Pentamidine, although there has been a regular moderate incidence of the disease amongst the villagers in the same areas, who do not experience such intimate and prolonged man-fly contact as does the mines labourer working in conditions extremely favourable for transmission.

In 1957, a total of 7,514 mines labourers were so protected with complete success: the incidence, that year, in mines not receiving protection was 0·12% representing 112 cases. Expansion of the scheme is not envisaged at present because of the uncertain position of the mines following the "quota" system of mining introduced as a result of the fall in the world price of tin.

This is an example of the application of chemoprophylaxis in a situation which is not fully covered by Lotte's basic categories although category (3) fits the situation to a certain extent—constant endemicity, with a large floating population, amenable to chemoprophylaxis only by a prolonged campaign. The main epidemiological picture here is the close, prolonged and continually repeated man-fly contact amongst the mines labourers—an occupational hazard—and the spread, locally within the mining area, of the infection, caused by the constant movement of labourers as camps open, close and move elsewhere. The striking success of the campaign is in great measure due to the lack of administrative difficulties: the labourers can be detailed to attend, and a nominal roll is available, so that regular and comprehensive injection is assured, given the co-operation of the management, which is almost invariably given now that "Pentamidinisation" has become, in these areas, a routine feature of all mining activities.

An example of chemoprophylaxis applied in accordance with Lotte's category (1) was the Lere epidemic of 1950. In the district of Lere in Zarina Province a local increase of Sleeping Sickness was reported from a group of villages and it was decided to carry out Pentamidine prophylaxis. Two village areas were concerned, Juran Kari consisting of several hamlets with a total population of about 600, and Lere village area whose population was in the region of 3·5. It is only fair to state that just prior to the campaign riverine clearing had been carried out in the neighbourhood of Juran Kari village. In spite of this control measure the incidence of infection had only dropped over a period of four years from 2·33% to 2·25% in the

Juran Kari area, and from 1·49% to 1·32% in the Lere area. At a preliminary survey in January 1952, forty-two cases were discovered (Sleeping Sickness Service, and Gall, 1954). From then until 1954 among those who had been protected, two cases, in which trypanosomes could not be found, had been diagnosed on clinical grounds and one case, showing scanty blood trypanosomes only, was detected in January 1954. On this date, the incidence in Juran Kari had fallen to 0·00%, and in the Lere village area to 0·11% after the third prophylactic injection. Of these three cases at least one was probably infected before receiving pentamidine.

Among the unprotected population in the area, which constituted 20–30% of the total population, sixteen new cases were discovered between 1952 and 1954, fourteen in October 1952, two in April 1953, and none in January 1954. This suggests that the reservoir of circulating trypanosomes had been reduced to a level where transmission was approaching extinction (Gall, 1954). In 1955, when prophylaxis was discontinued the incidence for both village areas was 0·02%, and routine dispensary resurveys during 1956 and 1957 have revealed an incidence of 0·12%.

And now I would like to turn to the present prophylactic Pentamidine campaign being carried out in the Tiv Division of Benue Province: this is an example of chemoprophylaxis applied to an active limited focus surrounded by healthy areas, or at least by areas of very low and comparatively insignificant incidence—a situation in which one would expect a rapid response to this method of control.

A resurvey of the Ndzorov, Kambe, Mbasaan and Abinsi areas of Tiv Division carried out in 1955 revealed a Sleeping Sickness rate of 5·1%: figures for previous resurveys were:

1951—4·8%
1953—3·0%
and in 1955—5·1%

It became immediately apparent that there was a very serious focus of infection here, surrounding areas of Tiv Division having an incidence of 0·2% or less, with a rising incidence: urgent action was necessary and there were two alternatives to consider:—

(1) Prophylactic Pentamidine.
(2) Control of Tsetse fly by riverine clearing.

There were several objections to tsetse control measures, the principal of which were the likely high cost of clearing, the inaccessibility of the area and the fact that economic trees were involved. It was decided, therefore, to give prophylactic Pentamidine to the entire population of this area which in view of the surrounding low incidence seemed ideal for such a method.

After consultation with the local authorities a census of the area was carried out towards the end of 1955, and the initial campaign was executed early in 1956. The census for such a campaign must of course be a detailed one, household by household, and if the follow-up is to be of any statistical value, individuals must be recorded by name, sex and estimated age. Records were kept in considerable detail and included the following data:

Clan and Sub-kindred.

Tax Census.

Sleeping Sickness Service Census.

Number and percentage of attendances.

Number and percentage injected.

Number of gland punctures performed.

Number of cases of Sleeping Sickness, gland positive, clinical and relapse.

Percentage Sleeping Sickness.

Number of pregnant women, sick people, babies too young for injection, and the presence of an epidemic of an infectious disease, such as Smallpox.

Number of deaths since the last census was taken.

Reactions to Pentamidine.

In January 1956, the first year of the campaign, out of a total population of 20,458, 17,708 people attended for injection and 246 cases of Trypanosomiasis were discovered, representing an infection rate of 1·38%—there had been a marked fall in the incidence since 1955 as a result of the treatment of the cases discovered then. A total of 16,882 people was injected, and the 246 cases given a routine course with Antrypal and Trypersamide. The protection rate at the end of the initial campaign was 79·09%. It should be pointed out at this stage that the only possible time for this campaign was during January and February. It could not be carried out during the rainy season which lasts in Benue Province from May until October or November, and other months are complicated by farming and fishing activities—indeed this year the campaign was almost jeopardised by the unexpected absence of Clan Heads who were called to attend local government meetings. I mention this to illustrate the impracticability of arranging, annually, any such campaign throughout the country—the period during which a satisfactory coverage can be obtained is limited to only a few months of the year: this of course also applies, to a certain extent, to the survey and treatment method of control, but in that method one is not bound by a strict annual programme and may vary surveys to suit circumstances of one sort or another. In chemoprophylactic control everybody must be injected every year if the control is to be maintained.

To return to the Benue campaign—one year later, in January 1957, the exercise was repeated, and the census findings revealed a considerable population drop, from 20,458 to an estimated 18,728. This was due to several factors, the main one of which was undoubtedly emigration due to a poor rain distribution and consequent failure of crops: the other cause of depopulation may be summarised simply as emigration caused by witchcraft and the wandering habits of the Tiv people (Ross, 1957). This emigration has been confirmed by the recent increase in the Tiv element in the adjacent Wukari and Lafia Divisions of Benue Province and in the southern part of Adamawa Province. A total of 14,939 people, representing an attendance rate of 79·76%, was examined, 14,171 people given prophylactic Pentamidine and 32 cases of Trypanosomiasis discovered, an incidence of 0·21%, i.e. almost a sevenfold reduction since the previous year.

When the campaign was repeated in January 1958 the attendance rate was 79·43%, 13,629 people received Pentamidine, a protection rate of 96·29%. This year only nine cases of Trypanosomiasis were diagnosed, an incidence of 0·06%; and when it is recorded that four of these cases were diagnosed on clinical grounds, two were recorded, again clinically, as "Relapses" and, therefore, presumably had not received Pentamidine previously, and that in only three cases were Trypanosomes demonstrated, two of whom had certainly not received prophylaxis previously, the campaign, at least as a temporary, emergency control measure, may be considered an unqualified success. It will be repeated next year and then, in the light of what is found, an assessment of the position will be made with a view to determining future policy. If, as is hoped, the infection rate remains at an insignificant level, the prophylactic campaign will be stopped, and the area subjected to resurvey and treatment every other year. Unless epidemic proportions should arise again it would be unjustifiable, in the light of other commitments, to divert the staff required every year for an indefinite period: if this campaign, followed by periodic resurvey and treatment does not prove effective then, obviously, more permanent control measures must be considered.

Throughout the campaign no fatalities occurred, and after the first year only a few trivial reactions: the medical officer in direct charge of the scheme formed the impression that in the second year there was an increased tolerance to the drug. The agent used was Pentamidine Isethiamate, given intramuscularly in an age-sex dosage scheme based on a dose of 4 mg./kg. of Pentamidine base.

I have gone into this campaign in some detail and at considerable length because it seems to be an ideal illustration of a situation in which chemoprophylaxis is the control method of choice, at least as an emergency measure; and also because there is conclusive evidence to show that this area, due to the wandering habits of the Tiv people has played a large part in the spread of Trypanosomiasis some 200 miles up the valley of the river Benue into Adamawa Province, and of the increasingly heavy infection rates in parts of the adjacent Wukari and Lafia Divisions of Benue Province.

One other small prophylactic exercise may be mentioned. Recently it was reported that tsetse fly, *G. tachivoides* and *G. palpalis*, were found in abundance in and around a small village in Niger Province, associated with the railway station of Akerri, and inhabited by villagers and railway staff. Flies were also found on the station platform, and as all the passenger trains on the main line stopped here, something had to be done. The population involved was in the region of 4–500 people only. Tsetse control measures were impracticable, so Pentamidine prophylaxis was carried out, of villagers and railway staff. In this case, chemoprophylaxis was instigated on entomological rather than epidemiological grounds, the incidence of Trypanosomiasis being low—the presence of fly being the deciding factor.

Later this year work will begin on an extension of the Nigerian Railway from Jos to Maiduyuri, a distance of some 400–500 miles, part of which, particularly in Bauchi Province, passes through tsetse country. Several thousand labourers will be employed on this project, which is estimated to take five years, some recruited locally as the line moves on, but many moving from place to place as the scheme progresses. This large immigrant labour force would appear to constitute a factor which could disturb the epidemiological balance of the areas through which it passes and in the populations with which it mixes, not only in respect of Trypanosomiasis, but of all other endemic and epidemic diseases.

Pentamidine prophylaxis of all staff engaged on the project will be carried out, although *ad hoc* tsetse control measures may be taken from time to time, particularly, it is expected, in connection with work at river crossings, where man-fly contact may be more intimate and prolonged.

This again seems to be an ideal situation for the use of chemoprophylaxis—a disciplined and controllable labour force giving ease of administration, and a good guarantee of success: it is, in fact, a true prophylactic measure, protecting labour gangs exposed to risk.

SUMMARY

1. A brief description of the epidemiology and geography of endemic human Trypanosomiasis (*T. gambiense*) in Northern Nigeria is given, defining the various factors which have influenced the pattern of the disease and its spread from the original stable focus associated with the Niger-Benue waterways: the factors limiting its spread are discussed.

2. The universal use of chemoprophylaxis in the control of Trypanosomiasis in this country is limited, and to some extent precluded, by various epidemiological, sociological, geographical, economic and administrative features.

3. Suramin prophylaxis was tried and abandoned. Pentamidine prophylaxis, applied on an *ad hoc* basis, and in accordance with basic principles has, in different circumstances, been extremely successful.

4. Control by chemoprophylaxis has been successful in dealing with an epidemic focus, an active limited focus surrounded by healthy areas,

and in the protection of labour gangs exposed to high risk. It is planned to protect a large labour force by this method.

5. The drug used is Pentamidine Isethiamate, given intramuscularly, in a dose of 4 mg./kg.

CONCLUSIONS

Chemoprophylaxis against human West Africa Trypanosomiasis is a powerful though temporary control measure, not applicable in all circumstances, and certainly not applicable to the exclusion of other control methods, such as survey and treatment, and tsetse control by clearing and insecticides.

Its proper use is when, for one reason or another, Trypanosomiasis control by other methods is impracticable, has failed, or has only been partly effective, and in an emergency as an expedient pending the instigation of more permanent control measures.

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THE CHARACTERISTICS OF STRAINS OF TRYPANOSOMES ISOLATED FROM PERSONS INFECTED WITH HUMAN TRYPANOSOMIASIS IN EAST AFRICA

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INTRODUCTION

The present paper gives the results of studies carried out on twenty-four strains of *Trypanosoma rhodesiense* Stephens and Fantham, 1910, isolated in East Africa. Twenty-two of these strains were derived from patients at the East African Trypanosomiasis Research Organisation hospital at Tororo. The remaining two strains were isolated from patients infected in Tanganyika and were received by us in white rats.

MATERIALS AND METHODS

1. The Strains

Patients from whom strains were isolated were interrogated as to their recent movements and the duration of their symptoms to determine where they were probably infected. All the infected persons were male, and all but one (a five years old child) were adults. Clinical and epidemiological aspects of the disease produced by these strains have been discussed by Roberston and Baker (in press).

Mainland strains. Isolated between June 1956 and February 1957 from persons probably infected at fishing ports on the north-east shore of Lake Victoria, between Jinja (Busoga District, Eastern Province, Uganda) and Kisumu (Central Kavirondo District, Nyanza Province, Kenya), or elsewhere in the *Glossina pallidipes* Austen, 1903, fly-belt in this area (Fig. 1).

Island strains. Isolated between June 1956 and February 1957 from patients probably infected at islands in the north-east corner of Lake Victoria, a few miles off the shore of the region from which the mainland strains originated.

Maswa strains. Isolated in August 1956 from patients infected in Maswa District, Lake Province, Tanganyika (Apted, 1956). Four of these strains were sent to us, but only two (numbers 2 and 3) were examined fully. They were received in white rats, having been syringe-passaged in rats about ten times since their isolation.

2. Technique of Isolation and Examination

On a patient's arrival at the hospital, 1 ml. of blood was inoculated intraperitoneally (IP) into one or more white rats. When these rats developed parasitaemia, blood was collected from the tail of one and inoculated IP into eight more rats, the blood being diluted so that each rat received an

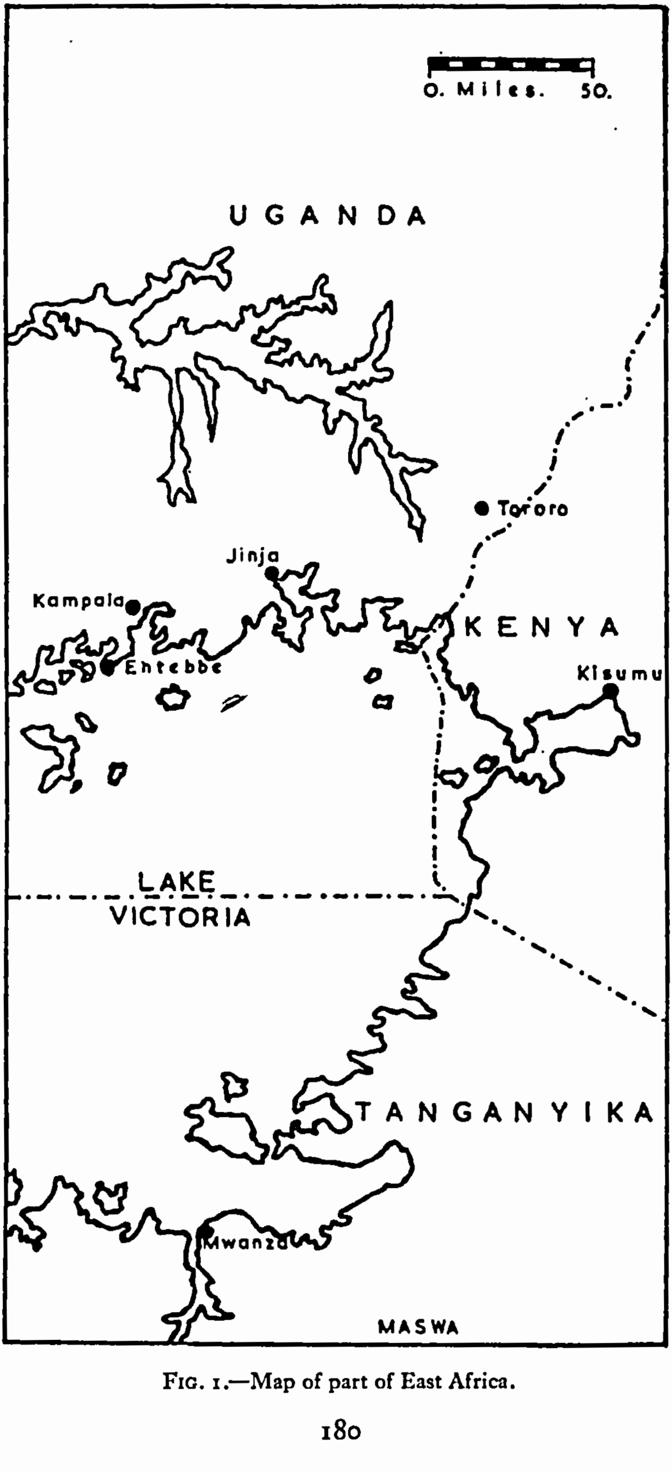

FIG. 1.—Map of part of East Africa.

estimated 500,000 trypanosomes, based on a haemocytometer count of the diluted blood. Initially sodium citrate was used as anticoagulant and normal saline as diluent; experience showed that heparin and isotonic glucose solution were less toxic to trypanosomes, so these substances were used latterly.

The eight rats were then examined daily (except Sundays) by means of fresh preparations of their peripheral blood, 20 fields being examined under the 4 mm. (1/6 in.) objective of the microscope, and their prepatent period was recorded: the prepatent period of rats in whose blood trypanosomes were first seen on a Monday was recorded as half a day less than the number of days which had elapsed between the inoculation of the rat and the day on which the trypanosomes were first seen. (The prepatent period was recorded in only six rats in the case of strain 8.) When their parasitaemia was fairly intense, four of these rats were weighed. The weights recorded lay between 42 and 195 g., with averages of 130 g. for the rats infected with the mainland group of strains, 127 g. for those infected with the island strains and 119 g. for those infected with the Maswa strains. These four rats were then injected IP with tryparsamide (May and Baker) in aqueous solution. Two rats received a single dose of 80 mg./kg. body weight each, and the other two received a single dose of 160 mg./kg. body weight. The daily examination of these rats was continued, and the number of days (if any) for which their blood was cleared of trypanosomes was recorded. The remaining four untreated rats were also examined daily, and the length of their lives from inoculation with trypanosomes was recorded as a measure of the virulence of the strain. The lengths of life of rats which died on Sunday or Monday were treated similarly to the prepatent periods (see above). Thin dried blood films were made daily from these rats, fixed with methanol and stained with Giemsa's stain. From these slides the proportions of stumpy and posteronuclear (PN) trypanosomes were determined, by counting and classifying usually 100 individuals.

Short broad trypanosomes without a free flagellum, or with a very short one, were considered as stumpy forms, and those in which the distance from the kinetoplast to the posterior border of the nucleus was equal to, or less than, the nuclear diameter (as determined by inspection only), were classified as PN forms.

As already stated, the Maswa strains were received by us in rats: from these, eight more rats were subinoculated as described above.

RESULTS

The mean prepatent periods of all the strains lay between 2½ and 7½ days. None of the rats used was cured by tryparsamide at the doses given, but in nine strains the blood of one or both rats receiving 160 mg./kg. was apparently cleared of trypanosomes for a period of five days or fewer:

in four strains, the blood of one rat receiving 80 mg./kg. was apparently cleared for three or fewer days. No correlation was observed between the clinical condition of the patient (whether with or without central nervous system involvement) and the virulence or other characteristics of the strain. A strain (No. 69) isolated from a man who had been ill with trypanosomiasis for nearly 2½ years was among the more virulent, killing rats in an average of twenty days.

Some of the results of the examination of the strains are set out in Table I. The quantities shown are individual values for each rat followed by the mean of the four values. The individual values have also been averaged and their standard deviations calculated, for each of the three groups of strains, Maswa, island and mainland. From these group averages it can be seen that the virulence of the strains, as measured by the length

Table I.—Virulence and Morphology of Twenty-four strains of *Trypanosoma rhodesiense*

Strains: Origin	Strains: Number	Length of life of infected rats in days *	Maximum percentage of: Stumpy forms *	Maximum percentage of: PN Forms *
Maswa	2	5, 5, 7, 8, (6)	0, 0, 0, 6, (2)	0, 0, 0, 3, (1)
Maswa	3	8, 9, 10½, 10½, (10)	3, 4, 4, 5, (4)	1, 1, 2, 2, (2)
Maswa	Mean	7·9 (1·9 **)	2·8 (2·2)	1·1 (1·1)
Islands	32	12½, 15, 17½, 17½, (16)	13, 16, 19, 20, (17)	2, 7, 10, 12, (8)
Islands	23	13, 14, 14, 26½, (17)	14, 16, 18, 28, (19)	2, 3, 7, 9, (5)
Islands	25	17½, 17½, 17½, 20, (18)	15, 19, 21, 22, (24)	7, 8, 10, 10, (9)
Islands	22	15, 19½, 19½, 24, (20)	16, 22, 23, 30, (23)	4, 6, 12, 15, (9)
Islands	49	17, 18, 20½, 20½, (20)	6, 9, 13, 15, (11)	4, 7, 9, 12, (8)
Islands	52	20, 23, 23, 25½, (23)	4, 8, 15, 17, (11)	4, 4, 5, 6, (5)
Islands	Mean	18·7 (3·6)	16·6 (6·2)	7·3 (8·1)
Mainland	57	13½, 19, 20½, 25, (20)	10, 20, 22, 26, (20)	8, 20, 20, 25, (18)
Mainland	46	14, 21, 24, 24, (21)	8, 13, 18, 22, (15)	5, 9, 12, 16, (11)
Mainland	60	19, 19, 20½, 25, (21)	16, 16, 17, 17, (17)	8, 10, 14, 15, (12)
Mainland	34	17, 19, 24, 26, (22)	5, 6, 7, 8, (7)	3, 5, 6, 8, (6)
Mainland	69	19½, 19½, 21, 26½, (22)	16, 18, 20, 20, (19)	14, 14, 18, 18, (16)
Mainland	26	19½, 23, 24, 25, (23)	25, 28, 39, 62, (39)	6, 8, 10, 13, (9)
Mainland	44	22, 23, 23, 24, (23)	10, 12, 13, 15, (13)	10, 11, 12, 15, (12)
Mainland	63	20½, 24, 28, 29, (25)	14, 17, 21, 24, (19)	8, 10, 18, 22, (15)
Mainland	8	23, 25, 26, 32, (27)	44, 46, 51, 58, (50)	9, 20, 26, 29, (21)
Mainland	21	24, 25, 26½, 39, (29)	12, 12, 24, 49, (28)	5, 6, 9, 16, (9)
Mainland	39	24½, 33, 38½, 40, (34)	7, 10, 12, 18, (12)	5, 10, 12, 12, (10)
Mainland	20	26½, 36, 37, 39, (35)	17, 21, 24, 26, (22)	5, 9, 15, 16, (11)
Mainland	19	13, 37, 37, 60, (37)	14, 45, 51, 54, (41)	0, 8, 14, 18, (10)
Mainland	16	32½, 32½, 37, 72, (44)	13, 22, 24, 32, (23)	3, 7, 8, 14, (8)
Mainland	17	43, 45, 49, 57, (49)	16, 16, 19, 22, (18)	7, 8, 11, 11, (9)
Mainland	24	43, 52, 66, 68½, (58)	12, 13, 19, 20, (16)	5, 7, 9, 10, (8)
Mainland	Mean	30·3 (13·3)	22·0 (13·5)	11·5 (5·8)

* Individual values for 4 rats with mean in brackets.
** Standard deviation of the mean.

of life of infected rats, differed from group to group: the two Maswa strains were the most virulent, the island strains less virulent and the mainland strains the least virulent. The differences between the mean length of life of rats infected with the island strains and those of the rats infected with the mainland and Maswa strains were statistically significant ($P<0 \cdot 001$ in both cases). The Maswa strains were not strictly comparable, as they had been syringe-passaged through rats about ten times, a procedure which (at least in mice) is known to increase the virulence of trypanosomes of the *brucei* group to the species in which they have been passaged, and to alter them in other ways (Murgatroyd and Yorke, 1937).

The table also shows that the more virulent strains of trypanosomes in general produced a lower maximum proportion of stumpy and PN forms in the blood of rats, although the correlation of morphology with virulence was by no means absolute. The difference between the mean maximum percentage of stumpy forms seen in the blood of rats infected with island strains and that of the rats infected with mainland strains was not statistically significant ($P<0 \cdot 1> 0 \cdot 05$), but that between the value for rats infected with the island strains and the value for rats infected with the Maswa strains was significant ($P<0 \cdot 0001$). The differences between the mean maximum percentage of PN forms seen in the blood of rats infected with the island strains and the corresponding values for rats infected with the mainland and Maswa strains were significant ($P<0 \cdot 01>0 \cdot 001$ and $P<0 \cdot 001$ respectively).

DISCUSSION

It is interesting to compare the strains of trypanosomes isolated by us from persons infected on the north-east shore of Lake Victoria (our mainland strains) between June 1956 and February 1957 with the strains isolated from the same area by MacKichan (1945) during the trypanosomiasis epidemic of 1940 to 1943. MacKichan found that the prepatent period of the infection in seventeen white rats inoculated with 1 ml. of blood from infected persons was five or six days, and the length of life of the infected rats was between four and five weeks. PN forms were common in all MacKichan's strains, in proportions of from 5 to 12%.

MacKichan concluded that all the strains which he had isolated were *T. rhodensiense*. It can be seen that there was no great difference between the strains isolated by MacKichan and those isolated by us, although the range of the virulence of our strains was somewhat greater. Thus the strain of parasite present in this region does not appear to have altered during the last six or seven years.

The general correlation noted between the virulence of the strains of trypanosomes and the maximum percentages of stumpy and PN forms produced by them in the blood of rats is in agreement with the observations of Wijers (1957) and Ashcroft (1957). These authors noted that, as earlier workers have reported, the appearance of stumpy forms heralded a remission of parasitaemia: they ascribed the development of stumpy forms to the action of the host's defensive mechanism (presumably antibodies). Thus, on this theory, those of our strains which were more virulent to rats were also, in general, less affected by the rat's defensive response and consequently produced fewer stumpy forms.

Although the rats which we used differed greatly in weight from one strain to another, those used for each strain were of similar size. The mean weights of the four rats used for testing each strain's sensitivity to tryparsamide can therefore be taken as giving an indication of the size of all eight rats used for each strain. As the weights of the rats which were given tryparsamide, when averaged for each group of strains, did not differ by more than 11 g. (see above, p. 181), it can be assumed that the different virulence of the strains of each group was not due to the rats used in any one group being predominantly large or small. The same argument applies to the different percentages of stumpy and PN forms. These differences presumably, therefore, reflect a real difference between the three groups of strains.

SUMMARY

1. Twenty-two strains of *Trypanosoma rhodesiense* from the north-east shore of Lake Victoria and adjacent islands (Uganda and Kenya) and two strains from Tanganyika were isolated from infected persons in white rats.

2. The following features of these strains were examined: virulence (length of life of infected rats), morphology (proportion of stumpy and posteronuclear trypanosomes), and susceptibility to an arsenical drug (tryparsamide).

3. The strains were all virulent to white rats, the average length of life of four rats infected with each strain lying between six and fifty-eight days: in two-thirds (16/24) of the strains, it was twenty-five days or fewer. The two strains from Tanganyika were the most virulent, but this may have been due, at least in part, to the fact that they had been syringe-passaged about ten times before their examination. Strains isolated from patients infected on islands in Lake Victoria appeared to be, in general, more virulent to rats than those isolated from patients infected on the mainland. In general, the more virulent strains produced lower maximum proportions of stumpy and postero-nuclear trypanosomes in albino rats. None of the strains was curable by tryparsamide at a dose of 160 mg./kg. body weight in white rats.

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NOUVELLES OBSERVATIONS AU COURS D'INFECTIONS EXPERIMENTALES PAR MELANGE DE SOUCHES DE TRYPANOSOMES POLYMORPHES

(Souches sensibles et souches résistantes à la tryparsamide)

Par M. VAUCEL et H. FROMENTIN

En 1954, M. Vaucel et H. Jonchère, puis en 1955, H. Fromentin ont montré par la mensuration des parasites et par l'étude de leur comportement biologique que lorsqu'un mélange de deux souches de trypanosomes polymorphes, à savoir *T. gambiense* " Yaoundé " et *T. brucei*, est inoculé au rat, le trypanosome *gambiense* est submergé, en quelques passages, par le trypanosome *brucei.*

Afin de pouvoir confirmer ces résultats, grâce à une méthode différente, nous avons inoculé cette fois à l'animal d'expérience, et pour chaque espèce ou souche parasitaire, des trypanosomes sensibles à la tryparsamide mélangés à des trypanosomes résistants au même arsenical.

METHODES

Des souches *T. brucei* et *T. gambiense* " Yaoundé " ont été rendues résistantes à la tryparsamide et, dans une première expérience, des rats ont reçu, par injection péritonéale, respectivement des mélanges de trypanosomes d'une souche sensible et d'une souche résistante de chaque espèce. Dans une seconde expérience, nous avons mélangé sur souris des trypanosomes de deux souches de *T. gambiense* l'une, souche " Eliane ", sensible, et l'autre, souche " Mbala Victor ", naturellement résistante à la tryparsamide.

Les passages ont été effectués ensuite régulièrement sur rats blancs, ou souris blanches, tous les trois ou quatre jours, et, à l'occasion de chacun des passages successifs un certain nombre d'animaux d'expérience, à l'acmé de la densité parasitaire, ont reçu des doses variables, mais faibles, de tryparsamide afin de faire disparaître les seuls parasites de la souche sensible à l'arsenic. Le sang des animaux a été examiné tous les jours à partir du moment de l'inoculation expérimentale.

Nos souches *T. gambiense* " Eliane " et *T. brucei* tuent souris et rats en trois à quatre jours, la souche *T. gambiense* " Mbala Victor " les tue en quatre à cinq jours et la souche *T. gambiense* " Yaoundé " en cinq à sept jours.

Les souches résistantes à la tryparsamide résistent respectivement : *T. brucei* à 25 mg., *T. gambiense* " Yaoundé " à 85–90 mg. et *T. gambiense* " Mbala Victor " à 90–95 mg., alors que pour les souches sensibles une dose de 3 à 4 mg. du produit (par 20 gr. de poids corporel) suffit pour assurer la " suppression ".

RESULTATS

I. Mélange de *T. gambiense* " Yaoundé " sensible et de *T. brucei* résistant

Des trypanosomes de chacune des deux souches sont inoculés, en quantités égales, à des rats blancs, puis le 1er passage est effectué sur souris. Vingt-quatre heures après l'inoculation, le sang des animaux est positif et 5 à 25 mg. de tryparsamide sont injectés aux souris d'expérience le même jour. Le lendemain la parasitémie a augmenté et les animaux meurent en quatre jours comme les témoins n'ayant pas reçu de tryparsamide.

La prolifération des *T. brucei* résistants a, vraisemblablement, dans cette expérience, masqué la disparition des *T. gambiense* sensibles à l'arsenical.

II. Mélange de *T. gambiense* " Yaoundé " résistant et de *T. brucei* sensible

Un rat reçoit un million de trypanosomes *gambiense* " Yaoundé " résistants, puis, le 4ème jour, lorsque la parasitémie est devenue positive, il lui est inoculé 40.000 trypanosomes *brucei* sensibles (de multiplication rapide).

A partir du 3ème passage la tryparsamide est injectée à raison de 15/20 gr. de poids corporel à chacun des rats des 3ème, 4ème, 5ème, 6ème, 8ème, 9ème, 12ème passages.

Nous constatons que, malgré cette posologie suffisante pour faire disparaître *T. brucei* sensible, les trypanosomes restent encore abondants, après le traitement, au 3ème passage. Les parasites deviennent rares à partir du 5ème passage. Lors des 8ème, 9ème et 12ème passages la tryparsamide fait disparaître tous les parasites.

Le sang des rats des 8ème, 9ème et 12ème passages a été examiné pendant 2 semaines après le traitement à la tryparsamide et il n'a pas été constaté de rechutes.

Il semble donc possible de conclure que *T. brucei*, sensible, à submergé *T. gambiense* " Yaoundé " résistant à la tryparsamide dès le 8ème passage et après 25 jours de séjour du mélange sur rat.

II. Mélange de *T. gambiense* " Eliane " sensible et de *T. gambiense* " Mbala Victor " résistant naturellement à la tryparsamide

Par voie péritonéale, 200.000 flagellés de chacune des souches sont inoculés à des souris, puis des injections de tryparsamide sont pratiquées à raison de 15 à 85 mg./kg. aux animaux d'expérience lorsque la parasitémie atteint 10 parasites par champ, soit vers le 3ème à 4ème jour.

On constate alors, dès le 1er passage, que 24 heures après l'injection de tryparsamide la parasitémie diminue notablement, ce qui doit correspondre à la disparition des parasites de la souche Eliane sensible à l'arsenical.

A partir du $15^{ème}$ passage la négativation du sang suit l'injection de tryparsamide comme si à ce moment la parasitémie était exclusivement due à *T. gambiense* " Eliane ".

Toutefois, dans les 24 à 48 heures qui suivent, réapparaissent dans la circulation des trypanosomes, représentant vraisemblablement des rechutes à *T. gambiense* " Mbala Victor ", et dont l'arseno-résistance, vérifiée, correspond exactement à celle de la souche originale Mbala " Victor ".

Il apparaît donc qu'à la suspension de l'expérimentation ($22^{ème}$ passage et 9 semaines de séjour du mélange sur l'animal), la souche Mbala " Victor " a été presque entièrement submergée par la souche Eliane d'incubation plus courte et de multiplication plus rapide.

CONCLUSIONS

Les résultats ci-dessus nous permettent de confirmer qu'après inoculation à un animal d'expérience d'un mélange de deux souches de trypanosomes polymorphes :

a) la souche ayant la vitesse de multiplication la plus rapide et, éventuellement, la virulence la plus grande submerge l'autre souche,

b) la submersion s'effectue d'autant plus rapidement que l'écart est plus accusé entre le degré de virulence de chacune des souches vis-à-vis de l'animal,

c) il n'est pas observé, au cours de l'expérience, d'indice de création de souche hybride de trypanosomes.

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THE EFFECT OF DIFFERENT TYPES OF MAN-FLY CONTACT UPON THE DISTRIBUTION OF *T. GAMBIENSE* SLEEPING SICKNESS IN NIGERIA

By T. A. M. Nash, West African Institute for Trypanosomiasis Research, Kaduna, Nigeria

One of the first descriptions of man-fly contact was that given by Taylor (1930) when describing the entomological aspects of severe epidemic sleeping sickness amongst the Ganawuri pagans of the Bauchi Plateau. This instance was typical in so far as there was a localisation of shade suitable for *G. palpalis* in and around the Ganawuri villages; but it was atypical in that the absence of both game and amphibious reptiles resulted in the fly obtaining an exceptionally large proportion of its food from man. It was the absence of reptilian blood that was so unusual, as in typical sleeping sickness areas this fly is believed to take from one-quarter to one-half of its meals from this source.

Epidemic sleeping sickness probably reached its peak in Nigeria in 1935, when the Sleeping Sickness Service of the Medical Department treated 100,000 cases. Between 1933 and 1937 the writer frequently followed up the medical surveys to locate the points at which villagers came in contact with fly and to advise on stream clearing; this work provided excellent opportunities for studying man-fly contact in different parts of northern Nigeria. Sometimes the focus would not be a stream, but a sacred grove adjacent to the village, or even the moat of the town wall, choked with thicket and supporting *G. tachinoides*. Having mapped the tsetse distribution of an area and inserted the incidences of sleeping sickness against the various villages, it became apparent that the nearer a hamlet was to a fly focus the higher would be the incidence of the disease; the occasional village which had permanent wells and was not dependent on a stream-bed, produced very few cases.

The second point of interest was that there appeared to be no relationship between the density of tsetse and the prevalence of the disease. Normally tsetse were exceedingly scarce although the incidence of sleeping sickness was high, but if one did find a focus where tsetse were numerous it was quite likely that the incidence figure would be very low.

It was not until the hamlet of Sambo had been visited in the late dry season of 1935, shortly after Dr. N. E. W. Anderson had found an infection rate of 70% amongst the forty-three inhabitants, that the writer appreciated that two types of man-fly contact existed, which he subsequently defined as " close personal " and " close impersonal " (Nash, 1948). Since the village of Sambo provides a perfect example of what is meant by close, personal man-fly contact, the following quotation may be of interest; it is taken from a note published some years after the event (Nash, 1944).

> " Sambo is situated above a small stream which dries up after the rains. Exhaustive search along the stream-bed for some miles on either side of the village failed to reveal the presence of a single tsetse or of any pools of water, but immediately below the hamlet there was a spot in the stream-bed where the sand was moist and where the villagers had scooped out a two-feet deep hole from which they obtained their meagre water supply. At this spot four *Glossina palpalis* were caught. The closeness of the man-fly contact presented ideal conditions for the spread of the disease. Each woman had to take her turn at sitting by the hole with a curved section of calabash with which she would scoop up a cupful of water and transfer it to the water pot. A pause would then be necessary to allow more water to seep into the hole. It took each woman about fifteen minutes to fill her water pot. Thus for many hours each day this small tsetse population of probably less than a dozen flies could feed on the queue of women, without expending any energy in search for food.
>
> The case described is considered to afford a classical example of close man-fly contact. Annually, at the end of the dry season, man is forced to depend upon this one spot for his water supply. Annually, the severity of the dry season climate compels the tsetse to evacuate the other parts of the stream as the pools dry up, and to concentrate at the village water-hole where the damp sand produces conditions of lower temperature and higher humidity, and where the presence of the water-hole assures a steady food supply within the microclimatic area."

Nine years later the opportunity arose to start research aimed at amplifying and confirming the conclusions, based on field observations, which were recorded in the second paragraph of the above quotation. For six years a population of *G. palpalis* was studied near the northern limit of this species' range (Nash and Page, 1953).

By means of marked flies, it was found that in the dry season the surviving tsetse do concentrate at pools, where the climatic conditions are far less severe than in the evacuated, dried up reaches of the stream; further, that the microclimatic conditions around the pools remain remarkably constant from year to year, although considerable annual variations in the severity of the late dry season may be recorded in the woodland and forest ecoclimate. It was also found that the amount of water persisting in a stream, and therefore the extensiveness of the microclimate, varies from year to year, being largely dependent upon the height of the water-table and therefore upon the rainfall of the preceding year or years.

In very severe years, when the extent of the microclimate is greatly reduced, *G. palpalis* is virtually confined to the immediate vicinity of certain pools which never dry up. African villages are sited near such traditionally reliable pools. It therefore follows that in dry seasons, after abnormally low rainfall, a very close, **personal** man-fly contact is established, which should lead to an increased transmission of sleeping sickness; a few surviving flies, whose movement is confined by the climatic barrier, are largely dependent for food on the villagers, who come down regularly for water.

In exceptionally mild years, when water is abundant, *G. palpalis* continues to travel up and down the stream throughout the dry season; in such years there is likely to be little transmission of human trypanosomiasis owing to the **impersonal** nature of the man-fly contact at the village water-hole. Admittedly the late dry season tsetse population will be unusually large in such years, and in consequence man will be bitten more frequently at the water-hole; but he will be bitten by **different** members of a shifting population of tsetse, and **not** as in severe years by a few individuals which **live** beside the village water-hole and feed on the same people, day after day, until about two months after the start of the rain when re-colonisation of the stream system begins. (Naturally, in some years the conditions will be intermediate between the two extremes described, and then one would expect a moderate degree of transmission.)

The time-lag between the start of the rains and fly dispersal is paralleled with a lag between the start of the rains and dispersal by man, back to his shallow village wells, which do not hold water until sufficient rain has fallen to raise the water-table; in the case of man, however, the lag is longer.

For a few months each year both man and tsetse are usually forced to concentrate at the permanent pool—the man for water and the fly for coolness and higher humidity. It has been suggested that in these months, the bulk of transmission must take place. But to prove this by showing that more cases are found, or report for treatment, at any given season is impossible. As everyone knows, the incubation period ranges from weeks, to months, or even to years, and the African farmer, even if feeling ill, is far too busy with his crops to seek treatment until the harvest is over.

In the same investigation, it was found that the expectation of life of tsetse emerging in the middle of the dry season is minimal, because the attainment of old age is rendered impossible by the approaching rigours of the late dry season, which discriminates against the older flies. But at the start of the rains the expectation of life is greatest, because the surviving population is young and has some months of very favourable conditions ahead. Dr. D. J. B. Wijers's recent finding that flies which can be induced to feed upon an infected host within twenty-four hours of emergence are much more readily infected than those which feed when rather older, carries the concept further. It is reasonable to suppose that in the very hot dry weather, at the extreme end of the dry season, newly emerged flies will be wanting to feed sooner after emergence than will young flies at cooler and more humid times of the year. Having a maximal expectation of life, if such flies become infected, they can do much damage before man and fly disperse from the village water-hole. It would seem that many a village epidemic may have been caused by one or two flies.

The investigation on man-fly contact was carried a stage further by Mr. W. A. Page after he had started our Ugbobigha field station on the edge of the main forest belt in south-western Nigeria—an area where sleeping sickness has never been known to occur. Mr. Page devised a most interesting experiment, which was duplicated in Northern Nigeria by Mr. W. A. McDonald and Dr. A. M. Jordan at Kaduna, where sleeping sickness used to be rife. (Paper going to press.)

Two water-holes were selected, one at Ugbobigha and one near Kaduna. Every day for a month, from dawn to dusk, *G. palpalis* were caught, marked, and released; any recaptures were recorded and released. Throughout the following month, no more flies were marked, but the water-hole was kept under observation for the presence of marked flies. Taking eighteen days as the minimal period between a fly becoming infected with *T. gambiense* and becoming infective, the object of the experiment was to compare the proportion of flies recaptured at the two water-holes after such a period had elapsed since first marking. Should the degree of concentration by individual flies at a water-hole prove to much be less at Ugbobigha than at Kaduna, it might explain the absence of the disease at Ugbobigha and most other parts of southern Nigeria. The results are given below:

	Numbers Marked	*Number Recaptured at Water-hole, 18 Days or Longer after Marking*
Southern Nigeria		
Dry Season	371	3 (0·81%)
Wet Season	729	4 (0·55%)
Northern Nigeria		
Dry Season	226	17 (7·52%)
Wet Season	1,942	75 (3·86%)

It will be noted from the percentage figures that man-fly contact in the dry season is about nine times as intensive in the north as in the south, and about seven times as great during the rains. In the north, it is nearly twice as great in the dry season as in the wet, reflecting concentration at the permanent pools, but it was felt that an even higher dry season figure could have been obtained by deviating from Page's southern technique of keeping all recaptures caged until dusk lest they be recaptured twice in the same day, since such denial of food under desiccating conditions had probably left the flies too weak to seek food on the following morning. Accordingly, the Kaduna dry season experiment has recently been repeated, the recaptures being fed on a goat before release at dusk. Unfortunately, owing to the very heavy rains of 1957, the stream continued to flow throughout the dry season, so that there was no concentration: out of 393 flies marked, 6·8% were recaptured at the water-hole, eighteen days or longer after marking. Although the results were disappointing, they confirm the big difference that exists in the magnitude of man-fly contact in the north and south.

Admittedly, the actual **number** of potentially infective recaptures in the north is greater in the wet season, but by that time man has gone back to his village wells and close, personal man-fly contact has ceased.

Whereas in the south, the chance in the dry season of an infected fly remaining by the water-hole long enough to become infective is less than 1 in 100, in the north it is approaching 8 in 100; such differences go far towards explaining why sleeping sickness is so rarely found in the south where, owing to a much more humid climate, the fly, unlike man, is independent of the stream. In the southern areas of Nigeria, *G. palpalis* is not strictly riverine in habit; even in the dry season, odd specimens can be found in farmland, savannah, within high forest and even in villages. What man-fly contact there is, is impersonal.

If one visualises seasonal, close personal man-fly contact as being most intense in the northern savannah regions, and decreasing as one approaches the main forest belt until it becomes entirely impersonal in the rain forest, one has an explanation which **in general** fits the picture of the incidence of sleeping sickness in West Africa. Very high incidences seem to be mainly confined to areas with a prolonged dry season, and when the disease occurs in the forest country it is usually confined to the drier mixed-deciduous forest where the incidence is low, e.g. Ashanti.

There are exceptions, such as the sleeping sickness epidemic which occurred in 1933 in the Ahoada Division of the Niger delta, where an infection rate of 29% was found among 16,000 people examined; unfortunately, it was impossible for the writer to make a tsetse survey of this area, but since out of 143 tsetse sent for identification 70 were *G. palpalis* and 72 were *G. caliginea*, it is quite possible that the latter species, about whose habits nothing is known, was responsible for most of the transmission.

Emphasis has been laid in this paper on the effect that the late dry season conditions have upon producing close, personal man-fly contact, because it is the factor that is believed to be most universal and therefore to have the greatest effect on the over-all picture in Nigeria. But there are many local exceptions: for example, at the village of Zagun on the Bauchi Plateau, man-fly contact was probably even more personal in the wet season, because then *G. palpalis* would come up from the adjacent water-hole, utilising the sunken footpaths roofed over by Euphorbia, and live inside the village: similarly, large, dense clumps of mango trees, growing within a village, will permit both *G. palpalis* and *G. tachinoides* to take up wet season residence amongst the houses, But such conditions are usually very local.

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THE LOCAL REACTION IN MAN AT THE SITE OF A FLY TRANSMITTED INFECTION OF *TRYPANOSOMA RHODESIENSE*

By D. G. Godfrey, West African Institute for Trypanosomiasis Research, Vom, Nigeria

Fairbairn and Godfrey (1957) undertook an experiment on an African volunteer to determine the nature of the carbuncle-like reaction at the site of the bite of an infected tsetse fly. The strain of *Trypanosoma rhodesiense* used was obtained from Bechuanaland in 1953, and since then has been passaged cyclically by *Glossina palpalis.*

A fly, shown to have many metacyclic trypanosomes by the probe test (Burtt, 1946), was allowed to bite the upper arm of the volunteer; it probed repeatedly for ten minutes before taking a small feed. Ten minutes afterwards a large urticarial weal appeared over the area where the fly had probed but it had disappeared within two and a half hours.

Blood, withdrawn by intravenous puncture one hour after the fly had begun probing and on each day afterwards, was inoculated intraperitoneally into rats to determine when trypanosomes had first been present in the general circulation. From the third day after inoculation, wet films of the rats' blood were examined daily for the first thirty days, and then weekly or twice weekly for a total observation period of sixty days.

The results of the experiment were as follows:

Day 0.	11.00 a.m.	Fly probed and fed.
	12.00 noon	1 ml. blood inoculated into each of 9 rats. All rats negative after 60 days.
Day 1.	7.00 a.m.	Stained thick blood film from patient negative per 200 fields.
	11.00 a.m.	2 ml. blood inoculated into each of 10 rats. All rats negative after 60 days.
Day 2.	10.10 a.m.	Stained thick blood film negative per 200 fields. Patient's skin normal.
	11.00 a.m.	2 ml. blood inoculated into each of 10 rats. All rats negative after 60 days.
Day 3.	7.30 a.m.	Stained thick blood film negative per 200 fields. Skin normal.
	11.00 a.m.	2 ml. blood inoculated into each of 10 rats. All rats negative after 60 days.
Day 4.	7.30 a.m.	Stained thick blood film negative per 200 fields. Skin normal.
	11.00 a.m.	2 ml. blood inoculated into each of 10 rats. All rats negative after 60 days.
Day 5.	7.30 a.m.	Stained thick blood film negative per 200 fields. Skin normal.

	11.00 a.m.	2 ml. blood inoculated into each of 5 rats and 1·5 ml. into each of 5 rats. All rats negative after 60 days.
Day 6.	7.30 a.m.	Patient's temperature 97·2° F. (36·2° C.); pulse 56. Small swelling, about 5 mm. in diameter, palpable in skin and raised above the surface. Puncture of the nodule negative per 200 fields of a stained film. Stained thick blood film negative per 200 fields.
	11.00 a.m.	2 ml. blood inoculated into each of 10 rats. All rats were negative after 60 days.
	6.00 p.m.	Temperature 99·6° F. (37·6° C.). Stained thick blood film negative per 200 fields.
Day 7.	7.30 a.m.	Temperature 97° F. (36·1° C.). Nodule in skin still 5 mm. in diameter. Volunteer complained of pain in nodule and area of bite. Puncture of nodule negative per 200 fields of a stained film. Stained thick blood film negative per 200 fields.
	11.00 a.m.	2 ml. blood inoculated into each of nine rats. All rats negative after 60 days.
Day 8.	7.30 a.m.	Temperature 96° F. (35·6° C.). Volunteer said he felt well. Nodule had disappeared but a slight thickening of the skin was just palpable.
	11.00 a.m.	Puncture of thickened skin was negative per 200 fields of a stained film. Stained thick blood film negative per 200 fields. No rats were inoculated as the strain was believed to have lost its infectivity to man.
Day 9.	10.00 a.m.	Temperature 97·4° F. (36·3° C.). Volunteer said he felt well. A firm raised rubbery swelling, about 1 cm. in diameter, was present at the site of bite. Puncture of the swelling showed the presence of 4 trypanosomes in 290 fields of a stained film. Stained thick blood film negative per 200 fields.
	10.30 a.m.	2 ml. blood inoculated into each of 9 rats. Five rats became infected with incubation periods of 8, 13, 13, 14 and 18 days. The other 4 rats remained negative for 60 days.
	6.00 p.m.	Temperature 98° F. (36·7° C.).
Day 10.	7.00 a.m.	Temperature 96° F. (35·6° C.); pulse 76. Volunteer complained of slight headache. There was a raised firm rubbery swelling, about 3 cm. × 2·5 cm. with a faint red patch about 1 cm. diameter in the centre. Puncture of the swelling showed the

presence of 5 trypanosomes in 151 fields of a stained film. Stained thick blood film negative per 200 fields.

11.00 a.m. 1·5 ml. blood inoculated into each of five rats. All the rats became infected with incubation periods of 5, 7, 7, 7 and 8 days.

1.00 p.m. Under general anaesthesia an ellipse of skin and subcutaneous tissue was excised down to the muscle fascia. Immediately after excision the block was cut in half, dab smears were made from the cut surfaces, and the tissue placed in Bouin's alcohol-picro-formol.

6.00 p.m. Temperature 100·2° F. (37·9° C.); pulse 96. Stained thick blood film showed 1 trypanosome in 150 fields.

Day 11. 7.00 a.m. Temperature 102·2° F. (39·0° C.). Stained thick blood film showed 1 trypanosome in 291 fields.

Antrypol, 1 gm. in 10 ml. distilled water, was given intravenously on Days 11, 13, 18, 25 and 32. Except for a slight wound infection, the patient made an uninterrupted recovery.

The dab smears made from the cut ends of the excised tissue revealed the presence of long blood forms of *T. rhodesiense*. In the thin sections made from the tissue, and stained by the Giemsa colophonium method, large numbers of trypanosomes were found in a limited area in the upper layer of the subcutaneous fatty tissues. This area was characterised by the presence of oedema, lymph exudate and marked cellular infiltration. Deep in the fatty tissue, there were lines of lymph exudate, oedema and cellular infiltration following the blood and lymphatic vessels, but no trypanosomes; and finally, deeper still, the fatty tissue presented a normal appearance. In the dermis, external to the concentration of trypanosomes, no trypanosomes were seen but there were marked pockets of cellular reaction.

These results show that ten days after an infected tsetse fly had fed on a man, large numbers of trypanosomes were found near the site of the bite in a limited inflammatory area in the subcutaneous fatty tissue. Since the trypanosomes were present in such large numbers and since the sub-inoculations of the patient's blood were not positive until the ninth day, it is a logical conclusion that the metacyclic forms had remained and developed into blood forms near the site of the bite. That this retention of trypanosomes near the site of the bite is the normal course of development is indicated by Dr. H. Fairbairn's findings at Tinde Laboratory in East Africa that 93% of volunteers developed trypanosomal chancres. Our results indicate that the blood did not contain trypanosomes until just before the chancre became puncture positive; this is supported by the account of another volunteer experiment in which trypanosomes could not be demonstrated in 425 ml. of blood withdrawn over the two days following a tsetse bite (Willett and Gordon, 1957).

This finding that trypanosomes have remained and multiplied near the site of the bite raises an interesting question. How are such activity motile organisms, present in large numbers, prevented from entering the general circulation ? This and many other questions regarding the early development of the chancre can only be answered by a series of experiments on human volunteers.

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L'EVOLUTION DE LA TRYPANOSOMIASE HUMAINE DANS LES PAYS D'AFRIQUE AU COURS DES DIX DERNIERES ANNEES

Par E. van OYE, Co-Directeur au titre belge du B.P.I.T.T.

Il nous a paru opportun de présenter, à cette VIIème Réunion du Comité Scientifique International de Recherches sur les Trypanosomiases, un bilan à la fois général et détaillé de l'évolution de la maladie du sommeil dans les territoires africains durant les dix dernières années. Nous présenterons ce bilan sous forme de tableaux[1] et nous aurons soin de faire la distinction entre les infections à *T. gambiense* et celles à *T. rhodesiense*.

Nous communiquerons pour chaque pays le nombre d'habitants, le nombre de nouveaux cas de trypanosomiase dépistés et l'indice d'infection calculé sur 10.000 habitants. Nous n'avons pas établi cet indice par rapport au nombre d'individus examinés ou recensés, pour deux raisons. D'abord, certains pays n'ont pas fourni les chiffres concernant les populations examinées. Ensuite, partout la partie de la population qui n'est pas prospectée au point de vue trypanosomiase est néanmoins régulièrement examinée par des membres du service médical. Un indice d'infection calculé en tenant compte des seules populations examinées au point de vue trypanosomiase risque donc de donner des chiffres inexacts en ce qui concerne l'importance de l'endémie pour le pays pris dans son ensemble.

L'éloquence des chiffres qui suivent est telle que nous ne devrons ajouter que très peu de commentaires.

1. Infections à *Trypanosoma gambiense*: Dans l'ensemble, on constate que l'importance de la maladie du sommeil diminue depuis 10 ans d'une manière régulière. Si la trypanosomiase constitue cependant toujours un danger qu'on ne peut sous-estimer, elle a cependant perdu son caractère de fléau social. Le nombre de mouveaux cas par 10.000 habitants est tombé de 7 à 2 entre 1948 et 1956 (voir fig. 1), et il n'y a pas de raison de craindre que cet indice pourrait remonter. Des recrudescences locales se manifesteront sans doute encore, mais il ne se produira probablement plus de véritables flambées comme cela a été parfois le cas dans le passé.

Cette situation augure bien de l'avenir, et tout permet d'espérer qu'une éradication de la trypanosomiase humaine en Afrique pourra se réaliser dans un avenir pas trop éloigné.

2. Infections à *Trypanosoma rhodesiense*: L'indice d'infection humaine est beaucoup plus faible que celui à *T. gambiense* (voir fig. 2) et varie d'année en année d'une façon irrégulière et très peu prononcée.

Les médecins ont parfois tendance à attacher peu d'importance à cette forme de la maladie du sommeil étant donné le peu d'ampleur qu'elle prend sur le plan humain. Pourtant, les petites épidémies qui ont été signalées en plusieurs endroits au cours des dernières années et l'extension

[1] Les chiffres que nous communiquons sont ceux qui nous ont été fournis par les services de santé gouvernementaux des pays en question.

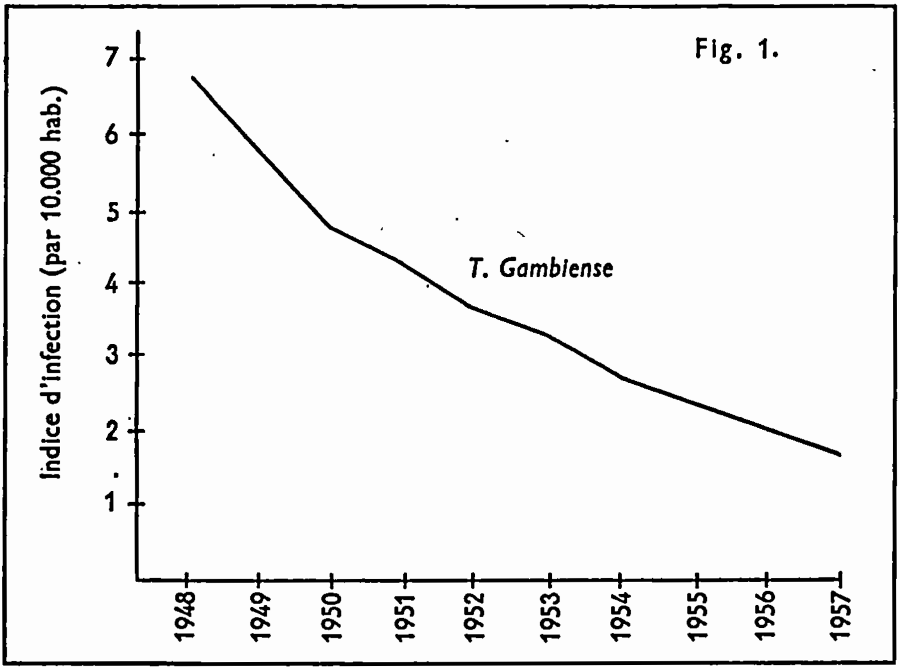
Indice d'infection (par 10.000 hab.)
1
2
3
4
5
6
7
1948
1949
1950
1951
1952
1953
1954
1955
1956
1957
T. Gambiense

Fig. 1.

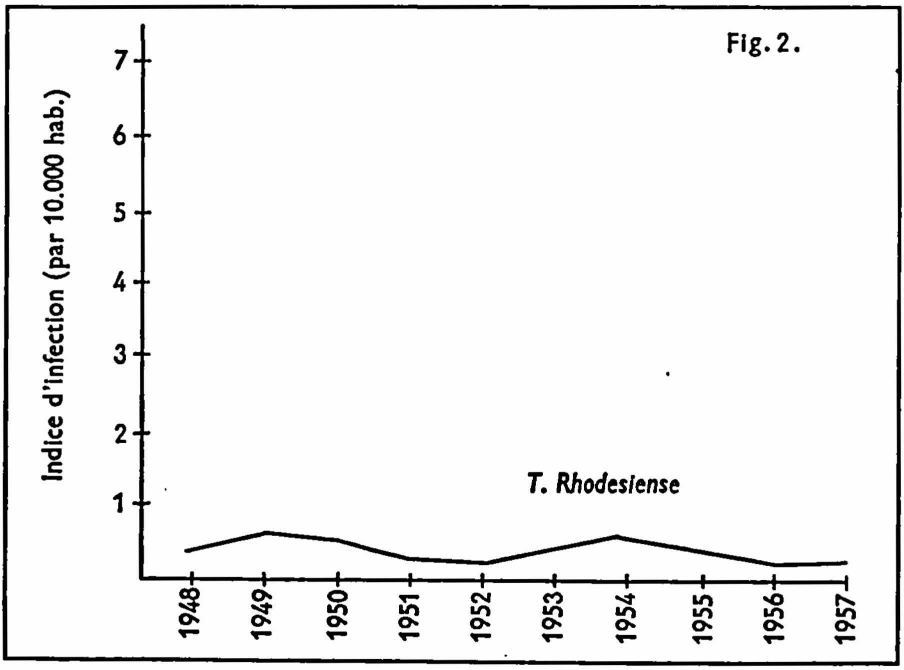
Indice d'infection (par 10.000 hab.)
1
2
3
4
5
6
7
1948
1949
1950
1951
1952
1953
1954
1955
1956
1957
T. Rhodesiense

Fig. 2.

Année	Population totale	Nouv. cas	Soit pour 10.000 hab.	Population totale	Nouv. cas	Soit pour 10.000 hab.
	A. E. F.			ANGOLA		
1948	4.119.000	3.556	8,63	3.738.010	3.647	9,75
1949	„	2.144	5,20	„	4.318	11,55
1950	4.386.000	3.176	7,24	4.145.266	2.499	6,02
1951	„	4.802	10,94	„	1.052	2,53
1952	4.417.000	3.080	6,97	„	989	2,38
1953	„	1.911	4,32	„	1.286	3,10
1954	4.633.000	1.566	3,38	„	997	2,40
1955	„	1.590	3,43	„	1.015	2,44
1956	4.697.000	785	1,67	4.362.264	418	0,95
1957	4.700.000	705	1,50	4.449.500	177	0,39
	A. O. F.			CAMEROUN FRANÇAIS		
1948	16.400.000	12.951	7,89	2.997.000	4.340	14,48
1949	„	11.120	6,78	2.997.000	3.627	12,10
1950	„	10.027	6,11	2.997.000	3.045	10,16
1951	„	8.138	4,96	2.997.000	1.430	4,77
1952	„	7.406	4,51	3.065.000	744	2,43
1953	„	6.902	4,20	„	1.125	3,67
1954	„	5.664	3,45	„	552	1,80
1955	„	4.973	3,03	„	668	2,17
1956	18.700.000	5.334	2,85	3.187.621	367	1,15
1957	„	4.910	2,62	3.173.600	367	1,15

Année	Population totale	Nouv. cas	Soit pour 10.000 hab.	Population totale	Nouv. cas	Soit pour 10.000 hab.
	CONGO BELGE			GAMBIE BRITANNIQUE		
1948	10.914.208	9.873	9,04	250.436	1.568	62,61
1949	11.073.311	7.609	6,87	265.886	1.828	68,75
1950	11.331.793	6.109	5,40	270.561	1.421	52,52
1951	11.395.494	6.086	5,34	271.991	1.760	64,70
1952	11.788.711	5.242	4,44	270.023	1.499	55,51
1953	12.026.159	3.804	3,16	281.387	1.568	55,72
1954	12.317.326	2.734	2,21	273.604	1.149	41,99
1955	12.562.631	2.117	1,68	266.547	1.026	38,49
1956	12.843.574	1.604	1,24	267.638	995	37,17
1957	13.174.883	1.560	1,18	267.087	709	26,55
	GHANA[1]			GUINEE PORTUGAISE		
1948	4.144.000	2.428	5,86	500.000	1.272	25,4
1949	4.209.000	1.319	3,13	„	1.341	26,8
1950	4.275.000	1.763	4,12	„	1.970	39,4
1951	4.342.000	528	1,21	„	1.945	38,9
1952	4.409.000	1.021	2,31	„	2.169	43,4
1953	4.478.000	558	1,24	„	1.793	35,9
1954	4.548.000	350	0,77	„	1.212	24,2
1955	4.620.000	968	2,09	„	1.328	26,6
1956	4.691.000	385	0,82	„	880	17,6
1957	4.836.000	563	1,16	508.970	642	12,6

[1] Sont inclus les chiffres pour le Togo faisant partie du Ghana.

Année	Population totale	Nouv. cas	Soit pour 10.000 hab.	Population totale	Nouv. cas	Soit pour 10.000 hab.
	LIBERIA			SIERRA LEONE		
1948	Seuls les chiffres pour 1957 nous sont parvenus.			2.005.000	41	0,20
1949				„	44	0,21
1950				„	54	0,26
1951				„	18	0,09
1952				„	107	0,53
1953				„	247	1,23
1954				„	58	0,28
1955				„	69	0,34
1956				„	41	0,20
1957	2.500.000	71	0,28	„	41	0,20
	NIGERIA			TOGO		
1948	31.000.000	13.575	4,38	971.824	150	1,54
1949	„	11.291	3,64	980.864	166	1,69
1950	„	7.101	2,29	998.660	100	1,00
1951	„	7.220	2,33	1.014.669	88	0,86
1952	31.200.000	6.060	1,94	1.029.946	157	1,52
1953	„	6.743	2,16	1.057.135	70	0,66
1954	„	7.043	2,26	1.070.826	154	1,43
1955	„	5.073	1,63	1.089.877	117	1,07
1956	„	6.128	1,96	„	118	1,08
1957	cf. ci-dessous.			1.089.000	77	0,70

Renseignements qui nous ont été communiqués par la Nigéria pour 1957 :

		Population totale	*Nouveaux malades*	*Soit pour 10.000 habitants*
Nigeria :	North . . .	17.000.000	5.045	1,6
	East . . .	7.800.000	?	
	West . . .	6.400.000		

Le Cameroun est inclus dans la Région Est.

Année	Population totale	Nouv. cas	Soit pour 10.000 hab.	Population totale	Nouv. cas	Soit pour 10.000 hab.
	RUANDA-URUNDI			TOTAL TRYP. GAMBIENSE		
1948	—	—	—	77.039.478	53.408	6,93
1949	—	—	—	77.288.071	44.807	5,79
1950	—	—	—	78.309.280	37.265	4,75
1951	3.835.075	147	0,38	82.292.495	33.214	4,03
1952	3.873.997	57	0,14	83.103.943	28.531	3,43
1953	4.154.263	56	0,13	83.729.210	26.063	3,11
1954	4.115.504	34	0,08	84.272.526	21.513	2,55
1955	4.227.360	20	0,04	84.714.681	18.964	2,23
1956	4.396.991	16	0,03	87.940.965	17.071	1,94
1957	4.517.495	7	0,01	91.121.535	14.874	1,63

Année	Population totale	Nouv. cas	Soit pour 10.000 hab.	Population totale	Nouv. cas	Soit pour 10.000 hab.
	AFRIQUE DU SUD			KENYA		
1948	Prévalence quasi nulle. Quelques cas, importés, sont traités dans l'Union.			5.399.000	26	0,04
1949				5.489.000	19	0,03
1950				5.579.000	154	0,27
1951				5.669.000	100	0,17
1952				5.760.000	203	0,35
1953				5.851.000	189	0,32
1954				5.948.000	313	0,52
1955				6.048.000	92	0,15
1956				6.150.000	32	0,05
1957				6.254.200	61	0,10
	MOZAMBIQUE			RHODESIES ET NYASSALAND		
1948	5.738.911	249	0,43	5.885.530	79	0,13
1949	»	184	0,32	5.981.163	82	0,13
1950	»	188	0,32	6.321.994	179	0,28
1951	»	197	0,34	6.506.612	130	0,20
1952	»	200	0,34	6.681.799	57	0,08
1953	»	238	0,41	6.786.630	56	0,08
1954	»	267	0,46	6.887.917	54	0,07
1955	5.764.362	170	0,29	7.103.600	41	0,05
1956	»	127	0,22	7.281.300	30	0,04
1957	»	221	0,38	7.476.100	24	0,03

Année	Population totale	Nouv. cas	Soit pour 10.000 hab.	Population totale	Nouv. cas	Soit pour 10.000 hab.
	RUANDA-URUNDI			TANGANYIKA		
1948	—	—	—	7.407.517	681	0,92
1949	—	—	—	»	1.412	1,90
1950	—	—	—	»	974	1,31
1951	—	—	—	»	477	0,64
1952	—	—	—	»	346	0,46
1953	—	—	—	»	756	1,02
1954	4.115.504	99	0,24	»	1.230	1,66
1955	4.227.360	91	0,21	»	923	1,24
1956	4.396.991	142	0,32	»	646	0,87
1957	4.517.495	26	0,06	8.788.265	418	0,47
	UGANDA			TOTAL TRYP. RHODESIENSE		
1948	4.949.000	54	0,11	29.379.958	1.089	0,37
1949	5.026.000	104	0,20	29.642.591	1.801	0,60
1950	5.103.000	78	0,15	30.150.422	1.573	0,52
1951	5.182.000	38	0,07	30.504.040	942	0,30
1952	5.262.000	48	0,09	30.850.227	854	0,27
1953	5.343.000	134	0,25	31.127.058	1.373	0,44
1954	5.425.000	103	0,18	35.522.849	2.066	0,58
1955	5.508.000	114	0,20	36.058.839	1.431	0,39
1956	5.593.000	108	0,19	36.593.170	1.085	0,29
1957	5.589.700	490	0,87	38.390.122	1.240	0,32

graduelle de son aire de dispersion géographique sont des avertissements qui ne peuvent être méconnus.

* * *

Les remarquables succès enregistrés au cours des dernières années dans la lutte contre la trypanosomiase humaine sont dus en ordre principal aux produits nouveaux qui ont permis l'application massive d'une chimiothérapie et surtout une chimioprophylaxie efficaces. Des populations entières ont été protégées contre l'infection à trypanosomes et, dans les régions où la chimioprophylaxie a été appliquée d'une façon systématique, on est parvenu à briser le cycle " hôte-parasite-vecteur " d'une manière telle que l'endémie a pu être jugulée, du moins en ce qui concerne *T. gambiense*. Le problème sera entièrement résolu le jour où nous serons armés d'une façon égale contre le *T. rhodesiense*.

LA TRYPANOSOMIASE RESIDUELLE EN AFRIQUE OCCIDENTALE FRANÇAISE

Par le Médecin Colonel Nodenot, Médecin-Chef du Centre Muraz à Bobo-Dioulasso, Haute-Volta

Depuis 1953, le nombre des nouveaux trypanosomés dépistés a diminué : de 6.902 en 1953, il est descendu à 5.664 puis 4.973 et remonté, en 1956, à 5.334 pour arriver à 4.921, en 1957.

Pendant ce temps, les indices de contamination nouvelle et de virus en circulation, après avoir diminué régulièrement jusqu'en 1956 montraient une légère tendance à remonter en 1957. Parti de 0,12 en 1953, l'I.C.N. passait à 0,10, 0,098, 0,090 et enfin 0,096. Pendant ce temps l'I.C.T. donnait : 0,77, 0,71, 0,66, 0,39, et 0,46 en 1957. L'I.V.C. de 0,10, à 0,08, 0,07 et 0,07, 0,09.

La discordance entre la courbe du chiffre brut des nouveaux trypanosomés et celles des indices s'explique par l'absentéisme de plus en plus important aux séances de prospection. L'indice de présence n'a pas cessé de diminuer et est arrivé à 67% en moyenne pour l'A.O.F. en 1957.

Les 2/3 seulement des nouveaux trypanosomés ont été dépistés par l'ensemble du système de contrôle : équipes mobiles, postes-filtres et contrôle de la main-d'œuvre saisonnière au départ. Ce dernier service voit son efficacité diminuer chaque année, car les travailleurs groupés sont de plus en plus rares. Ils voyagent isolément, évitant ainsi les examens médicaux et vaccinations avant de quitter leur territoire d'origine. Le dernier tiers est formé par les gens qui viennent se faire examiner dans les formations sanitaires du service d'Hygiène mobile. Ils sont presque tous en deuxième période et l'atteinte de l'axe cérébro-spinal est souvent sévère. Nous avons malgré tout un pourcentage de 37% de malades en période lymphatico-sanguine parmi ces 4.921 nouveaux trypanosomés en 1957.

L'absentéisme est dû au fait que la maladie du sommeil étant devenue aux yeux des Africains une endémie mineure, les populations ont une impression, hélas ! bien fausse, de sécurité et presque partout ne se dérangent plus pour venir aux rassemblements de la prospection ou fuient la seringue de l'infirmier qui vient faire des injections préventives de lomidine.

Mais si la trypanosomiase n'est plus aussi répandue qu'autrefois dans l'ensemble de l'Afrique Noire, il n'en reste pas moins des endroits, le long des principaux cours d'eau ou des grandes routes, où elle sévit de façon endémique et doit être surveillée de très près pour éviter son extension.

En détaillant sa répartition actuelle, nous trouvons un certain nombre de foyers en activité.

Un foyer assez important s'est développé en 1957 dans la région de M'Bour, petit port de pêche situé à 80 kms. au Sud de Dakar où 112 nouveaux trypanosomés, dont les 2/3 en période lymphatico-sanguine, ont été dépistés dans le canton dont M'Bour est le chef-lieu. Ce foyer n'est pas encore éteint à cause de l'incompréhension des habitants qui répugnent à venir aux examens systématiques et à se faire protéger contre le trypanosome.

LE FOYER DES FRONTIERES DE L'A.O.F.

Le foyer qui s'étendait le long des frontières avec la Guinée et la Côte d'Ivoire, d'une part, le Sierra Leone et le Libéria de l'autre, est en voie d'extinction, y compris la petite portion de territoire guinéen qui s'enfonce en coin dans le Sierra Leone près du Libéria, et la région du Cavally et du Sassandra, avec son affluent le Nzo, en Côte d'Ivoire. Le Cavally forme frontière avec le Libéria et ses rives sont restées longtemps très infestées.

Ces denières années, à la faveur de l'indifférence et de l'apathie manifestées par la population en face de lui, le foyer avait débordé vers l'est et pénétré dans le bassin du Sassandra. Il a pu être maîtrisé en deux ans et, sur tout le pourtour du Libéria et du Sierra Leone, on n'a plus trouvé que 782 nouveaux malades, dont le 1/5 seulement dans la phase lymphatico-sanguine. Ceci est dû aux prospections constantes et aux lomidinisations préventives faites dans ces régions depuis 1948.

Mais le danger paraissant s'éloigner, les populations redeviennent réticentes et nous ne sommes pas à l'abri d'un retour offensif comme dans la région de M'Bour.

Le long de la frontière du Ghana, à la hauteur d'Abengourou, Adzopé, Agboville, en face du pays des Ashantis, un foyer important et très actif s'est développé ces trois dernières années.

Dans ces trois cercles, on a trouvé, en 1957, 849 nouveaux trypanosomés, dont 252 à la prospection avec un pourcentage de 67% en 1ère période. Le faible rendement des équipes de prospection, opérant de la façon habituelle d'après les recensements administratifs tenus à jour chaque année, est dû au fait que les nouveaux trypanosomés sont, pour la plupart, des étrangers non recensés vivant en pleine brousse et échappant à tout contrôle médical, à toute prospection, population flottante de travailleurs descendant de Haute-Volta et du Soudan, de commerçants qui circulent constamment à travers la frontière du Ghana.

Les commerçants sont également dépistés dans les postes-filtres. Pour pouvoir atteindre les travailleurs étrangers dans les meilleures conditions, c'est-à-dire le plus tôt possible, avant qu'ils aient eu le temps de disséminer leurs trypanosomes, il a été créé un système de prospection " en marguerite " appelé barrage mobile.

Une équipe de microscopistes s'installe à un carrefour de routes à proximité d'un groupe de campements, et des infirmiers vont les examiner et ramènent les suspects.

Par ce procédé, 81 nouveaux malades ont été trouvés, dont 47, soit 58%, en période lymphatico-sanguine.

Le cercle d'Abengourou est le plus infesté avec 600 nouveaux trypanosomés en 1957 (470 en 1956), puis vient le cercle d'Agboville avec 121 nouveaux malades (64 en 1956) dont 45% en 1ère période avec un index moyen de contamination nouvelle de 1,16%.

Ceci s'explique par le grand nombre de travailleurs étrangers qui viennent dans les plantations.

Un autre foyer se trouve au nord-ouest du Dahomey, dans la boucle de la Pendjari ou Oti, et entre cette rivière et la frontière avec le Togo et la Haute-Volta. Ce foyer, résidu de l'endémie ancienne, est très difficilement réductible à cause de l'indocilité des Berbas qui se refusent à venir à la prospection et, encore moins, à la lomidinisation. Pourtant celle-ci a pu être faite en partie en 1956 où une montée du nombre de nouveaux malades a rendu les gens plus dociles et leur nombre a diminué.

Il était passé à 183 au lieu de 106 à 116 les années précédentes. En 1957, il est retombé à 105. Sur ce nombre, il y en avait 80 dont 53, soit 66%, en période lymphatico-sanguine, dans les 6 cantons en bordure du Togo, domaine des Berbas particulièrement peu ouverts à la médecine préventive. Ces gens se contaminent le long de la rivière et aussi pendant leurs voyages dans les pays voisins : Togo et Ghana.

A l'intérieur du pays, le long du Niger, le foyer de Bamako, qui n'a jamais pu être réduit, s'étend depuis 2 ans par suite de la mauvaise volonté des habitants à se présenter aux propsections et aux séances de lomidinisation préventive.

Autrefois limité autour de Bamako, il a gagné en aval jusqu'aux environs de Niamina, chef-lieu de canton à mi-chemin entre Koulikoro et Ségou et, en amont, est remonté jusqu'en Guinée le long du Niger et de ses affluents : le Sankarani à droite, le Tinkisso à gauche dans les cercles de Siguiri et de Kankan, région de savane à l'est-nord-est de la Guinée. Il s'élargit en remontant le fleuve ; limité à une bande de quelques kilomètres de large jusqu'au sud-ouest de Bamako, il s'étale dans les subdivisions riveraines en amont de cette ville, pour gagner en Guinée plus de la moitié des cercles de Siguiri et de Kankan. La partie la plus active est à Bamako et ses environs immédiats. En 1956, 184 nouveaux trypanosomés, dont 5 européens et 1 libanais, ont été dépistés dans la ville et ses environs jusqu'à Kati. Plus de 60% étaient en première période. Sur 49.048 personnes visitées on n'a pu faire que 1.288 lomidinisations dont 47 sur des Européens.

En 1957, à Bamako, on a pu examiner 101.623 individus et dépister 81 nouveaux trypanosomés dont 2 Européens. Les deux tiers de ces malades étaient en première période.

Ces résultats ont été obtenus grâce à l'aide de la municipalité et des autorités locales qui ont organisé une propagande préliminaire à notre action par voie de presse, affiches, émissions de radio et haut-parleurs. Des travaux de prophylaxie agronomique ont été poursuivis le long du Niger et de ses affluents autour de Bamako, la Farako et l'Oyanko, toujours avec l'aide de la municipalité. On a lomidinisé 1.466 personnes.

Dans l'ensemble du foyer soudanais on a trouvé, en 1957, 813 nouveaux trypanosomés, dont 60% en première période, avec un indice de contamination nouvelle moyen de 0,72% dans les cantons visités.

Enfin, au Soudan toujours, le long de la Bagoé, affluent du Niger, il reste un foyer à peu près permanent qui s'étend sur 9 cantons. Après lomidinisation, on n'a plus trouvé, dans 4 de ces cantons prospectés en 1957, que 95 nouveaux trypanosomés dont 59 en première période sur 41.547 personnes visitées.

Dans la partie Est du Soudan et dans la région de savane de la Haute-Volta, de nombreux petits foyers erratiques se rencontrent tous les ans. Ce sont des quartiers, des villages, parfois un groupe de villages contaminés par des voyageurs, soit étrangers venant colporter trypanosomes et marchandises diverses, soit travailleurs revenant des plantations ou mines du Ghana et de Côte d'Ivoire. Ce n'est jamais bien grave dans ces régions où le souvenir de l'endémo-épidémie sommeilleuse n'est pas encore éteint et où les gens viennent à peu près régulièrement aux prospections en temps ordinaire, avec empressement quand ils sentent le danger menaçant. On voit alors, chose qu'on ne rencontre plus ailleurs, jusqu'à 95% de la population venir se faire examiner et traiter. L'extinction rapide du foyer montre que la lomidine a toujours la même action préventive, d'autant plus efficace que le nombre de sujets protégés est plus grand.

Partout ailleurs, il y a peu de malades nouveaux. Le long de la côte cependant, surtout en Côte d'Ivoire, on trouve encore de nouveaux malades disséminés dans les plantations et il convient de les surveiller. De même en Guinée.

Le Bas-Dahomey, le Haut-Sénégal et l'Ouest et le Nord du Soudan sont de moins en moins touchés et on ne trouve dans ces vastes territoires que de très rares trypanosomés étrangers au pays. Il en est de même au Niger où dans la région de Niamey, autrefois assez touchée pour avoir nécessité la création d'un secteur spécial, on ne trouve plus qu'un ou deux malades par an, commerçants qui se sont contaminés le plus souvent au Ghana. La trypanosomiase devient, dans cette région, du ressort de la médecine individuelle.

En somme, la trypanosomiase reste encore dangereuse en A.O.F. dans les régions où il y a des déplacements de population. C'est une maladie qui a perdu beaucoup de son importance puisque, pendant ces dernières années, nous n'avons trouvé qu'un indice de contamination très faible, inférieur à 0,1% malgré le relèvement de 1957. Elle reste néanmoins encore menaçante comme le prouvent les flambées de M'Bour et de Bamako et l'extension du foyer soudanais.

RESUME

La Trypanosomiase humaine en A.O.F. continue de constituer une endémie menaçante.

Si elle a pratiquement disparu en un Territoire — Niger —, si elle est dans l'ensemble ramenée à un taux rassurant dans la plupart des autres Territoires, elle ne peut absolument pas être considérée à la légère comme une endémie mineure ou en voie d'extinction et continue d'imposer une surveillance aussi constante que draconienne dans toute l'étendue des zones à glossines vectrices des sept Territoires intéressés.

Le cliché bien connu reste malheureusement vrai: " L'incendie semble éteint mais les braises couvent sous la cendre . . . ".

La Trypanosomiase demeure menaçante dans les foyers suivants:

Le long de la Petite Côte de la presqu'île du Cap Vert au sud de Dakar, à côté de M'Bour, dans le canton de Nianning où 112 nouveaux trypanosomés ont été dépistés cette année avec un I.C.N. de 0,71%.

Le long des frontières : du Sierra Leone et du **Libéria,** qu'elles coiffent depuis la région de Mamou en Guinée, jusqu'à celle de Danané et Duékoué en Côte d'Ivoire, le long des deux fleuves côtiers, le Cavally et le Sassandra avec son affluent le Nzo, dans leur cours moyen (782 nouveaux trypanosomés en 1957),

du Ghana, dans les régions d'Abengourou, Agboville, Adzopé (849 nouveaux trypanosomés en 1957 dont 600 dans le cercle d'Abengourou, avec 1,16% d'indice de contamination nouvelle),

du Togo, dans le cours supérieur du Pendajari au Dahomey (105 nouveaux trypanosomés en 1957, dont 66% en première période).

Le long du cours supérieur du Niger, depuis les cercles de Siguiri et Kankan, en Guinée, jusqu'à Niamina, à mi-chemin entre Bamako et Ségou (813 nouveaux trypanosomés en 1957 avec 0,72 d'indice de contamination nouvelle).

Plus à l'Est, le long de la Bagoé, autre affluent du Niger, un foyer existe aussi où on a trouvé, en 1957, 95 nouveaux trypanosomés dont 59 en première période dans 4 cantons riverains prospectés.

Les territoires à l'est du Soudan et la Haute-Volta, dans la région des savanes, sont le siège de petits foyers erratiques autour de cas importés dans le voisinage des cours d'eau ou des mares à glossines et rapidement éteints par la stérilisation des malades et la lomidinisation des individus sains.

Les foyers encore actifs sont entretenus et souvent provoqués par l'inconscience des populations qui, rebelles à toute discipline et inconscientes du danger, estiment avoir le droit de se soustraire aux prescriptions d'hygiène et contaminent ainsi gravement leurs voisins.

DOCUMENTS PRESENTED TO THE SEVENTH I.S.C.T.R. MEETING

DOCUMENTS PRESENTES A LA SEPTIEME REUNION DU C.S.I.R.T.

II. THE TSETSE FLY/LA MOUCHE TSE-TSE

I.S.C.T.R. (58).

1 Night observations on *G. swynnertoni* Aust.—(Southon).

2 Variations with time of day in intensity of attack by *G. morsitans orientalis*—(Welch).

(3) The effect of partial feeding on the probing reaction on tsetse flies, in relation to trypanosomiasis challenge—(Bursell).

4 The use of records from traffic control points in Southern Rhodesia—(Cockbill).

5 *G. pallidipes* Austen in Southern Rhodesia's northern tsetse belt—(Lovemore).

6 A note on the location of *G. morsitans* Westw. on transect fly-rounds—(Ford).

7 Some effects of bush clearing in Southern Rhodesia—(Goodier).

8 The Broken Hill–Mulungushi Dam tsetse eradication scheme, 1941–1956—(Steel and Gledhill).

(9) On the incidence of Trypanosomiasis in game—(de Andrade Silva and Marques da Silva).

10 The use of phytocides to control stump and other secondary plant growth in areas cleared against *G. Austeni*—(Esteves de Sousa).

11 Chingola tsetse control scheme—(Steel, Gledhill and Norton).

16 The natural hosts of *G. longipennis* Corti and of some other tsetse flies in Kenya—(Weitz, Langridge, Napier Bax and Lee-Jones).

17 The economic importance of some West African species of *Fusca* group tsetse flies—(Page and Jordan).

18 Progress made in ascertaining the natural hosts favoured by different species of tsetse—(Jordan, Page and McDonald).

22 The importance of the age of *G. palpalis* at the time of the infective feed with *T. gambiense*—(Wijers).

(25) Les Glossines de nouveau à l'Ile du Prince—(Fraga de Azevedo, Tendeiro, de Almeida Franco, Da C. Mourão, de Castro Salazar).

29 The extermination of *Glossina palpalis* on the Kuja-Migori River Systems with the use of insecticides—(Glover, Le Roux and Parker).

33 The rearing of *Glossina palpalis* in the laboratory for experimental work—(Nash, Page, Jordan and Petana).

34 Some observations on the breeding of *Glossina morsitans* in the laboratory—(Foster).

36 The distribution and significance of *Glossina morsitans submorsitans* in Northern Nigeria—(Maclennan).

37 Recent advances of *Glossina morsitans submorsitans* in Northern Nigeria—(Wilson).

NOTE.—The numbers in brackets refer to I.S.C.T.R. papers which were not presented at the session.

Les chiffres entre parenthèses réfèrent à des documents I.S.C.T.R. qui n'ont pas été présentés à la session.

INTRODUCTORY REMARKS

W. H. Potts

I propose to do little more than briefly relate the papers presented to this session to the resolutions of the Sixth Meeting, so far as this can be done, and to indicate generally the lines of the remainder, at the same time putting all into a sequence and grouping that will, I hope, facilitate discussion; in doing this I hope also to give some indication of the present trends of development in entomological work on the vectors of trypanosomiasis.

Under **Resolution 1** which related to the determination of the natural hosts of tsetse by the identification of their blood meals by serological methods, outstanding progress in this field is outlined in Papers 16 and 18, the first on the natural hosts of *Glossina longipennis* and other Kenya tsetse flies, and the second from West Africa on the same subject in relation to their species of tsetse.

Resolutions 2 and 3 concerned game destruction notably in South Africa (Zululand) and in Southern Rhodesia; though there is in the papers presented to this session perhaps not such great emphasis on this form of control as there has been at some times in the past, the subject was mentioned in Paper 44 (which was considered by this meeting on Monday) and possibly if members wish to hear more of what is going on in Southern Rhodesia, Mr. Ford would give more detailed information. The use of this method in Northern Rhodesia is also referred to in Papers 8 and 11, shortly to be presented.

Resolution 4 related to trypanosomes in game, on which subject a most interesting communication from Portuguese East Africa was presented to this meeting on Monday (No. 9) and it is to be hoped that the contents of this paper will be borne in mind, and referred to, in the discussions that arise from Papers 16 and 18, already mentioned.

Resolution 5 recommended the prosecution of entomological studies designed to discover methods of eradication producing less disturbance to natural habitats than the present methods of clearing, game destruction and non-selective insecticides. Although no developments are reported which have an obviously direct bearing on this subject, no one can really say to what extent some of the observations on the ecology of tsetse presented in various papers to be mentioned shortly might eventually lead in this direction, as well as bearing very directly, as they do, on existing methods of control. One new development has received some attention since the last meeting—the irradiation of tsetse pupae. I expect the details of this are already familiar to all here so I will not spend valuable time speaking about them; it is sufficient, if a little disappointing, to say that although this method appears to have met with marked success when used against the screw-worm fly by the Americans, who eliminated this pest of cattle from the island of Curaçao by the introduction of irradiated pupae, tsetse would appear to be a more difficult subject for this method. In the first place, it is not so effectively sterilised by gamma radiations which, however, appear to shorten the life of a tsetse somewhat more than they did that of the screw-worm fly. Secondly, the supply of tsetse pupae in quantities sufficient, and continuously enough, for this method to be carried out, present considerable difficulties. There is, however, a possibility that the degree of sterilisation effected by gamma radiation may be increased without a corresponding decrease in length of life of the flies and I personally consider that exploration of this avenue of control should not yet be abandoned.

Resolution 6 concerned the identification of trypanosomes in the tsetse; whilst there is no specific mention of this subject in any of the papers presented, No. 17 (on the economic importance of some West African species of the *fusca* group) and No. 22 (on the relation of the age of *G. palpalis* at the time of its infective feed with *T. gambiense*) both deal with the trypanosome in the tsetse and it is possible that in the course of this work some observations may have been made that would bear on this subject. E.A.T.R.O. has also made some observations relating the trypanosome infections of tsetse to the two species studied, to the habitat, and to the season, so that they may also be able to contribute to the subject.

The papers bearing on tsetse ecology are: **No. 1,** relating to the activity of tsetse at night; **No. 2,** relating to factors affecting the intensity of tsetse attack; both of these, together with No. 3 on the probing action of tsetse which was considered earlier, bear very markedly on the vital subject of tsetse challenge, which is also touched on in **Paper 36. Paper No. 6** describes a new approach to fly sampling designed to reveal more precisely the relation of fly to habitat, and **No. 7** bears on the way in which discriminative clearing under certain conditions may produce its effect on the fly so that both are examples of the kind of study so badly needed to place the method of control of the woodland tsetse by discriminative clearing on a sound footing; **Paper 36** also bears on the relation of fly to its habitat in Northern Nigeria, whilst **No. 5** emphasises once again the great difficulty that *G. pallidipes* may present in its detection by routine survey methods. Two important papers, **Nos. 33 and 34,** give accounts of methods used in the breeding of tsetse under laboratory conditions; I need not stress the importance of this work which has never, in my opinion, received the attention it needs. Finally, a series of papers review the progress in the control of the vector generally—in Southern Rhodesia (**No. 4**), in Northern Rhodesia (**Nos. 8 and 11**—by discriminative clearing, game eradication and the use of insecticide), in Kenya (**No. 29**—by the use of insecticides), in Portuguese East Africa (**No. 10**—relating to the use of arboricides for the control of bush regeneration), and in Nigeria (**No.** 37—a general discussion of the problems concerning *G. morsitans* from the veterinary aspect); we have already heard the admirable account of the measures taken to control *G. palpalis* on its recent reappearance in the Island of Principe (**No.** 25), which shows how, in favourable conditions of isolation, prompt use of all the tried methods available can succeed if swiftly and vigorously applied, in eliminating the insect vector.

Here I would like to suggest that the papers should be taken in the order I have used above and in five groups, opportunity being afforded for discussion when the papers of each group have been briefly introduced, as follows:

Group I: Nos. 16 and 18 (on natural hosts): discussion; **Group II**: Nos. 1, 2, 17 and 22 (bearing on trypanosome challenge and the trypanosome in the tsetse): discussion; **Group III**: Nos. 6, 7, 36 and 5 (relation of fly to habitat and its bearing on control measures, particularly discriminative clearing and selective use of insecticides): discussion; **Group IV**: Nos. 4, 8, 10, 11, 29 and 37 (relating to control generally): discussion; **Group V**: Nos. 33 and 34 (the maintenance and breeding of tsetse in captivity): discussion.

In concluding, I would like to stress that, in my view, the most important developments presented in these papers are:

(1) those contained in the last two mentioned, bearing on the maintenance of tsetse in captivity; this subject is the basis of all experimental work, and might in future be essential to some forms of control work; in spite of the advances made, it is still not possible in the laboratory to produce as many fly pupae as may be wanted, the production of such numbers as are possible is an arduous and difficult task, nor am I satisfied that the flies so produced are as equivalent to the normal fly in its wild state, in general vigour and in physiological condition, as is desirable;

(2) those concerning the ecology of the fly in relation to its habitat. The tendency to relate such studies to the problems of control as evinced in these papers, though indeed no new thing, is nevertheless to be welcomed; I have particularly in mind in this connection discriminative clearing, whilst the contribution such studies can make to the efficient and economic use of insecticides needs no stressing.

There have recently been reports of continued advances of tsetse on a large scale, threatening large areas of country to a degree that is alarming and, I believe, causing great concern to the countries involved. It seems to me that for the species of tsetse mainly involved, the woodland tsetses, the method of discriminative clearing, which so changes the habitat that the fly cannot live in it for a very considerable time though this change seems to disturb the habitat to only a very small extent, is the method of choice; but we still do not know enough about the relation of these flies to their habitat to base this method on general principles that will allow its application with confidence to any new situation that may arise. I believe that entomological measures for use against the vector are needed now as much as they have ever been and I hope that the discussions that follow will suggest lines that will be profitable to explore.

NIGHT OBSERVATIONS ON *G. SWYNNERTONI* AUST.

By H. A. W. Southon, East African Trypanosomiasis Research Organisation, Tororo, Uganda.

SUMMARY

Observations are recorded on *Glossina swynnertoni* Aust. located at night in thornbush at Shinyanga, Lake Province, Tanganyika, in March 1958. The observations were made both on flies marked with small reflecting glass spheres and on wild unmarked flies.

The flies were found to move at dusk from diurnal resting sites on the undersides of branches, to perch on leaves at night and to return to branch resting sites at dawn.

These observations largely confirm and extend those made by other workers.

* * *

Previous attempts to study the night resting sites of *Glossina swynnertoni* Aust. have been made by marking tsetse with fluorescent paint and using ultra-violet light to locate the marked flies. (Jewell, 1956 and 1958.) In March 1958 investigations were carried out to discover whether the reflection of visible light by small glass spheres could be employed as an alternative to the above method. The spheres, of diameters 0·10 to 0·40 mm. were applied to the tacky surface of a spot of artists' oil paint on the thorax of the tsetse. The method was found to be successful and 6-volt torches provided an adequate light for the location of the flies in the field. The development of this method has been reported by Rennison *et al.* (1958) working in Uganda. The observations recorded here were made in an area of thornbush at Shinyanga, Lake Province, Tanganyika Territory, during the long rains.

The diurnal resting sites of *G. swynnertoni* during the early part of the wet season have been described by Isherwood (1957). These were on the undersides of the branches of small trees in hard-pan areas at heights of three to fifteen feet. Few published records refer to tsetse observed at rest by day in situations other than on the trunk and branches of trees. Swynnerton (1921) recorded *G. brevipalpis* Newst. and *G. pallidipes* Aust. resting by day on leaves but the former species at least was seen to rest only temporarily in this position. Isherwood did not find *G. swynnertoni* resting on leaves when investigating diurnal resting sites (personal communication). On two occasions the writer has observed this species resting on the undersides of leaves of *Lannea humilis* Engl. These observations were made in a cage built round a small tree of this species and although the conditions were artificial much of the behaviour observed corresponded with that seen under natural conditions. It seems possible therefore that some tsetse may rest on leaves by day.

Evidence has previously been obtained that the type of resting site widely occupied by day is not used at night. During investigations into the use of fluorescent paint a number of *G. swynnertoni* were seen resting on leaves after dusk while none could be located on branches (Jewell, 1958). In addition, Isherwood (1958) has recorded that tsetse under observation regularly left branch resting sites at dusk and that flies reappeared in these positions at dawn.

The present observations were made on four occasions at dusk and four at dawn. Work was confined to a semi-circular area of twenty-five yards radius in which the following trees occurred: *Commiphora schimperi* Engl, *Lannea humilis, Commiphora subsessilifolia* Engl, *Combretum parvifolium* Engl, and *Acacia senegal* Willd. The observations were made on ninety marked *G. swynnertoni* and thirty-seven unmarked flies. The latter not only provided confirmation that the behaviour of marked flies was generally valid for the wild population but demonstrated the possibility of locating unmarked tsetse at night.

All tsetse observed invariably left branch resting sites at dusk and moved on to leaves. The reverse movement took place at dawn. It was not possible to follow the movement of individual flies, so no estimate could be made of the actual distance travelled from branch to leaf. Both types of site, however, frequently occurred within a few inches of one another. From the small number of tsetse, about twenty on each occasion, which it was possible to keep under constant observation the movement appeared to be completed in twenty to thirty minutes.

With the exceptions noted below all tsetse observed at night were resting on leaves, predominantly those of *Commiphora schimperi*, at heights of 1½ to 10 feet. Considerable search was carried out to a height of twenty feet but no further flies were found. Most flies observed were perched on the upper surfaces of leaves. Differences in the positions of the nocturnal resting sites were largely connected with variations in growth form of the species of tree concerned. Thus *Commiphora schimperi* commonly produces descending sprays of slender branches with leaves to within two or three feet of the ground. These situations were extensively used by resting flies at night. By contrast *Lannea humilis* has a more compact leaf canopy, the base of which is frequently at a height of more than six feet.

Two exceptional night resting sites were recorded. One marked fly was seen resting on the trunk of a *Commiphora schimperi* at a height of one and a half feet shortly before dawn. Two *G. swynnertoni*, one of them marked, were found resting on horizontal thorns of *Commiphora schimperi* in close proximity to other flies resting on leaves.

Occasional flies were seen to leave a leaf resting site during darkness; in the absence of evidence to the contrary it was assumed that these occurrences were due to disturbance. More frequently it was possible to keep a fly under observation in the light of a torch for a considerable period without apparent effect and it was subsequently found that such resting flies could be removed from the leaves by hand with ease.

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VARIATIONS WITH TIME OF DAY IN INTENSITY OF ATTACK BY *GLOSSINA MORSITANS ORIENTALIS*

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The existence of a diurnal rhythm in the activity of *Glossina* was shown by Vanderplank (1948) for *G. pallidipes* and was mentioned by Potts (1950) for *G. swynnertoni*. It was also discussed at length by Buxton (1955). Unpublished work by Ford and Culwick indicated that the intensity of attack by *G. swynnertoni* was at a maximum in the morning and late afternoon, and at a minimum during the hottest part of the day. The experiments described here were designed to investigate diurnal rhythms in *G. morsitans orientalis*.

In this paper the word " attack " is used to indicate flies coming to a catching party, though, of course, not all of them come to feed.

Experiment 1

The investigation was carried out near Kingolwira, Morogoro, Tanganyika, in *Isoberlinia–Brachystegia* wooded grassland, with numerous dense thickets. The Apparent Density (number of non-teneral male flies caught per 10,000 yards traversed) of *G. morsitans orientalis* in this area was about 150. Three parallel transect fly-rounds (Ford, Glasgow, Johns and Welch, 1957), 200 yards apart, were each divided into nine 50-yard sectors. Two flyboys were used on each fly-round and the three parties started each traverse simultaneouslv at specific times. Each party halted at the end of each sector and caught all the flies on and around them. All flies were marked (Jackson, 1953), recorded and released.

Each traverse of the fly-round occupied about fifteen minutes and the traverses were repeated at forty-five minute intervals, alternate catches being made in opposite directions. Whirling psychrometer readings were taken on the centre fly-round only, one sector behind the catching party. The series of catches was done three times, at various seasons, corresponding with the early rains, the middle of the rains and the cold dry season. The first series was started forty-five minutes after dawn, but the other two were started as soon as it was light enough to see the flies. The last catch in each series was after sunset.

The catches of non-teneral males on all sectors of all three fly-rounds for each time period were summed and these totals were expressed as histograms. The curves of temperature and saturation deficit were also shown, each point on the curves representing the average of the ten readings for that time period.

The resulting diagram shows a more or less massive attack in the early mornings between 06.00 and 08.00 hours. Some flies attacked each time the fly-rounds were traversed and there was a slight increase in the intensity of attack at various times after 12.00 hours. A sudden fall in temperature and saturation deficit, usually associated with rain or cloudy conditions, was followed by an intensification in the attack. The flies ceased to attack after sunset.

Experiment 2

Arising out of the observations from the first day's work on Experiment 1, parallel series of catches were made on the same fly-rounds and using the same technique, except that these series were made at half-hour intervals over a period of four hours. The first series was started at dawn and subsequent ones an hour later each time.

The results of the catches were treated in the same way as for Experiment 1 and entered on a second diagram.

Here, the first series showed an increase in the intensity of attack from dawn to 06.30 hours and then a decrease. In all the others, except the last one, the maximum attack was made during the first traverse of the fly-round no matter at what hour of the day this traverse was made. This initial catch varied between 20% and 48% of the four-hour catch, with an average of 38%. Thus rather less than half the available flies in the area came to a catching party in a single traverse of the fly-round. As some flies probably moved into the area during the period in which work was being done, a single traverse of a fly-round probably collects about half the available flies in its area. The decrease in catches was, in part, due to a catching-out effect. Although the flies were marked and released to avoid such an effect, out of 1,780 marked non-teneral male flies, only 92 or 5·17% were recaptured, showing that marked flies were available only to this extent for the rest of the day of marking. The increase in attack with falling temperature and saturation deficit, noted in Experiment 1, was also seen in these series of catches. The last two series also show the almost complete cessation of attack after sunset.

During the course of this investigation the catching parties were, several times, bitten by *G. morsitans orientalis* while travelling in a truck in darkness, but this may be due to disturbance by the headlights of the truck.

CONCLUSIONS

Glossina morsitans orientalis attacked at all times of day, but the attacks were much less before sunrise and after sunset. There was some indication of a very slight diurnal cycle, with two peaks of attack, one in the morning and one in the afternoon, but this was frequently overshadowed by other factors.

Falls in temperature and saturation deficit, usually caused by an increase in cloud cover and/or by rain, led to an intensification of the attack.

The first traverse of a fly-round at almost any hour, produced the maximum attack, but this represented only about half the flies available for attack in the area of the fly-round. Since *G. morsitans orientalis* will attack in numbers at any hour of the day, there is no period of daylight when it would be safe to graze or move cattle through an area infested with this subspecies. It is also doubtful whether it is safe to move cattle in such an area during the hours of darkness.

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THE EFFECT OF PARTIAL FEEDING ON THE PROBING REACTION OF TSETSE FLIES, IN RELATION TO TRYPANOSOMIASIS CHALLENGE

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INTRODUCTION

Recent work on trypanosome challenge (Smith and Rennison, in the press) has drawn attention to the possible importance of repetitive feeding in determining the intensity of such challenge. Observations on the attack of tsetse on experimental herds gives the impression that feeding flies are often disturbed and that such flies tend to persist in their attack, thus increasing the chances of transmission (Smith, personal communications). It seemed desirable to make a preliminary study of this phenomenon in the laboratory where some idea of the feeding behaviour of the insects might be gained, admittedly under highly artificial conditions.

MATERIAL AND METHODS

The probing reaction was chosen as a criterion of feeding propensity; this reaction may be elicited by a variety of stimuli, tactile, olfactory and thermal, the most important being temperature, which is capable of compensating for the absence of other normally associated stimuli (e.g. Burtt's probe technique, Burtt, 1946) and even of overriding repellent stimuli (e.g. Dethier, 1953).

The experimental procedure was as follows: newly emerged males of *Glossina morsitans* Westw. were maintained for forty-six hours at 60% R.H. and 26° C. singly in 3 × 1 in. tubes corked at one end and covered with mosquito gauze at the other. They were transferred to a single-ended 3 × 1 in. tube closed by a rubber bung, weighed, and the open end of the tube was then opposed to the inner surface of the arm of the experimenter and the fly made to alight on the skin surface where it was allowed to feed. Under these circumstances more than 90% of the flies would take a meal. Feeding was interrupted at different stages and the tube and fly reweighed to determine the amount of blood taken. The flies were then maintained as before and tested at intervals, precautions being taken to keep stimulation intensities as constant as possible (light, temperature, duration of exposure, etc.), until a positive probe reaction occurred. The first trial was made one hour after feeding, by which time the "primary" excretion of water had taken place and most of the blood meal had passed from the crop to the midgut.

Flies which had given a positive reaction were killed and their thoracic surface was measured. The relation between size and weight of a full blood meal had previously been determined as

$$\text{Blood meal (mg.)} = 3 \cdot 6478 \text{ Size} - 2 \cdot 991$$

so that the amount of blood actually taken by a fly could be expressed as a percentage of the full meal.

RESULTS

The time taken for the probe reaction to develop after partial feeding was plotted on a chart. The regressions of the two variables were calculated and the upper and lower fiducial limits estimated over the whole range. Extrapolation of the curve to a full meal (100%) shows that the probing interval is 3·5–4·0 days which accords well with the duration of the hunger cycle recorded in the field at comparable temperatures (Jackson, 1954); this agreement suggests that in spite of the artificial conditions the results may with some confidence be applied to the problems which prompted the present study.

At the lower end of the range the curve cuts the ordinate at a value of 10%; it would seem that the probing reaction is not inhibited by meals amounting to less than 10% of the normal, but that partial meals greater than this cause some degree of inhibition so that only a proportion of the individuals will feed. At 30% of the full meal and over, there is no tendency to repetitive feeding, and the probing action is not reconstituted until some digestion of the meal has taken place.

It seemed possible that flies which have had one or more blood meals might differ from general flies in respect of the tendency to repetitive feeding because the gut of such flies would not be completely empty at the time of feeding. To test this possibility a comparison was made between flies taking their first and flies taking their second meal, the results of which are set out in Table 1. There is clearly no difference between them, and it must be concluded that for non-tenerals as well as for tenerals a meal amounting to about a third of the normal is necessary for complete inhibition of the probing reaction.

Table 1.—The Proportion of Flies Probing One Hour after a Partial Feed

Percentage of full meal taken	Percentage Probing	
	Tenerals	Non-tenerals
0	100	100
10–20	56	60
20–30	36	25
30–40	0	0

Some tests were done with flies less than half a minute after an interrupted feed, the flies being re-tested after an hour. It was found that of flies which had taken less than a third of their normal feed 61% would probe when tested half a minute later, while only 43% would probe at the end of an hour. With numbers available (38) this difference did not reach the 0·05 level of significance, but the results do suggest that inhibition of the probing reaction may be in part determined by distension of the mid-gut and that the propensity to probe persists to some extent until the blood meal has passed out of the crop.

DISCUSSION

Results obtained under laboratory conditions thus indicate that, provided a fly takes more than a third of its normal meal, there will be no tendency for it to attempt to feed again until the blood meal has been digested. If less than a third is taken, probing will be repeated in a certain proportion of the individuals, and the chances of such repetitive probing seem to be increased if the stimulus is offered before the blood meal has passed into the midgut.

Considered in relation to the question of trypanosome challenge it seems that the possibility of repetitive probing is one which deserves consideration. Cattle appear to be far from indifferent to the attack of tsetse flies and there seems reason to suppose that feeding may regularly be interrupted. In that case the trypanosome challenge would be far in excess of any value calculated on the basis of tsetse density and hunger cycle. It would be of interest to make a collection of fed flies from a herd of cattle and determine what proportion of the flies have taken meals smaller than a third of the normal value.

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THE USE OF RECORDS FROM TRAFFIC CONTROL POINTS IN SOUTHERN RHODESIA

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1. INTRODUCTION

Pickets or traffic control barriers have been widely used for many years to restrict the carriage of fly on traffic to fly-free areas, but there appears to have been no critical examination of the data obtained from them. This paper deals with some of the more obvious conclusions that have been drawn from records collected in Southern Rhodesia between 1952 and 1957.

The tsetse *G. morsitans* shows a marked tendency to follow and alight on moving objects. Jack (1) in 1930 pointed out that " where there is a large amount of traffic to and from a heavily infested fly area, definite spread of the fly may possibly be facilitated, but the most important aspect of the problem in this Colony at present lies apparently in the danger of transported flies causing sporadic outbreaks of trypanosomiasis amongst cattle in occupied country ". This statement is true today. A total of 44,339 *G. morsitans* were taken at our traffic control points between 1st October 1952 and 30th September 1957. These flies could have added their contribution to the spread of trypanosomiasis in the settled areas marginal to tsetse country.

The traffic control points, both cleansing chambers and gates (or pickets), are so situated on the estimated fringe of the tsetse habitat that there is the minimum risk of traffic transporting tsetse into fly-free territory. In some areas, gates a few miles apart serve as a double precaution against the carriage of fly.

2. TYPES OF TRAFFIC CONTROL POINTS

Cleansing chambers were used in Uganda as early as 1915 (2). Smoke from burning vegetation was used to dislodge and possibly kill the carried tsetses. However, from experiments carried out in Southern Rhodesia, Jack (1) found that similar smoke chambers were not altogether efficient. On the grounds of fire hazard and because of the discomfort caused to travellers, the method was not adopted here. Instead, traffic was required to enter a cleansing chamber and be subjected to an application of a paraffin based insecticide applied by means of a hand operated pump. Flies dislodged by the treatment were attracted to a light source coming from a gauze-proofed antechamber which served to trap them. When the guards had captured the flies, the traffic was allowed to proceed.

The chambers now in use have been improved by the elimination of the antechamber and the provision of traps with sliding doors inserted into the side walls of the chamber, so that traffic may continue its journey without awaiting the capture of the flies.

Trials carried out in 1956 showed that where the volume and size of the vehicular traffic was large, as it is on the main roads leading to the Kariba Dam site, the cleansing chamber appeared to have reached its limits of efficiency. It was found that the application of 4% gamma BHC in diesoline, applied in the form of an aerosol by means of Swingfog machines, effectively removed and killed tsetse. Although the method was more costly in operation than that of the chamber with hand pump, it could cope effectively with large lorries and trailers in a matter of seconds.

Gates are used where the volume of traffic is not heavy. Guards examine traffic for carried tsetse and apply insecticide by means of hand pumps.

The number of control points operating in Southern Rhodesia has been increased from five in 1950 to forty-five at the present time.

3. CATCHES AT TRAFFIC CONTROL POINTS AS AN INDEX OF AVAILABILITY OF TSETSE

Glover *et al.* (3) have used data from picket catches (equivalent to our traffic control gates) in conjunction with conventional fly-round catches to demonstrate the decline in tsetse population and its final disappearance at Abercorn, Northern Rhodesia, following anti-tsetse measures, which included discriminative clearing and fire exclusion. The apparent density of tsetse as revealed by fly-round catches was reflected in the picket catches. The main purpose of the pickets was, however, to prevent the carriage of tsetse on to the neighbouring farms.

In Southern Rhodesia, in areas marginal to fly country, trypanosomiasis occurs sporadically amongst cattle where prolonged searches fail to discover tsetse. Chorley (4), in 1929, considered that tsetse could be carried up to ten miles beyond its known habitat and could produce trypanosomiasis in cattle living well outside the fly-belts. In areas marginal to fly country, records from traffic control points serve as a useful index of the availability of tsetse. Data obtained by Goodier (in litt.) from the Sabi Valley, Table 1, show clearly the close relationship between catches

Table 1.—Showing Relation between Numbers of Carried Tsetse and Incidence of Trypanosomiasis in Neighbouring Cattle

Area	No. of Smears taken	Infection Rate	No. of tsetse taken at associated control points.	
			G. morsitans	*G. pallidipes*
Makoho . . .	18	39%	106	30
Mabee . . .	76	21%	42	51
Chisuma . . .	108	5%	4	—
Murongwezi . . .	108	5%	7	—
Mwangazi . . .	238	—	—	—

Table 2.—Catches, *G. morsitans* at Traffic Control Points. Urungwe Native Reserve 1.10.52–30.9.57

Control Point	1.10.52 to 30.9.53		1.10.53 to 30.9.54		1.10.54 to 30.9.55		1.10.55 to 30.9.56		1.10.56 to 30.9.57		
	E Bound	W Bound	E Bound	W Bound	E Bound	W Bound	E Bound	W Bound	E Bound	W Bound	
Magunge Chamber	19	0	1	0	1	0	0	0	0	0	East Fence
Magunge Gate	20	2	2	0	0	0	Gate removed				
Badze Stile	3	1	2	0	0	0	0	0	0	0	
	S	N	S	N	S	N	S	N	S	N	
Nzoe Gate	126	0	107	0	68	0	44	0	20	1	North Fence
Karambanzungu	28	4	45	7	103	0	44	0	7	0	Central Fence
Cheoka	162	46	76	4	49	0	9	0	7	0	
Zadze Gate	24	2	39	13	16	0	2	0	3	1	
Tengwe	11	6	13	0	1	0	0	0	0	0	
Chiroti	2,480	1,172	2,204	1,202	1,186	615	383	182	153	82	West Fence
Zemaiwe	451	2	484	0	54	0	38	0	74	0	
Kawaya	4	1	0	2	1	2	0	0	0	0	
	3,328	1,236	2,973	1,228	1,479	617	520	182	264	84	
	4,564		4,201		2,096		702		348		

Table 3.—Annual Totals of *G. morsitans* male and female, taken at all Traffic Control Points, 1952–1957

CARS

Towards Fly							From Fly						
Year	No.	♂	♀	Total	% ♀	Fly per 100 units	Year	No.	♂	♀	Total	% ♀	Fly per 100 units
1952/3	28,184	357	186	543	34	1·93	1952/3	28,581	1,524	931	2,455	38	8·59
1953/4	39,147	327	288	555	52	1·42	1953/4	40,371	1,833	1,322	3,155	42	7·82
1954/5	55,392	179	138	317	43	0·57	1954/5	55,152	1,907	1,428	3,335	43	6·05
1955/6	90,399	238	134	372	36	0·41	1955/6	91,300	1,251	1,006	2,257	45	2·47
1956/7	86,889	183	137	320	43	0·37	1956/7	97,092	1,481	1,225	2,706	45	2·79
Total	300,011	1,284	883	2,107	42	0·70	Total	312,496	7,996	5,912	13,908	43	4·45

CYCLES

Towards Fly							From Fly						
1952/3	28,957	275	176	451	39	1·56	1952/3	37,616	1,220	665	1,885	35	5·01
1953/4	40,328	281	216	497	43	1·23	1953/4	39,700	1,618	1,102	2,720	40	6·85
1954/5	37,039	276	153	429	36	1·16	1954/5	35,687	1,784	880	2,674	33	7·49
1955/6	51,197	292	177	469	38	0·92	1955/6	52,511	1,694	1,001	2,695	37	5·13
1956/7	71,180	335	213	548	39	0·77	1956/7	74,877	2,517	1,209	3,726	32	5·11
Total	228,701	1,459	935	2,394	39	1·05	Total	240,391	8,833	4,857	13,700	35	5·70

PEDESTRIANS

Towards Fly							From Fly						
1952/3	30,050	255	147	402	36	1·34	1952/3	32,234	961	465	1,426	33	4·42
1953/4	40,779	259	205	464	44	1·14	1953/4	40,603	1,094	763	1,857	41	4·57
1954/5	34,021	238	101	329	31	0·97	1954/5	35,655	937	590	1,527	39	4·28
1955/6	74,173	318	196	514	38	0·69	1955/6	75,280	1,176	715	1,891	38	2·51
1956/7	124,738	419	268	687	39	0·55	1956/7	128,227	1,938	1,195	3,133	39	2·44
Total	303,761	1,489	917	2,396	38	0·79	Total	312,049	6,106	3,728	9,834	34	3·15

at the control points and incidence of trypanosomiasis in neighbouring cattle. It is probable that the catches at the control points indicate the relative availability of tsetses.

In the Urungwe Native Reserve trypanosomiasis had spread throughout the native-owned cattle to such an extent that in 1952 all cattle were removed from the Reserve, and anti-tsetse operations were intensified. Records from the traffic control points since their introduction are summarised in Table 2. The Reserve is roughly rectangular in shape, with the long axis running north and south. It is fenced on all sides, and a central fence divides it into approximately equal east and west portions. The pressure of fly is from the north and west. Most of the tsetse are taken at the gates on the western fence and least at the eastern fence which adjoins European-owned farms. It can be seen from the records in Table 2 that there has been a progressive decline in the catches at all points, and that only one *G. morsitans* has been taken from traffic leaving the eastern portion of the Reserve since before September 1955. The situation has changed from 1952–53 when tsetse could be taken from all traffic control points and from each direction, save westbound traffic at Magunge chamber, and northbound traffic at Nzoe, to that, in 1956–57 when the distribution is limited to a local concentration near Chiroti gate. Only two flies were taken elsewhere within the Reserve. The virtual absence of *G. morsitans* in the records from the eastern part of the Reserve would warrant the introduction of cattle under suitable supervision.

4. THE RELATION BETWEEN CATCHES AT CONTROL POINTS AND TRAFFIC

In demonstrating the decline in the catches at the traffic control points, Table 2, no account was taken of the change in the volume of traffic. In fact, traffic had increased over the period. It is thus reasonable to relate this decline to a change in the availability of tsetse in the neighbourhood, on the assumption that a linear relationship exists between the volume of traffic and number of tsetse caught. That such a relationship exists in some cases is evident from a consideration of the twelve-month running totals of tsetse taken and cars examined at Chiroti gate between April 1956 and March 1958 (the latest figures available), where a positive correlation of $r = 0{\cdot}922$ is obtained ($P > {\cdot}001$). Under these conditions fluctuations in the catch per vehicle (or 100 vehicles) could be regarded as indicating that similar variations might be occurring in the availability of tsetse.

However, at another control point, at Vuti Chamber, on the main Karoi–Chirundu road, where the volume of southbound traffic examined has reached over 4,000 vehicles per month, a similar relationship does not hold. For the same period, the correlation between the number of southbound cars and tsetses caught is not significant ($r = -0{\cdot}3455$; $P < 1$). It would seem that at this traffic control point, the volume of traffic has saturated the available tsetse population, so that an increase in the number of cars is not accompanied by an increase in tsetse carried. In this case, it would be more realistic to compare the total number of tsetse taken without regard to the volume of traffic.

In treating data from traffic control points, it seems to be necessary to consider the degree of correlation that exists between volume of traffic and fly catches. Where the correlation is significant, the number of tsetse per unit of traffic should be used as an index, but where there is no significant correlation, then the total number caught is preferable.

The speed at which vehicles move influences the catch, and may account for absence of correlation. Thus at Chiroti vehicles approach the traffic control point slowly over bush roads, but at Vuti, on a good highway, most vehicles exceed a speed of 40 m.p.h. The chances of picking up tsetse are considerably reduced at such speeds.

5. SUMMARY OF CATCHES OF *G. MORSITANS* AT ALL GATES 1952–1957

Table 3 summarises the catches of *G. morsitans* at all gates from 1st October 1952 to 30th September 1957. The volume of traffic examined has increased over the period, but the number of tsetse caught per unit of traffic has diminished, except in the case of the catch on cyclists leaving fly areas. There is no significant difference between the percentage of females in the catch from year to year, or from traffic approaching or leaving fly areas, or from different kinds of traffic. The general mean is 38·9%. Cyclists collect more tsetse per unit than cars and both more than pedestrians when leaving fly areas, but cyclists and pedestrians carry more than cars when approaching fly areas.

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GLOSSINA PALLIDIPES AUSTEN IN SOUTHERN RHODESIA'S NORTHERN TSETSE BELT

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Glossina pallidipes Austen was only found for the first time in Southern Rhodesia's northern tsetse belt in September 1942: this was at Markwa vlei near the Sebungwe river. Since then numerous records have been made elsewhere in the Binga and Gokwe districts (prior to 1957 the Sebungwe district and the eastern part of the Wankie district) and in the Urungwe and Kariba districts (prior to 1957 just the Urungwe district) and these would seem to indicate that this species is almost as widespread as *Glossina morsitans* Westwood.

The obvious question now is, why did it take so long before *G. pallidipes* came to light? And the following possibilities are suggested:

1. When one has appreciated the great distances that our very few early entomologists had to cover on foot and the general unwillingness of this species to attack man, one can, I think, understand the situation—bait animals were not available in the tsetse belts and anyway if they were introduced they could not have survived for long; furthermore since *G. morsitans* was considered to be the insect in question there was no need to use screens. Incidentally, this elusiveness of *G. pallidipes* is well illustrated by that classic example at the Veterinary Research Station at Mpwapwa, Tanganyika, and to quote Buxton (1955) "it was believed for a number of years that tsetse was completely absent from the Veterinary Research Station, Mpwapwa, Tanganyika; occasional cases of trypanosomiasis occurring in experimental cattle were attributed to other causes. Eventually, however, careful search and the use of an ox as bait showed that small numbers of *G. pallidipes* occurred in the bush fringing the paddocks. It is, of course, possible that, when they were detected, the insect had recently extended its range; but it seems that they had probably remained undetected, in spite of the presence of excellent workers on trypanosomiasis".

2. It is possible that the *G. pallidipes* population may have taken longer to recover than *G. morsitans* after the great rinderpest epizootic of 1896, that is if it was affected; there is the evidence recorded by Duke (Buxton, 1955) in Northern Uganda of a *G. pallidipes* population which was considerably reduced after a rinderpest epizootic.

3. An extension of *G. pallidipes* may have been taking place up the Zambesi from the east into our northern tsetse belt and this could have been aided by the shifting cultivation which has taken place from time to time with consequent regeneration of the vegetation. To illustrate this suggestion I quote Buxton (1955) again—"A similar problem occurs, again associated with *G. pallidipes* in coastal and low land and towns in

Tanganyika. This insect is associated with the thicket that grows up when a patch of garden land is abandoned, as it so frequently is in tropical Africa. Man is therefore continually making breeding places for *G. pallidipes* in and about towns on the East African coast so that cattle cannot be kept in them."

I rather favour the first two possibilities suggested, with emphasis on the former: the country has opened up considerably in recent years and this has enabled tsetse officers to spend more time looking for tsetse in remote places and less time travelling.

In ending I would add that, whatever the reason for the long delay in *G. pallidipes* coming to light, it is now quite obvious that we have a combined *G. morsitans/G. pallidipes* problem in our northern tsetse belt and not just a *G. morsitans* problem as it has always been considered.

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A NOTE ON THE LOCATION OF *GLOSSINA MORSITANS* WESTW. ON TRANSECT FLY-ROUNDS

By J. Ford, Department of Tsetse and Trypanosomiasis Control and Reclamation, Salisbury, Southern Rhodesia.

In a paper recently prepared for publication (1) the writer and three colleagues have examined certain aspects of transect fly-rounds. Fly-rounds of this kind were mentioned by Buxton (2) as not yet critically described. In the paper it was demonstrated that the section catches on such fly-rounds may be statistically examined according to their departure from expectation of the Poisson series calculated from the mean section catch. In the present note, which is concerned only with non-teneral male flies, a not uncommon feature of transect fly-rounds, namely a tendency for significantly higher catches to appear on the terminal sections, is examined.

In Tables I and II the accumulated section catches on two transect rounds worked for twelve months in the *morsitans* belt of Ankole, S.W. Uganda, are given. Catches exceeding expectation at the 5% level of significance are shown in italics, those below expectation being in bold type. Following normal practice these rounds were worked alternately in opposite directions. (The slight disparity in numbers of forward and backward catches is due to omissions caused by bad weather.) Data thus obtained are generally examined after summing the catches in both directions. They are given thus in the third (total) line in each table. In Table I it will be seen that there is a high catch at both ends of the round. In Table II at one end only.

In Table I when the direction of catching is from Section 1 to Section 32 (forward) the high catch disappears from the last section. When the catching direction is reversed and begins at Section 32, it disappears again from the last section worked, No. 1. The explanation at once suggests itself that the fly-boys having approached the fly-round through tsetse infested bush have failed to catch out following tsetse before beginning their work. In fact they were especially instructed to do this by stopping first fifty yards from the starting point and removing all tsetse and to repeat the operation at the actual starting point. They were checked from time to time to see that this was done and in any case recorded the flies so removed. It must therefore be supposed that a number of tsetse were following them which were not at once visible to them, either because they were approaching from a distance and had not yet caught up or because they remained concealed from view.

This hypothesis is supported by Table II where there is no high catch at Section 1, either on forward or on backward workings, although there is a high catch on Section 28 which is very clearly associated with catches beginning at that end of the fly-round. In this round Section 1 was approached through cultivation and ran 100 yards through relatively open grassland before entering the bush. There was therefore little opportunity for the catching party to accumulate following tsetse in approaching their work. The records of tsetse removed before work began strengthen the argument. Referring to Table I, fly-boys approaching Section 1 removed thirty-five non-teneral males before beginning work and approaching Section 32 removed forty-three. Referring to Table II, fifty-five non-teneral males were removed before beginning work at Section 28; at Section 1 only two.

If the terminal catches thus differ in size according to the direction of approach of the fly-boys, it may be supposed that the quality of the catch also differs. The hunger stages of the whole rounds and of the terminal sections or groups of sections are given in Tables III and IV.

Comparing the data of Tables I and III we see that for the whole round the Mean Hunger Stage is 3·089 and that the same statistic for forward and for backward catches does not differ appreciably from this. On Sections 1 and 2, where there are high catches, both forward and backward catches have a higher M.H.S. than the whole round, but the proportion of stage four flies to stage two is greater on the forward catch where we suppose that following tsetse have augmented it (cf. Bursell (3) who does not use the Mean Hunger Stage). On Sections 31 and 32 the difference is more marked. The forward catch, here lacking following tsetse, does not differ appreciably (though the catch is small) from the round as a whole, but the backward catch shows a high proportion of stage four flies.

Comparing Tables II and IV we find that on Section 28 the difference in hunger composition between the high catch on the backward working and the low on the forward is most marked, the tsetse which we assume to have followed to the beginning of the round being very hungry, with 44% of stage four flies. If we take the three groups of terminal sections in Tables III and IV in which a high catch is obtained on entering the fly-round (i.e. omitting Sections 1 to 5 in Table IV, where there is no following-in effect) we find that together they have thirty-four stage four tsetses as against eight stage two, but when caught over in the reverse direction there are only seven stage four to five stage two; the probability that the proportion of stage four flies to stage two in the first group exceeds that in the second, lies between 0·05 and 0·01.

The evidence supports the view that fly-boys moving through tsetse infested bush are followed by a number of tsetse which do not appear to them at once when they stop. Since, when they do appear, they are hungry it may, perhaps, be assumed that they have approached from a distance and have not previously been close enough to attack; being hungry it is to be supposed that, having reached their target, they would attack at once. Jackson (4) gives data which show that of 580 stage four *morsitans*

Table I.—Section catches over 12 months (1952–53) of non-teneral *G. morsitans* males on No. 1 Transect Fly-round, Ankole, Uganda. (32 sections of 50 yards each.)

SECTIONS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	Total	Mean Section
77 Forward Workings	*31*	*14*	7	6	8	7	6	3	3	3	7	3	5	2	7	*14*	6	4	8	10	*15*	12	7	3	3	5	6	7	5	3	4	5	229	7·15
70 Backward Workings	6	7	4	5	3	5	4	4	4	2	2	8	9	5	5	*13*	9	6	7	9	12	8	4	9	4	9	12	8	5	10	*13*	*18*	229	7·15
Totals	*37*	21	11	11	11	12	10	7	7	5	9	11	14	7	12	*27*	15	10	15	19	*27*	20	11	12	7	14	18	15	10	13	17	*23*	458	14·3

Table II.—Section catches over 12 months (1952–53) of non-teneral *G. mortisans* males on No. 2 Transect Fly-round, Ankole, Uganda. (28 sections of 100 yards each.)

SECTIONS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	Total	Mean Section
70 Forward Workings	0	3	0	2	3	15	11	8	5	4	5	0	0	5	*21*	12	2	11	10	*16*	15	12	12	*26*	*18*	8	5	12	241	8·6
75 Backward Workings	1	2	1	4	8	15	9	4	1	2	1	4	4	9	15	9	5	8	9	12	*18*	*16*	6	*19*	*17*	*16*	13	*25*	253	9·0
Totals	1	5	1	6	11	*30*	20	12	6	6	6	4	4	14	*36*	21	7	19	19	*28*	*33*	*28*	18	*45*	*35*	24	18	*37*	494	17·6

Table III.—Hunger Stages of Fly round No. 1 Whole Round and Terminal Sections

	Hunger Stages				M.H.S.
	1	2	3	4	
Whole Round: Forward . .	21	28	123	57	3·139
Whole Round: Backward . .	17	39	126	47	3·038
Total	38	67	249	104	3·089
Sections 1 and 2: F . .	1	4	24	16	3·272
Sections 1 and 2: B . .	1	1	8	3	3·167
Sections 31 and 32: F . .	1	1	6	1	3·000
Sections 31 and 32: B . .	1	3	20	7	3·133

Table IV.—Hunger Stages of Fly-round No. 2 Whole Round and Terminal Sections

	Hunger Stages				M.H.S.
	1	2	3	4	
Whole Round: Forward . .	19	58	123	41	2·923
Whole Round: Backward . .	37	44	116	56	3·055
Total	56	102	239	97	2·965
Sections 1 to 5: F	0	1	5	2	3·125
Sections 1 to 5: B	3	1	7	5	3·308
Section 28: F	0	3	6	3	3·000
Section 28: B	1	1	12	11	3·417

facing p. 238.

taken throughout a twelve-month period, only 14% were taken on the ground and not on the catchers. The observations discussed in this paper may, in fact, be presented as a special case of the behaviour of hungry *G. morsitans* described by Jackson in the paper cited.

The distance over which following tsetse appear to augment the catch cannot be judged with certainty, but in Table I catches are higher on forward than on backward workings on the first seven sections (350 yards), but on backward workings the catch is larger only on Sections 26, 27 and 28 (150 yards). In Table II three sections (300 yards) exceed on the backward catches and may be supposed to be increased by the arrival of following flies.

We must now examine the internal data of the two fly-rounds to see if a following effect is observable here, for if it is it may be necessary to modify our interpretation of fly density data as applied to different places on the round. In Table II Sections 9 to 13 inclusive show values below expectation when all data are counted and we may say that they lie in an area which non-teneral *G. morsitans* tend to avoid. Separating the forward and backward components, however, we at once see that the distribution of tsetse in the five sections noted (and adjacent sections) suggest that in forward catches they follow out into the usually avoided area from the high density zone around Section 6 and in backward catches similarly from the high density zone on Section 15. Sections 9 and 10 yield nine flies on forward catches against three on backward and Sections 12 and 13 give eight tsetse on backward against nil on forward. The difference between the two distributions in a 2 × 2 table is highly significant, P lying between 0·01 and 0·001. Also on Table II we may note that Sections 1 to 5 yielded only eight tsetse when fly-boys were approaching the high density zone on Section 6, but gave twice as many when they were leaving it. In Table I Sections 12 to 15 inclusive yielded seventeen tsetse to fly-boys approaching the high density zone on Section 14, but gave twenty-seven when they were coming away from it. In all, the sections examined, when caught over on approaching high density zones through unfavourable areas, yielded twenty-eight tsetse: in the reverse direction they gave sixty or rather more than twice as many. There is no appreciable difference in the hunger staging of the two groups of tsetse, both having, as one would expect in such circumstances, a preponderance of stage four over stage two flies.

Indications of distance followed are again provided by the data. In Table I excess of backward over forward catching on Sections 12 to 15 suggests that the fly-boys may have moved 200 yards, with four stops before tsetse from the high density zone of Section 16 have caught up with them. In Table II greater distances are indicated. The excess of tsetse on forward catches on Sections 8 to 11 suggests that fly-boys have moved 400 yards (with eight stops) before tsetse have arrived from the high density zone on Sections 6 and 7. On backward workings of Sections 12, 13 and 14, a movement of 300 yards from Section 15 is suggested. We ought here to note that the attacking tsetse may have begun their approach from an unknown distance on either side of the fly-round path (Napier Bax (6) obtained results with *G. swynnertoni* suggesting they might be activated to attack by passage of bait at 150 yards).

We may conclude by observing that the direction of movement of the catching party ought to be taken into account when interpreting the tsetse distribution data provided by transect fly-rounds. Clearly peak catches at the end of such rounds should be regarded with suspicion. More important, however, is the demonstration that the catch of non-teneral males in areas avoided by tsetse is increased when they are entered from areas of high density. This is brought about by hungry tsetse following (as demonstrated by Jackson (4)) and failing to reach the point of attack until the fly-boys have moved from 150 to perhaps 400 yards, in spite of several stops. The distribution of the tsetse flies at rest or prior to activation by the passage of the catching party, is not accurately revealed by the fly-round (even within the limits imposed by discontinuous catching). It would seem that the aggregation of *Glossina morsitans* in its " concentration sites " or " true habitat " (Nash (6)) is probably far more marked than would appear from the use of fly-round or reconnaissance techniques. It is likely that many of the tsetse which are caught outside such sites, either in " feeding grounds " or " dispersal areas " have moved into them, possibly from considerable distances, in response to the passage of the observer, even although he may have made frequent stops for catching.

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SOME EFFECTS OF BUSH CLEARING IN SOUTHERN RHODESIA

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1. INTRODUCTION

The importance of local conditions in influencing the outcome of ecological methods in the control of tsetse is well known.

To quote Buxton (1):

"The ease or difficulty of control by these ecological methods will depend on local circumstances. It is likely to be easiest in places where the climate is extremely unfavourable to tsetse at one season as in the hot dry season in Northern Nigeria and the cold season in Southern Rhodesia."

In the present paper are presented the results of some small investigations into the application of control measures against *Glossina morsitans* Westwood in such circumstances as visualised by Buxton in the above quotation.

During 1957 a small reclamation scheme was undertaken in the Urungwe District of Southern Rhodesia in which bush clearing, followed by native settlement, was the method employed. The main centre of this scheme was the Rengwe River Valley which lies approximately on the co-ordinates 17° 12′ South 29° 07′ East and is part of the Umniati-Zambesi drainage system. The area occupied by the Rengwe watershed is approximately seven square miles.

On the alluvial soils of the Rengwe Valley the Brachystegia/Julbernardia woodland of the surrounding hills gives place to three fairly distinct vegetation types. The dark and poorly drained vlei soils one finds dominated by *Combretum ternifolium* Engl and Diels accompanied by such species as *Piliostigma thonningii* (Schumach) Milne Redhead, *Lonchocarpus capassa* Rolfe and *Afrormosia angolensis* Harms. The better drained reddish soils support a very mixed association in which *Pseudolachnostylis maprounaeifolia* Pax, *Combretum zeyheri* Sond, *Ostryoderris stuhlmannii* (*Taub*) Dunn ex Bakf, and *Terminalia stenostachya* Engl and Diels are important components.

A riverine fringe association was present on the Rengwe River, being particularly well developed on the lower reaches and including such large trees as *Tamarindus indica* L., *Diospyros mespiliformis* Hochst, *Trichilia emetica* Vahl, *Kigelia pinnata* D.C., *Acacia nigrescens* Oliv., together with a dense understorey and shrub layer of *Combretum mossambicense* (*Klotszch*) Engl, *Popowia obovata* (*Benth*) Engl and Diels and *Acacia* sp. (probably *A. ataxacantha* D.C.).

2. RECLAMATION OPERATIONS

It was decided that the bush clearing operations should be limited to the felling of riverine vegetation on the Rengwe River. Clearing work was commenced in May 1957 with a small force of thirty-six African labourers under the supervision of the local tsetse field officer and was completed by the end of August. Approximately eighty acres of riverine fringe vegetation were felled. The clearing undertaken was " discriminative " in the sense that only certain types of vegetation were felled but not " selective " as the felling was complete and removed all the riverine vegetation. Although it was realised that " selective " clearing may possibly have been sufficient it was decided to take no chances on the tsetse finding alternative habitats within the riverine vegetation.

3. THE EFFECTS OF THE CLEARING

a. The Effect on the Tsetse Situation in the Area

Fly-rounds were, unfortunately, not established in the area until shortly before the operations commenced. The catches on these fly-rounds are shown in Table 1.

The Rengwe fly-round was situated centrally in the area covered by the bush clearing operations, the Kadzomba and Whami fly-rounds were outside the area covered by the bush clearing and have been included for purposes of comparison.

Several points of interest arise from Table 1. It will be noticed that the initial great decline in tsetse caught on the Rengwe fly-round occurs before the commencement of the bush clearing operations and can probably be attributed to the effect of the onset of the cold season accentuated by the topography of the Rengwe Valley which appears to be a cold hollow.

Table 1.—Total catches of *G. morsitans* on the Rengwe, Kadzomba, Whami fly-rounds March to October 1957.

	Rengwe	Kadzomba	Whami
March .	75	—	—
April . .	29	—	8
" . .	7	—	7
May . .	19	—	—
" . .	3	11	14
" . .	5	5	7
June . .	8	—	—
" . .	6	10	10
" . .	4	5	4
" . .	nil	—	13
" . .	6	—	—
July . .	1	—	—
" . .	1	9	1
" . .	1	12	2
" . .	nil	—	—
August .	2	—	—
" .	nil	9	3
" . .	nil	2	nil
" .	1	—	—
September	nil	12	6
October	nil	7	—
"	nil	13	2
"	nil	10	2

Table 2.—Maximum and minimum temperatures at cleared and uncleared stations in riverine vegetation of the Rengwe Valley

	Date July	7	8	9	10	11	12	13	14	15	16	17	18	19
Station 4 Cleared	Max.	29·9	29·4	29·4	28·3	27·8	26·7	28·9	28·9	29·4	30·6	29·4	29·4	27·8
	Min.	3·3	3·3	3·3	2·7	1·1	1·6	0·0	0·0	0·6	2·2	1·1	1·6	1·1
Station 5	Max.	26·7	27·8	27·8	27·2	26·7	22·2	26·7	26·7	27·8	29·4	28·3	27·2	26·1
	Min.	6·1	6·1	6·1	5·6	4·4	4·4	3·3	2·7	3·3	4·9	4·4	4·4	3·9

Mean Range St. 4. Cleared 27·2° C.
St. 5. Uncleared 22·3° C.

Nevertheless whereas the catches stabilised on the Kadzomba and Whami fly-rounds, on the Rengwe fly-round the decline was maintained and no tsetse have been taken on it since the end of August 1957.

Approximately 200 African families were moved into the Rengwe Valley during August 1957. The area has remained free of tsetse since that time.

b. The Effect on the Local Climate

Although prior to the reclamation operations the Rengwe Valley was known to support a high population of tsetse it was nevertheless thought that the conditions in the area were rather close to the climatic limits of tsetse distribution. It was therefore decided to make a small investigation of the climatic effects of bush clearing in the area by placing shaded maximum and minimum thermometers in the cleared and uncleared areas of riverine vegetation at a height of about four feet above ground level. The data obtained, which are admittedly rather limited, are given in Table 2.

It will be seen from Table 2 that the effect of bush clearing has been to render the climate more extreme by increasing the daily range of temperatures as compared with the uncleared areas. The mean range in the cleared area was found to be 27·2° C. as against 22·3° C. in the uncleared. Although in normal circumstances within a tsetse belt a difference of this magnitude is probably of little importance, in the Rengwe Valley where climatic conditions approximate to the limits which can be tolerated by tsetse during certain seasons a difference of this magnitude may mean the difference between the survival and extension of the tsetse population. The mean minimum temperature in the cleared station was 1·7° C. during that part of the cold season when the experiments were carried out as against 4·46° C. in the uncleared. Investigations by Burnett (2) have suggested that exposure to 2° C. for two hours is more lethal than exposure to 4° C. for four hours so that the difference between the mean minimum temperatures in the two areas may be an important factor in determining the survival of the tsetse.

DISCUSSION

The present data are insufficient to support any definite conclusions but nevertheless suggestive of a possible reason why the reclamation scheme in the Rengwe Valley was so immediately successful, complete elimination of the resident tsetse being achieved in the course of three to four months as against two to three years in similar trials in other parts of Africa, and provide interesting confirmation that ecological methods in the control of tsetse can be expected to have their greatest effect when applied to tsetse populations inhabiting country near to climatic limits of their distribution. It seems probable that such conditions are to be found quite frequently in the marginal areas of tsetse distribution in Southern Rhodesia.

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THE BROKEN HILL—MULUNGUSHI DAM TSETSE ERADICATION SCHEME : 1941–1956

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1. HISTORY

In 1941 following a report that the Broken Hill Town Board cattle had been infected with trypanosomiasis, an investigation into the fly position around Broken Hill was carried out by D. G. Lancaster. In his findings, he states that the environs of the present township of Broken Hill had been more or less infested with tsetse fly (*G. morsitans*) since the occupation of Northern Rhodesia by Europeans, though between 1920 and 1930 the fly had retreated in the face of the increased human activity attendant on the establishment of the Mine and Township. Following the movement of the African population into their Native Reserves and the delimitation of fuel reserves around the Township, the fly began to recover from this set-back, until in 1939 and 1940 they were being regularly caught in the Township area itself, and in its immediate vicinity; many cattle were infected and numbers had to be sold to avoid them dying of trypanosomiasis.

The main fly concentration was discovered to lie to the east of Broken Hill, between the town and Mulungushi Dam.

As a preliminary measure, five Fly Pickets were instituted to prevent fly being carried from out of the fly-belt, and these were sited at the following points:

(*a*) On the main Broken Hill–Mkushi road.
(*b*) On the Watersmeet road.
(*c*) On Gray's Old road.
(*d*) On the Broken Hill–Mulungushi " Power Line Road ".
(*e*) On a track near Kangombe Siding south of Broken Hill.

Of these, numbers (*a*) and (*b*) did not catch any fly and were abandoned in 1942. In an attempt to alleviate the situation, efforts were made to foster resettlement between Broken Hill and the Mulungushi Dam but this was not very successful and was finally brought to a standstill in 1943 by the appearance of human trypanosomiasis in the fly area.

Because of this outbreak, a further survey was carried out and on the results of this a scheme for tsetse eradication was evolved.

The control measures were based on game elimination combined with discriminative clearing, the latter being confined solely to the clearing of dambo edges at the outset. As a further precaution all the remaining resident Africans were moved from the fly concentrations, and restrictions were placed on fishing and on travellers passing through the fly-belt, enforced under the Infectious Diseases Ordinance.

Operations on the above lines were continued until 1946, when the area was visited by an Entomologist and the fly disposition as he found it was duly recorded. As no fly was found west of the Mututu Stream, representations were made by the Game and Tsetse Control Department to consolidate the cleared area by resettling Africans around the Mswishi River, and, at a joint meeting of the departments concerned, together with a representative of the farming community, this was agreed upon. Combined extensive discriminative clearing and game elimination continued until 1947 and by this time almost all the dambos with which fly concentrations were associated had been dealt with. A narrow clearing to denote the fly area was then cut from Mile 20 on the Power Line Road, to Mile 28 on the Watersmeet Road, and game elimination was continued between this clearing and the Mulungushi Dam unti 1950.

Resettlement in the cleared area was proceeding very slowly but wood coupes for Broken Hill were sited and felled between the Township and the residual fly pocket to render the country more inimical to fly, and thus reduce the danger of reinfestation.

In spite of continued operations the situation deteriorated towards the end of 1948 and the beginning of 1949, and fly crossed the clearing mentioned above and encroached towards Broken Hill. During the whole of this period, the fishing in Mulungushi Dam had proved an irresistible lure to Africans, and there were numerous cases of trespass in the prohibited area in spite of stringent measures taken to prevent it. The human sleeping sickness position had however improved considerably and only one case was reported after 1948.

To meet the renewed threat of reinfestation of the cleared area, further efforts were made to reinforce the settlement between Broken Hill and the Mulungushi Dam, and in 1949 the Mswishi River area was surveyed by an Agricultural Officer. Attendant on his report, in 1950 a comprehensive scheme incorporating a dam and irrigated crops was formulated and put into operation to offset the infertility of the comparatively poor soils found in the vicinity.

In the same year, the area was again surveyed by an Entomologist, and though game elimination had continued, it was found that while the position was more or less static, there was no real improvement.

It was, however, confirmed that the belt was indeed an isolated pocket of fly, and had no connection with any other larger area of fly infestation.

In 1951, an Entomologist financed by the Belt Trustees was posted to the territory to investigate the possibility of using insecticides in the eradication of tsetse fly. Because of the findings outlined above, this officer was directed to the Mulungushi Dam area and after an exhaustive survey to assess the intimate fly distribution at different seasons and the possibility of any reinfestation from outside the fly-belt, a scheme was evolved for the complete eradication of the fly concentration by the use of further discriminative clearing, to be finally assisted by insecticides applied from the ground. These operations are dealt with in detail below, together with a detailed description of the area.

2. TOPOGRAPHY AND VEGETATION

The Mulungushi Fly Belt lies on the Central Plateau of Northern Rhodesia along the west bank of the Mulungushi Dam, and about fifteen miles north of the Luano Valley escarpment. The general aspect is of gently undulating country of a height of about 3,200–3,400 feet, with drainage lines eastwards to the dam. The predominant vegetation is a mixture of *Isoberlinia paniculata–Brachystegia* woodland and eastern *Brachystegia–Isoberlinia* woodland (Trapnell *et al.*, 1947) which is in this instance broken by fairly extensive tracts of mixed tall grass woodland (*Chipya*). A small area of mixed *Isoberlinia globiflora–Mupani* woodland also occurs.

The soils and vegetation are actually more varied, and some of a better type than is general in adjoining Central Plateau areas. The drainage lines are associated with well-developed dambos, all of which in the fly concentration area are waterless in the dry season and do not support any river line woodland or thicket along their watercourses. These watercourses are continuous and well defined only near the dam and in the *Mupani* area where the clay soil is in a state of active erosion. Once the grass is burned, it is possible to traverse almost the whole of the area by Land Rover without preparation of tracks, though the going may be rather rough in the *Chipya* communities, where the surface tends to be uneven, and in the *Mupani* where gulleys occur.

Detailed Description of Main Vegetational Types.

(*a*) *Isoberlinia–Brachystegia short-grass woodland*

On the poor grey sandy soils away from the *Chipya* areas, this is largely typical central *Isoberlinia paniculata–Brachystegia* woodland with *Brachystegia burtii* dominant only in small patches, mostly within one to two miles of the Mulungushi Dam. *Brachystegia spiciformis* becomes dominant in limited areas, particularly on reddish soils approaching the *Chipya*, while in and near the *Chipya* ecotones which may be up to 500 yards broad, good stands of this species occur. Well-developed stands of *Isoberlinia tomentosa* occur in similar sites along the edges of the northern *Chipya* belt where the soils are more sandy. *Brachystegia boehmii* is locally dominant in some areas and often appears to be associated with sluggish drainage conditions. The main understorey component is *Diplorrhyncus mossambicensis* with *Uapaca* and *Monotes* spp. becoming more frequent on poorer soils and watersheds.

(*b*) *Chipya*

The composition of this varies enormously. Some small areas are little more than *Combretum* scrub grassland similar to dambo edges, whilst at the opposite end of the scale are found patches of close woodland consisting of large *Erythrophloeum africanum* and *Afrormosia angolensis* trees with some *Pterocarpus angolensis*. In general the *Chipya* is open tall-grass woodland, in which the following trees most commonly occur :

Combretum spp., *Terminalia torulosa*, *Afrormosia angolensis*, *Cassia abbreviata*, *Pterocarpus angolensis*, *Lannea discolor*, *Acacia* spp., *Markhamia lanata*, *Albizzia harvei*.

Approaching the ecotone with *Brachystegia* woodland, large *Brachystegia spiciformis* specimens may enter, and in some cases these are associated with *Landolphia kirkii*, or rubber creeper.

(*c*) *Dambos*

These seasonally swampy grasslands usually support a bush or scrub community along their edges, and the extent and make-up of this community vary considerably with the type of adjoining woodland. It is noticeable that dambos running through pure stand woodland of *Isoberlinia paniculata*, *Isoberlinia globiflora* or *Brachystegia boehmii*, show relatively poor development of this dambo ecotone at Mulungushi. The change from well-developed *Isoberlinia paniculata* woodland to dambo grassland is often extremely abrupt.

Dambo ecotones on to *Brachystegia spiciformis* woodland and *Chipya* are usually well developed, the main components being small *Combretum* spp. with *Terminalia torulosa* and some larger *Acacia* and *Albizzia* spp. having the general appearance of scrub grassland increasing in size towards the woodland edge except where this is poorly developed *Chipya* woodland.

Large anthills with thicket occur in the bush edge along practically all dambos. *Capparidaceous* shrubs and creepers are often in evidence associated with *Albizzia harveii* and *Diospyros mespiliformis*.

(*d*) *Chipya–Brachystegia spiciformis ecotone.*

This was the only inter-woodland ecotone (as opposed to dambo-woodland ecotones) with which tsetse concentrations were found to be associated.

The change over from *Chipya* to *Brachystegia spiciformis* woodland often occupied wide belts where the vegetation was a thorough mixture of the two types, only showing gradation towards the edges. Stands of *Brachystegia spiciformis* with short grass are interspersed in the tall grass *Chipya*, and often have perimeters of bare ground or very short grass typical of the margin of close woodland on some kinds of dambos. In general the change over from *Chipya* to other types of woodland—for example that dominated by *Isoberlinia tomentosa*, is more abrupt. It should be emphasised however that it was impossible to decide solely by the physical appearance of an ecotone whether it was or was not supporting fly. Some areas that looked "right" were found not to constitute essential fly habitat, though the reverse was never found to be true. In practice therefore, which ecotones were cut was decided only by the proximity of fly concentrations revealed by fly rounds.

(*e*) *Isoberlinia globiflora–Mupani woodland*

This community is shadeless in comparison with other *Brachystegia–Isoberlinia* woodland types in the area, and generally showed poor growth with a maximum of twenty to twenty-five feet in height. *Mupani* is only of occasional occurrence, and some fairly large specimens occur. Much of the soil is clayey and eroding, with poor grass cover and dambos rather ill-defined. No permanent fly habitat was found in this vegetation type.

3. GAME

(*a*) Species Present

The following species of game animals have been resident in the area holding fly since 1951:

Greater kudu, waterbuck, reedbuck, warthog, common duiker, grysbok, bushpig, impala, bushbuck and oribi, together with baboon, vervet monkey and leopard. Migrants include Lichenstein's hartebeest, sable antelope, roan antelope, eland, buffalo (2) and elephant (1), besides others of the species on the resident list. Before the game elimination campaign reached maximum effect, most of those species on the migrant list, including buffalo, had been resident in the area. It will be seen that all the species that were still present by 1951 are thicket dwellers (at least when heavily hunted) with the exception of reedbuck, impala and oribi. Conditions in the *Chipya* make effective hunting impossible when the grass is long, and this does not burn well until late August when visibility still remains restricted in the thicket areas.

(*b*) Progress of the Game Elimination Campaign to 1956

In 1945, eleven hunters under a Ranger accounted for 858 head including 195 sable, 192 duiker, 168 warthog and bushpig, 86 kudu, 60 hartebeest, 60 reedbuck, 41 waterbuck and 11 buffalo (the last remnants of the resident herd.)

In 1947, 483 head were killed including 34 sable, 129 duiker, 94 warthog and bushpig, 25 kudu, 7 hartebeest, 18 reedbuck, 25 waterbuck, but no buffalo were killed.

As will be seen, the proportion of resident species had risen. It should also be pointed out that these hunting operations covered a much larger area than that of the 1951 "fly country" and included much sand veldt in the Mswishi area. This still holds sable but even at that date was devoid of resident fly.

In 1948, a determined effort was made to eliminate the remaining tsetse fly by means of game destruction; 572 animals were killed including 24 sable, 275 duiker, 75 bushpig, 31 warthog, 22 kudu, 11 hartebeest, 20 reedbuck, 17 waterbuck, but again no buffalo. It should be noted that a large proportion of the animals destroyed (duiker and bushpig) are of doubtful significance in the maintenance of a *G. morsitans* population. The game elimination campaign was continued in 1949, when just under 400 animals were destroyed, with no decisive effect on the fly. After this, the number of hunters was reduced to three operating on a cordon along the western limits of the fly pocket, and this measure was combined with a scheme to consolidate the ground gained during the tsetse control campaign by means of resettlement in the Mswishi area. The cordon with latterly only one or two hunters has been maintained to the present date, concurrently with the other tsetse control operations described in this report. An annual average of about 90 animals has been accounted for including about 20 kudu. Much of the meat was utilised for labour rations.

4. TSETSE DISTRIBUTION 1951

(*a*) Wet Season

The fly pocket occupied an area of between sixty and seventy square miles bounded by the Mtutu River, Mulungushi Dam, Katondo Dambo and a line drawn from the top of the Katondo to the head of the Kasemba then northwards to the Mtutu. In this season, fly was still at its maximum dispersal. Outside these boundaries, only occasional wandering or carried fly were caught. Within this area, the heaviest fly concentrations occurred roughly between the lower Kasamba and the Chinyeta Dambos, corresponding closely to the dry season foci described below.

Sample survey rounds from the concentration areas are:

(i) From the central Kasamba down the north side of this Dambo, then north to Nyankuru.
Catch: 86 males, 22 females, 4 young.

(ii) Kalusenga to the top of Nyankuru and on to centre of Mtoto I.
Catch: 99 males, 9 females, 1 young.

(iii) From Mtoto II to top of Mtoto I, and to Kalusenga.
Catch: 74 males, 7 females, 9 young.

Apparent Density approx. 200 per 10,000 yards for the above rounds.

(*b*) Dry Season

The concentration of the pocket was very marked following the burn, and tsetse could only be caught regularly in large numbers in three areas covering an aggregate of about five square miles. These were between the upper Nyankuru and Kalusenga, central Nyankuru and Bwawawa, and lower Kasamba–Nyankuru. Besides these principal foci, a few tsetse fly could always be taken on fly rounds between Chinyeta and Mtoto I, Mtoto II and Mtoto VI north of the Kasamba. Of the three main foci that on the upper Nyankuru Dambo appeared to be closely associated with uncut dambo edge ecotone, the other two showed very little relationship to any dambo. All three foci occurred in well-grown *Brachystegia–Isoberlinia* woodland with *Chipya* areas adjacent, though the extent of these was not well known in 1951. Apparent Density of tsetse in the fly foci in April was of the order of 200 per 10,000 yards, but this dropped in August–September to about 80. A rough population estimate in the Kalusenga–Nyankuru pocket in the more dispersed wet season phase (April) gave a figure of 4,900 non-teneral males in about 4½ square miles. There was probably little movement in and out of the pocket at this time of the year as the whole is enclosed by *Chipya.*

5. STATUS OF MULUNGUSHI *G. MORSITANS*

In response to a request from the late Dr. C. H. N. Jackson of E.A.T.R.O., specimens of *G. morsitans* from various parts of the territory were sent to him for examination to build up a picture of the distribution of the Western and Eastern races of this fly, based on measurement of wing-length, in Northern Rhodesia, as well as for comparison with Tanganyika specimens. Judging by the distribution in Tanganyika, it was expected that the line of the Great North Road, along the main watershed, would prove to be the dividing line between these two races, and this was in fact found to apply except in the case of the Mulungushi pocket, in which the Western race occurred to the east of the Great North Road. This finding was confirmed and it was also established that fly in the Luano Valley and on the edge of the plateau above the Luano escarpment within fifteen miles of the Mulungushi pocket belonged quite clearly to the Eastern race. This would appear to indicate at least that *morsitans* at Mulungushi was linked to the western belt, the closest outlier of which is now sixty-five miles away, much more recently than with the Eastern race which is now within fifteen miles of it, following a rapid advance up the Luano Valley in the 1920's–1930, presumably reoccupying country that was disinfested as a result of the rinderpest epizootic.

The results of the survey, in which no suggestion of a connection between the Mulungushi pocket and the Luano fly belt could be found, were thus strikingly confirmed.

From the data available, the general movement of this portion of the Great Western fly belt can be deduced. Originally there must have been encroachment of a fly front around the north and east of the Lukanga Swamp, which infested the region now occupied by Broken Hill Township, and eventually ended in the vicinity of the Mulungushi Dam. The connection between this fly salient and the main belt was severed by the impact of human settlement, attendant on the establishment of Broken Hill Mine and the increased activity along the Great North Road. This hypothesis is borne out by the fact that another residual fly focus still exists on the Chowa tributary of the Lukanga River, and also that fly to the north-west of Broken Hill has only disappeared within living memory. The fly elimination was assisted during the 1940's by active tsetse control measures, until finally east of Broken Hill the only concentration left was in the eminently favourable region around the Mulungushi Dam. Both the 1940 and the 1948–49 encroachments emanated from this focus and were in effect an attempt by a thriving fly population to re-invade land from which it had been ousted. As the encroachment was towards the west, the opinion formed on casual inspection was that the fly had originated in the Luano Valley, and it is not until the situation and morphology of the fly has been reviewed in detail that the true facts are uncovered.

It is of interest to note that early in 1957 it was discovered that fly from the Luano Valley was being carried into the Mulungushi area by pedestrian and cycle traffic, up the Muchingas, on a path a few miles east of the Mulungushi Gorge. This is undoubtedly a recent development, and ties in with an upsurge of fly in the upper Luano Valley and an encroachment of fly on the adjacent plateau area east of Chisamba in the last two years.

6. ANTI-TSETSE OPERATIONS 1952–1954

(*a*) Indirect Measures

Indirect measures were confined to discriminative and selective bush clearing, the game elimination campaign having been suspended. The grass was burned in July–August when the fire was always fierce.

(i) 1952

It was decided in this year to extend the dambo edge clearing which had not been completed in the 1944–46 operations. Nyankuru and Bwawawa dambos had been left entirely uncleared, together with the upper parts of Mwanas II and III, and some of the Chinyeta. Other small dambos including the Kapani and Mwana I had not been cleared, but were not holding fly.

A total of 660 man-days was used in discriminative clearing of the edges of the Nyankuru and Bwawawa dambos, and the upper parts of Mwana I and II: the Chinyeta was not touched.

(ii) 1953

Early in that year it became evident that dambo edge clearing had not affected the fly concentrations to any considerable extent, except in the upper Nyankuru area. Fly round results showed that fly concentrations in the other foci were now associated with *Chipya–Brachystegia* ecotones, more closely than with dambos.

Twenty-six labourers were signed on for two pickets from March, and after completing dambo edge clearing on the Chinyeta and augmenting the old clearing at the top of Mtoto I, a start was made with selective clearing of *Chipya* edges. This involved the thinning out of the ecotone vegetation with the idea of changing the physiognomy of this to approximate to the open *Chipya* woodland. This would result, in practice, in a very abrupt change from close *Brachystegia* woodland to open " artificial *Chipya* " with the intervening mixed ecotone woodland eliminated, the presumption being that this ecotone constitutes a feeding ground habitat for *G. morsitans*. Selective clearing on these premises was completed between Nyankuru and Bwawawa.

Between Kasamba and Nyankuru, for the sake of comparison, clearing was carried out on a more restricted pattern. In this case, the *Chipya* tongues and pockets in the ecotone were treated as dambos, and sheer felled, leaving clumps of untouched tall woodland scattered about in the area.

Besides this, discriminative clearing was deepened on the Mwana III, where fly appeared to be building up, and also at the top of Mtoto II. Labour employed on clearing totaled 1,350 man-days.

(iii) 1954

As a result of the full-scale selective clearing between Bwawawa and Nyankuru, there had been a very marked drop of fly numbers in that fly focus, and it was decided to extend this pattern of clearing to all remaining fly concentrations, preparatory to large-scale insecticide applications which would start as soon as the country could be clean burned.

In the Kasamba–Nyankuru focus, a very rapid increase in fly numbers had occurred, once the effects of some residual D.D.T. trials had worn off, and it was apparent that the restricted pattern of selective clearing had produced a habitat if anything more favourable to *G. morsitans* than the natural ecotone vegetation. This cutting was therefore extended to the full-scale pattern, and full-scale selective clearing was also carried out in the Mwana III–II focus. Besides this, some ten-year-old dambo edge clearing was recut on the lower part of Mwana II, where a secondary concentration appeared to be building up. Clearing operations were completed in July, a total of 1,710 man-days having been employed.

(*b*) Direct Measures

(i) Insecticide Applications—Equipment

A Todd Insecticide Fog Applicator (large type) was bolted on to a Land Rover trailer, which also carried a 45-gallon insecticide drum forward of the applicator. This was drawn by a Land Rover in the back of which was bolted, by means of an iron frame, another 45-gallon insecticide drum, allowing a total of 90 gallons to be sprayed before returning to base for refilling. The Land Rover was driven at 2½ to 4 miles per hour for fog application, and to facilitate refuelling with the minimum loss of time insecticide depots were made at convenient points. The insecticide was carried to these bases in a 5-ton Bedford truck, after having been formulated at the main camp.

(ii) Insecticide Trials

Insecticide trials were carried out in the dry season of 1953 with a D.D.T. residual formulation, and a B.H.C. in dieseline formulation applied as a fog. A total of 1,900 gallons of D.D.T. formulation consisting of 1,720 lb. D.D.T. 50% wettable powder in water was applied in three applications at monthly intervals, to selected parts of the concentration area between Kasamba and Nyankuru, in all about 1½ square miles. The reduction in the fly round catches as compared with the same months of the previous year was around 83% but the method was found to be a difficult one to operate, and there appeared to be no prospects of cutting down the cost which was £45 per square mile per application for insecticides only; in fact, results suggested that the rate would have to be increased.

The trials with fog application of B.H.C. were made in the area around Mwana 111, spraying at various times between evening and morning along parallel tracks at 100-yard intervals. A total of 783 gallons of B.H.C. was applied in two applications over an area of about 2 square miles. Under the conditions prevailing, the best spraying time assessed visually was between 3 and 5 a.m. though at all times between 6 p.m. and 7 a.m. the blanket of fog drifted compactly, to well over the 100-yard intervals of the spraying traverses. Fly reduction immediately after fog application was 100% for the first application and 85% for the second. The flies caught after the second application, however, were on the edge of the spraying area and probably were migrants from outside foci. A commercial B.H.C. formulation and one prepared on the spot were used for the purpose of comparison in this trial. Preparation on the spot was found to be quite practicable, whereas difficulty was experienced with the commercial preparation due to sedimentation.

Comparative costs were: Commercial formulation £10 10*s.* per 45-gallon drum; Local preparation £7 13*s.* 3*d.* per 45-gallon drum. On the basis of the cheaper preparation the cost was approximately £33 10*s.* per square mile per application for the insecticidal solution only. Working on the basis of length of gestation period of a newly emerged female, at the average existing temperature, it was established that applications would be required at eighteen to twenty-day intervals. There was also evidence that the distance between spraying transects could safely be increased. On the basis of these trials, preparations were made for full-scale fog application in 1954.

(iii) 1954 Application

To ensure that complete coverage was obtained over the whole of the spraying area, it was necessary to mark out lanes along which the Land Rover could travel. These lanes were set at distances sufficiently far apart to enable consecutive fog swathes to overlap each other. To facilitate this, a base-line was first cut on a compass bearing to the north of the area, and Gray's Old Road (after some slight extension) was utilised to form a second. From these lines, the lanes were marked off, giving a swathe width of 150 yards and so orientated that they were at right angles to the direction of the prevailing wind. As it had been found during the trials of the previous year that the best meteorological conditions for a fogging were usually to be found during the hours of darkness, the time-table was so arranged that the fogging took place between sunset and sunrise. Whilst the spraying was in progress, a continual check was kept on the behaviour of the fog by the operator, and if necessary appropriate action was taken to " fill in " areas which might have been missed had the operation been carried out in a purely mechanical fashion.

Various natural features of topography were used to delimit the area which could be covered in any one night, and in each succeeding sortie an appreciable overlap over the previous night's fogging was allowed.

From the above remarks, it can be seen that continuity of application of insecticides was essential, and the fact that this was achieved was due to a large extent to the generous co-operation of two other Government Departments. The Director of Veterinary Services kindly loaned a second T.I.F.A. which was kept in reserve against the occurrence of any breakdown of the departmental machine, and which at times had to be brought into action. The Public Works Department Mechanical Branch gave invaluable aid, often at short notice and considerable inconvenience to themselves, in keeping both machines and vehicles in running order.

The first application was made from August 10th to 22nd with 2,135 gallons of insecticide over an area of about 19 square miles. About a quarter of the area was fogged at 150-yard intervals, and the rest under more favourable conditions at 300-yard intervals. Mechanical hold-ups and the fact that there was only one European available to operate the T.I.F.A. and conduct the fogging, lengthened the application period and restricted the area which could be covered. For the third, fourth and fifth applications, two European officers were available to conduct operations, and for the last two operations 25 square miles were covered.

Meteorological conditions varied to a considerable extent during the period of applications. The prevailing wind is East–South–East and at night this normally dropped to a light breeze or stopped completely, and was replaced by a downhill drift. It would appear that the intensity of this was dependent upon the intensity of the temperature inversion of the air, which in turn was affected by the rapidity of the drop in air temperature and the strength of the prevailing wind. Local topography also affected the case to a certain extent, and in some areas very good spraying conditions could always be relied upon, provided the wind was not strong enough to obviate any fog application at all.

The various conditions encountered are listed below.

	Fogging time hr. min.		Area covered sq. mls.	Petrol consumption		Gallons insecticide applied
				TIFA	Land Rover	
1st Application Aug. 10–22	47	35	18	110	39	2,135
2nd Application Aug. 31–Sept. 11	53	40	19	98	39	2,155
3rd Application Sept. 21–Oct. 2	57	55	23	120	58	2,445
4th Application Oct. 13–23	69	15	25	134	39	2,700
5th Application Nov. 2–9	69	35	25	128	44	2,700
Totals	298	0		590	219	12,135

Average area covered per application = 22 square miles.

A. Spraying Suspended

Wind speeds above eight to ten miles per hour (under the bush canopy) particularly if the wind direction is variable causing undue turbulence.

B. Intermediate

(Spraying transects usually made at 150-yard intervals)

(*a*) Conditions virtually still.

(*b*) Very strong air inversion resulting in rapid drainage of fog into dambos and watercourses. Where the spraying transects ran parallel to dambos, excellent cover was obtained under these conditions but in general the lay-out did not allow for this. With a good moon or by the light of dawn when it was possible to see the bank of fog as it drifted downhill, fog application was made independently of the marked transects where these did not run with the dambos. Intervals of 450 yards were sometimes quite adequate under these special circumstances to give full coverage.

C. Good

(Spraying intervals of 300 yards)

(*a*) Light breeze of about three to five miles per hour in the direction of the prevailing wind across the spraying lanes.

(*b*) General inversion drift towards the major drainage line of the Mulungushi Dam. This drift moved in practically the opposite direction to the prevailing wind, and therefore also at right angles to the marked transects.

(iv) Tsetse Catches during 1954 Insecticide Applications

During applications the totals of fly from regular fly rounds, about twenty extra inspections monthly and odd tsetse caught at the camps and along the roads were as follows:

Between 1st and 2nd Applications (21 days)	28 males,	8 females,	15 young.
Between 2nd and 3rd Applications (21 days)	3 males,	4 females,	7 young.
Between 3rd and 4th Applications (23 days)	7 males,	1 female,	4 young.
Between 4th and 5th Applications (20 days)	3 males,	no females,	no young.
Up to two months after 5th Application	Nil catch.		

From the end of the fifth application no flies were caught on the regular fly rounds until the January 25th, when two males were caught near Bwawawa. That is, the fly concentration areas had remained free as far as could be judged, for two months after the end of fogging operations. Odd flies continued to be picked up, however, outside the area sprayed and mainly along roads. It then remained to be seen whether this population was well enough established to survive the dry season in secondary habitats that have not so far held fly.

7. FLY ROUNDS AND MANNER OF ASSESSMENT

Regular fly rounds were instituted in June 1952, when eight routes were marked. Catching stations were set at approximately two hundred yard intervals except along part of the main Kalusenga Road, where they are further apart. One further round was marked out in March 1953 after it was found that fly was extending southwards. Eight fly rounds were visited four times a month following the method developed by the Department of Tsetse Research, Tanganyika Territory, the starting and ending points on each round being alternated. The Mankoya round was visited twice a month, and peripheral areas were covered by random inspection, while road inspections were also carried out regularly. The sum distance covered on the regular fly rounds alone was about 160 miles monthly. This routine work was carried out by a staff of four African Tsetse Control Guards who were stationed at Kalusenga. Returns for each round were entered on printed sheets, showing the number of flies caught at each station together with sex ratios, hunger stages and young flies. These figures were recorded on three graphs, to show monthly fluctuations in apparent fly density. Also histograms were drawn to facilitate a comparison of fly catches from different sectors of the rounds.

The first of the graphs illustrates the monthly fluctuation in fly catches from the eight rounds covering the main fly concentration area, with arrows to indicate the times to which control operations were being put into effect.

The second is a graph from the fly round which most nearly covered the Kyankuru–Bwawawa fly concentration area. The drop in August 1952 represents the normal seasonal decline in the Mulungushi area. Full-scale selective clearing in April 1953 resulted in a decline occurring much earlier than is normal and after this the population never really recovered. By July 1954, odd fly could still be caught in the area, though none were picked up by the regular fly rounds. Fog application followed from August to November, and no more tsetse were caught until 25th January 1955. These flies were the first to be caught within the whole spraying area after the termination of fog applications on 11th November 1954.

In a similar graph from a round covering part of the Kasamba–Nyankuru concentration area, the restricted selective clearing appears to have had little initial effect. Trials with a residual D.D.T. formulation accentuated the seasonal decline in August–October 1953 and extended it to November, but thereafter the tsetse population recovered very rapidly. Full-scale selective clearing in June 1954 was followed by an immediate drop in the fly catch and no further fly were caught in this area after the second insecticidal fog application early in September. A histogram was made up from parts of two fly rounds in the Kasamba–Nyankuru concentration area, most of it from the same data as the preceding graph, with numbers 1, 2, 3, 4 and 5 on the ordinates, each representing a sector of 2,000 yards with ten catching stations and No. 6 representing a sector of 600 yards with three catching stations. Sector No. 1 initially runs through *Chipya Brachystegia* ecotone. Sector 2 runs mainly alongside the Kasamba Dambo which was cleared in 1946. Sector 3 traverses almost unbroken *Brachystegia* woodland after leaving the Kasamba, whilst Sector 4 passes largely through *Isoberlinia globiflora–Mupani* woodland and the Kapani Dambos, and Sector 5 skirts or runs through *Chipya–Brachystegia* ecotone. Sector 6 also runs through this ecotone but alongside the Nyankuru Dambo. The correlation between high fly catches and proximity of the inter-woodland ecotone shows up very clearly .

8. EFFECT OF ROADS ON FLY CATCHES

The lay-out of some of the fly rounds made it possible to compare fly catches along the roads with the catches made in similar country within a quarter to three-quarters of a mile of the road. A transect of about 3,400 yards of fly round is compared with a similar length of road along which regular fly rounds were carried out. If anything, the area traversed in the bush was a somewhat more favourable fly habitat than that through which the road runs. It will be seen that during the rains and early dry season, catches were very similar on and off of the road. From May to October, however, the road catch is relatively very much higher:

Period	*Fly Catches* *Off Road*	*On Road*
June–October, 1952	70 males	174 males
	19 females	70 females
	9 young	28 young
Nov. 1952–April 1953	89 males	86 males
	29 females	13 females
	9 young	1 young
May–October 1953	18 males	40 males
	15 females	16 females
	3 young	3 young
Nov. 1953–April 1954	32 males	46 males
	8 females	22 females
	6 young	6 young
May–October 1954	5 males	20 males
	– females	5 females
	1 young	– young

It will be seen that as the tsetse population dropped with the implementation of control measures, the proportion of the road catch rose and therefore higher catch on the road in the dry season seems to go with more adverse conditions for fly. The reason, however, might possibly be attributed to a higher volume of traffic on the road, though in the 1952 dry season this could hardly be the case as another access road was opened and very little extra traffic passed over the old road.

9. MOVEMENT OF FLY TO SECONDARY HABITATS FOLLOWING BUSH CLEARING

Clearing

This occurred in a general way to the south only of the 1951 fly foci. The Mwana 111 focus built up as far as can be judged in 1952. Bush clearing here (and in other concentration areas later on) was followed by the appearance of tsetse in some numbers in areas that had previously yielded only the odd fly on inspection rounds. The fly moved mainly to places associated with regenerated dambo edge clearing which had reached ten feet or more in height and some very small uncut tributary dambos. As control operations (bush cutting and spraying) were instituted almost immediately, it was not possible to get any firm data as to the permanency of these secondary habitats.

10. SUMMARY OF OPERATIONS AND COSTS

(*a*) **Full-time Staff**

		£
1952	4 Tsetse Control Guards	156
	2 Fly Picket Orderlies	78
	3 Hunters	90
	3 Labourers	75
	Services of Entomologist, 4 Tsetse Control Guards, 1 Driver for 2 months	140
		539

1953	4 Tsetse Control Guards	216
	2 Fly Picket Orderlies	101
	2 Hunters	114
	2 Labourers	78
	Services of Entomologist, 4 Tsetse Control Guards, and 1 Driver for 4 months	410
		919
1954	4 Tsetse Control Guards	220
	2 Fly Picket Orderlies	108
	2 Hunters	120
	2 Labourers, full year	78
	6 Labourers, 6 months	117
	2 Tsetse Control Guards and 1 Driver for 6 months	120
	Services of Entomologist, Driver and 2 Tsetse Control Guards for 5 months	550
	Various European Officers, 2 months	170
		1,483
	Total for Staff, 1952–1954	£2,941

(*b*) **Labour**

Total labour employed on bush clearing	3,720 man-days
Total labour employed on road, track, camp and picket buildings and carriers	2,355 „ „
Total	6,075 „ „
Estimated Acreage of clearing	2,010 acres
Estimated Mileage of bush roads	65 miles
Estimated Mileage of blazed spraying lanes	260 „

Buildings

8 huts, 1 pole and mud plaster fly chamber and 4 temporary camps

Cost of Labour	£	s.	d.
Wages	396	11	3
Rations	206	8	0½
Total	£602	19	3½

Of the rations total, only £33 4*s*. 10*d*. was spent on meat, the rest of the protein ration being made up with game meat or fish.

Tsetse Control Guards were used as *capitaos* for the clearing, about four-fifths of which was carried out without direct European supervision.

(*c*) **1954 Fog Applications**	£	s.	d.
Dieseline: 270 drums	1,285	0	0
Insecticide: 30% gamma B.H.C. 90 × 40 lb. tins	825	10	0
	£2,220	10	0

Running Costs			
Petrol: Land Rover	115	0	0
T.I.F.A. and Land Rover Repairs and Maintenance Estimate	125	0	0
	£240	0	0

Transport

Insecticides and Solvents 20 × 280 mile trips by Bedford truck	63 0 0
Transport of Insecticides from base camp to application area	19 0 0
Repairs and Maintenance Estimated	25 0 0
Railway Transport cost B.H.C.	23 0 0
	£130 0 0
Total cost 1954 Application excluding Staff	£2,480 10 0

(*d*) **Summary of Costs, 1952–1954**

	£
Staff	2,941
Labour	603
Insecticide Trials, 1953 (Total cost including transport, etc.)	425
Insecticide Applications, 1954	2,481
Transport and General, not included in other items (including miscellaneous stores)	450
African Staff Uniforms	210
	£7,110
Estimated depreciation on equipment applicable to insecticide operations:	
Bedford 5-ton truck approx.	200
Land Rover	120
T.I.F.A. 350 hours	100
	£ 420
Grand Total 1952–1954 inclusive	£7,530

11. TSETSE FLY POSITION AND OPERATIONS SUBSEQUENT TO THE ABOVE

No tsetse were caught on fly rounds or inspections during November and December 1954. In 1955, a Tsetse Control Supervisor was appointed to Chisamba and the Mulungushi Scheme became part of his operating area. During 1955 the following catches were made:

	No. of Tsetse
(i) At the road picket	69
(ii) On fly rounds	26 (of which 15 were caught on road sections)
(iii) On inspection rounds	8 (5 on roads)
Total	103

Two small tsetse infestations in secondary habitats were revealed by these fly rounds, and discriminative clearings were made in the places indicated, i.e. a section of dambo edge on Mtoto 1, and an area of *Chipya–Brachystegia* ecotone close to the top of the Nyankuru dambo.

Fly catches in 1956 were as follows:

	No. of Tsetse
(i) Road picket	21
(ii) On fly rounds	3
(iii) On inspection rounds	20
Total	44

Of the twenty fly caught on inspections, ten were caught in the Nyankuru–Bwawawa area during April when this was covered intensively due to suspicions that a fly focus existed there. As a result of this it was decided to apply insecticides by T.I.F.A. to all remaining suspected concentration areas and this was carried out between September and November by the Tsetse Control Supervisor in charge of the area.

The fly round and inspection catches of 34 and 23 for 1955 and 1956 respectively were from annual totals of about 2,280 miles traversed by a catching party of two. These give the extraordinarily low Apparent Densities (catch per 10,000 yards) of 0·0847 and 0·0523 respectively and it should be noted that in 1956 the greater part of the catch was made on inspection rounds in which the catching party set out specifically to look for tsetse in suspected areas, as opposed to catching only those fly that came to them along a fixed route.

In view of exhaustive investigations, there can be no doubt that the above rounds cover the whole of the currently infested area, and therefore provide a reliable index of the fly population within the pocket.

12. OUTBREAK OF BOVINE TRYPANOSOMIASIS

Early in 1954, before the spraying programme started, bovine trypanosomiasis was diagnosed on the European farm nearest to the fly concentration. Failure to recognise the disease, and delay in calling in professional assistance—the Veterinary Department was not notified until the first beast had died—resulted in the disease spreading by mechanical transmission to other members of the herd. Previously, as the Mswishi resettlement scheme progressed, cattle had been introduced into the the resettlement area to aid the agricultural pursuits of the Africans, and though the expected odd case of trypanosomiasis had occurred, there had never been any cause for alarm.

This outbreak in European cattle was followed by a series of alarmist and misleading reports, which gave rise to groundless fears that the whole area was quickly reverting to tsetse infested bush. Although the fly confines were known, and in fact patrolled daily, a further large-scale survey of the cleared area was carried out as a precaution, but as expected, no fly were found. The origin of this outbreak of trypanosomiasis is a matter of conjecture, but some of the possible reasons are:

(*a*) Fly may have been carried out of the fly concentrations by fish traders illegally traversing the area, for although this malpractice had been reduced to a minimum by constant patrol, both by the Game and Tsetse Control Department, and the Provincial Administration, the possibility could not be ruled out.

(*b*) Cattle may have strayed into the fly area and returned to the " clean " side infected with trypanosomiasis, the disease than being carried on by mechanical transmission. On this score, evidence was obtained that the European cattle had left the unfenced farm and had grazed together with African stock; further, the spoor of cattle wandering through the fly concentration area had in fact been observed by the African staff employed there.

(*c*) The outbreak may have been the sudden flare-up of a **cryptic** infection of long standing.

(*d*) Fly may have escaped the road picket and been carried by ordinary traffic into the cattle area.

A Committee was appointed to investigate the reasons for the outbreak of trypanosomiasis but could not find any evidence that there had been any reinfestation of cleared land by the fly itself, and was only able to formulate a few recommendations to tighten up control of traffic and cattle movements.

A proposal that game elimination should be recommenced was also considered, but in view of the fact that continued destruction over a period of seven years had produced no significant results in the restricted concentration area, whilst two years discriminative clearing and the trial application of insecticides had resulted in a marked drop of some 80% in fly numbers, this course was decided against, and the spraying programme for 1954 continued without hindrance.

CONCLUSIONS AND SUMMARY

Though the Broken Hill–Mulungushi anti-tsetse campaign has not yet been brought to an absolutely successful conclusion, it is still possible to derive from it some valuable lessons which may be summarised as under:

1. Because of the urgency of the situation, the initial operation consisted of the application of methods of game destruction and bush clearing which had been proven elsewhere and these showed their worth by the initial success gained in the more marginal fly areas.

2. Eventually, however, their efficacity began to wane, for as far as discriminative clearing was concerned, it was based on visual inspection only, and this was not accurate enough to differentiate the more subtle variations of the vegetational complexes on which the fly was then depending, whilst the concurrently further reduction of the game population was becoming ever more difficult.

The eventual concentration of fly into those areas which are preeminently favourable to it, is a phenomenon which occurs time and again with the application to the general fly belt of a control measure. Once this has occurred it is necessary to reassess the resultant fly distribution, in order that appropriate control measures may be applied to meet the changing circumstances. Further, in the initial stages of any campaign, the fly population in the primary and more obvious foci tends to mask the distribution in the secondary habitats, and it is not until the former have been dealt with that the more obscure subsidiary concentration areas are revealed, and even then, only as the result of systematic investigation.

3. The failure of game destruction alone to produce total eradication after the initial successes was obviously due not to the breakdown of the theory motivating the method, but to the impracticability of carrying it out, for it appeared that the country in which the residual pocket was found provided an irresistible lure for game at certain seasons of the year, the influx being therefore sufficient to support the resident fly population indefinitely. In support of this statement, it can be seen from the preceding text that for a period of some five years, although an equivalent amount of game was being destroyed each year, the fly situation did not change significantly. This meant in effect that to produce this change it would have been necessary to eliminate not only the resident ungulates, but also any potential migrants—a task which involved the incorporation of a very much larger area within the sphere of operations.

Whilst the basic principles of game elimination as a method of tsetse control cannot be refuted, it would appear that, as with all other methods, there comes a time when the measure applied must be altered to accommodate changing circumstances if efficiency is to be maintained. Appreciation of these circumstances must therefore be an essential part of the conduct of any campaign, and this can only be built up on regularly accumulated data. Also, the methods employed must be sufficiently elastic to allow them to be altered to meet each changing phase, for blind adherence to a preconceived notion can at best only prolong the operation by hand.

4. The inadequacy of the present state of detailed knowledge of fly behaviour is also strikingly illustrated, for although the effect of any control measure can be gauged, the underlying reason for the change in distribution it causes, and the exact impact of the altered ecological conditions on the biology of the fly, remains a matter for conjecture.

For example, it has been noted that as the operation progressed the number of flies caught on roads and tracks, as compared with those found in the natural habitat, rose considerably and also that this was to some extent a seasonal phenomenon. Though many reasons can be submitted to account for this, they are mere hypotheses, and at present seem incapable of being proved.

5. Even now, when the fly population has been reduced to minute proportions, the only way to find out whether or not the community will continue to exist, is to " wait and see ", for the will to survive of the fly is strong and the threshold value of population density necessary for the continuance of the fly population is simply not known. Though it has been shown that it is possible to reduce a fly population very considerably at a reasonable cost by the use of insecticides applied from the ground, it is still uncertain how long it will take to effect total eradication. It must be emphasised also that conditions here were favourable for ground

application, for there was no likelihood of reinfestation from outside sources, and the terrain was reasonable for regular traverses. Given these two requisites, it is clearly possible to apply insecticides from the ground both in the appropriate place, and under optimum conditions—two factors which are often well beyond operational control in aerial application.

6. Any feeling of complacency is dispelled by the fact that a comparatively large-scale outbreak of bovine trypanosomiasis occurred at a time when the campaign was progressing satisfactorily, and in spite of daily checks in the fly area. It illustrates the point that, in dealing with a situation of such complexity and comprised of so many diverse mutable factors, there is an ever present danger of trypanosomiasis occurring, in spite of any action or regulation imposed to circumvent it, and notwithstanding the fact that the mathematical chances of infection occurring at the time of the outbreak may be smaller than at any previous time.

LATEST DEVELOPMENTS

Though total eradication was not achieved in 1957, the fly catch from fly rounds, inspections and pickets remained almost identical with that of 1956. The restricted application of residual insecticides using 3% Dieldrin emulsion applied by a " Micron " sprayer was attempted in areas Mtoto 1 and 2 and Nyankuru. Persistent investigation into the possibility of fly being introduced from the Luano Valley concentrations has now established that this is indeed the case, and a picket established to the east of the area is now accounting for an equivalent number of flies as were previously caught at the Mile 19 picket. It is considered that this is a new development but has occurred at such a time that it masked the full effect of the Mulungushi operations.

ON THE INCIDENCE OF TRYPANOSOMIASIS IN GAME

By M. A. DE ANDRADE SILVA and J. MARQUES DA SILVA

During the *G. morsitans* and *G. austeni* control operations we examined the blood of game killed for the purpose of finding data on the incidence of pathogenic trypanosomes in different species of the wild fauna.

Game control as an indirect method against *G. morsitans* takes place in two areas. In the Mutuáli area we started in 1947 but blood examination only commenced one year later. In 1949 in the Govuro area game control and blood examination were started simultaneously. Blood examination was carried out up to the end of 1957.

In the Sabiè area we used against *G. austeni* discriminative clearing and, whilst this was in progress, we had the opportunity of examining the blood of animals shot in the area. Blood examination was carried out from 1953 to 1957.

Native hunters were instructed on how to make blood smears. As soon as the animal had been shot, blood would be taken from the jugular vein or from another big vein. Naturally with dangerous animals there would be a delay before blood could be taken.

Owing to conditions under which the natives had to work and their inexperience, of course many of the blood slides were far from perfect. Many blood slides were not workable. E.g. in the Govuro area, up to the end of 1957, 55,312 animals were shot, blood was taken from 30,458 but only the blood slides of 16,567 were fit for examination.

Smears were stained with Giemsa. For each smear examined, a minimum of 300 fields were searched before the slide was considered to be negative.

To put things clearly, we intend to consider first the two *G. morsitans* areas, Govuro and Mutuáli, and afterwards the *G. austeni* Sabiè area.

I. AREAS OF GOVURO AND MUTUALI

It is necessary to explain that, before tsetse control operations were started, there existed some difference in these areas as to the predominance of certain species of animals.

Elephant, buffalo, eland, wildebeest and hartebeest were more common in the Govuro area whereas in the Mutuáli area roan and sable antelopes, zebra and impala predominated.

In Govuro klipspringer was absent and in Mutuáli oribi and nyala were non-existent.

Rhino only existed near Mutuáli and giraffe was absent from either area.

As for kudu, waterbuck, reedbuck, bushbuck, warthog, bushpig, baboon, monkeys (*Cercopithecus* spp.) the position was similar in both areas.

Before the game was disturbed we could distinguish between animals which preferred the plains and animals which preferred the forest. These habits, however, were changed and all species sought cover in the forest once they were hunted and animals usually to be seen in the plains afterwards only came out of the bush at night.

Some species practically disappeared. Such is the case of the wildebeest. Before they were disturbed they could be found regularly in their thousands gathered in big herds near and around salt-licks or salt-pans of the Govuro area. In the first two years 331 were shot but in the face of continuous hunting they migrated. The same goes for elephant, buffalo, eland and hartebeest.

It seems feasible to divide game into three groups according to their size. Necessarily such classification is artificial but for our purpose it facilitates matters.

Group A—Big game with a minimum of 100 kg. live weight: elephant, rhino, hippopotamus, buffalo, eland, wildebeest, hartebeest, tsesseby, roan and sable antelopes, kudu and waterbuck.

Group B—Medium-sized game with 30 to 100 kg. live weight: nyala, impala, bushbuck, reedbuck, warthog, bushpig, and so on.

Group C—Small game with up to 30 kg. live weight: Oribi (*Ourebia ourebi*), grey duiker (*Sylvicarpa grimmia*), steenbok (*Rhaphicerus campestris*), red duiker (*Cephalophus natalensis*) and suni (*Nesotragus livingstonianus*), and so on.

The tactics we use in game elimination are as follows: native hunters work in pairs and are given an area of about 30 square kilometres in which to hunt. The whole area is operated for three years after which they move to a further area, some hunters staying behind to chase small game or other animals which occasionally infiltrate.

At the end of the third year the only species which appear in groups are the baboons, monkeys and sometimes warthogs.

We found that the great decrease of *G. morsitans* takes place during the third year of operations.

* * *

In Tables I and II are summarised the results of the blood examinations.

We failed to find carriers of trypanosomes amongst the primates and the carnivora. In rhino, hippopotamus and two species of rodents' blood examination was always negative.

With the exception of the tsesseby we found trypanosomes in all ruminants present as well as in elephant and zebra.

In the Govuro area blood of zebra and impala was negative but only a small number of animals was examined. No trypanosomes were found in the elephant on this area.

In Mutuáli no hartebeest and sable were found to be infected.

On the whole we found that the incidence of trypanosomiasis in game was very low.

Table I—Trypanosomiasis of Game from the Govuro Area

Tableau I.—Trypanosomiase des Animaux Sauvages de la Région de Govuro

Species Espèces	Number examined	Number positive	Group *congolense*		Group *vivax*		Mixed infections (*congolense*+*vivax*)		Group *brucei*		Undetermined		Infection % per species. % infection par espèce
			Number positive	Percentage	Number positive	Percentage	Number positive	Percentage	Number positive	Percentage	Number positive	Percentage	
Loxodonta africana	23	0	—	—	—	—	—	—	—	—	—	—	0
Hippopotamus amphibius	7	0	—	—	—	—	—	—	—	—	—	—	0
Syncerus caffer	165	5	3	1·8	1	0·6	1	0·6	—	—	—	—	3
Taurotragus oryx	280	1	—	0·39	—	—	—	—	—	—	—	—	0·39
Equus burchellii	3	0	—	—	—	—	—	—	—	—	—	—	0
Gorgon taurinus	172	5	4	2·32	1	0·58	—	—	—	—	—	—	2·9
Hippotragus niger	231	4	1	0·43	3	1·29	—	—	—	—	—	—	1·7
Strepsicerus strepsicerus	521	12	8	1·53	4	0·77	—	—	—	—	—	—	2·3
Alcelaphus lichtensteini	325	4	2	0·6	2	0·6	—	—	—	—	—	—	1·2
Damaliscus lunatus	24	0	—	—	—	—	—	—	—	—	—	—	0
Kobus ellipsiprymnus	287	6	3	1	3	1	—	—	—	—	—	—	2
Tragelaphus angasii	1,416	22	6	0·4	16	1·1	—	—	—	—	—	—	1·5
Tragelaphus scriptus	770	25	5	0·64	16	2·07	2	0·25	2	0·25	—	—	3·2
Redunca arundinum	401	10	8	1·99	2	0·48	—	—	—	—	—	—	2·4
Aepyceros melampus	1	0	—	—	—	—	—	—	—	—	—	—	0
Ourebia ourebi	2,463	57	40	1·62	17	0·68	—	—	—	—	—	—	2·3
Raphicerus campestris	232	2	2	0·8	—	—	—	—	—	—	—	—	0·8
Sylvicapra grimmia	4,518	86	62	1·4	20	0·44	4	0·08	—	—	—	—	1·9
Cephalophus natalensis	216	1	1	0·46	—	—	—	—	—	—	—	—	0·46
Nesotragus livingstonianus	513	5	3	0·58	2	0·58	—	—	—	—	—	—	0·97
Phacochoerus aethopicus	1,143	11	6	0·5	—	—	—	—	—	—	5	0·4	0·9
Potamochoerus koiropotamus	418	2	2	0·48	—	—	—	—	—	—	—	—	0·48
Papio comatus	1,759	0	—	—	—	—	—	—	—	—	—	—	0
Cerocopithecus spp.	593	0	—	—	—	—	—	—	—	—	—	—	0
Galago spp.	2	0	—	—	—	—	—	—	—	—	—	—	0
Felis leo.	1	0	—	—	—	—	—	—	—	—	—	—	0
Felis pardus	12	0	—	—	—	—	—	—	—	—	—	—	0
Felis caffra	2	0	—	—	—	—	—	—	—	—	—	—	0
Leptailurus serval	2	0	—	—	—	—	—	—	—	—	—	—	0
Hyaena crocuta	1	0	—	—	—	—	—	—	—	—	—	—	0
Thos adustus	9	0	—	—	—	—	—	—	—	—	—	—	7
Civettictis civetta	14	0	—	—	—	—	—	—	—	—	—	—	0
Histrix africaeaustralis	5	0	—	—	—	—	—	—	—	—	—	—	0
Tryonomis swinderianus	38	0	—	—	—	—	—	—	—	—	—	—	
Total	16,567	258	157	—	87	—	7	—	2	—	5	—	—

Table II.—Trypanosomiasis of Game from the Mutuáli Area

Tableau II.—Trypanosomiase des Animaux Sauvages de la Région de Mutuáli

Species Espèces	Number examined	Number positive	Group *congolense*		Group *brucei*		Mixed infections (*congolense* + *brucei*)		Mixed infections (*vivax* + *brucei*)		Infection % per species. % infection par espèce
			Number positive	Percent-age	Number positive	Percent-age	Number positive	Percent-age	Number positive	Percent-age	
Loxodonta africana	64	1	1	1·5	—	—	—	—	—	—	1·5
Diceros bicornis	2	0	—	—	—	—	—	—	—	—	0
Hippopotamus amphibius	6	0	—	—	—	—	—	—	—	—	0
Syncerus caffer	67	1	1	1·47	—	—	—	—	—	—	1·47
Taurotragus oryx	53	1	1	1·84	—	—	—	—	—	—	1·84
Equus burchellii	60	1	1	1·66	—	—	—	—	—	—	1·66
Gorgon taurinus	14	1	1	7·1	—	—	—	—	—	—	7·1
Hippotragus niger	96	0	—	—	—	—	—	—	—	—	0
Hippotragus equinus	40	1	1	2·5	—	—	—	—	—	—	2·5
Strepsiceros strepsiceros	148	1	1	0·67	—	—	—	—	—	—	0·67
Alcelaphus lichtensteini	110	0	—	—	—	—	—	—	—	—	0
Kobus ellipsiprymnus	213	6	2	0·94	2	0·94	2	0·94	—	—	2·81
Tragelaphus scriptus	426	2	2	0·46	—	—	—	—	—	—	0·46
Redunca arundinum	73	4	3	4·11	—	—	—	—	1	1·36	5·47
Aepyceros melampus	175	5	5	2·85	—	—	—	—	—	—	2·85
Rhaphicerus campestris	1,627	6	5	0·3	—	—	—	—	1	0·06	0·36
Sylvicapra grimmia	1,589	6	4	0·25	1	0·06	1	0·06	—	—	0·37
Oreotragus oreotragus	19	1	1	5·2	—	—	—	—	—	—	5·2
Cephalophus natalensis	20	1	1	5	—	—	—	—	—	—	5
Phacochoerus aethiopicus	373	2	2	0·53	—	—	—	—	—	—	0·53
Potamochoerus koiropotamus	325	1	1 ?	0·3	—	—	—	—	—	—	0·3
Papio comatus	2,500	0	—	—	—	—	—	—	—	—	0
Cercopithecus spp.	649	0	—	—	—	—	—	—	—	—	0
Galago spp.	1	0	—	—	—	—	—	—	—	—	0
Felis leo.	1	0	—	—	—	—	—	—	—	—	0
Felis pardus	22	0	—	—	—	—	—	—	—	—	0
Leptailurus serval	5	0	—	—	—	—	—	—	—	—	0
Hyaena crocuta	4	0	—	—	—	—	—	—	—	—	0
Lycaon pictus	7	0	—	—	—	—	—	—	—	—	0
Thos adustus	26	0	—	—	—	—	—	—	—	—	0
Hystrix africaeaustralis.	4	0	—	—	—	—	—	—	—	—	
Total	8,779	41	32+1 ?	—	3	—	3	—	2	—	—

Table III.—Trypanosomiasis in Game According to Their Size **Trypanosomiases des animaux sauvages selon leur taille**

	Species	1949		1950		1951		1952		1953		1954		1955		1
		Number examined	Number positive	Number examined	Number positive	Number examined	Number positive	Number examined	Number positive	Number examined	Number positive	Number examined	Number positive	Number examined	Number positive	Number examined
GROUP A Big Game	Buffalo	29	1 (3·7%)	6	1 (16·6%)	72	2 (2·7%)	27	1 (3·7%)	8	—	1	—	—	—	—
	Eland	109	—	49	1 (2%)	56	—	34	—	8	—	1	—	11	—	4
	Wildebeest	140	5 (3·5%)	25	—	4	—	—	—	—	—	—	—	—	—	—
	Sable	43	—	40	1 (2·5%)	59	—	53	1 (1·8%)	10	—	22	2 (9%)	4	—	—
	Kudu	30	—	60	2 (3·3%)	163	3 (1·8%)	92	1 (1·08%)	31	5 (16·1%)	51	—	15	—	19
	Hartebeest	83	—	89	—	83	—	35	2 (5·7%)	5	1 (20%)	28	1 (3·8%)	2	—	—
	Waterbuck	70	1 (1·4%)	42	1 (2·3%)	82	1 (1·2%)	38	1 (2·8%)	10	2 (20%)	4	—	—	—	—
GROUP B Medium sized game	Nyala	159	—	204	3 (1·4%)	158	4 (2·5%)	226	5 (2·2%)	88	9 (10·2%)	49	—	1	—	108
	Reedbuck	70	5 (7·1%)	46	1 (2·3%)	78	1 (1·2%)	51	—	52	2 (1·9%)	40	1 (2·5%)	1	—	4
	Bushbuck	32	—	83	7 (8·4%)	69	3 (4·4%)	93	1 (1%)	65	6 (9·2%)	27	1 (3·7%)	8	—	107
	Wart-hog	178	—	132	4 (3%)	236	2 (0·8%)	161	2 (1·2%)	122	1 (0·8%)	78	1 (1·2%)	7	1 (14·2%)	54
	Bush-pig	28	—	20	—	35	—	28	—	43	—	35	—	2	—	48
GROUP C Small game	Oribi	312	2 (0·6%)	183	8 (4·3%)	395	9 (2·2%)	314	7 (2·2%)	329	14 (4·2%)	352	14 (3·9%)	95	2 (2·1%)	117
	Grey duiker	8	—	30	—	23	—	47	2 (4·2%)	35	—	30	—	5	—	14
	Steenbok	256	6 (2·3%)	399	13 (3·2%)	713	18 (2·5%)	659	3 (0·4%)	534	22 (4·1%)	362	8 (2·2%)	124	7 (5·6%)	424
	Red duiker	24	—	26	—	7	—	30	1 (3·3%)	9	—	6	—	3	—	34
	Suni	—	—	—	—	16	—	41	—	19	1 (5·2%)	29	1 (3·7%)	6	—	90

Table III.—Trypanosomiasis in Game According to Their Size **Trypanosomiases des animaux sauvages selon leur taille**

1950		1951		1952		1953		1954		1955		1956		1957		Total	
Number examined	Number positive	Number examined	Number positive	Number examined	Number positive	Number examined	Number positive	Number examined	Number positive	Number examined	Number positive	Number examined	Number positive	Number examined	Number positive	Number examined	Number positive
6	1 (16·6%)	72	2 (2·7%)	27	1 (3·7%)	8	—	1	—	—	—	—	—	22	—	165	5 (3%)
49	1 (2%)	56	—	34	—	8	—	1	—	11	—	4	—	8	—	280	1 (0·39%)
25	—	4	—	—	—	—	—	—	—	—	—	—	—	3	—	172	5 (2·9%)
40	1 (2·5%)	59	—	53	1 (1·8%)	10	—	22	2 (9%)	4	—	—	—	—	—	231	4 (1·7%)
60	2 (3·3%)	163	3 (1·8%)	92	1 (1·08%)	31	5 (16·1%)	51	—	15	—	19	—	60	1 (1·6%)	521	12 (2·3%)
89	—	83	—	35	2 (5·7%)	5	1 (20%)	28	1 (3·8%)	2	—	—	—	—	—	325	4 (1·2%)
42	1 (2·3%)	82	1 (1·2%)	38	1 (2·8%)	10	2 (20%)	4	—	—	—	—	—	41	—	287	6 (2%)
																1,981	37 (1·8%)
204	3 (1·4%)	158	4 (2·5%)	226	5 (2·2%)	88	9 (10·2%)	49	—	1	—	108	—	423	1 (0·2%)	1,416	22 (1·5%)
46	1 (2·3%)	78	1 (1·2%)	51	—	52	2 (1·9%)	40	1 (2·5%)	1	—	4	—	59	—	401	10 (2·4%)
83	7 (8·4%)	69	3 (4·4%)	93	1 (1%)	65	6 (9·2%)	27	1 (3·7%)	8	—	107	3 (2·8%)	286	4 (1·3%)	770	25 (3·2%)
132	4 (3%)	236	2 (0·8%)	161	2 (1·2%)	122	1 (0·8%)	78	1 (1·2%)	7	1 (14·2%)	54	—	175	1 (0·5%)	1,143	11 (0·9%)
20	—	35	—	28	—	43	—	35	—	2	—	48	1 (2·2%)	179	1 (0·5%)	418	2 (0·48%)
																4,148	70 (1·7%)
183	8 (4·3%)	395	9 (2·2%)	314	7 (2·2%)	329	14 (4·2%)	352	14 (3·9%)	95	2 (2·1%)	117	—	366	1 (0·2%)	2,463	57 (2·3%)
30	—	23	—	47	2 (4·2%)	35	—	30	—	5	—	14	—	40	—	232	2 (0·8%)
399	13 (3·2%)	713	18 (2·5%)	659	3 (0·4%)	534	22 (4·1%)	362	8 (2·2%)	124	7 (5·6%)	424	4 (0·9%)	1,047	5 (0·4%)	4,518	86 (1·9%)
26	—	7	—	30	1 (3·3%)	9	—	6	—	3	—	34	—	77	—	216	1 (0·46%)
—	—	16	—	41	—	19	1 (5·2%)	29	1 (3·7%)	6	—	90	1 (1·1%)	312	2 (0·6%)	513	5 (0·97%)
																7,942	151 (1·9%)

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Table IV.—Trypanosomiasis of Game from the Sabiè Area

Tableau IV.—Trypanosomiase des Animaux Sauvages de la Région de Sabiè

Species Espèces	Number examined	Number positive	Group *congolense*		Group *vivax*		Indetermined		Infection percentage per species. Pourcentage d'infection par espèce
			Number positive	Percentage	Number positive	Percentage	Number positive	Percentage	
Loxodonta africana . .	20	0	—	—	—	—	—	—	0
Gorgon taurinus . . .	1	0	—	—	—	—	—	—	0
Strepsiceros strepsiceros . .	8	0	—	—	—	—	—	—	0
Kobus ellipsiprymnus . .	1	0	—	—	—	—	—	—	0
Tragelaphus scriptus . .	6	0	—	—	—	—	—	—	0
Redunca arundinum . .	4	0	—	—	—	—	—	—	0
Raphicerus campestris . .	37	2	2	5·4	—	—	—	—	5·4
Sylvicapra grimmia . .	46	3	3	6·5	—	—	—	—	6·5
Cephalophus natalensis . .	13	0	—	—	—	—	—	—	0
Nesotragus livingstonianus .	370	22	17	5·9	4	1·08	1	0·27	5·9
Phacochoerus aethiopicus . .	2	0	—	—	—	—	—	—	0
Potomochoerus koiropotamus .	1	0	—	—	—	—	—	—	0
Cercopithecus sp. . . .	6	0	—	—	—	—	—	—	0
Otolemur crassicaudatus . .	7	0	—	—	—	—	—	—	0
Galago sp.	1	0	—	—	—	—	—	—	0
Felis caffra	2	0	—	—	—	—	—	—	0
Hystrix africaeaustralis . .	1	0	—	—	—	—	—	—	0
Lepus sp.	19	0	—	—	—	—	—	—	0
Thryonomis swinderianus .	5	0	—	—	—	—	—	—	0
Total	550	25	22	—	4	—	1	—	—

Facing p. 270

In the Govuro area bushbuck, buffalo, wildebeest, oribi and kudu were the most infected animals; oribi and bushbuck were more consistently infected.

We are shown by the results from Mutuáli area (Table II) that wildebeest, reedbuck, bushbuck, klipspringer, red duiker, impala and waterbuck were the most infected. We have to draw attention to the small number of wildebeest, klipspringer and red duiker examined. Reedbuck and bushbuck were the ones more consistently infected in this area.

With the exception of elephant, rhino, hippopotamus, zebra, roan antelope, klipspringer, carnivores and rodents the number of animals of each species examined exceeded 150. We are of the opinion that the blood examination of a few animals per species can lead to erroneous conclusions as we could attribute exaggerated importance to a certain species as reservoir of trypanosomes.

In both areas the trypanosomes most frequently encountered were of group *congolense*, then came the trypanosomes of group *vivax*. After that the mixed infections of *congolense* and *vivax*. Trypanosomes of group *brucei* isolated or in association with other trypanosomes were rarely identified.

Table III gives also particulars about the blood examination in the Govuro area. We tried to discover if there existed annual variation of the incidence of trypanosomiasis in the wild fauna. We can offer no proof on this point but we would like to mention that in 1953 the infection percentage was higher than in any other year.

We noticed from the same table that the global percentage of trypanosome infection was similar in the three game groups.

II. THE SABIE AREA

This area is poor in game. Elephants do pass there during their periodical migrations but do not stay long. There are kudu, waterbuck and bushbuck in small numbers. Warthog and bushpig are rare. More abundant are the suni, steenbok and grey and red duikers.

In this area blood examination was carried out from 1953 up to the end of 1957.

The game in this area being of small size we were able to collect blood from the heart and make smears from the heart, lung, liver and spleen. The most infected organ proved to be the heart, liver and lung following.

In Table IV data on blood examination of game in this area are given.

We only found trypanosomes in the grey duiker, suni and steenbok. The highest percentage was found in the grey duiker but suni was the species more consistently infected.

In the Sabiè area, covered with thick xerofitic forest, suni is the most prevalent animal and therefore is the species most available to *G. austeni*.

From the results obtained we deduce that *G. austeni* depends on suni and grey duiker for its food.

In this area also trypanosomes of group *congolense* were more frequently found than *vivax*. No infections of group *brucei* were found.

CONCLUSIONS

The microscopic examination of some thousands of smears enabled us to establish as carriers of pathogenic trypanosomes all ruminants present in two *G. morsitans* areas, as well as elephant and zebra.

We failed to find trypanosomes in primates, carnivora, rhino, hippopotamus and three species of rodents.

Incidence of Trypanosomiases found was low. We believe the actual incidence is higher and these finds were not those we expected. We hold the bad conditions under which the blood was taken to be responsible for the poor results. The natural high tolerance of most game towards trypanosome infections must make the course of these infections cryptic, even more so than in the bovines. This makes it difficult to make reliable observations for the purpose of establishing the exact part taken by game as reservoirs of trypanosomes.

Our results however show that small and medium-sized game are as important as big game in maintaining the pathogenic trypanosomes, especially those pathogenic to domestic animals.

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THE USE OF PHYTOCIDES TO CONTROL STUMP AND OTHER SECONDARY PLANT GROWTH IN AREAS CLEARED AGAINST *GLOSSINA AUSTENI*

By A. Esteves de Sousa, Ecologist

INTRODUCTION

Amongst the species of *Glossina* present in Mozambique the *G. austeni* has the most disconcerting behaviour. It thrives well either in the thickets, both deciduous or evergreen, of the coastal belt; in the savannah woodlands of the low country; in the dry deciduous forest of low and medium altitudes, in some very dry areas; and in some moist semi-deciduous forest of medium altitudes.[1]

Due to its habits the adult fly is not frequently seen even in areas where we find the insect to be quite abundant and its detection usually follows the appearance of some unexpected cases of nagana or the finding of *pupae* or pupal cases in potential breeding grounds during routine entomological prospections.

Being a potential carrier and spreader of animal trypanosomiasis, *G. austeni* is a latent or permanent danger threatening the development of cattle areas wherever its presence is suspected or found to be a fact.

In a previous paper (Esteves de Sousa, 1956) I have referred to its presence in a cattle area quite near Lourenço Marques where the control measures taken against this fly were " discriminate bush and forest clearing followed by the controlled burning of the dead vegetable material " (Dias, 1953). Due to the vastness of the area to be treated, stump pulling was not considered necessary because this operation would both greatly delay forest clearing and increase the costs more than tenfold.

However, leaving the cut-down stumps of felled trees and shrubs proved later to be an enormous drawback in the control because the stumps would not burn readily, and in many cases they would give rise to a stump regrowth which quickly formed a dense new canopy of bushy appearance permitting the tsetse fly to re-establish itself again in blocks which had already been found clean (Dias, 1953, Esteves de Sousa, 1953, 1955, unpublished reports).

It was then decided to try out my suggestion of experimenting chemical methods to deal with the troublesome secondary vegetation and some preliminary experiments were realised, on thorny bush thickets in a farm miles away from the areas under control (Esteves de Sousa, 1956).

The encouraging results obtained in those preliminary experiments—although with a different finality—(Esteves de Sousa, 1956) gave us the confidence to lay out the experiments described in the present paper.

However, before dealing with the actual experiments proper I must

[1] The nomenclature of types of vegetation used throughout in this paper is that proposed at the C.S.A. Specialist Meeting of Phytogeography, at Yangambi, 1956.

refer to some difficulties encountered which might have altered completely the results.

One of them was the choice of a suitable diluting medium. All the manufacturers of the products under trial mentioned diesel oil (or diesoline) and water as the recommended diluents. It was found to our regret that, under our conditions, the diesel oil used had a very high caustic effect over the foliage of most of the species present and as this effect was much quicker than that of the phytocide, it hindered and inhibited the absorption of the chemical used and, in the cases where water was tried, the drug was easily washed off the plants even by the night dews occurring frequently during the season.

The other difficulty was the volatility of the esters employed which, under our climatic conditions of light, temperature and moisture, are lost to a considerable extent into thin air.

My ideas of a good diluent is a sort of miscible oil or emulsion capable of reducing the volatility of the esters used (or the use of a much less volatile type of product) not easily washed off by rain or heavy dews, entirely innocuous to the foliage, spreading well and sticking long, i.e. a miscible oil or emulsion with a spreader and a sticker which I was unable to obtain.

Having to discard water and diesel oil whenever foliage spraying was to be done, some tests were made to compare the effects of diesoline, power paraffin, illuminating paraffin, a miscible oil and water as diluents, and it was found that the most caustic was diesoline followed by power paraffin. Illuminating paraffin only affected the most tender young shoots and leaves, therefore interfering little with the absorption of the drugs; the miscible oil was quite satisfactory but only a small sample was available, being by far insufficient to use in all the experiments. Illuminating paraffin was chosen as the general diluent, for the sprays over the foliage, and used in one series against water and miscible oil.

It may also be said that the volatility of the diluted phytocides depends, to a certain extent, on the type of diluent used and, in this respect, illuminating paraffin is quite satisfactory in keeping it down considerably.

Therefore, illuminating paraffin was taken as a general diluent, and diesel oil was used only in the treatment of stumps, against illuminating paraffin.

1. MATERIALS AND METHODS

The experiments were distributed over three series according to the finality we wished to attain, as follows:

(*a*) Treatment of stumps of recently felled trees, by drenching with phytocides.

(*b*) Treatment of the natural deciduous thickets, by spraying with phytocides.

(*c*) Treatment of secondary forest regrowth arising from stumps of felled trees of at least two years standing, by foliage spraying.

For these experiments the following drugs were available:

(1) **Geigy Brush Killer No. 22**—an American commercial compound herbicide containing 21·7% of the active equivalent of each of 2,4-Dichlorophenoxyacetic acid (2,4-D) and 2,4,5-Trichlorophenoxyacetic acid (2,4,5-T) under the form of their butyl esters.

(2) **"Diamond" herbicide**—also an American commercial plant killer, made by another manufacturer under licence from Geigy. This phytocide has exactly the same composition as that of **Geigy Brush Killer No. 22** and it was used in its place when we could acquire no more of the latter.

(3) **KOP 250** (ready for use)—a South African commercial product, containing the butyl ester of 2,4,5-T in a percentage representing 1·5% of the active acid equivalent.

(4) **KOP 250**—Solution concentrate—a commercial product, the same as above, with an active acid equivalent of 61·5%.

(5) **KOP specially prepared mixture**—a complex phytocide prepared specially for us by the Klipfontein Organic Products Corporation, of Elandsfontein, South Africa, containing the butyl esters of both 2,4-D and 2,4,5-T in amounts representing 26% of each of the active acid equivalents.

The application of the drugs was done by following closely the manufacturers' instructions for each different case and also bearing in mind our previous experiences (Esteves de Sousa, 1956). In each series of experiments several concentrations of each product were tried against each other but the lowest concentration used contained no less than 1·5% of active acid equivalent of the drug employed, which is generally accepted as being the lowest economical concentration giving efficient results.

Spraying was done with portable, one-man hand pumps of the constant high pressure type, using a very fine spray nozzle, ruby tipped. The spray was applied over the foliage and top branches until thoroughly wet and also over a good portion of the trunks from the ground upwards whenever possible.

Drenching of stumps was done by hand-made brushes prepared from the branches of a local species of *Vellozia* cut to shape and with the thickest end beaten to free the fibres. The freshly cut surface of the stumps and also a ring of the bark of at least six inches below the cut, were thoroughly wet (drenched) with the drugs until run off.

The areas where the experiments were laid were chosen after comparative ecological surveys of the most suitable and representative ones. In these surveys we had in mind to ensure the similarity of conditions in the plots to be treated in each series in regard to floristic composition and frequency of the species present, climatic, edaphic and biotic factors.

As a result of these surveys it was chosen for the " stump treatment " an area where the forest was of most homogeneous floristic composition with a high frequency of those species we had found to be more subject to " stump regrowth ". This area was included in a " fly-barrier " of some twenty odd kilometres long by one kilometre wide which was being completely cleared of forest and bushes. Plots were marked, measured and numbered (see sketch No. 1) and the stumps were treated as soon as possible after felling the trees, care being taken to drench each day all the stumps of plants felled the same day.

A similar procedure was followed for the other two series of experiments (see sketches Nos. 2 and 3) which were laid a few kilometres from the " fly-barrier " but well within the area under control, and well apart from each other.

In every case the quantity of diluted phytocide was registered for economical calculations.

The area of the experiments was regularly visited since after the treatments and observations were made at least at fortnightly intervals until the end.

2. THE EXPERIMENTS

2.1. First Series : Treatment of Tree Stumps Immediately After Felling

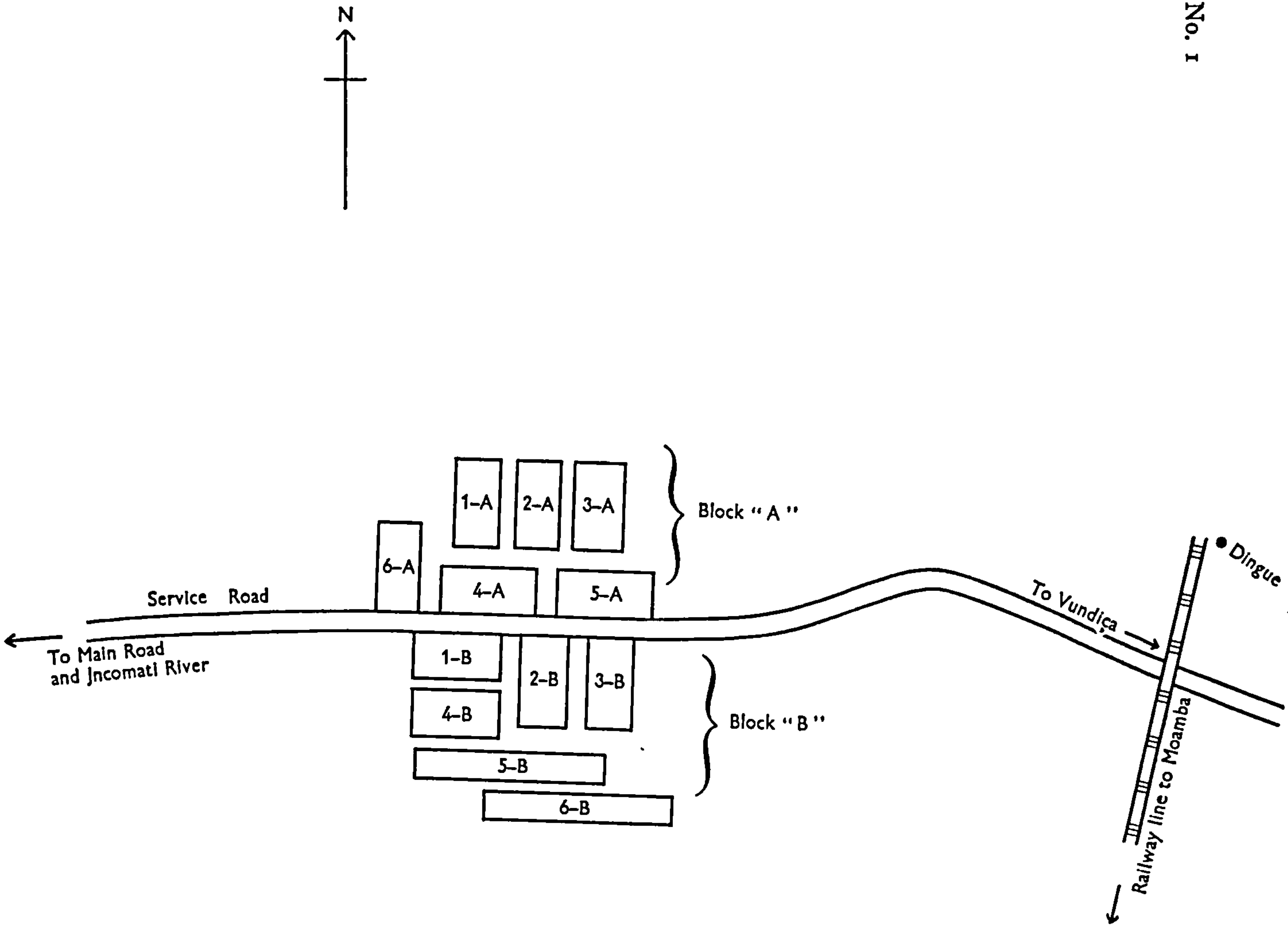
For this experiment an area was chosen where the forest was quite homogeneous and with a good representation, in numbers, of those species which had been found to regenerate themselves easily from the stumps (stump regrowth).

A sufficiently large block of dry deciduous forest was staked out in very large strip which was being cleared as a " fly-barrier ", in which the most frequently represented genus were: *Spyrostachys*, *Combretum*, *Piptadenia*, *Albizzia*, *Pteleopsis*, *Terminalia*, *Andradia*, *Strychnos*, *Dialium*, *Afzelia*, *Portulacaria*, *Eugenia*, *Oxyanthus*, *Commiphora*, *Xilotheca*, *Randia*, *Grewia*, *Strophanthus*, *Landolphia*, *Sansevieria*, *Carissa*, *Commelina* and *Hibiscus*.

Of these the species *Spyrostachys africana*, *Combretum kraussii* and *Combretum* sp. aff. *C. transvaalensis*, *Albizzia fastiagiata* and *Albizzia* spp., *Andradia arborea*, *Eugenia cordata*, *Piptadenia* sp. aff. *P. buchananii*, *Pteleopsis* sp. and *Portulacaria caffra*, sprout easily from the cut stumps giving rise to a new type of unwanted secondary forest regrowth in a very short time. Therefore, in staking out the plots where the stumps were to be treated care was taken to select the areas where those plants were present in highest number.

Twelve plots of approximately equal areas, 2,500 square metres constituting two groups of six plots each (Blocks A and B) (see sketch No. 1) were marked and staked out and in each the stumps were treated by

No. 1


N
Block "A"
1–A
2–A
3–A
4–A
5–A
6–A
Service Road
To Main Road
and Jncomati River
1–B
2–B
3–B
4–B
5–B
6–B
Block "B"
Dingue
To Vundiça
Railway line to Moamba

drenching immediately after the trees were being felled. Every stump was treated independently of the size or species.

The lay-out of this experiment was as follows:

Plot No.	Commercial name of phytocide	Active ingredients	Dilution used	% of each active acid equivalent	Date of treatment
Block " A "—Drugs diluted in illuminating paraffin.					
1-A	KOP 250	2,4,5-T	1 : 40	1·5	22.3.57
2-A	KOP 250	2,4,5-T	1 : 20	3·1	23.3.57
3-A	KOP 250	2,4,5-T	1 : 10	6·15	24.3.57
4-A	KOP special	2,4-D + 2,4,5-T	1 : 18	1·45	24.3.57
5-A	KOP special	2,4-D + 2,4,5-T	1 : 9	2·9	26.3.57
6-A	Geigy Brush Killer No. 22	2,4-D + 2,4,5-T	1 : 9	2·4	28.3.57
Block " B "—Drugs diluted in diesel oil (diesoline).					
1-B	KOP 250	2,4,5-T	1 : 40	1·5	23.3.57
2-B	KOP 250	2,4,5-T	1 : 20	3·1	24.3.57
3-B	KOP 250	2,4,5-T	1 : 10	6·15	25.3.57
4-B	KOP special	2,4-D + 2,4,5-T	1 : 18	1·45	25.3.57
5-B	KOP special	2,4-D + 2,4,5-T	1 : 9	2·9	27.3.57
6-B	G.B.K. No 22	2,4-D + 2,4,5-T	1 : 9	2·4	28.3.57

The treated stumps were well drenched in the top or cut surface and thoroughly wet in a band of bark, of at least six inches wide, all round the stump. Run off to the ground was not avoided nor deliberately practised.

2.1.1. Results

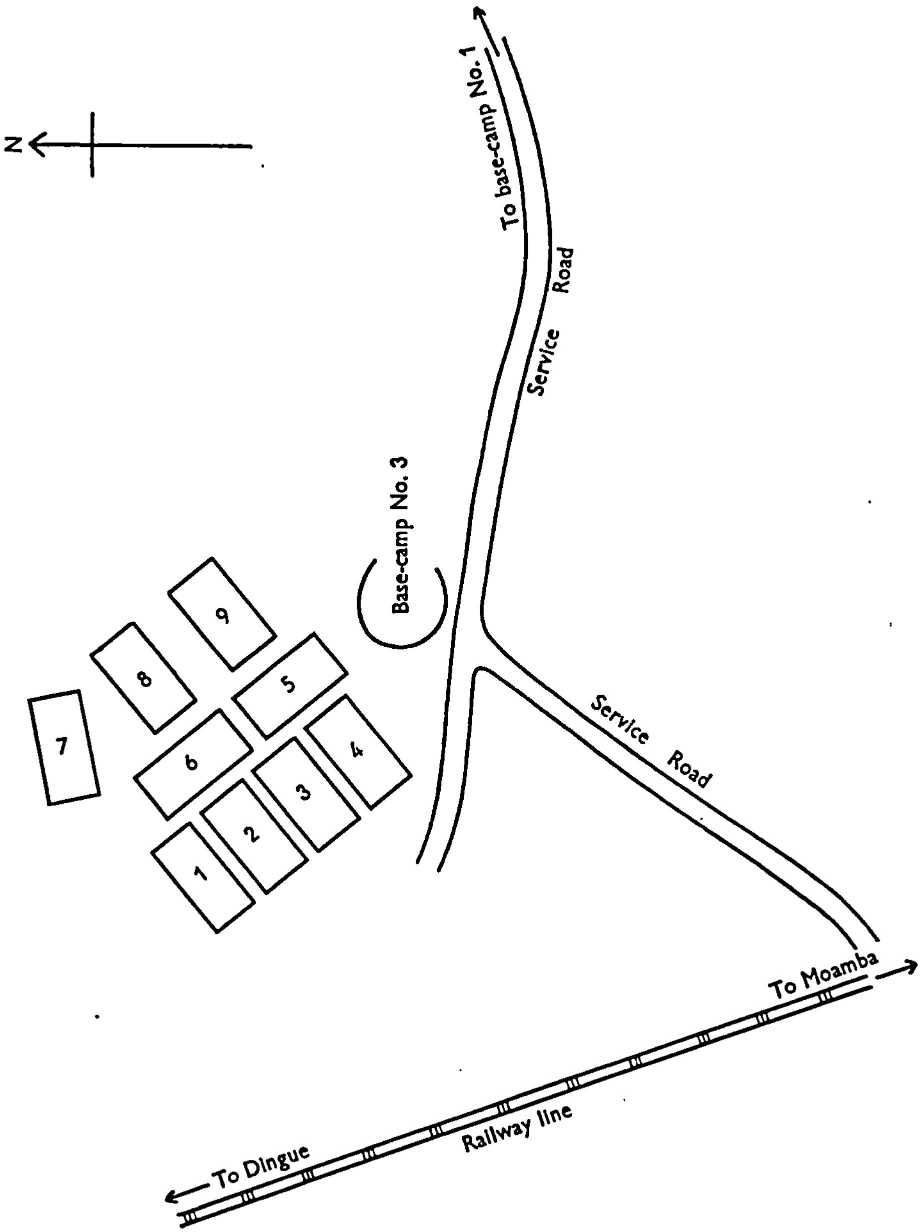
For the first three months after the treatments no new sprouting could be observed in any of the plots although in the surrounding untreated areas sprouting could be observed as soon as a fortnight and three weeks after cutting the trees.

In the plots treated with 2,4,5-T (KOP 250) diluted at 1 : 40—as recommended by the manufacturers, and independently of the diluent used—many stumps presented new basal growths from the fourth month onwards. Towards the middle of the activity season—December 1957 January, 1958—no great visible difference could be noticed between plots 1-A and 1-B and the surrounding untreated secondary regrowth unless for the fact that most of the latter was better developed and more exuberant. The last counts showed only 20% of dead stumps and of these we do not know how many died from other causes.

The stumps treated with 2,4,5-T (KOP 250) diluted at 1 : 20 and 1 : 10, independently of the diluent used (plots 2-A and 3-A, 2-B and 3-B), presented similar reactions and almost the same percentages of death stumps in January 1958.

The number of deaths varied from 36% to 43% with some species which were either little or not affected at all, by the drug. Amongst these

No. 2


N
To base-camp No. 1
Service Road
Base-camp No. 3
1
2
3
4
5
6
7
8
9
Service Road
To Moamba
Railway line
To Dingue

Spyrostachys africana, *Combretum kraussii*, *Eugenia cordata* and *Portulacaria caffra* were the most resistant.

On the other hand it may be mentioned that many herbaceous plants, some of them perennial grasses and phorbes which were accidentally wet when drenching the stumps, dried out and were killed by the action of the drug.

Stumps treated with the compound phytocides containing 2,4-D plus 2,4,5-T presented a better percentage of deaths and growth inhibitions than those mentioned formerly.

Plots numbers 4-A and 4-B (KOP special preparation, diluted at 1 : 18) presented respectively 52% and 59% of dead stumps by January 1958, which is already a very good percentage if the fact is considered that only one treatment was applied. Amongst the stumps which did not show any signs of sprouting or which were actually dead we found included some of the species most susceptible to sprout after cutting, such as *Portulacaria caffra*, *Eugenia cordata*, *Combretum* spp., *Spyrostachys africana* and others.

The plots which were treated with 2,4-D + 2,4,5-T mixed butyl esters (KOP special preparation and Diamond = Geigy Brush Killer No. 22) diluted at the rate of 1 part of phytocide into 9 parts of diluent, and irrespective of the diluent used (plots numbers 4-A and 6-A, 5-B and 6-B) gave us the best results for a single treatment. In the middle of January 1958, i.e. almost 10 months after the treatments, in the height of an exceptionally moist and warm season, 72% to 82% deaths and inhibitions to sprouting were registered.

The most significant results may be tabulated as follows (referred to the middle of January 1958) :

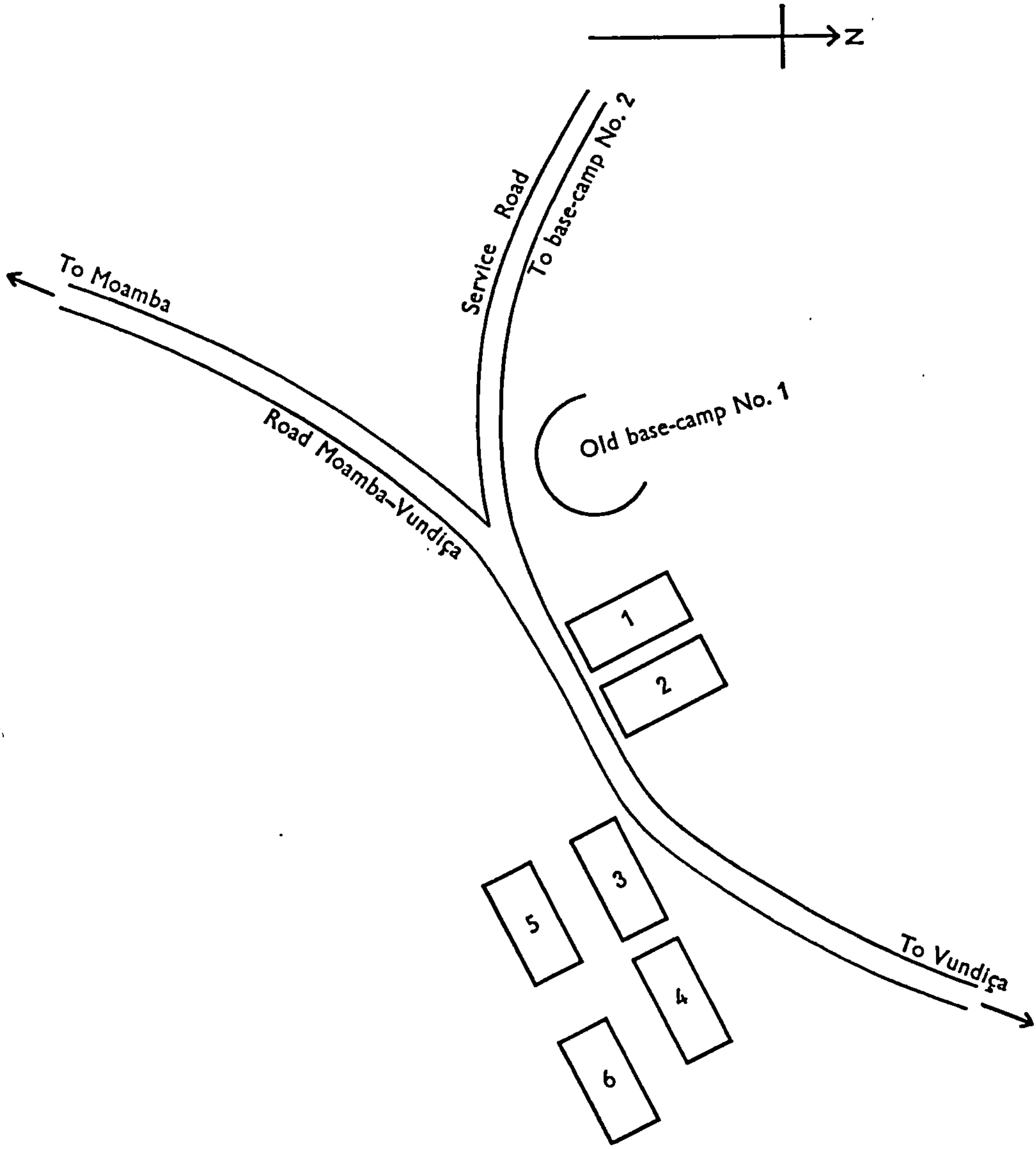
Plot No.	Active drugs	% of each active acid equivalent in the dilution	Diluent	% of kills and inhibition
4-A	2,4-D + 2,4,5-T	1·45	Illum. paraffin	52
4-B	Same	1·45	Diesel oil	59
5-A	Same	2·9	Illum. paraffin	72
5-B	Same	2·9	Diesel oil	80·5
6-A	Same	2·4	Illum. paraffin	82
6-B	Same	2·4	Diesel oil	74·5

2.2. Second Series : Spraying of the Natural Thickets

This experiment was laid near one of our old abandoned camps where the forest was open and the trees well scattered with a thick undergrowth of deciduous and semi-deciduous plants of about six feet high making a possible good cover for the *G. austeni*. (Sketch No. 2.)

The ecological survey of the area revealed as more abundant the presence of *Olea* sp. (aff. *Olea verrucosa*), *Grewia* sp., *Terminalia sericea*,

No. 3


Z
Service Road
To base-camp No. 2
To Moamba
Road Moamba–Vundiça
Old base-camp No. 1
1
2
3
4
5
6
To Vundiça

Spyrostachys africana, Dialium schlechteri, Albizzia spp., *Strychnos gerrardii, Strychnos spinosa, Combretum* spp., *Oncoba* sp., *Strophanthus* sp., *Acacia* spp., *Dichrostachys* sp., *Vangueria infausta, Randia* sp., *Oxyanthus* sp., *Abutilon* sp. and *Hibiscus* sp. with *Commelina* sp., *Sansevieria* sp., *Justicia* sp. and several scattered grasses in the lower stratum and *Landolphia* spp., *Uvaria* sp., *Dalechampia* sp. and *Tragia* sp. as the more frequently observed climbers.

Nine plots were staked and numbered, all with approximately the same area, 2,000 square metres. Sprays were applied to the foliage and trunks of the vegetation, taking care to treat all the shrubs.

The drugs used in this experiment were 2,4,5-T (KOP 250) and 2,4-D + 2,4,5-T mixed together (KOP special preparation and Diamond or Geigy Brush Killer No. 22) diluted in illuminating paraffin or in miscible oil and water in the proportion of 1 : 5.

The lay-out of this experiment was as follows:

Plot No.	Commercial name of phytocide	Active ingredients	Dilution used	Diluent	% of each active acid equivalent	Date of treatment
1	KOP 250	2,4,5-T	1 : 40	Ill. paraffin	1·5	1.4.57
2	KOP 250	2,4,5-T	1 : 40	Water + M. oil	1·5	1.4.57
3	KOP sp.	2,4-D + 2,4,5-T	1 : 17·5	Ill. paraffin	1·5	2.4.57
4	KOP sp.	as above	1 : 35	Ill. paraffin	0·75	3.4.57
5	KOP sp.	as above	1 : 35	Water + M. oil	0·75	3.4.47
6	Diamond	2,4-D + 2,4,5-T	1 : 29	Ill. paraffin	0·75	2.4.57
7	Diamond	as above	1 : 14·5	Water + M. oil	1·5	3.4.57
8	Geigy B.K. No. 22	as above	1 : 29	Water + M. oil	0·75	4.4.57
9	Geigy B.K. No. 22	as above	1 : 14·5	Ill. paraffin	1·5	4.4.57

It rained on the night of April 3rd, about six hours after spraying plots numbers 4, 5 and 7. These plots were for that reason affected by the rain washing off at least part of the drugs mainly in those plots which were sprayed with phytocides diluted in water plus miscible oil.

Observations were taken regularly at intervals which never exceeded a fortnight, and as the treatments were directed against the shrubby woody vegetation only this was considered in the results.

2.2.1. Results

The first symptoms of intoxication were noticed fifteen days after spraying when leaves began to wither and to change the normal shades of green to a yellowish-green hue.

Until the end of the third week almost the same symptoms could be observed in all the plots with this significant difference: in plots numbers 1 and 2 (sprayed with 2,4,5-T) there was a certain percentage of plants which seemed not to be affected at all whilst in the remaining 7 plots (sprayed with 2,4-D + 2,4,5-T) practically all the plants were affected although it could be noticed that some of them reacted more than the others.

Differences of reaction meaning different effects of the drugs over the vegetation were patent only after the fifth week after spraying.

Through regular observation it was noticed that some plants which were heavily affected, recovered sufficiently and were sprouting and covered with new shoots and leaves by the middle of January 1958. In many others the drugs affected only certain branches and portions which died within a couple of months after spraying and the more susceptible species were killed outright within seven to ten weeks after spraying.

In the plots numbers 1 and 2, which were treated with 2,4,5-T diluted at 1 : 40 as recommended by the manufacturers, diluted respectively in illuminating paraffin and in water plus miscible oil, the percentage of deaths in the middle of January 1958 can be tabulated as follows:

Plot No.	Active ingredient	Solvent	% of total active acid equivalent	Percentage of deaths		
				Verified	Possible +	Possible Total
1	2,4,5-T	Paraffin (1)	1·5	47%	5%	52%
2	2,4,5-T	W + o (2)	1·5	35%	5%	40%

(1) Illuminating paraffin. (2) Water + miscible oil mixed at 5 : 1.

The differences in the percentage of kills may be attributed to a certain extent to the fact of the rain which fell two days after spraying having washed off some of the drug. In this case the ingredient diluted in water would wash off more easily than that diluted in paraffin. However, another reason of greater importance was the presence in the second plot of a higher percentage of plants less susceptible to this drug, such as *Combretum* sp., *Portulacaria caffra*, *Spyrostachys africana*, *Olea* sp. and *Dialium* sp. Incidentally it may be stated that most of the herbaceous plants sprayed were also killed.

The plots which were sprayed with the compound phytocide 2,4-D + 2,4,5-T diluted to contain a percentage of 0·75 of each of the active acid equivalents (or a total of 1·5% if both are considered) presented very interesting results because almost all the vegetation was affected showing undoubted signs of intoxication although many of the affected plants recovered completely towards the rainy season which is also that of highest plant activity. The results obtained, as observed in the middle of January 1958, may be tabulated as follows:

Plot No.	Active ingredient	Solvent	% of total active acid equivalent		Percentage of deaths		
			Of each acid	Total	Verified	Possible +	Possible total
4	2,4,-D + 2,4,5-T	Paraffin (1)	·75	1·5	43	5	48
5	Same	W + O (2)	·75	1·5	40	5	45
6	Same	Paraffin (1)	·75	1·5	54	5	59
8	Same	W + O (2)	·75	1·5	51	5	56

(1) Illuminating paraffin. (2) Water plus miscible oil mixed at 5 : 1.

Bearing in mind that the experiment was conducted under field conditions and that plots numbers 3 and 5 were affected by light rain soon after being sprayed—which may account for the lower percentage of kills—the results are satisfactorily similar.

Although the percentage of deaths was not very high, the fact remains that many plants which were not or were little affected by 2,4,5-T alone (plots numbers 1 and 2), were now affected by the mixture of 2,4,5-T and 2,4-D.

The plots sprayed with the compound phytocides 2,4-D + 2,4,5-T diluted to contain a percentage of 1·5 of each of the active acid equivalents (or a total of 3·0% if both are considered and added) presented the best results of this series. As observed in the middle of January these results may be tabulated as follows:

Plot No.	Active ingredients	Solvent	% of total active acid equivalent		Percentage of deaths		
			Of each acid	Total	Verified	Possible +	Possible total
3	2,4-D + 2,4,5-T	Paraffin (1)	1·5	3·0	79	3	82
7	Same	W + O (2)	1·5	3·0	66	5	71
9	Same	Paraffin (1)	1·5	3·0	82	3	85

(1) Illuminating paraffin. (2) Water plus miscible oil mixed at the rate of 5 : 1.

Plot number 7 suffered the effects of a light shower of rain a few hours after being sprayed and that may account for the lower percentage of deaths. The same rain also affected plot number 3 but this had been sprayed more than thirty hours before, and therefore could not be affected so much as a good dose of the drug should have already been absorbed. Also the drug being diluted in paraffin it is considerably less susceptible to be washed off by rain.

Independently of the solvents and of the commercial brands used (the esters being the same—butyl) these results are considered exceedingly good, consistent and, to a certain extent, unexpected.

2.3. Third Series : Spraying of Secondary Forest Regrowth Arising from Stumps of Previously Felled Trees

The experiment was laid down near another of our abandoned base camps where forest clearing operations had been carried out at least three years previously. (See sketch No. 3.)

Discriminate clearing had changed the original dry deciduous forest into a open woodland forest with grasses, after controlled burning of the dead vegetable materials.

However, the sprouting of many stumps of several species gave rise to a secondary type of bushy thicket, quite dense and in some cases tall, which had to be cut down again and again to keep the area clean and to prevent the re-establishment of *Glossina austeni.*

In the area chosen to lay out the experiment the secondary vegetation had already been cut down twice but the new stump regrowth was again about three to four feet high.

The following species were registered as sprouting freely from the cut-down stumps: *Spyrostachys africana*, *Combretum* sp. (aff. *C. kraussii*), *Combretum* sp., *Olea* sp. (aff. *O. verrucosa*), *Portulacaria caffra*, *Albizzia* spp., *Dialium schlechteri* and *Pteleopsis* sp.

Besides the above-mentioned species it was also registered the presence of species of the following genera:

Piptadenia, Quisqualis, Terminalia, Andradia, Entandophragma, Afzelia, Balanites, Euphorbia, Kirkia, Commiphora, Randia, Eugenia, Oxyanthus, Schotia, Peltophorum, Bridelia, Grewia, Strophanthus, Carissa, Landolphia, Hibiscus, Abutilon, Sansevieria, Commelina and several grasses and weeds.

Six plots with an individual area of about 2,000 square metres were staked in the above-mentioned area, taking the precaution of staking them where the floristic composition was as similar as possible.

Sprays were applied over all the foliage and trunks of all stump regrowth and new shrubs, in the same manner as described in the previous experiment.

The phytocides used in this experiment were 2,4,5-T (KOP 250) and a mixture of 2,4-D + 2,4,5-T (KOP special preparation and Diamond and/or Geigy Brush Killer No. 22) diluted in illuminating paraffin to obtain certain percentages of the active acid equivalents.

The lay-out of this series was as follows:

Plot No.	Commercial name of phytocide	Active Ingredients	Dilution used	% of each active acid equivalent	Date of treatment
1	KOP 250	2,4,5-T	1 : 40	1·5	1.4.57
2	Same	Same	1 : 20	3·0	1.4.57
3	KOP special	2,4-D + 2,4,5-T	1 : 35	0·75	1.4.57
4	Same	Same	1 : 17·5	1·5	2.4.57
5	Diamond or Geigy B.K. No. 22	2,4-D + 2,4,5-T	1 : 29	0·75	2.4.57
6	Same	Same	1 : 14·5	1·5	2.4.57

N.B. The diluent used was illuminating paraffin.

Observations and notes were made at regular intervals never exceeding one fortnight.

2.3.1. Results.

The results obtained, as referred to the middle of January, i.e. about the height of plant activity season, were very similar to those obtained in the previously described series, only in this case the percentages of deaths or total inhibitions to new growths was slightly lower than in the former.

From the beginning it could be noticed that in the plots treated with 2,4,5-T (plots numbers 1 and 2) many plants did not seem to be affected by the phytocide or if affected at all they soon recovered. Amongst those less affected *Portulacaria*, *Dialium*, *Combretum*, *Spyrostachys*, *Olea* and one *Albizzia*, were outstanding.

In these two plots no sensible differences could be observed meaning that the stronger solution was not responsible for a proportionally higher percentage of kills or inhibitions to sprout.

In the plots sprayed with a compound phytocide containing 2,4-D and 2,4,5-T (KOP special preparation and Diamond or Geigy Brush Killer No. 22) practically every plant sprayed presented at one time symptoms of intoxication even if some of them recovered later.

No doubt that there was a difference in the action of the phytocides used which may be attributed to the degree of dilution.

The results obtained can be tabulated as follows:

Plot No.	Active ingredients	Percentage of active acid equivalent		Percentage of deaths and inhibitions		
		Of each acid	Total	Verified	Possible +	Possible total
1	2,4,5-T	1·5	1·5	32	5	37
2	Same	3·0	3·0	35	5	40
3	2,4-D + 2,4,5-T	0·75	1·5	48	5	53
4	Same	1·5	3·0	73	5	78
5	Same	0·75	1·5	47	5	52
6	Same	1·5	3·0	72	5	77

3. ECONOMICS

Before discussing the results and drawing the conclusions it was considered to be of some worth to give an idea of the possible costs of the treatments in our field conditions.

It is realised that the cost of each kind of treatment per surface-unit —the hectare = 10,000 sq. metres, in our case—may vary considerably with the type and density of the vegetation to be treated, with the efficiency of the labour used, with the way the drugs are applied and with the distances to be covered by transport, supplies and workers. However, the figures calculated herein will give a reasonable idea of the expenses to be incurred and may help in comparing with the costs of maintaining previously cleared areas which have to be kept clean by regular hand-cutting of the new vegetation every year or every other year.

In calculating the costs per surface-unit only those dilutions giving the best results were considered and the following items, although the values are still subject to revision:

(*a*) Cost of native labour at the current local rates of 11·15 escudos per man-day: 5 man-days necessary to treat one surface-unit of stumps; 7 man-days necessary for one surface-unit of foliage spraying, including preparation of drugs.

(*b*) Cost of European supervising work at the current local rates of 155·00 per man-day: one-eighth of a day necessary for one surface-unit.

(*c*) Cost of drugs employed per surface-unit at local market retail prices of 309·00 per gallon of Diamond or Geigy Brush Killer No. 22 and approximately 33·500 per gallon KOP special (verbal information as the drug was kindly made at our request). 2½ gallons were necessary to treat one surface-unit in either case, for stump treatment and 2½ gallons of KOP special or 3 gallons of Diamond (or Geigy B.K. No. 22) per surface-unit of foliage-spraying.

(*d*) Cost of diluents at the retail price per drum of 339·55 for 44 gallons of diesel oil and 397·60 for 45 gallons of illuminating paraffin. 22½ gallons of either were found necessary to treat one surface-unit of stumps and 42-45 gallons of paraffin to foliage-spray an equal area.

(*e*) Cost of transport of drugs and diluents to the local of application, at the rate of 60·00 per ton for railage plus 6·50 per ton for lorries.

(*f*) Cost and devaluation of pumps and implements used: original cost of each pump 1,929·00; replacement valves 3·50; replacement nozzles 195·60 3 pumps used per surface-unit working about thirty hours altogether.

(*g*) Cost of transportation of labourers, materials and implements from base camps to local of operations about 35·00 per day. Only one-fifth is considered per surface-unit in our calculations and this would be still considerably reduced in large-scale operations.

(*h*) Detergents, supply of water and other hygienic necessities: about 7·50 per surface-unit.

Treatments	Native labour	European super-vision	Drugs	Diluents	Transport of drugs and diluents	Cost and devaluation of machinery	Transport of labourers and material from camps	Hygienic necessities	Total per surface unit (Ha)
(KOP sp. Stumps)	55·75	19·30	837·50	169·78	6·70	—	7·00	7·50	1,103·53
(Diamond	55·75	19·30	772·50	198·80	6·70	—	7·00	7·50	1,067·55
(KOP sp. Foliage)	78·05	19·30	837·50	397·60	13·50	28·20	7·00	7·50	1,388·65
(Diamond	78·05	19·30	927·00	397·60	13·50	28·20	7·00	7·50	1,478·15

Note: Values are given in **escudos**, the present rate of exchange being about 80 escudos to the £.

4. SUMMARY AND CONCLUSIONS

A large area adjacent to a cattle-raising district has become infested with *Glossina austeni*, the spreading of which made it imperative to take control measures to cope with the menace. (Silva, 1950.)

Due to the peculiar local conditions and to the versatility of the *Glossina austeni* it was decided to attack the fly by discriminate thicket and forest clearing followed by controlled burning. These measures gave really good results and large areas were cleaned. (Silva, 1952, 1954.)

However some of the more fequent species of the original forest are very susceptible to regeneration from the cut stumps, giving rise to a new type of secondary forest regrowth in which this tsetse fly can very easily establish itself again. In fact some blocks became re-infested two or three years after having been found free of fly. (Dias, 1954; Esteves de Sousa, 1954, unpublished reports.)

This state of affairs forced us to cut down this secondary vegetation time and again to keep open and cleared the areas most susceptible to re-infestation. Stump burning has been found impractical and the firing of the mounded up dry cutting remains is ineffective in keeping down regeneration of these regrowths from stumps, at least for long.

Several measures were tried and amongst them some experiments with phytocides. This paper deals with the last experiments based on previous work on the same lines. From the results obtained the following conclusions can be drawn:

(1) The plants to be attacked belong to more than one hormonal group. Therefore the phytocides to be employed must contain active inhibitors belonging to at least two different and opposed hormonal groups such as, for instance, *auxin-type* and *antiauxin-type* (Resende, 1949; Esteves de Sousa, 1950, 1056; Mitchell and Brown, 1946 and Tam, 1947).

(2) In our climatic conditions preference should be given to the less volatile esters of 2,4-D and 2,4,5-T. (It was tried out without avail to obtain a compound phytocide made in a concentrated solution form of the butoxy-polyetoxy-propanol esters of 2,4-D and 2,4,5-T the trial of which or of something similar should be done.)

(3) In our field conditions care should be taken in selecting the solvents to use to spray the foliage. Diesel oil has a very pronounced caustic effect over most of the species present. As this effect develops very fast the drugs are not absorbed in lethal quantities. Water alone cannot be used because it washes off very easily from the foliage. Illuminating paraffin seems to be a satisfactory answer. Diesel oil is quite satisfactory to use in the treatment of stumps, although the plots where paraffin was used seemed to yield a slightly higher percentage of deaths.

(4) When dealing with natural bushy thickets of considerable size it is advisable to start with the cutting of the vegetation, as it is quite difficult

to spray the foliage properly and excessive quantities of phytocides will be needed for an efficient coverage. Spraying should follow when the plants are active again, that is, mostly from the beginning to the middle of the rainy season.

(5) Stump treatment should be done as soon as possible and within twenty-four hours after felling the trees. Concentrations of the active ingredients should be considerably higher than those used for foliage-spraying. Dilutions containing less than 2·4% of each of the active acid equivalents present did not give economically good results, but concentrations containing much more than 3% of the active acid equivalents of each acid present did not give proportionate results.

(6) To ensure the treatment of every stump (or every cluster of plants) it is advisable to add some contrasting chemically neutral, bright colouring matter, to the phytocide solution used so that every treated plant or stump will be marked.

(7) A second spraying towards the end of the rainy season (or during the next plant activity season, for stumps cut during the dormant season) is advisable to ensure better results.

(8) Controlled burning should be practised after the treatments and when good masses of plants are dead and dry.

(9) The cost of the treatments compare favourably with that of hand-cutting. Even if that was not the case, the fact that a high percentage of plants are killed by the compound phytocides as used which otherwise would give rise to a dense secondary regrowth, should be enough to recommend stump treatment in the areas to be cleared. The increased expense would save a lot of trouble and higher expenses later on.

ACKNOWLEDGMENTS

Thanks are due to Messrs. Klipfontein Organic Products Corporation, of South Africa, for the generous samples of their products and also for the preparation without charge of a special concentrated phytocide containing 2,4-D and 2,4,5-T mixed together in equal proportions of the active equivalents.

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CHINGOLA TSETSE CONTROL SCHEME

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1. INTRODUCTION

The Tsetse Survey of the Copperbelt region of Northern Rhodesia was carried out in a series of tours in 1952 and coincided with surveys made by other technical departments to provide the basis of the Regional Land Usage Plan for that area.

Up to this time, virtually nothing was known of the tsetse distribution on the Copperbelt since the official policy had been at least not to encourage full-scale farming there, and livestock was almost non-existent; there was also no history of human trypanosomiasis in the area.

Despite lack of encouragement there were, however, some dairy farms on the Copperbelt, and requests for aid in coping with tsetse fly were coming from the Chingola District. Consequently, the survey of the Western Province was commenced in this region and a pocket was discovered in which tsetse fly was firmly established over an area of about eighty square miles lying west of Chingola associated with the Kamita and Mimbula Dambos and the Pafu and Lungu streams, situated between the Kafue River and the Chingola-Solwezi road. An area very much larger than eighty square miles was affected by the presence of this tsetse pocket through which a great deal of traffic passed, resulting in the fly being carried far and wide from the source of infestation. Occasional tsetse were picked up within a minimum area of five hundred and thirty square miles but the true area influenced was, without doubt, of considerably larger dimensions. The absence of livestock, a very sensitive indicator, in most of the surrounding country makes this impossible to assess, but it is of interest to note that in Zululand, where the country surrounding two fly pockets had been developed for ranching and farming, a total area of two hundred square miles of tsetse infestation was adversely affecting the surrounding seventy thousand square miles (Du Toit). Within the fly pocket, the main concentration was found to be associated with the Kamita Dambo while subsidiary foci occurred on the Lungu and to a lesser extent, the Pafu. Besides this, the results of the survey rounds suggested that some of the roads through the area were providing artificial feeding grounds for the fly, since unexpected numbers could be caught along them particularly where they approached fairly close to the Kamita Dambo and the Lungu stream.

In the preliminary survey, a hundred and fifteen fly rounds were conducted in Chingola District; typical of rounds within the tsetse concentration area were the following:

No. 28. From Page's road westwards, across the upper Kamita Dambo to the Pafu and return one mile to the south. This largely traversed woodland, and caught six males and four females.

No. 29. From Lambertsen's farm upstream along the Pafu for five miles, then east and return down the Kamita. Catch : fifteen males, eight females and one young female, mainly along the Kamita.

No. 32. From Lambertsen's farm south along the Kamita and continued southwards to the Solwezi road. The catch was nineteen males and four females, all along the edge of the Kamita.

No. 30. A round along the road from Page's to where it meets Lambertsen's road, along this road to the latter's farm, then east to Page's by-path. Catch : fifteen males, eight females and one young female. The catch was evenly spaced along the full length of this round in spite of the fact that large parts of it passed through homogeneous woodland away from dambos. This is considered to be due to the artificial concentration effect of traffic along roads and paths.

A total of eleven tsetse were caught outside what was indicated to be the resident fly concentration area, and of these only two were caught off roads or paths, though in both cases, close to such.

On the basis of the survey findings, a scheme for the eradication of the pocket was proposed, based, in the first instance, upon the use of discriminative clearing, to be followed up, if required, by the use of insecticides.

At the outset, early in 1953, an area including the full extent of the tsetse infestation was declared a Tsetse Fly Area, and entry or exit confined to three roads across which provision was made for the establishment of fly pickets as a measure to control the carriage of fly on to the nearby farms.

These roads allowed access to the land holders within the tsetse area and all other roads and paths were closed.

The eradication scheme was approved on an estimate of £18,025 spread over four years, to be financed out of Colonial Development and Welfare funds; authority to proceed was received in May 1953, and as the European Tsetse Control Supervisor for the scheme had already been recruited, and had in fact spent the previous four months getting acquainted with the area, and blazing fly rounds, operations commenced immediately.

His first tasks were:

(*a*) To recruit labour and extra African technical staff.

(*b*) Build quarters of a reasonable standard (Kimberly brick and thatch) for himself and also provide accommodation for African staff at various points including the pickets.

(*c*) Institute regular patrolling of fly rounds covering the whole of the infested area on the results of which the discriminative clearing could be planned, and the effects of the control measures assessed.

(*d*) Make access roads where required.

2. GAME ANIMALS

Game animals were not plentiful in the area, though more numerous than the proximity to Chingola Township might lead one to expect. The main species present were bushpig, baboon, duiker, reedbuck, a few warthog and a small herd of about twelve hartebeest besides occasional migratory elephant from the west and south-west.

With such small numbers of the larger animals, the only dependable blood source for the tsetse population must have been provided by the smaller animals of which duiker and bushpig were the most common.

With the declaration of the Tsetse Fly Area, the amount of hunting and particularly night shooting in the area was reduced very considerably and it is interesting to note that the effect of this upon the hartebeest was to reduce the area in which these animals wandered. During 1953, the herd was usually split up into groups of twos and threes and might with equal likelihood be seen anywhere between the Lungu stream and the Chamwambwe. By 1956, the numbers had increased to about thirty-five, but it was nevertheless unusual to find them very far from the northern half of the Pafu River.

3. VEGETATION AND TOPOGRAPHY

The area is dominated by fairly heavy northern *Brachystegia–Isoberlinia paniculata* woodland on gently undulating plateau soils dissected by numerous streams and dambos flowing northwards into the Kafue River which is edged by variable but mainly very wide stretches of often rather poor leached dambo grassland. A line of evergreen trees occurs fringing the banks of the Kafue, and similar narrow mushitus are associated with some sections of the perennial streams, i.e. the Lungu and Pafu. Some small patches of *Combretum–Afrormosia–Terminalia–Erythrophleum–Chipya* (tall grass mixed open woodland) occur in which tree growth is relatively very poor; this variant has little importance with regard to fly distribution in the area. Concretionary ironstone (or Murram) outcrops occur on many of the subsidiary watersheds and in these instances the woodland cover may be much more open than that immediately adjacent. As the discriminative clearing operations progressed it was found that fly was moving to some of these outcrop areas which were thus providing a secondary habitat as conditions became more inhospitable in the normal fly foci in consequence of the control measures applied. The dambos more favourable to fly, such as the Kamita, showed a graded ecotone from well-developed close woodland to dambo. The succession passed through relatively open woodland broken by the more numerous large anthills of the dambo edges, often supporting large trees such as *Diospiros* and Fig, and resulting in the appearance of this zone being markedly heterogeneous, to open dambo grassland where almost the only woody growth consists of occasional shrubby *Combretum* spp.

Apart from one small hill just north of the Muo Menchie, the topography is gently undulating and in the dry season it is traversable almost in its entirety by Land Rover except for the Lungu and Pafu streams, which cannot be crossed at any time of the year without bridging.

In general, it is not possible to single out any vegetational characteristics which would account for the presence of tsetse in this area and its absence from the surrounding country. All that can be said is that some of the dambos and their associated vegetation complex, e.g. the Kamita and parts of the Lungu and Pafu, had the appearance of highly favourable plateau fly habitat. Similar sites do, however, occur in tsetse-free country to the west and south, in regions where the human disturbance factor has certainly been no more intense.

4. LAY-OUT OF FLY ROUNDS AND PICKETS

Early in 1953, twelve fly rounds of about eight miles each in length were laid out.[1] These were divided into sections, the Lungu and the Pafu, each consisting of six rounds, and in each section the stops were numbered consecutively from 1 to 60, thus allowing about five-sixths of a mile between numbered catching stations. During the weekly patrols of these rounds, catches were made at more frequent intervals, these later being totalled for each numbered stop when the catches were graphed.

Regular patrolling of the fly rounds was commenced in July 1953 and continued until the end of 1956. Four Tsetse Guards were employed constantly on this work, and checks were carried out regularly by the Tsetse Control Supervisor in charge.

That part of the tsetse area lying to the west of the Pafu was not covered by regular fly rounds due (*a*) to the lightness of the fly density and (*b*) to the fact that an extra camp would have been required. The position in this section was checked constantly with a view to taking further measures if required, but in the end it was found that no anti-tsetse operations were necessary, the presence of fly in this area having apparently been dependent upon a " feed " from the better established population of the east of the Pafu.

Fly pickets, each manned by two orderlies supplied with nets and an insecticidal spray gun, were in the first instance established across the three official roads to the tsetse fly area. That on Hepker's road was abandoned after a few months and on Evans's road after a period of eighteen months, but the picket on Lambertsen's–Page's road covering all traffic from the main fly concentrations was still being maintained by the end of 1956. A picket was also established on the footpath leading from the Kafue River, in the north-east of the closed area, and crossing the Kajela stream and Evans's road towards Chingola. This was maintained until the end of 1955.

[1] For technical reasons it has not been possible to reproduce the map and figures illustrating this article.

5. BUSH CLEARING OPERATIONS

Two distinct types of clearing were made in the area.

(*a*) Discriminative clearings carried out departmentally in essential fly habitat, as indicated by fly rounds.

(*b*) Clearing carried out by wood contractors to the Copper Mines, and sited by arrangement with the Forestry Department, so as to form a barrier clearing one to two miles wide along the eastern and southern flanks of the fly pocket, i.e. more or less along the line of Evans's road in the east, and north of the Solwezi–Chingola road between Evans's road turn-off and the west of the Muo Menchie Dambo in the south.

Discriminative clearing operations were commenced in June 1953 in the Kamita Dambo ecotone from the centre of the dambo to the limits of the uniform *Brachystegia* woodland, leaving a clearly defined and fairly straight edge to the woodland. Small subsidiary dambos and drainage lines were ignored in the first instance. Cutting on a similar pattern was then applied to the Mimbula Dambo, and these two were completed by April 1954. At this stage, it began to be apparent that the many subsidiary dambos and small openings or intermittent dambo " patches " associated with ill-defined subsidiary drainage areas (they could scarcely be termed " lines ") were playing an important part in the maintenance of the tsetse population.

From this stage onwards the labour force was divided, and while the larger gang remained on clearing work in the main dambos with which fly was associated, between ten and twenty men were transferred to somewhat piecemeal clearing of small dambos and open patches, wherever fly round results indicated that this might be necessary. Initially, most of the sites were found to be between the Kamita and the Pafu with a predominance within the Pafu drainage area proper.

In May 1954, the main cutting gang was moved to the Pafu extension dambo, this being dealt with in about three months, and completing the major dambo clearings in the Pafu half of the tsetse area. Major cutting operations were then transferred to the Lungu side and by the end of 1945, Strydom's Dambo, a small dambo south of Page's and an extension of the Lungu Dambo on the east side of the central section of that river, had been cut. Fly round results and surveys on the Pafu side now indicated that tsetse fly were hanging on in association with a concretionary ironstone outcrop about four miles long, forming the inter-fluvial between the Kamita and the Pafu north of the Pafu extension. The relatively open, though by no means light woodland, of the variant was felled during the next two months to a width varying from twenty-five to two hundred yards, depending upon the local vegetational pattern. This was followed by cutting in the last of the larger discriminative clearing sites, that of the upper Lungu (north). During this time, further " spot " clearings were being made both in the Lungu and the Pafu halves of the tsetse area, until in July 1955 the discriminative clearing programme was brought to an end, and the remaining labour force diverted to all-out preparations for the application of insecticides.

The over-all result of the discriminative clearing had been to reduce the numbers of tsetse by 85% (fly rounds caught 485 in July 1953, as compared with 78 in July 1955) and at the same time cut down the area of infestations from eighty square miles to about twenty square miles. The progress of the campaign as shown by the fly round results, is dealt with in detail in a later section, and summaries of labour employed and costs are also given.

More or less concurrently with the discriminative clearing programme the barrier clearing by wood contractors forged rapidly ahead. As will be seen by reference to the map, most of this clearing was done outside the resident fly area, the only exception being in the vicinity of Henry's farm and Duck Dambo. It did not, therefore, have any direct effect upon the tsetse position, but judging by the early reduction in the number of bovine trypanosomiasis cases on adjacent farms, certainly played an important part during 1954, and part of 1955, in reducing the number of fly wandering or carried outside their normal ambits.

6. INSECTICIDAL OPERATIONS

As a result of the large reduction in the area of fly infestation brought about by the discriminative clearing programme, the position by the middle of 1955 was such as to provide the opportunity for knocking out the remaining tsetse by the application of insecticides over an area of manageable size.

The alternative of continuing with discriminative clearing in increasingly more obscure sites could not at the best possible estimate be expected to eliminate fly within one year, and the time might feasibly extend to a few years. The use of insecticides offered at least the possibility of eliminating tsetse fly by the end of 1955, if 100% effectiveness was obtained, and at any rate, the certainty (judging by results at Mulungushi) of drastically reducing the fly population (perhaps below its threshold for survival) was apparent.

Meteorological observations for wind direction, wind speed and direction of cold air drift were made during the night at various sites in the area from 15th–18th July, and the best course for the spraying lanes was found to be north-east–south-west at right angles to the prevailing wind.

Work on the ground lay-out was started immediately. This consisted of:

(*a*) Spraying lanes running parallel to each other at two hundred yard intervals, marked by blazes on trees at frequent points, and cleared where necessary to allow the passage of a Land Rover and trailer.

(*b*) Ancillary spraying lanes, marked just inside the bush edge from all dambos and discriminative clearing sites, providing for extra cover of these, should this appear necessary to the operator during applications, and also allowing for connecting up between the parallel lanes where these were not taken across the dambos or clearings.

(*c*) Access roads, wide enough to take a 5-ton truck, constructed at about one mile intervals in east to west direction, through the spraying area.

This lay-out covered the area between the Pafu River and Muo Menchie in the west, the barrier clearing in the south, a line between two hundred and four hundred yards east of Lambertsen's road formed the eastern boundary and Lambertsen's farm the northern one.

Besides this, the western side and the whole of the top of the Mimbula Dambo, the eastern side of Duck Dambo, the discriminative clearing sites along the north of the Lungu stream, and all farm roads north of the Lunga that were not covered by the spraying lanes, were fogged when visibility permitted, i.e. either morning or evening or bright moonlight.

The equipment and insecticides used were as for the Mulungushi spraying in 1954, described elsewhere in this report: briefly a Todd Insecticidal Fog Applicator mounting on a Land Rover trailer with two 45-gallon drums, one each bolted on to the vehicle and the trailer, a 1% gamma B.H.C. solution formulated on the spot from 30% gamma technical; B.H.C. and dieseline, and a five ton truck.

Five fog applications were made as follows:

1st	15. 8.55–24. 8.55	number of drums recorded				55½
2nd	6. 9.55–17. 9.55	,,	,,	,,		67
3rd	26. 9.55– 5.10.55	,,	,,	,,		43½
4th	24.10.55–24.10.55	,,	,,	,,		48½
5th	18.11.55–16.12.55	,,	,,	,,		32½
						247

In all, two hundred and forty drums or 10,800 gallons of the B.H.C. formulation were applied, the discrepancy of seven drums being due to the fact that the T.I.F.A. did not pump out the whole of the forty-five gallons from each of the reservoir drums before they were refilled.

Mechanical breakdowns in the T.I.F.A. and the trailer attachment together with the advent of the rains, resulted in the fifth application being late in starting, and long drawn out, and this undoubtedly affected the efficacity of the operation to some extent.

During the whole programme, two European operators were available to conduct the fogging, and it was found best to alternate each night between the evening to midnight, and midnight to morning shifts. When things run well this can be done without causing any undue fatigue. An African driver trained in the operation of the T.I.F.A. was available during the whole period to carry out daily routine cleaning and servicing of the T.I.F.A. and vehicles, a task which is absolutely necessary if this kind of operation is to run smoothly and exasperating interruptions or undue delays are to be obviated.

Two labourers under the supervision of a Tsetse Control Guard were employed in formulating the insecticides, and a further three or four were used on drum filling and replenishment at night.

Total fly catches fell from seventy-eight in July 1955, immediately prior to the fogging, to one in December 1955, at its completion.

7. POSITION IN 1956

The Tsetse Control Supervisor in charge of the area went on long leave in February of this year, and the scheme was temporarily placed on a care and maintenance basis.

All the fly rounds were continued and further to this, all flies seen whether on or off the rounds were captured and recorded. Cord-wood cutting by contractors continued, and their operations included felling between Henry's farm and Duck Dambo, one of the sectors in which it was suspected that fly might be hanging on.

In March it appeared that the fly population might be building up again, and although the fly round catches subsequently dropped to nil in August, restricted insecticide applications were made in October and November in sites indicated a total of 360 gallons being applied before the rains started.

By the end of December 1956, only one tsetse fly had been caught in six months, and it would appear that the drop off from March was largely due to the inability of the tsetse population to maintain itself. Checks in the following dry season when an increase in the number of fly caught would be expected, did not catch a single fly.

8. FLY ROUND RESULTS

The lay-out of the fly rounds has already been described, and the positions of the numbered stops can be seen by reference to the map.[1]

In a full year, a total of about 4,900 miles was covered by these rounds, and the progress of operations was reflected in the catches.

For each fly round, the data was treated in two ways:

(*a*) By making block diagrams of monthly totals of males, females and young flies for each numbered stop. This enabled easy comparison of monthly catches in any given part of the tsetse area.

(*b*) By graphing the catch, male, female, young and total, against the month of the year, to enable fluctuations in fly numbers either seasonal or induced by control measures, the more easily to be followed.

Total by months for each of the sections of six fly rounds, the Pafu and Lungu, were also graphed to indicate the over-all position and trends.

Fig. 1[1] provides an example of a histogram from one of the rounds (No. 3 Lungu). Section 21–23 runs along the western side of the upper Lungu River; from 23 to 26 the round more or less follows Strydom's road (which was officially closed) and from 26 to 30 the two upper Lungu

[1] See footnote to page 294.

Dambos are crossed, and the round ends at the top of the Mimbula. This diagram indicates the main concentration to be along Strydom's road and near the Mimbula Dambo; the former was almost certainly artificially induced to a great extent while that near the Mimbula reflected high fly numbers associated with open patches and small dambos near the top of the Mimbula. Arrows show the months in which control measures were applied to areas covered by the fly round, but it became more apparent as the scheme progressed that operations on the Pafu side also affected the Lungu sector. The reverse was however not so manifested.

Large-scale cutting of dambos on the Pafu side was completed by August 1954, and this corresponds with an over-all drop in fly numbers on this round after only relatively small amounts of clearing (top of Mimbula and spot clearings) had been carried out in the area actually traversed by the round.

Fig. 2 shows a graph of the monthly fly catches from one of the rounds (Pafu No. 3) and illustrates the seasonal fluctuation in fly numbers combined with the progressive reduction of the fly population as the anti-tsetse measures were put into effect. This round sampled the Kamita Dambo and the ironstone ridge area as well as a section of the Pafu Dambo edge, close to which many of the piecemeal clearings were made.

It will be seen that the seasonal minimum occurred about July, and that old male catches for this month were respectively 1953: 17; 1954: 3; 1955: 2. In 1956 the catch was nil. Seasonal maxima occur about March, and the respective catches (old males only) were 1954: 41; 1955: 25. In 1956 this also was nil.

Since December 1955, only one tsetse fly has been caught on this round, that being one female in February 1956.

Figs. 3 and 4 show the total fly catch by months from the Pafu and the Lungu sections for the period July 1953 to December 1955. In 1956, the following numbers of tsetse were caught on all fly rounds (see table).

January		February		March		April	
Pafu	Lungu	Pafu	Lungu	Pafu	Lungu	Pafu	Lungu
1 m 1 f	1 f	2 m 1 f 1 y	3 m	3 m 4 f	3 m	1 m	2 m 1 y
May		**June**		**July**		**August**	
Pafu	Lungu	Pafu	Lungu	Pafu	Lungu	Pafu	Lungu
3 m 1 f	1 m	1 f	1 m	nil		nil	
September		**October**		**November**		**December**	
Pafu	Lungu	Pafu	Lungu	Pafu	Lungu	Pafu	Lungu
1 m	—	nil		nil		nil	

The total number of tsetse caught on fly rounds during the last six months of 1953 can be arrived at by adding together the monthly totals for males, females and young flies, from the Lungu and the Pafu sections over this period, and comes to 2,366. The comparable figure from the same rounds in 1956 is, as can be seen above, one tsetse fly. No tsetse were caught in the area in 1957 despite extensive surveys supplementary to the regular fly rounds. Cattle, sheep and horses have been introduced and as they have not contracted trypanosomiasis the tsetse infestation is now considered to have been eradicated.

9. SUMMARY OF STAFF LABOUR EMPLOYED, EQUIPMENT AND COSTS

Staff

(i) Routine

European	Tsetse Control Supervisor	1
African	Tsetse Control Guards	3
	Fly Picket Orderlies	9
	Bricklayers (for 4 months)	1
	Labour (inc. Capitaos)—	
	May 1953 to May 1954 approx.	24
	May 1954 to July 1955 approx.	36
	August 1955 to December 1955 approx.	10

Much useful assistance in the recruitment of labour was received from the Provincial Administration.

(ii) Extraordinary

During the insecticidal applications, another European Officer assisted in the area, in the first instance an Entomologist and later a Tsetse Control Supervisor who was seconded from survey work. At the same time, an African Driver was seconded from the Entomologist's staff, and employed on maintenance of equipment and transport of stores.

Equipment

Main items of equipment acquired were:

(*a*) Land Rover and Trailer.

(*b*) Camp Equipment for all staff.

(*c*) Fire-arms.

(*d*) Tools, including axes, builder's tools, forge, picks, shovels, etc.

(*e*) One departmental T.I.F.A. was used for the insecticide applications and a 5-ton Bedford truck was used for heavy transport during these operations.

(*f*) Semi-permanent field quarters were built.

SUMMARY OF COSTS TO JUNE 1956

	1953–54			*1954–55*			*1955–56*			*Total*		
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
Personal emoluments .	1,621	16	2	1,612	11	5	2,013	2	9	5,247	10	4
Travelling on duty . .	203	0	4	312	3	9	318	9	9	833	13	10
African staff uniforms .	227	18	4	179	0	9	144	5	9	551	4	10
Arms maintenance and ammunition . .	21	12	10	—			Cr. 5	1	8	16	11	2
Repairs and maintenance of equipment . .	—			4	4	4	—			4	4	4
Maintenance of camps .	—			39	7	4	35	3	2	74	10	6
Vehicle repairs . .	71	9	9	46	15	11	160	19	1	279	4	9
Labour	1,511	1	5	1,488	4	5	788	16	4	3,788	2	2
Motor vehicles . .	804	10	5	—			—			804	10	5
Camp equipment . .	59	14	2	—			—			59	14	2
Field quarters . .	283	0	2	—			—			283	0	2
Fire-arms . . .	93	5	4	—			—			93	5	4
General and technical equipment . . .	292	16	10	865	9	10	569	8	2	1,727	14	10
Insecticide applications (petrol, oil, dieseline and B.H.C.) . .	—			1,925	0	0	—			1,925	0	0
Total . . .	£5,190	5	9	£6,472	17	9	£4,025	3	4	£15,688	6	10

THE NATURAL HOSTS OF *GLOSSINA LONGIPENNIS* CORTI AND OF SOME OTHER TSETSE FLIES IN KENYA

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The biology of *G. longipennis* Corti, especially in relation to its feeding habits, has received only limited attention. The only information available about the hosts of this fly was obtained from tests, on nine gorged flies which contained rhinoceros blood (Weitz and Glasgow, 1956) and which were captured at Mluza in Tanganyika. One of us (W. P. L.) discovered how to find engorged *G. longipennis* at Kiboko in Kenya, about one hundred miles from Nairobi on the Nairobi–Mombasa road, where three hundred and thirty-six gorged *G. longipennis* were captured over a period of approximately one year. In the same area twenty-three gorged *G. pallidipes* Aust. and four gorged *G. brevipalpis* Newst. were obtained. In addition, two hundred and six engorged *G. swynnertoni* Aust. were collected in Masailand, in the Talek area near the northern frontier of Tanganyika. The information gained by testing the blood meals of these flies forms the subject of this communication.

DESCRIPTION OF AREAS FROM WHICH FLIES WERE COLLECTED

Engorged flies were difficult to find in large numbers and most of them were obtained from the underside of branches. At Kiboko, the collecting area was a six-acre patch of dry *Acacia–Commiphora* bush, which included a waterhole, although many of the flies were actually caught off a *Berchemia discolor* tree within the block. Spoor records of the game visiting the waterhole were taken periodically and correlated with the identifications of the blood meals of the tsetse caught (Langridge unpublished). The vegetation at Talek in Masailand was made up of thicket patches in open savannah. The most common species in the thickets, where the tsetse were found resting, were *Cordia ovalis*, *Rhus glaucescens*, *Croton* sp. and *Acacia pennata*, and in the more open country flies were collected from *Balanites aegyptiaca*, *Boscia salisifolia* and *Gardenia jovis-tonantis*. About eighty trees were searched regularly in an area three miles square as part of an ecological study on tsetse in relation to their habitat and game. The few flies from Gede on the coast were caught on the trunks of *Trachylobium* trees, on fly rounds through a patch of tall forest, in which *Brachystegia spiciformis*, *Trachylobium verrucosum* and *Cynometra* spp. were important constituents. The animals living in these areas are listed in Table I which, although as complete as practicable, may perhaps not include some of the rarer animals which were not seen or which left no spoor.

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METHODS

The blood meals were obtained from engorged flies immediately after capture by dissecting the stomach contents into filter papers, which were dried and then sent to England. The identification of the blood meal, which was normally carried out within two months of capture, was made by the methods described by Weitz, 1956 using the precipitin test and the inhibition test.

RESULTS

The results of the identification tests of *G. longipennis* meals from Kiboko (Table II(*a*)), showed very strikingly that rhinoceros was the host most commonly fed on and buffalo was a poor second. 336 blood meals were identified and of these 74% were from rhinoceros, 16% from buffalo and the remaining 10% were from birds (probably ostrich), elephant, giraffe, pigs, cats and unidentified bovids. Single feeds were found from man, dog, porcupine and aardvark.

Table I.—Potential Hosts at Kiboko and Talek

Vernacular Name	*Latin Name*	*Kiboko Waterhole*	*Kiboko Area*	*Talek Area*
MAMMALS				
PRIMATES				
Man	*Homo sapiens.*	+	+	+
Baboon, Anubis	*Papio anubis.*	+	+	—
Yellow	*P. cynocephalus.*	—	—	+
Monkey, Vervet and Sykes	*Cercopithecus* spp.	?	+	+
HYRACOIDEA				
Rock Hyrax or Rock Rabbit	*Procavia* sp.	—	?	—
	Heterophyrax sp.	—	?	—
Tree Hyrax	*Dendrohyrax* sp.	—	?	?
PROBOSCIDEA				
African Elephant	*Loxodonta africana.*	+	+	+
TUBULIDENTATA				
Aardvark or Antbear	*Orycteropus afer.*	—	+	+
CARNIVORA				
Bat-eared Fox	*Otocyon megalotis.*	—	+	+
Domestic Dog	*Canis familiaris.*	—	+	+
Jackal, Side-striped	*C. adustus.*	—	—	+
Oriental	*C. aureus.*	—	—	?
Black-backed	*C. mesomelas.*	?	+	+
Wild Dog	*Lycaon pictus.*	+	+	+
Civet Cat	*Civettictis civetta.*	—	+	+
Genet Cat	*Genetta tigrina* & *G.* spp.	—	+	+
Mongoose, Various		?	+	+
Hyaena, Spotted	*Crocuta crocuta.*	+	+	+
Striped	*Hyaena hyaena.*	—	—	?
Cheetah	*Acinonyx jubatus.*	—	+	+
Leopard	*Panthera pardus*	—	+	+
Lion	*P. leo.*	+	+	+
Serval Cat	*Leptailurus serval.*	—	+	+
Wild Cat	*Felis lybica.*	—	+	+
PERISSODACTYLA				
Zebra	*Equus burchellii.*	+	+	+
Rhinoceros, Black	*Diceros bicornis.*	+	+	+

Vernacular Name	Latin Name	Kiboko Waterhole	Kiboko Area	Talek Area
ARTIODACTYLA				
Bushpig	*Potamochoerus koiropotamus.*	—	+	?
Warthog	*Phacochoerus aethiopicus.*	+	+	+
Giraffe	*Giraffa camelopardalis.*	+	+	+
Buffalo, African . . .	*Syncerus caffer.*	+	+	+
Bushbuck	*Tragelaphus scriptus.*	—	+	+
Dik-Dik	*Rhynchotragus kirkii.*	+	+	+
Domestic Goat—				
African smooth-haired .	*Capra hircus.*	—	—	+
Domestic Sheep	*Ovis aries.*	—	—	+
Masai breed—				
Duiker, Common . . .	*Silvicapra grimmia.*	—	+	+
Other spp. . .	*Cephalophus* sp.	—	+	+
Eland	*Taurotragus oryx.*	+	+	+
Gazelle, Grant's . . .	*Gazella granti.*	+	+	+
Thomson's . .	*Gazella thomsonii.*	—	—	+
Hartebeest (Coke's) . .	*Alcelaphus cokei.*	+	+	+
Topi	*Damaliscus korrigum jimela.*	—	—	+
Impala	*Aepyceros melampus.*	+	+	+
Klipspringer	*Oreotragus oreotragus.*	—	?	+
Lesser Kudu	*Strepsiceros imberbis.*	—	+	—
Oribi	*Ourebia* sp.	—	?	+
Oryx, Fringe-eared . .	*Oryx beisa callotis.*	+	+	—
Reedbuck	*Redunca redunca.*	—	?	+
Steinbuck	*Raphicerus ? campestris.*	—	?	+
Waterbuck, Defassa . .	*Kobus ? defassa.*	—	—	? +
Common . .	*K. ellipsiprymnus.*	+	+	? —
Wildebeest	*Gorgon taurinus.*	+	+	+
RODENTIA				
Ground Squirrel . . .	*Xerus* sp. *et al.*	—	+	+
Porcupine	*Hystrix galeata.*	+	+	+
LAGOMORPHA				
Hare	*Lepus capensis* or *L.* sp.	+	+	+
BIRDS				
Crested Crane	*Balearica* sp.	+	+	—
Doves and Pigeons . . .		+	+	+
Francolins	*Francolinus & Pternistis* spp.	+	+	+
Guinea-fowl	*Numida mitrata.*	+	+	+
	Guttera pucherani.	—	+	—
Ostrich	*Struthio camelus.*	+	+	+
And very many other birds.				
REPTILES				
Land Tortoises	*Testudo* sp.	—	+	+
Lizards		+	+	+
Snakes		—	+	+
AMPHIBIANS				
Frogs and Toads . . .		+	+	+

Note 1. Under the heading " Kiboko Waterhole " are the species of animals which have been seen, or whose spoor has been noted, at the waterhole around which the tsetse were caught.

2. Under the heading " Kiboko Area " are the species which are known to occur in the area, but which have not been observed at the waterhole.

3. Under " Talek Area " is a list of animals known to occur where the flies were caught.

4. + Host present.
— Host absent.
? Host probably present.

The identification tests on the twenty-three *G. pallidipes* blood meals, also from Kiboko (Table II (*b*)), indicated a more random feeding than *G. longipennis*, particularly on the large bovids. The blood meals were from eland (5), eland or kudu (1), kudu (1), buffalo (4), waterbuck (1), unidentified bovids (3), man (4), rhinoceros (2) and elephant (2). Of four *G. brevipalpis* meals from this area two were from rhinoceros and two from eland.

Two hundred and three identifications of the blood meals of *G. swynnertoni* from Talek indicated that the pigs formed the chief source of food of this fly (61% of all feeds) mainly from warthog, bushpig not having been observed in the area. 28% of all feeds were from ruminants, very largely contributed by giraffe and buffalo, the remaining feeds being derived from man (8%) elephant, rhinoceros, monkey and other mammals.

From Gede three *brevipalpis* squashes were all of bushpig with one *G. pallidipes* squash from an unidentified bovid.

Table II (a).—Hosts of *G. longipennis* at Kiboko

	Male	%	*Female*	%	*Total*	%
Rhinoceros	111	79	138	71	249	74·2
Buffalo	18	12	36	18	54	16·0
Bird (? Ostrich)	2	1	6	4	8	2·5
Elephant	5	5	1	0·5	6	1·8
Giraffe	2	1	3	1	5	1·5
Warthog	0	—	2	1	2	0·6
Pig Unidentified	0	—	1	0·5	1	0·3
Felid (? Lion)	0	—	2	1	2	0·6
Canid	0	—	1	0·5	1	0·3
Man	0	—	1	0·5	1	0·3
Porcupine	0	—	1	0·5	1	0·3
Aardvark	0	—	1	0·5	1	0·3
Bovid Unidentified	1	0·5	1	0·5	2	0·6
Mammal Unidentified	1	0·5	0	—	1	0·3
Unsuitable for Testing	0	—	2	1	2	0·6
	140 (42%)	99·0	196 (58%)	100·5	336	100·2

Table II (b).—Hosts of *G. pallidipes* at Kiboko

Hosts	*Numbers*		%	*Total %*
Ruminants				
Eland	5		21·7	
Eland or L. Kudu	1		4·3	
L. Kudu	1		4·3	
Buffalo	4		17·4	
Waterbuck	1		4·3	
Unidentified Bovids	3		13·0	
		15		65·0
Primates				
Man	4		17·4	
		4		17·4
Other Mammals				
Rhinoceros	2		8·7	
Elephant	2		8·7	
		4		17·4
		23		99·8

Table II (c).—Hosts of *G. swynnertoni* at Talek in Masailand

Hosts	*Male* Nos.	*Male* %	*Female* Nos.	*Female* %	*Total* Nos.	*Total* %
Suidae						
Warthog	52	44	59	69	111	54
Unidentified Pigs	8	7	7	8	15	7
	60	51	66	77	126	61
Ruminants						
Giraffe	17	14	7	8	24	12
Buffalo	16	14	4	5	20	10
Hartebeest, Topi or Wildebeest	1	1	1	1	2	1
Impala	0	–	1	1	1	1
Unidentified Bovids	7	6	0	–	7	4
	41	35	13	15	54	28
Primates						
Man	9	8	5	6	14	7
Monkey	1	1	0	–	1	1 (Monkey and Unidentified Primate together)
Unidentified Primate	1	1	0	–	1	
	11	10	5	6	16	8
Other Mammals						
Elephant	3	2	0	–	3	1
Rhinoceros	2	2	0	–	2	1
Jackal (or dog)	0	–	1	1	1	1 (Jackal and Hyaena together)
Hyaena	0	–	1	1	1	
	5	4	2	2	7	3
Total	117 (58%)	100	86 (42%)	100	203 (100%)	100

(6 double feeds, 10 smears unsuitable for testing.)
Total number of smears: 207.

In the results quoted above "bird" was most probably ostrich, "cats" was probably lion and "dog" was most likely jackal, but possibly wild or domestic dog or bat-eared fox. Few double feeds were found, 0·6% for *G. longipennis*, none for *G. pallidipes* and 3·9% for *G. swynnertoni*, and these have been included in the results without distinction.

DISCUSSION

In the study of natural feeding habits of tsetse flies the importance of obtaining an unbiased sample has been emphasised (Weitz and Glasgow, 1956) and the factors which govern the validity of the samples have been studied (Glasgow, Isherwood, Lee-Jones and Weitz, 1958). Flies caught on fly rounds were not truly representative of the population as indicated particularly by the sex ratio of the engorged flies caught. In these experiments 58% of the sample of *G. longipennis* were females and 42% males, and the percentage of males and females was 58% and 42% of *G. swynnertoni* catches. There is thus no indication of any fault in the samples caught and the two sexes showed no significant differences in their feeding habits, indicating that the samples were unbiased.

G. longipennis

It is always difficult to interpret the availability of potential hosts in an area. In Kiboko, careful records indicated that waterbuck, Grant's gazelle, impala, Coke's hartebeest, zebra, baboon and dik-dik were very numerous in comparison with rhinoceros or buffalo which were the favoured hosts of *G. longipennis*. In these terms, therefore, *G. longipennis* showed a strong preference for feeding on rhinoceros and possibly also on buffalo. An earlier set of 9 meals of *G. longipennis* was also from rhinoceros (Weitz and Glasgow, 1956). The very high proportion of feeds on rhinoceros assumes a certain dependence of the fly on this host and, in fact, no areas have been studied where this fly lives in the absence of rhinoceros, although *G. longipennis* lingers on in some of the clearings at Simba, near Kiboko, where there is neither rhinoceros nor buffalo and very little game of any kind. It is tempting to inquire what would be the result of the elimination of the two favourite hosts in this area. A point to note is the high proportion of other feeds derived from birds, most probably ostrich (2·5% of the total). Gaschen (1945) has shown that *G. longipennis* will feed between 7 p.m. and midnight and in this connection the feeds on aardvark and porcupine (both nocturnal creatures) are of interest.

Vanderplank (1941) and Burtt (1946) used an aardvark for experimental feeds of *G. morsitans* and Vanderplank (1944) refers to porcupines as an attractive bait for *G. pallidipes*.

The pattern of host preferences varies only little between the blood meals of flies captured in different months. (Table III). In August 94% of feeds were on rhinoceros and in November 57%, other months show a remarkably consistent proportion of feeding on this host (72 to 78%).

Table III.—Hosts of *G. longipennis* at Kiboko during 1957

Hosts	June		July		August		September		October		November		December–January	
	No.	%	No.	%	No.	%	No.	%	No	%	No.	%	No.	%
Rhinoceros	36	72	81	78·6	32	94·1	22	78·6	12	75·0	23	57·5	45	72·6
Buffalo .	12	24	11	10·7	0	—	3	10·7	3	18·8	13	32·5	9	14·5
Other .	2	4	11	10·7	2	5·9	3	10·7	1	6·3	4	10·0	8	12·9
	50	100	103	100	34	100	28	100	16	100·1	40	100	62	100

These figures taken with the proportion of blood meals from buffalo show that these two hosts are responsible for about 90% of all feeds and suggest that an increase of buffalo feeds in any given catch is compensated by a corresponding decrease in rhinoceros feeds or vice versa. The proportion of feeds on other animals is consistently between 4 and 12%.

For convenience we may refer to rhinoceros and buffalo as "standard hosts" of *G. longipennis* in this area and the fly will normally feed on these animals when possible. In the absence or shortage of "standard hosts" certain flies may be hungry and feed on a large selection of other animals.

There is no suggestion that the flies feeding on other animals than the "standard hosts" fall into a particular category of age (see Glasgow *et alia*, 1958), sex or other organised distribution.

The factors which cause any fly population to have a "preference" for any particular host are not understood, but they are probably inherited characters and so subject to natural selection. A possible mechanism by which a preference might become evident in such a population which in its history had been in close contact with suitable hosts, as for instance, rhinoceros and buffalo, is that selection might build up a "preference" for these hosts. Theoretically, if in its history a population of the same species has been in association with another host, even if perhaps less suitable, such as, say, giraffe, the process of natural selection might then have built up a "preference" for this other host.

At Kiboko, some very common potential hosts, such as waterbuck and impala, are never used at all by *G. longipennis*, so that while the availability of rhinoceros and buffalo may well be the most important factor in deciding the pattern of what hosts are used, yet it seems probable that even for a very "hungry" fly "host selection" operates to a marked degree.

G. pallidipes

The sample of *G. pallidipes* blood meals from Kiboko is too small—twenty-three squashes—to draw any valid conclusions from it. A point to note is that large bovids such as eland, buffalo and kudu seem to form an important source of food rather in contrast to other results (Weitz and Glasgow, 1956; Glasgow, 1956) in which bushbuck and bushpig were the main host animals. Bushbuck occur at Kiboko but possibly not at the particular spot where the *G. pallidipes* were caught. With our knowledge of the feeding habits of *G. pallidipes* in other areas (unpublished), the absence of feeds on Suidae in this area is unusual. Again, no flies fed on hartebeest, zebra and impala, and only one on waterbuck, all of which were abundant in the area.

G. swynnertoni

The feeding habits of this species have been previously fully studied (Weitz and Glasgow, 1956; Glasgow *et alia*, 1958) and the characteristic high proportion of flies feeding on Suidae (62%) was again observed at Talek, as also the expected proportion of ruminant feeds (total 27%), chiefly from giraffe and buffalo (11% each) although two feeds were obtained from hartebeest, topi or wildebeest, hosts on which no species of fly had been found to feed on before.

RELATIVE IMPORTANCE OF OTHER HOSTS

Man as a Host

The identification of blood meals bears out the field observations that *G. swynnertoni* and *G. pallidipes* with 8% and 17·4% respectively of human feeds attack man more readily than does *G. longipennis* with only 0·3%. The percentage for *G. pallidipes* 17·4% may well be too high, either due to smallness of the sample or because the flies had bitten the fly boys, escaped, and had then been collected at a later catch.

Game Animals

In the observations made at Kiboko and Talek there is a striking absence or scarcity of feeds from some of the most common game present in the areas. At Kiboko, waterbuck, Grant's gazelle, impala, Coke's hartebeest, zebra, dik-dik and baboon are very numerous; wildebeest is present though rather less common. From all these potential hosts only one *G. pallidipes* feed was found and that from waterbuck. At Talek, the plains game dominate: zebra, wildebeest, hartebeest, topi and Thomson's gazelle, all of which were abundant, as were impala, dik-dik and baboon. Grant's gazelle and waterbuck were present in small numbers. Apart from two *G. swynnertoni* feeds on hartebeest, topi or wildebeest (the serological distinction between these three species of the tribe *Alcelaphini* is not practicable at present) no other feeds were recorded from any of these numerous potential hosts. These findings correspond with the results obtained by Weitz and Glasgow (1956) who found that waterbuck was an unimportant host of *G. morsitans* and *G. swynnertoni* and that impala were very rarely attacked. No feeds were recorded from any of the other species mentioned. A total absence of hartebeest, topi, wildebeest and zebra feeds was noticed. It is a point of some considerable interest that at Talek two feeds were found from either hartebeest, topi or wildebeest, whilst never before have any blood meals been identified from these animals in our experience. It should be noted, however, that Van den Berghe and Lambrecht (1956) found that *G. morsitans* at Mutura had fed on topi and also on zebra. The serological identification in this case was not fully reported and it may be that there is some doubt about the accuracy of the results.

The reluctance with which flies feed on game animals of this kind as a rule is a point of considerable interest. As yet, no satisfactory explanation can be given and it would appear that the answer must lie in the behaviour of the fly in relation to these animals. More detailed studies are required on the methods of feeding before this phenomenon can be satisfactorily explained.

The correlation of results of identification of blood meals with the incidence of trypanosome infection in varous species of game would confirm the feeding behaviour of the fly. Unfortunately, very few records are obtainable of the infection of game animals with trypanosomes. Swynnerton's records (1936) of the incidence of trypanosomes in game appear to be at variance with the feeding habits of *G. swynnertoni* at Talek. He found a large proportion of impala and waterbuck and a smaller proportion of topi, Lichtenstein's hartebeest, wildebeest and zebra infected with various trypanosomes. The baboon was not found to be infected. It is difficult to see how the relative importance of different species of game as hosts of tsetse could be correlated on the basis of trypanosome infection and on the collection and identification of blood meals. Perhaps it is necessary to take into account the direct transmission of trypanosomes by other blood sucking flies which may occur far more commonly than is usually believed. Some studies on the feeding habits of other biting flies would thus appear to be indicated. This might provide the answer to the apparent discrepancies between the feeding habits of tsetse flies and the incidence of trypanosome infection in game animals.

SUMMARY

The blood meals of three hundred and thirty-six *G. longipennis*, twenty-three *G. pallidipes* and two hundred and three *G. swynnertoni* captured from two areas in Kenya were identified by the precipitin and inhibition of agglutination tests.

The engorged flies were collected from their resting places and were not collected on fly rounds. In this way a valid sample of the fly population was obtained which contained approximately equal numbers of males and females.

G. longipennis at Kiboko was found to feed mainly on rhinoceros and to a lesser extent on buffalo. The fly appears to have a definite preference for these hosts.

G. swynnertoni at Talek obtained more than half its food supply from warthog.

No flies fed on zebra and only one on waterbuck, one on impala and two on hartebeest, topi or wildebeest in spite of the large numbers of these animals in the area.

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THE ECONOMIC IMPORTANCE OF SOME WEST AFRICAN SPECIES OF *FUSCA* GROUP TSETSE FLIES

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It is a remarkable fact that virtually no work has been done on the large forest species of *Glossina* which occur in West Africa, and are members of the *fusca* group. It has always been said that Zebu cattle cannot be kept in the forest belt because of trypanosomiasis, but there seems to have been little evidence for this statement. Further, it was not even known whether certain members of the *fusca* group carried trypanosomes. When we found that, by using a bait-ox, these species could be attracted out in large numbers we started to assess their economic importance by ascertaining their trypanosome infection rates.

In this work, only mature infections have been counted. If the fly was both gut- and hypopharynx-positive the infection was recorded as belonging to the *congolense* group, but to the *vivax* group if only the hypopharynx was positive. Salivary glands were always examined, but may be ignored as only one positive was recorded. Apart from fifty specimens of *G. medicorum* from Olokemeji (Nash, 1952), all the results given in the following table are from flies collected at our Ugbobigha field station, which is situated sixty miles north-east of Benin in southern Nigeria.

Species	*Number Dissected*	*Infection Rate* %	*Analysis of Infections by Groups* *Vivax* %	*Congolense* %
G. tabaniformis	2,722	3·5	56	43
G. fusca	717	13·9	77	22
G. nigrofusca	124	26·3	85	15
G. medicorum	103	15·5	94	6
G. medicorum (Olokemeji)	50	14·0	43	57

The first three species have all been taken from the same block of high forest, over the same period of time, yet the over-all infection rates are remarkably different. The very low infection rate found in *G. tabaniformis* could be due to this tsetse being naturally resistant to trypanosome infection, or to its having unusual food preferences; we have no evidence for the former supposition, but out of 109 blood meals identified 20% were from porcupine. It will be seen that *G. fusca* is much more heavily infected than *G. tabaniformis*, and that the infection rate so far recorded for *G. nigrofusca* is exceptionally high. Amongst the flies caught in this block, the proportion of *congolense* group trypanosomes is only high when *G. tabaniformis* is the vector.

G. medicorum should be considered separately because it does not inhabit the main belt of forest, but appears to be confined to forest outliers; it is interesting that *congolense* group infections are so much greater at

Olokemeji, although the over-all infection rates are similar to those found at Ugbobigha.

G. tabaniformis is believed to be of little economic importance, both because of its low trypanosome infection rate, and because its distribution appears to be confined to the high forest where there is no grazing. On the other hand, *G. fusca*, *G. nigrofusca* and *G. medicorum* are known to penetrate the savannah in many localities, being based on forest islands or riverine forest; they have been found to feed freely on the bait-ox throughout the day, and to support a heavy trypanosome infection rate; hence, there can be no doubt that these three species would be of considerable veterinary importance, were attempts to be made to utilise the forest grasslands by introducing Zebu cattle.

The following figures suggest that females are much more heavily infected than males, except in the case of *G. nigrofusca*:

	Males			*Females*		
Species	*No. Dissected*	*No.* +	% +	*No. Dissected*	*No.* +	% +
G. nigrofusca	99	27	27·1	25	6	24·0
G. tabaniformis	1,080	23	2·1	1,642	72	4·4
G. fusca	414	46	11·1	303	52	17·1
*G. medicorum**	89	10	11·0	64	13	20·0

* Includes Olokemeji figures.

If females of these little studied species live considerably longer than males, as is the case with other species of tsetse, then they would have considerably longer in which to become infected. On the other hand, comparable figures from Ugbobigha for *G. palpalis* indicate that the infection rate in this species is similar in each sex; thus out of 913 males dissected, 19 were positive or 2·1%, and out of 722 females, 15 were positive or 2·1%.

These findings for the forest species of tsetse should become more readily understandable when we have collected further data on both infection rates and the sources of food for each sex.

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PROGRESS MADE IN ASCERTAINING THE NATURAL HOSTS FAVOURED BY DIFFERENT SPECIES OF TSETSE

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Mr. Bernard Weitz of the Lister Institute of Preventive Medicine, London, has perfected serological tests which enable him to identify, in most cases, the origin of the blood found in the stomach of wild tsetse flies (Weitz, 1956). Unfortunately, gorged flies are rarely encountered, so that it will be some years before sufficient identifications have been received from Mr. Weitz to permit of valid conclusions. Nevertheless, since the subject is stimulating so much interest and the results so far obtained often tend to upset preconceived ideas, it was thought that a progress report covering the first two years of collection might be of value.

The results have been divided into those for tsetse caught in the high forest belt and adjacent savannah in the south-western part of Nigeria, and those from the northern savannah woodlands within ninety miles of Kaduna.

FOREST BELT AREA

Flies were either collected from around our field station at Ugbobigha, which is sixty miles north-east of Benin, or from Olokemeji which is one hundred and thirty miles to the west.

(*a*) High Forest

G. tabaniformis

Ugbobigha: Out of 109 meals identified, 71 (65%) were from Red River-hog (*Potamochoerus porcus*), and 22 (20%) from porcupine (*Atherurus africanus*); the remainder were all from Bovids. The high percentage which had fed on porcupine was most unexpected.

G. nigrofusca

Ugbobigha: Out of 15 meals identified, 7 were from bushbuck (*Tragelaphus scriptus*), 3 from Red River-hog and 5 from Bovids.

G. fusca

Ugbobigha: Out of 30 meals, 23 (77%) were from Red River-hog and only 2 from bushbuck.

Olokemeji: Out of 128 meals, 106 (73%) were from bushbuck, and none from Red River-hog.

G. medicorum

Ugbobigha: Out of 11 meals, 6 were from Red River-hog and only 2 from bushbuck.

Olokemeji: Out of 30 meals, 24 were from bushbuck and none from Red River-hog.

It will have been noted that whereas at Ugbobigha the available evidence suggests that both *G. fusca* and *G. medicorum* favour the Red River-hog, at Olokemeji they favour the bushbuck. This is readily explainable because this hog is very common at Ugbobigha, but uncommon at Olokemeji. Clearly caution must be exercised in drawing conclusions as to the most favoured host, until data have been collected from a number of localities.

It must be mentioned that the Ugbobigha specimens of *G. fusca*, *G. nigrofusca* and *G. tabaniformis* all came from the same part of the high forest; whereas *G. fusca* and *G. tabaniformis* showed a very marked preference for Red River-hog, the available data suggest that *G. nigrofusca* may greatly prefer bushbuck.

Out of 323 meals from tsetse of the *fusca* group, none were from Primates, reptiles or birds. Personal observation has shown that it is most unusual for these tsetse to attack man; catchers, in attendance on a bait ox, will be completely ignored when tsetse flies are swarming around the animal.

(*b*) Savannah Woodland Adjacent to High Forest

G. longipalpis

Ugbobigha: Out of 186 meals identified, 124 (67%) were from bushbuck, 18 (10%) from buffalo (*Syncerus nanus*) and 17 (9%) from Red River-hog. In East Africa it has been found that the very closely related tsetse *G. pallidipes* also strongly favours bushbuck (Weitz and Glasgow, 1956). Even though elephant are seasonally common at Ugbobigha, none of the identified meals came from this host; this is interesting as according to some of the earlier authors *G. longipalpis* is associated with this beast.

N.B.—Out of only 7 *G. longipalpis* meals from the northern savannah belt, 5 were from bushbuck.

NORTHERN SAVANNAH BELT AREA

(*a*) The Savannah

G. morsitans

Mando Road and Jos Road: The data are insufficient to permit of dealing with each locality separately.

Out of 110 meals identified, 61 (55%) were from wart-hog (*Phacochoerus aethiopicus*), 19 (17%) from man and 14 (13%) from Bovids.

The high percentage of wart-hog feeds is in accordance with East African findings (Weitz and Glasgow, 1956); in our Jos Road collecting area the figure is as high as 77% for the 44 meals identified. In West Africa, where game is much scarcer than in East, it is probable that the wart-hog is an even more important host. The proportion of flies feeding on man is unexpectedly high and is probably attributable to the presence of road maintenance gangs. Out of 13 identified meals from Bovids, 6 were from cattle, 3 from buffalo, 2 from bushbuck and 2 from Roan antelope (*Hippotragus equinus*). Avian blood was found in 2 cases.

(*b*) Riverine Vegetation in the Savannah

G. palpalis

Twenty localities, within ninety miles of Kaduna: Out of 83 meals, 37 (45%) were from reptiles, 20 (24%) from man and 15 (18%) from Bovids, four of which were cattle.

Man, his domestic animals and reptiles formed 74% of the meals. These results do much to explain why *G. palpalis* is found in even heavily populated areas; in such areas the usual reptiles, such as Varanus lizards, persist.

The presence of antelope, buffalo and wart-hog seems to be unnecessary, as even though our samples were collected from twenty different places, these animals provided only 8% of the meals.

GENERAL CONSIDERATIONS

Out of 702 meals from seven different species of tsetse, collected in many different localities, there has been no record of one from Duiker (*Cephalophus*, *Sylvicapra* and *Philantomba* spp.); yet these small animals must form the commonest species of antelope in our fauna, and previously were considered by us to be important hosts.

It is worth recording that out of 516 meals identified from the six tsetse species dealt with in the forest belt, human blood was found only in *G. palpalis* (5 out of 7 meals).

If we exclude *G. palpalis* because of its strong preference for reptiles, we find that in each of the remaining six species of tsetse collected from both forest and savannah, either bushbuck or the local species of pig are the most favoured hosts; out of 619 feeds from these six different species of tsetse, 454 (73%) were provided by bushbuck or Suids.

Apart from being obviously attractive to tsetse flies, these hosts have one thing in common—they are readily available. Because they do not tend to wander long distances, the fly, having digested its meal, will not find that it has lost contact with its hosts.

ACKNOWLEDGMENTS

We are greatly indebted to Mr. Bernard Weitz and his staff for making this investigation possible, and for all the work they have done in identifying our material.

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THE IMPORTANCE OF THE AGE OF *G. PALPALIS* AT THE TIME OF THE INFECTIVE FEED WITH *T. GAMBIENSE*

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The greatest hindrance to the laboratory study of cyclically transmitted infections of *T. gambiense* has been the difficulty experienced in infecting the flies; even the maintenance of strains by cyclical transmission has often proved impossible. For example, in our Epidemiology Section, during the last four years 766 flies have been fed, usually on a number of occasions, on infected monkeys, but only 0·4% of the flies have become infected: similarly, using infected rats, out of 1,925 flies used only 0·9% became infected. It therefore seemed important to study the conditions necessary to infect *G. palpalis*.

Batches of flies were fed singly on monkeys infected with *T. gambiense*. Each fly was allowed to feed only once on the infected monkey and was fed thereafter on clean rats. Only newly hatched flies were used which had never been fed before. If a fly refused to feed on the monkey on the first day after it was hatched, it was allowed to feed on the second day, or, if it refused again, on the third day, and so on.

Starting on the nineteenth day after the infected feed the flies were induced to probe and exude a drop of saliva on a slide to ascertain if their salivary glands had become infected: probing was continued until the thirty-fifth day. The flies which were still alive were then dissected to check that no salivary gland infection had been overlooked, and to see if any had gut infections only.

The most remarkable observation was that flies which fed on the monkey on the first day of life were much more readily infected than those which would not feed until older. Of the 343 first-day flies, subsequently induced to probe, twenty-six had mature infections—7·6%.

Of the 262 second-day flies subsequently induced to probe, three had mature infections—1·1%.

Of the 146 third-day flies, subsequently induced to probe, none had mature infections—0·0%.

Of the thirty-six flies which did not feed until after the third day, and which were subsequently induced to probe, none had mature infections —0·0%.

In addition, two second-day and one third-day flies had gut infections only.

It was then decided to investigate the period between 0 and 24 hours, to see if those flies which fed nearer the beginning of this period produced even higher infection rates. It was found that, out of 82 flies which were persuaded to feed within 3 to 19 hours of emergence, forty-eight survived nineteen days and of these six (12·5%) were subsequently found to have mature infections.

Newly emerged flies are not, under laboratory conditions, very willing to feed, but by coaxing and giving individuals several opportunities to feed on the first morning, from 50–60% were persuaded to do so.

It is hoped that this finding will prove of value to future laboratory investigations, but it also throws interesting light on the epidemiology of sleeping sickness.

It explains why so few flies caught at village water-holes in northern Nigeria, even when there has been epidemic sleeping sickness in the vicinity, have been found to be infected with polymorphic trypanosomes. It suggests that infected flies become infected soon after emergence and will therefore have a long expectation of life; a single fly may thus be able to do much damage before death. It adds support to the belief, based on entomological investigations, that sleeping sickness must be mainly spread in the dry season (Nash, 1948; Nash and Page, 1953), since it is reasonable to suppose that hot dry weather will stimulate the newly hatched fly to take its first meal very soon after emergence.

It was also found that, in so far as the numbers involved permit of conclusion, there was little difference in infectivity between the two sexes:

Out of 358 males induced to probe, sixteen were positive (4·5%).

Out of 431 females induced to probe, sixteen were positive (3·7%). Dealing with first-day feeds only, out of 155 males 8·4% were positive and out of 187 females 7·0%, but these numbers are too small to permit of valid conclusions.

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LES GLOSSINES DE NOUVEAU A L'ILE DU PRINCE

Par J. Fraga de Azevedo, J. Tendeiro, L. T. de Almeida Franco, Manuel da C. Mourao, J. Maria de Castro Salazar

En avril 1914, la dernière glossine a été capturée dans l'Ile du Prince par la Mission qui, sous la direction de Bruto da Costa et avec la collaboration de Correia dos Santos, Firmino Sant'Ana et Araùjo Alvares, avait travaillé avec succès contre la maladie du sommeil et à l'éradication de l'insecte vecteur.

Quarante-deux ans plus tard on apporte à la Junta de Investigaçoes do Ultramar quelques spécimens de diptères, envoyés de l'Ile du Prince, que l'un de nous (J. Tendeiro) identifie, le 3 mai 1956, comme *Glossina palpalis palpalis*.

Ainsi, on constatait de nouveau la présence de la mouche tsé-tsé dans ce territoire, et l'on devine la surprise et l'émotion que cette nouvelle apportait, non seulement parce que l'on considérait ce sujet comme étant définitivement réglé, mais aussi parce que l'aspect tragique de l'endémie hypnosique de l'Ile du Prince, à la fin du siècle dernier et au début de celui-ci, restait encore dans la mémoire de beaucoup.

On comprend, dans ces conditions, l'urgence de l'étude de la nouvelle situation. Dix jours après l'identification de la glossine, soit le 13 mai 1956, une mission d'étude partit pour l'Ile du Prince, organisée par l'Instituto de Medicina Tropical et la Junta de Investigações do Ultramar. Les auteurs de cette communication y participaient.

Lorsque l'on a organisé cette mission on a considéré sa préparation pour la réalisation des études qu'il faudrait effectuer, de nature entomologique et, peut-être, de nature protozoologique. Dans ce but, elle a été équipée avec le matériel nécessaire aux recherches.

En effet, on ignorait si, parallèlement à la réapparition des glossines, on n'allait pas constater la réapparition de la maladie du sommeil et des trypanosomiases des animaux, et on devait prévoir, en conséquence, la réalisation de travaux en rapport avec ces sujets.

On comprend, par conséquent, que la première préocupation de la mission devait consister à faire des recherches sur la présence desdites affections, et c'est ainsi que l'on a commencé par l'examen de la population, en vue de trouver des cas de maladie du sommeil, et par l'observation des animaux domestiques, pour vérifier la présence d'une forme quelconque de trypanosomiase.

En même temps, on a dès le début effectué les travaux nécessaires pour préciser la distribution et l'incidence des glossines, ainsi que pour vérifier, par la dissection de l'intestin moyen de la trompe et des glandes salivaires, s'il n'y an avait pas d'infectées par des trypanosomes.

De la façon dont ces investigations ont été réalisées on trouvera un aperçu plus loin. D'abord, cependant, nous désirons faire une courte référence à l'Ile du Prince, en considérant les différents aspects géographiques qui aient pu avoir de l'intérêt pour notre travail. Nous nous servirons, en grande partie des éléments du rapport concernant la campagne de 1911–1914 dont nous recommandons la lecture à ceux qui voudraient approfondir le sujet.

* * *

L'Ile du Prince est l'une des quatre îles du Golfe de Guinée : Fernando Pó, Prince, S. Thomé et Annobon. Elle se trouve entre 1° 32′ et 1° 41′ latitude Nord, et entre 7° 19′ et 7° 27′ longitude Est du méridien de Greenwich.

Elle est ainsi entre l'Ile de S. Thomé, au sud, dont elle est distante de 130 km. seulement, et celle de Fernando Pó, au nord, dont elle est distante de 200 km., celle-ci étant seulement à 40 km. de la côte du Cameroun Britannique. Le point le plus proche de l'île, dans le Continent Africain, est celui du Cap S. Juan, dans la Guinée Espagnole, à 200 km. de distance.

Avec une surface totale de 126 km.^{2}, l'île a une longueur maxima de 17 km. environ, dans la direction nord-sud, et une largeur maxima de 10 km. environ, dans la direction est-ouest.

Malgré sa petitesse, le territoire présente une côte extraordinairement taillée, tantôt avec de nombreux et agréables plages et bassins, tantôt avec des falaises abruptes tombant verticalement sur la mer. L'île, pour ainsi dire toute entière, est extrêmement accidentée, car les pics à pentes presque verticales sont très nombreux, ce qui fait que des vallées profondes à parois presque verticales se retrouvent fréquemment.

On doit rappeler avec un intérêt particulier qu'une chaîne de pics et de montagnes, presque ininterrompue, sépare les deux tiers nord du tiers sud, d'où il résulte des conditions spéciales de climat et de végétation pour chacune des deux parties de l'île, du plus grand intérêt pour la compréhension du problème des glossines. En effet, conformément à ce qui a été dit dans le rapport précité, cette chaîne, " agissant comme une barrière contre les vents du sud, lesquels durent toute l'année, intercepte le grand volume d'humidité apporté par ceux-ci pendant la saison pluvieuse, et elle devient ainsi le centre principal de précipitation de l'île ".

Etant donné la nature volcanique de l'île et son climat équatorial, la végétation y est très puissante, de telle façon que, pour ainsi dire, il n'y a pas un seul endroit, aussi petit qu'il soit, qui ne soit verdoyant.

Cependant, les différences climatiques précitées, entre les deux tiers nord et le tiers sud, donnent à l'île des différences de végétation entre le nord et le sud. Ainsi, la partie nord est utilisée pour l'agriculture tandis que la partie sud reste presque totalement couverte par la forêt vierge.

En tant que cultures d'intérêt économique, il faut mentionner le cacao, principal produit de ce territoire, et ensuite le café et les oléagineux. Ces cultures sont assez bien tenues dans la région centrale correspondant à la Roça Porto Real, mais elles sont assez abandonnées en maints endroits de la zone nord.

En ce qui concerne la faune de l'île présentant un intérêt pour cette communication, nous devons mentionner tout d'abord les porcs qui, lors de notre arrivée, étaient élevés en liberté dans le territoire, leur nombre étant d'environ un millier. Comme en 1911–1914, ces animaux ne se trouvaient pas dans le tiers sud de l'île.

En outre des porcs, nous devons mentionner quelques espèces d'animaux domestiques, dont l'énumération suivante donne une idée de leur importance : bœufs — 383 ; chevaux — 50 ; mulets — 36 ; ânes — 63 ; chèvres — 119 ; moutons — 147 ; porcs — 1.172.

Les chiens étaient très nombreux dans l'île, soit à l'état sauvage soit élevés près des habitations.

Des autres animaux pouvant intéresser notre travail, nous mentionnerons les singes, dont la seule espèce, le *Cercopithecus mona mona* (Schreb.) se trouve largement distribuée dans l'île, notamment auprès des cultures de cacao, où ils pratiquent des dévastations assez sérieuses, et la " lagaia " ou chat musqué — *Civectittis civetta* (Schreb.) — qui certainement est en nombre très réduit dans l'île puisque l'on ne le trouve que rarement. Les rats sauvages y sont aussi très abondants.

En ce qui concerne la population, l'Ile du Prince est habitée par des autocthones dont le nombre a augmenté depuis 1914, par des travailleurs importés surtout des îles du Cap-Vert, et en nombre plus réduit de Mozambique, et par quelques européens.

Le tableau I indique l'évolution de la population de l'île à travers les ans.

Par rapport au climat, l'Ile du Prince possède un climat équatorial avec une température moyenne annuelle de 25,4, une oscillation de 2° environ entre la moyenne de la saison chaude (pluvieuse) et de la saison froide (sèche) et une pluviosité moyenne annuelle qui, dans les deux tiers nord (Aéroport), a été de 1.938 mm. (1952–1955) et dans le tiers sud (Roça Infante D. Henrique), a été de 4.303 (9 ans d'observation).

L'humidité relative est toujours très élevée, puisque ses valeurs moyennes mensuelles se placent entre 76,87% et 86,22% respectivement pendant les périodes entre les soirs d'août à octobre (observations de 1952 à 1955 du poste météorologique de l'aéroport situé dans les deux tiers nord).

Deux saisons sont bien définies, la saison sèche ou de la " gravana ", de juin à septembre, et celle des pluies, d'octobre à mai, avec une courte

Tableau I.—Evolution de la population humaine dans l'Ile du Prince

Années	Population Flottante						Population Locale			Total
	Européens	Travailleurs			Autres	Total	Autochtone (Forros)	Descendants de travailleurs (Tongas)	Total	
		Du Cap Vert	D'Angola	Du Mozambique						
1885 .	—	—	—	—	—	—	3·000	—	3.000	3.000
1900 .	—	—	—	—	—	—	800	—	800	4.747
1908 .	150	134	3.196	—	—	3.480	350	—	350	3.830
1909 .	—	—	—	—	—	—	—	—	—	3.488
1910 .	—	—	—	—	—	—	—	—	—	3.603
1911 .	160	634	2.593	—	28	3.415	400	—	400	3.815
1913 .	169	1.409	2.029	—	—	3.607	550	781	1.331	4.938
1914 .	199	2.120	1.529	—	142	3.990	668	604	1.272	5.262
1921 .	99	5.804			8	5.911	994		994	6.905
1940 .	56	1.950			14	2.020	1.088		1.088	3.108
1950 .	81	1.481			—	1.562	2.770		2.770	4.332
1956 .	108	1.458	101	680	—	2.347	1.667		1.667	4.014

interruption, ou plutôt une courte réduction de la pluviosité au cours des mois de janvier et février, qui constitue la saison du " gravanito ".

Par suite de ces caractéristiques climatiques, de végétation et de faune, nous pouvons dire que les deux tiers nord offrent à la *Glossina palpalis palpalis* des conditions optima à son développement. Le tiers sud, par contre, est défavorable à son développement, étant donné la forte

Tableau II.—Etude comparative des captures realisées dans l'Ile du Prince par des capturateurs avec de la glu (méthode Maldonado) et par des pièges Morris dans le même endroit (Praia da Ribeira Izé)

Numéro du capturateur	h 18 mai (8,40 — 14,30)			Numéro du piège	Jours du mois de mai					
					10 (Du lever au coucher du soleil)			20 (Du lever au coucher du soleil)		
	♂	♀	♂ ♀		♂	♀	♂ ♀	♂	♀	♂ ♀
1 . .	1	1	2	1 .	3	1	4	0	0	0
2 . .	1	2	3	2 .	2	1	3	1	0	1
3 . .	1	3	4	3 .	15	12	27	20	13	33
4 . .	1	3	4	4 .	8	11	19	9	8	17
5 . .	0	0	0	5 .	18	21	39	24	15	39
6 . .	2	1	3	6 .	3	0	3	2	2	4
7 . .	1	0	1	7 .	10	6	16	24	25	49
8 . .	1	0	1	8 .	6	10	16	9	3	12
9 . .	0	1	1	9 .	23	23	46	4	12	16
Total . .	8	11	19	Total.	88	85	173	93	78	171

Tableau III.—Essais comparatifs de plusieurs types de pièges Morris installés au même endroit (Praia da Ribeira Izé)

	Numéro du piège	Mai													Juin			
		19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4
PIÈGE MORRIS :																		
Peau de bœuf :																		
Avec porc (*a, c*)	10	16	30	22	25	16	30	17	Pas de Récolte	26	29	17	9	10	18	11	7	10
Pas de porc (*a*)	8	16	12	19	25	7	9	4		11	8	12	15	4	0	0	8	0
Tissu de coton et peau de bœuf :																		
Avec porc (*a, c*)	5	39	39	22	25	21	16	9		5	6	5	1	2	3	1	1	0
Pas de porc	3	27	33	18	26	5	8	7		2	3	0	7	0	0	0	0	3
Tissu de coton en noir (*a*)	20	—	—	—	6 (*d*)	16	19	7		2	8	9	6	2	0	4	3	5
Simple (*b*)	18	—	—	—	5 (*d*)	6	5	0		3	3	1	1	0	0	1	3	2
Double (*a*)	19	—	—	—	15 (*d*)	0	0	2		1	3	6	2	0	0	2	2	1
PIÈGE HARRIS	1	8	2	2	3	2	0	2		0	2	1	1	0	1	1	0	0

(*a*) — Avec DDT le 25/5/1956.
(*b*) — Avec Gamexane le 25/5/1956.
(*c*) — Porc retiré l'après-midi du 28/5/1956.
(*d*) — Installés ce jour-là.

pluviosité, presque permanente, la grande densité de la végétation, le manque de sources alimentaires — car on n'y trouve pas de porcs en liberté, c'est-à-dire leur principale source alimentaire, comme c'est le cas dans les deux tiers nord.

Travaux réalisés — Le premier souci de la mission a été celui de faire des recherches sur l'existence de trypanosomiase humaine et animale. Dans ce but, toute la population a été examinée, soit au total 4.014 individus —, au point de vue clinique et de laboratoire. Aucune personne n'a été trouvée infectée.

En ce qui concerne les animaux, on a fait des recherches de trypanosomes sur 27 chevaux, 211 ânes, 17 mulets, 244 bœufs, 303 porcs, 44 ovins et 11 chiens ; les résultats ont tous été négatifs.

La dissection de 6.500 glossines, faite jusqu'au 17 août, n'a rapporté aucune infectée.

De ces résultats il ressortait que le problème des glossines était seulement entomologique, et nos travaux ont été orientés, en conséquence, dans ce sens. Dans ce but, nous avons étudié la distribution et l'incidence des glossines, et ensuite nous avons dressé le plan de lutte contre ces insectes.

Distribution et incidence des glossines — Nous avons effectué des études comparatives de quatre méthodes de capture de ces insectes : la méthode Maldonado (glu sur le dos des natifs), celle du " fly-boy ", celle du piège Morris avec plusieurs types de revêtement, et celle du piège Harris.

De toutes les méthodes, nous avons trouvé que la plus efficiente (tableau II) était celle des pièges Morris, avec revêtement de tissu noir (tableau III), et nous l'avons adoptée exclusivement.

Pour l'étude de l'incidence des glossines nous avons installé des groupes de 10/12 pièges aux endroits que nous voulions étudier, et, en divisant par 10 ou 12 le nombre capturé, nous avions ainsi ce que nous appelions le piège-jour ou le piège-semaine, selon que la référence était faite à la moyenne des glossines capturées pendant un jour ou pendant une semaine, par un piège du groupe.

Au moyen du piège-jour ou du piège-semaine nous pouvions aussi suivre l'évolution de la population glossinique de l'île, et contrôler ainsi les résultats des mesures adoptées pour la lutte contre ces insectes.

Le nombre de captures au début a permis aussi d'étudier les caractéristiques de la population glossinique lors de notre arrivée en envisageant la proportion des sexes, l'âge, l'état de nutrition et l'état de gestation. Nous en donnons un résumé dans les tableaux IV et V, en ajoutant seulement qu'il a toujours été difficile de trouver des pupes.

En ce qui concerne sa distribution, nous devons conclure qu'elle s'est superposée à celle de 1911–1914, avec la seule différence d'une descente légère vers le sud.

Comme complément à l'étude de la population glossinique il était fort convenable de déterminer aussi ses sources d'alimentation, et il était nécessaire, donc, d'identifier le sang contenu dans leur tube digestif.

Le nombre très limité de glossines capturées avec du sang vif dans leur tube digestif ne nous a pas permis d'effectuer cette étude d'une façon précise.

Considérant cependant la faune de l'île, nous sommes amenés à conclure que les porcs sauvages étaient leur principale source alimentaire, suivie immédiatement par les animaux domestiques.

Plan d'éradication des glossines — La distribution et l'incidence de glossines dans l'île ayant été étudiées, il était nécessaire de dresser un plan de lutte contre ces insectes dans le but d'atteindre leur éradication.

On vérifie ainsi que deux types de travaux se présentaient : ceux de préparation et ceux d'exécution.

Parmi les derniers nous avons considéré comme fondamentaux ceux qui concernent l'application d'insecticides, étant donné la sensibilité des glossines à ces produits et considérant la petitesse du territoire et son caractère insulaire.

Tableau IV.—Proportion de mâles et de femelles capturés par des pièges Morris en 1956 dans un même endroit de l'Ile du Prince (Uba-Belmonte)

	27/5 à 2/6	3/6 à 9/6	10/6 à 16/6	17/6 à 23/6	Total dans les 4 semaines
♂	902	868	457	921	3.148
♀	1.490	1.693	1.026	1.992	6.201
Indeterminés . .	4	15	—	117	136
Total . . .	2.396	2.576	1.483	3.030	9.485
Nombre de pièges .	12	12	12	12	
Indice piège/semaine	199,7	214,7	123,6	252,5	

Indice moyen piège/semaine . . 197,6
Indice moyen piège/jour . . 28,2

Tableau V.—Quelques aspects de la population glossinique dans l'Ile du Prince (17 mai au 15 juin 1956)

Sexes	Age (Classification de Jackson)							Nutrition (Classification de Jackson)					Gestation		
	1	2	3	4	5	6	Total	1	2	3	4	Total	En gestation	Pas de gestation	Total
♂ . .	39	32	23	29	3	23	149	2	8	61	215	286	—	—	—
♀ . .	27	15	27	46	13	64	192	10	58	223	129	420	446	1.183	1.629
Total . .	66	47	50	75	16	87	341	12	66	284	344	706	446	1.183	1.629

Les résultats obtenus par l'exécution du plan indiqué seront donnés dans une autre communication.

Considérations finales — En faisant une exposé sur les glossines dans l'île du Prince, nous ne pouvons pas passer outre sans présenter quelques considérations sur leur réapparition, ainsi que sur les moyens de lutte utilisés vis-à-vis de leur éradication.

Au sujet de la réapparition des glossines dans l'île, deux hypothèses se présentent à notre esprit: ou bien les glossines n'ont pas été tout à fait supprimées en 1911–1914, ou alors elles y ont été introduites après leur suppression pendant ladite période.

Nous croyons cependant que la plupart des arguments sont en faveur de l'opinion d'après laquelle les glossines ont été supprimées en 1914, parce que, après l'année indiquée, elles n'ont pas été retrouvées, quoique des recherches aient été faites spécialement dans ce sens, comme celles de Tams, entomologiste du Musée Britanique qui a visité l'île en 1943 sans y avoir trouvé de glossines, et celles de Sousa Santos qui n'en a pas non plus découvert en 1946.

En 1954 et 1955, des missions de zoologie de la Junta de Investigações do Ultramar n'ont pas, non plus, trouvé de glossines.

En admettant donc que les glossines aient été réintroduites dans l'île, nous devons considérer que l'hypothèse la plus probable sera celle de leur importation de Fernando Pó. En effet, après 1914 il y a eu, pendant des années, des communications maritimes entre Prince et Fernando Pó, où les glossines à l'heure actuelle persistent, et à partir de 1950 des communications aériennes régulières entre les deux îles ont été établies, sans aucune mesure spéciale de défense contre l'entrée de ces insectes, tout au moins au début.

De cette façon elles auraient pu être transportées par l'un ou par l'autre de ces moyens, mais plus probablement par avion, puisque le voyage ne dure que 1 heure 30. Il faut aussi admettre leur transport dans des pots à plantes sous la forme de pupes, puisque quelques plantes ont été apportées de Fernando Pó à l'Ile du Prince.

D'autres hypothèses ne sont pas à considérer, étant donné que, pratiquement, il n'y a pas d'autres communications entre l'Ile du Prince et des territoires où il y a des glossines.

En ce qui concerne la date de l'introduction des glossines dans l'île, il est difficile de faire une détermination exacte. D'après l'information verbale de quelques européens, les glossines existaient dans l'île depuis plus de 3 ans, mais comme on ne savait pas les identifier on ne faisait pas attention.

Cette affirmation est conforme aux déductions suivantes:

D'après les résultats de Geigy (1948), chaque femelle de *Glossina palpalis palpalis* pond de 6 à 10 larves, le nombre de 16, que l'on a constaté une fois, étant tout à fait exceptionnel. Comptant de 10 à 22 jours la période de gestation, et de 35 à 37 jours dans l'état de pupe, il y aura une période de 50 à 60 jours pour chaque génération, et, en conséquence, six générations par an. D'autre part, d'après les calculs de Thompson (1931) et un schéma de Buxton (1955), dans les conditions optima de développement et comptant 70 jours de vie pour les femelles, avec six générations, alternativement de mâles et femelles, à partir du 12ème jour de vie et dans des périodes successives de 10 jours, de la descendance d'une seule femelle subsisteront 9 femelles le 172ème jour, 10 le 178ème jour et 21 le 212ème jour; autrement dit: la population doublera en un mois environ et sera 21 fois plus nombreuse tous les 212 jours.

Théoriquement, de cette progression résulteraient, dans la meilleure des hyptothèses, 328 tsé-tsés à la fin d'un an, 86.127 dans deux ans, 14.294.353 dans trois ans, 85.766.121 dans trois ans at demi et 1.595.249.851 dans quatre ans.

En présence des captures effectuées, dont le total, en deux mois (du 17 mai au 17 juillet), a été de 66.894 glossines, et continuant ensuite dans le même rythme, nous pouvons, en principe, reculer au moins de trois ans ou trois ans et demi l'entrée probable de la *Glossina p. palpalis* dans l'Ile du Prince. Ce délai est conforme aux informations susmentionnées, et on peut admettre qu'une population glossinique de 21 tsé-tsés les premiers sept mois, ou encore de 328 tsé-tsés dispersées à la fin de la première année, n'a pas été suffisante pour attirer l'attention sur sa présence.

Le même calcul théorique, fait sans regarder ni la stabilisation de la population glossinique ni les fluctuations conséquences aux raisons climatologiques, limitations des sources alimentaires, intervention humaine, etc., donnerait, pour les 66.894 tsé-tsés capturées pendant les deux premiers mois de la Mission, 22 millions de mouches environ à la fin d'un an et, au delà 5 billions et demi en deux ans.

Quoi qu'il en soit, il semble que l'invasion de l'île par les glossines ait eu un aspect explosif, puisque nous avons été informés que, par exemple, lorsque, en mai 1955, il a été possible, à quelques européens, de faire un pique-nique à leur aise, sur la plage d'Izé, en avril 1956 les choses se sont passées autrement, car il a fallu fuir la plage, étant donné les piqûres insistantes des mouches dont on n'a su que plus tard qu'il s'agissait de glossines.

Par suite de nos observations nous pouvons arriver aux conclusions suivantes:

En ce qui concerne le plan de lutte établi et dont la réalisation sera considérée dans un autre travail, on constate qu'il nous a fallu être éclectiques et prendre en considération les particularités de l'île.

Ainsi, l'application d'insecticides par avion, qui aurait pu être envisagée, ne nous a pas semblé praticable, étant donné la densité de la végétation et aussi parce que l'on risquait de troubler l'équilibre biologique de l'île, d'autant plus que la dissémination du pollen du cacao — sa principale richesse — est faite par les insectes. Et il y avait encore la crainte de supprimer la coccinelle — *Criptognata nodiceps* Muls. — que l'on y avait introduite afin de lutter contre la cochenille *Aspidiotus destructor* Signt. Il fallait considérer, en outre, le cout très élevé d'une telle campagne.

On doit encore dire que, malgré la petitesse du territoire, l'exécution du plan établi a occasionné des difficultés considérables, en raison du manque de ressources locales, de la puissance de la végétation, du climat extraordinairement humide et de la grande pluviosité.

THE EXTERMINATION OF *GLOSSINA PALPALIS* ON THE KUJA-MIGORI RIVER SYSTEMS WITH THE USE OF INSECTICIDES

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INTRODUCTION

The object of this paper is to describe how *G. palpalis fuscipes* Newstead has been exterminated from a large tract of country without the costly and destructive effort of clearing the vegetation and without shooting a single game animal.

The technical and experimental work which led us to adopt insecticide spraying as a practical means of exterminating tsetse flies has been detailed by Symes *et al.* (1947), Woodcock (1949), Hocking and Yeo (1953), Burnett (1955) and others. We wish to stress the practical importance of applied ecology in problems of this kind.

It was the success of the Nyando River Basin Scheme (Wilson, 1953; Fairclough and Thomson, 1957) in Central Nyanza where *G. palpalis* was exterminated for the first time in Kenya from three hundred square miles of country, that led to the launching of a similar project in South Nyanza where there had been a bad endemic focus of the Gambian type of sleeping sickness for a long time (Nelson, 1956).

Between 1950 and 1954, 666 cases of human sleeping sickness were reported from South Nyanza and various methods of exterminating *G. palpalis fuscipes* Newstead were investigated. Symes and Vane (1937) had some success in hand catching these flies in small isolated patches of bush, but Glasgow and Duffy (1947) failed to achieve a significant reduction of numbers with this method in a larger, heavily infested, isolated block on the Upper Kuja river.

From 1948 to 1951, total clearing, coupled with discriminative clearing, was found to be very effective on the Kitere, Oyani and Migori rivers, but the cost of treating hundreds of miles of river in this way proved to be prohibitive (i.e. £200 to £300 per river mile). Moreover, there still remained the problem of settling the land and putting it to productive use after clearing.

However, in 1950, before the introduction of the present scheme, felling of bush for half a mile on each side of river crossings, adopted as an interim measure, afforded a certain amount of protection to the local inhabitants.

At the the end of 1952, the doctor at the Macalder Mines, which lie in the fork between the confluence of the Kuja and Migori rivers, requested our assistance in dealing with the high incidence of sleeping sickness amongst the mine workers. Consequently, between early January and the end of March, 1953, seven miles of the Kuja and fourteen miles of the Migori rivers were sprayed four times with Arkotine S.D. 18 (a 15% D.D.T. emulsion diluted with water to 5%) using " Four Oaks " shoulder sprayers along narrow paths cut on both banks, as near to the water as possible.

The number of *G. palpalis* caught on this length of river in the month before spraying began was 4,651. After the first spraying, 1,821 flies were caught, 560 after the second, 132 after the third and 16 after the fourth. Although the areas treated were farily well isolated at either end by the anti-tsetse clearings made in the past, the fly numbers began to build up again gradually, until in August 1953, 362 were caught over the twenty-one miles which had been sprayed. The cost of this was £31 per river mile, excluding staff wages and transport.

Subsequently a plan was put forward to the Provincial Team for the clearance of 65 miles of the Kuja and Migori rivers and fourteen miles on the Lake shore at an estimated cost of £10,000. This proposal was never implemented owing to shortage of labour and the reluctance of the local people to settle the cleared areas.

In 1954, a certain amount of slashing of *Papyrus* and reeds at the mouth of the Kuja river was carried out and the scheme described below was put into operation in collaboration with the Medical Department and financed partly by funds from the U.S.A. International Co-operation Administration (I.C.A.).

MATERIALS AND METHODS

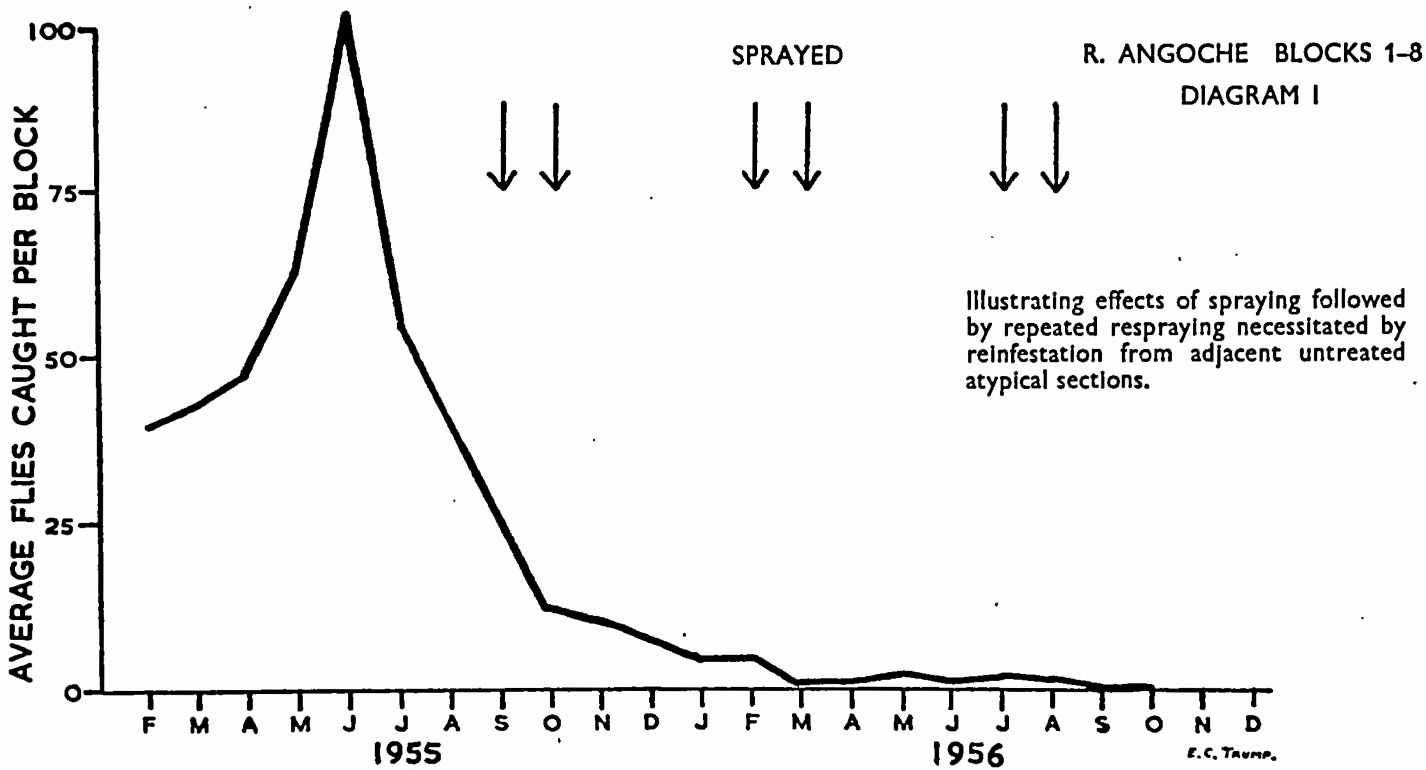
This scheme was designed to exterminate *G. palpalis* from about two hundred and fifty miles of the Kuja and Migori rivers and their tributaries, an area extending from the mouth of the Kuja river on Lake Victoria to Migori in the east and from the tributaries Angoche and Ondoiche on the Tanganyika border in the south, to the Kabwoch forest on the Upper Kuja in the north. Thus more than nine hundred square miles of country would be freed from human and animal trypanosomiasis. This was to be achieved by a combination of spraying with insecticides and the creation of cleared " barriers " to prevent re-infestation. It would take approximately three years to complete and would cost about £32,000.

Work was to proceed according to the following programme:

Phase 1. Eradication of *G. palpalis* from the lake shore, Kuja flood area and the Kuja river up to the Ong'er river by means of a combination of bush clearing and spraying, to render the area fly-free and to serve as an effective barrier to re-infestation of the upper Kuja–Migori system on completion of Phase 5.

Phase 2. Spraying the Angoche river and its fly infested tributaries, for some 30 miles.

Phase 3. Spraying of the Munyu river and its tributaries for about 18 miles.



R. ANGOCHE BLOCKS 1–8
DIAGRAM I
SPRAYED
Illustrating effects of spraying followed by repeated respraying necessitated by reinfestation from adjacent untreated atypical sections.
AVERAGE FLIES CAUGHT PER BLOCK
100
75
50
25
0
F M A M J J A S O N D J F M A M J J A S O N D
1955
1956
E.C. TRUMP.

333

Phase 4. Bush clearing two tributaries to the east of Migori township on the Migori river.

Phase 5. Spraying the remaining areas of the Kuja and Migori rivers and their tributaries, about 150 miles.

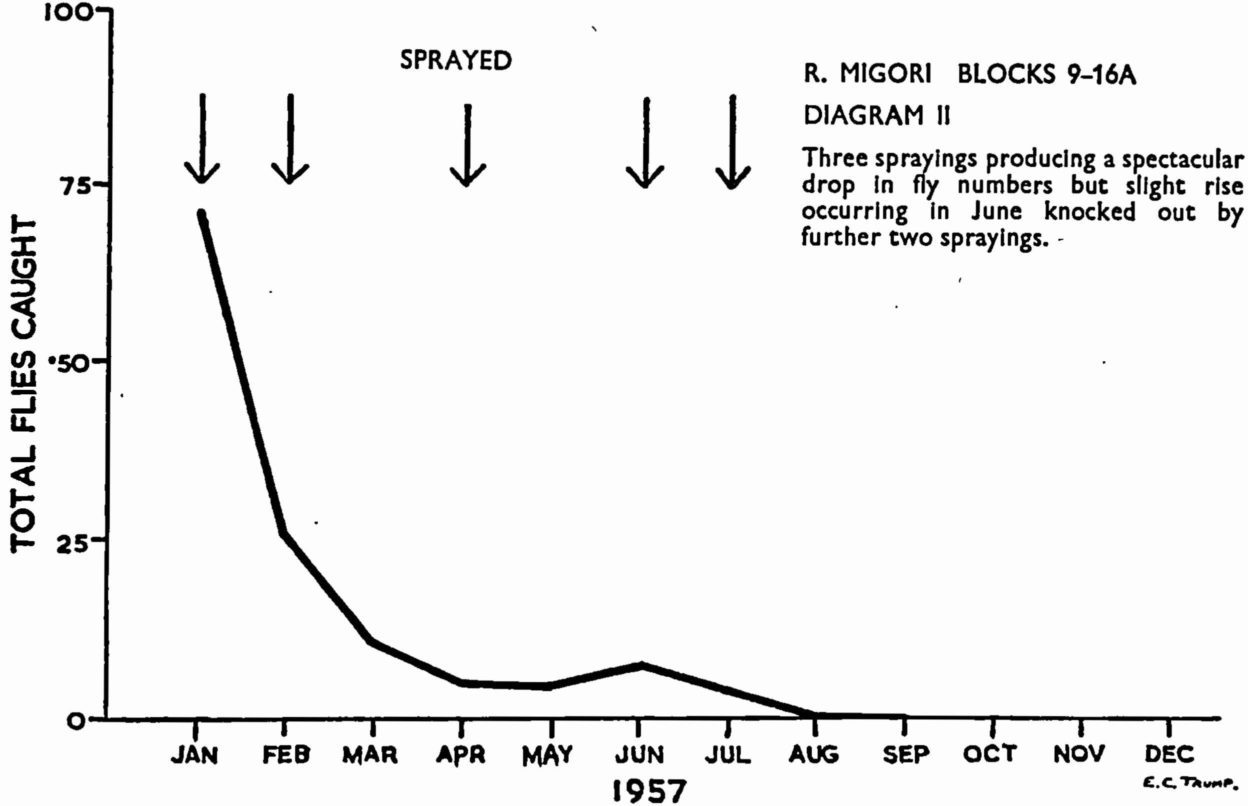
Phase 6. Bush clearing of the Nyamaririya, Nyamanethe and Ebua rivers and of the Migori river upstream from Migori township to its confluence with the Ebua. This phase had a dual purpose: firstly to control sleeping sickness, primarily on the Ebua, which is the limit of *G. pallidipes* infestation, and secondly to prevent the possible advance of *G. pallidipes* from the east. By clearing all these tributaries of the Migori river and thereby creating a barrier, the encroachment by *G. pallidipes* into the sprayed areas would be prevented.

Initially, different makes of pressure pumps with lances four to five feet long were used and various types of nozzles were tested. The "Eclipse" sprayer fitted with a lance that gives a fan-shaped spray proved to be the strongest and most efficient, despite being a little more expensive than some other types (it costs about £17) and it needs pumping up only once each time the container is filled with insecticide. The vegetation on both sides of a path for about 500 yards can be sprayed with one filling and the container holds three gallons.

The method of applying the insecticide consists in the operators walking along the paths at about two miles an hour slowly moving the spray lances up and down from ground level to about five feet and ensuring that the spray falls evenly on the leaves and stems of the plants. Two operators work on one path, one on one side and one on the other.

In 1956 a new type of portable petrol-driven, mechanical mist-blower, known as the "Kiekens Dekker", was tested. This is carried on the back with shoulder straps and weighs about thirty pounds. The insecticide containers are carried on the chest of the operator. They hold half a gallon of insecticide and are detachable, so that refills can be fitted in a few minutes. This machine proved to be very efficient. It produces a mist which is blasted into the undergrowth, providing an even cover of insecticide on the leaves and stems and penetrating very deeply into the undergrowth. It uses about the same quantity of insecticide as the "Eclipse" sprayer and costs £80. From the middle of 1956 onwards both "Eclipse" sprayers and "Kiekens Dekkers" were used on this scheme.

In the "Phase 1" operations begun in 1955, a Shell Chemicals' product known as "Arkotine S.D. 18", a 15% D.D.T. emulsion diluted to 5% with water (mentioned above), was applied to the vegetation along paths cut on both banks of the infested rivers at fortnightly intervals, the method used earlier on the Nyando River Basin Scheme (Fairclough and Thomson, 1957). Each river was demarcated into spraying "blocks", one mile or more in length. It was therefore possible to return to exactly the same areas for each spraying, and also to relate the fly catches to them.


SPRAYED
R. MIGORI BLOCKS 9-16A
DIAGRAM II
Three sprayings producing a spectacular drop in fly numbers but slight rise occurring in June knocked out by further two sprayings.
TOTAL FLIES CAUGHT
100
75
·50
25
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1957
E.C. TRUMP.

In November 1955 a new Shell Chemicals' product, " Dieldrex 15 ", was tested in collaboration with the Colonial Pesticides Research Unit (Burnett *et al.*, 1957).

The results of these tests were so promising that, on the advice of the C.P.R.U., " Arkotine " was replaced by " Dieldrex 15 ", despite the latter's cost of Shs. 52/50 against only Shs. 18/50 for " Arkotine ". Experiments had shown that, under field conditions, after nineteen days at a dilution of 1·8% " Dieldrex 15 " still had a 90% kill. The actual cost of the spray at this dilution, therefore, worked out slightly in favour of Dieldrex and, moreover, the interval between sprayings could be increased to three weeks. From the beginning of 1956 onwards, " Dieldrex 15 " was used exclusively on this scheme.

G. palpalis lives only on the lake shore and in riverine vegetation. Upon this practical ecological fact this work is based.

On the rivers (except for the Kabwoch forest on the Upper Kuja), the vegetation in which *G. palpalis* occurs is seldom more than sixty yards wide on either bank. Work on the Nyando River Basin had shown that all that was necessary, therefore, was to cut a path on either bank as near to the water's edge as possible and of sufficient width to walk along with a spraying machine. Whenever the width of the vegetation exceeded sixty yards, further paths had to be cut at sixty-yard intervals.

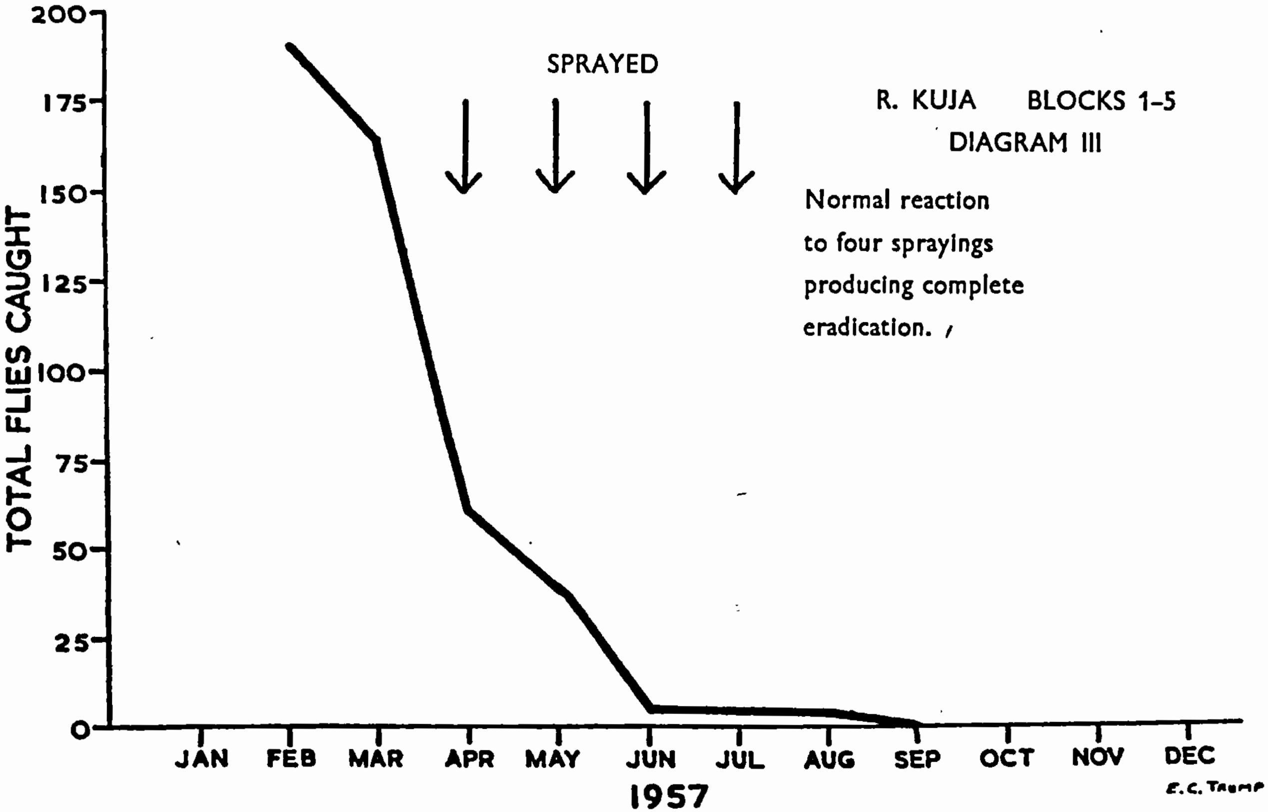
The vegetation on the river banks consists of large trees up to sixty feet high, such as *Ficus* spp., with an undergrowth of shrubs up to about fifteen feet, amongst which *Grewia*, *Allophylus* and *Haplocoelum* are common.

On the lake shore and in the mouth of the Kuja river, there are wide zones of *Papyrus* and reeds backed by " Ambach " (*Aeschynomene elephroxylon*) and *Sesbania*. *G. palpalis* does not live in these zones but disperses into them from its true home in the other vegetation types nearby. The " ambach " had therefore to be removed and the reeds slashed in the mouth of the Kuja river and for some distance on either side of it, as a precautionary measure.

RESULTS

A certain amount of slashing of *Papyrus* and reeds was carried out in 1954 in the mouth of the Kuja river but progress in the first half of 1955 was disappointing, owing to shortage of staff. Nevertheless, routine fly rounds were established and maintained in the areas to be treated and a small force of labourers was engaged on clearing the lake shore near the mouth of the Kuja river.

From August onwards, however, progress so improved that, by the end of December, 2,300 acres of lake shore had been cleared to three miles south of the mouth of the Kuja river and half a mile north of it. In addition to this, the *Papyrus* and reeds in the swamps between Got Achola and


200
175
150
125
100
75
50
25
0
TOTAL FLIES CAUGHT
SPRAYED
R. KUJA BLOCKS 1-5
DIAGRAM III
Normal reaction
to four sprayings
producing complete
eradication.
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1957

Kabwana (two hills near the Kuja mouth) had been slashed and burnt. The banks of the Kuja river had been cleared for three miles up from its mouth and the undergrowth removed around the foothills of Got Achola and Kabwana. This amounted to a further 1,676 acres cleared, so that the total " Phase 1 " clearing done in 1955 was 3,976 acres. The local inhabitants were encouraged to burn and cultivate the cleared areas. The first section of spraying was completed by the end of October and by the end of the year no *G. palpalis* had been caught in many of the treated blocks for three months.

During " Phase 2 " operations in February and March of 1956, the entire Angoche system, covering some sixty odd linear miles, was treated twice with 5% Dieldrex at intervals of one month, in an endeavour to make quite sure that all the flies were killed. The Munyu river system was treated only once during that time, owing to a delay in the delivery of insecticide.

The effect on the Angoche was not as good as had been anticipated although no flies were caught on the lower part of the river after the second treatment with 5% Dieldrex, but along the upper reaches of the river occasional flies still occurred. The significance of this was not immediately appreciated and it was thought that the two applications of 5% Dieldrex within a month of one another had not allowed sufficient time to cover all successive pupal emergences.

Shortly afterwards, however, *G. palpalis* were found in some quite atypical places, adjacent to the sprayed areas on very small drainage lines with hardly any vegetation in them and no standing water. These proved to be the sources of re-infestation. This discovery emphasised the importance of continuous, intensive survey. A two-mile clearing was immediately made by slashing down the bush on the lower part of the Angoche to prevent dispersal of fly up this river from its confluence on the lower Kuja.

New supplies of insecticides became available and spraying was resumed in July and August on the Munyu and the upper parts of the Angoche river, again using two applications of 1·8% Dieldrex at intervals of one month. The effect was immediate and the fly numbers dropped to nil, though a few tsetses were still taken in localised spots, until in November no more were caught.

This proved that a strength of 1·8% Dieldrex applied at intervals of one month was effective against *G. palpalis*. It should be noted here that " Phases 2 " and " 3 " were proving much more formidable propositions than was at first anticipated and subsequent intensive surveys revealed small pockets of fly in many hitherto unsuspected places, even penetrating to a few miles south of the Tanganyika border on the Ondoiche river.

In addition to the " Phase 2 " and " Phase 3 " operations on the Angoche and Munyu river systems, " Phase 1 " spraying was undertaken

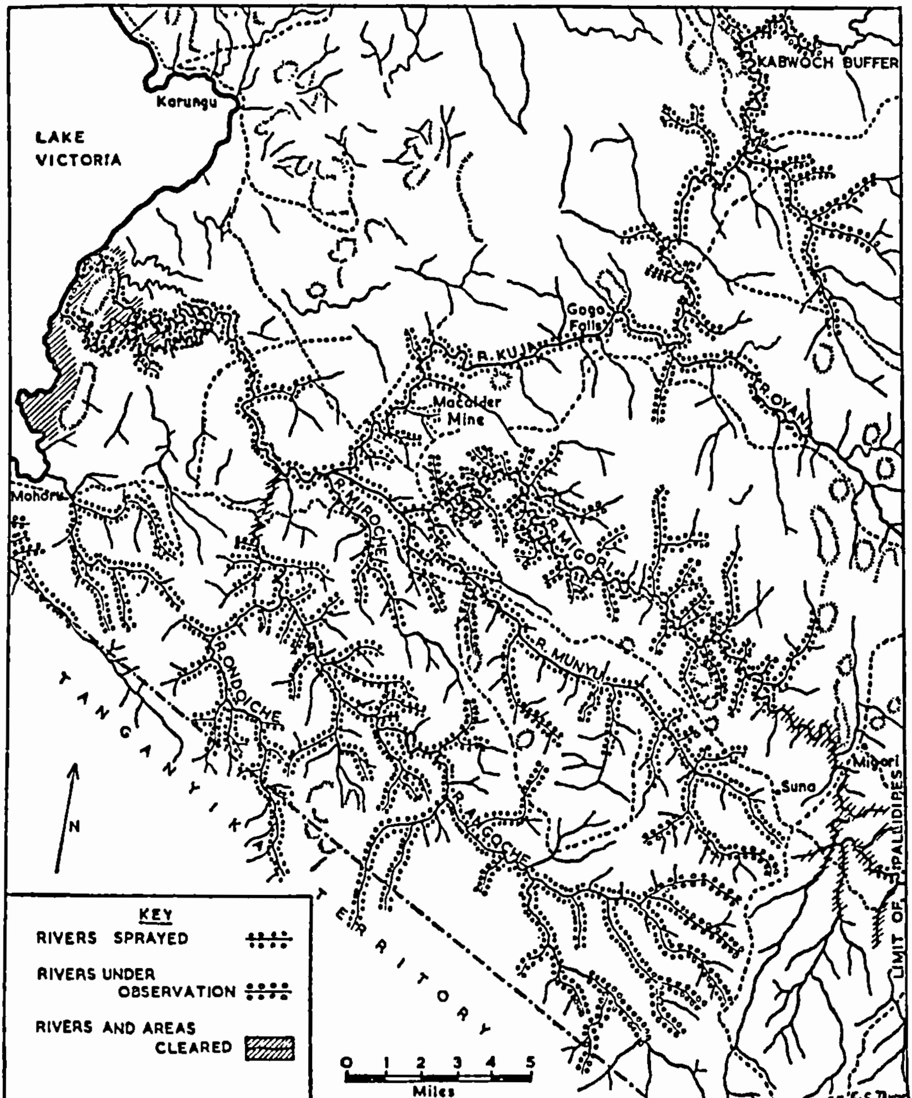


DIAGRAM IV MAP OF KUJA—MIGORI AREA

from October onwards on the lower sections of the Kuja river. Part of this work had to be done from a canoe, as it was impossible to cut paths on the northern bank. This was carried out at three weekly intervals with 1·8% Dieldrex. Also, where the area covered by reeds in the Kuja delta near its mouth was very wide, paths had to be cut and sprayed at sixty-yard intervals, before the last fly could be exterminated.

Little bush clearing was done in the first half of 1956 but in the latter half of the year 5·5 miles (240 acres) of riverine vegetation was felled on the Migori river below Migori township bridge (Phase 4).

During 1957, the spraying operations outlined in "Phases 1" and "5" were completed as far as the Kabwoch forest on the Kuja river in the north and up to the Migori clearings to the west. The use of 1·8% Dieldrex at three-weekly intervals was continued, but wherever pockets of fly reappeared after the third application or in the extreme upper reaches of tributaries, a "knock-out" dose of 5% Dieldrex was administered.

After October 1957, no more flies were caught on any of the 300-odd linear miles of river ultimately included in "Phases 1" to "6". The "Phase 6" clearings were completed by the end of December, 1957. These included the Migori river west of Migori township and five of its tributaries, a total length of 16·5 miles at an average width of sixty yards on both banks (720 acres).

Up to June 1958, continuous weekly patrols covered all the areas treated. One more *G. palpalis* was caught on the Omicha river, a small tributary of the Lower Kuja, in February but no more were taken after that time.

As an added precaution a "buffer" block was made at the southern end of the Kabwoch forest. This is sprayed every three months with 5% Dieldrex to prevent the movement of fly down the Kuja river. The tsetse population in the Kabwoch forest is, however, so large that one or two flies penetrate through the "buffer" from time to time into Block 10, adjacent to it. It is consequently necessary to re-spray this block frequently, i.e. every time flies are found in it.

Light infestations of *G. palpalis* were found on the Rayhudi, Tito and Rutienye, which are small drainage lines running into the Lake on either side of the Muhoru peninsula. These were treated in 1957, but as a reinforcement, the clearings have been extended along the shore on either side of the peninsula.

After the operations described above were completed, surveys revealed that *G. palpalis* still extended up the Migori river and its tributaries from the "Phase 6" clearings at the confluence of the Ebua river to Lolgorien, a distance of about fifty miles (including tributaries). *G. pallidipes* also occurs here, whilst on the Kuja river there are very heavy infestations of *G. palpalis* and *G. brevipalpis* in the Kabwoch forest for about seven miles upstream. Small pockets of *G. palpalis* are still to be found for about thirty miles on the Oyani and Sari rivers, which flow into the Kuja.

CONCLUSION

This scheme up to date has cost £38,100.

G. palpalis has been exterminated from more than 300 miles of river at an average cost of £120 per mile which includes the expenses of bush clearing and insecticides, vehicles and wages. The average cost of bush clearing in the "barriers" was £150 per river mile. In the denser areas it cost £200 to £300 per mile.

The total amount of undiluted insecticide used, including Arkotine, was 4,055 gallons, the price of which was £10,644 7 – 50 cts. The average cost of "Dieldrex 15" per application per mile was 2 × Shs. 52/50 at 1·8% concentration and 2 × Shs. 151/50 at 5%. Arkotine at 5% cost 2 × Shs. 61/60 per application per mile when both banks of the river were sprayed.

The average quantity of insecticide used per application was 2 × 10 gallons per mile (i.e. 10 gallons on either bank). The average cost of three applications of "Dieldrex 15", including the cutting of spraying paths, was £60 per river mile.

The most important fact which has emerged from the work on the Nyando river and the Kuja-Migori scheme is that *G. palpalis* can be exterminated from riverine vegetation in Nyanza much more cheaply by the application of insecticides than by any other method. This is contingent, however, upon the whole area being treated and re-infestation made impossible.

Table I below shows the number of human trypanosomiasis cases treated in South Nyanza from 1950 to 1957. It will be seen that there is a marked reduction in numbers from 1955 onwards, and a slight rise again in 1957. These figures are for the whole of South Nyanza but the incidence of human trypanosomiasis outside the Kuja–Migori area is very small so that they do really show the effect of the insecticide-spraying on the rivers. The slight rise in the number of cases in 1957 is partly due to old chronic infections not previously located. (All the information regarding the incidence of human sleeping sickness in South Nyanza has kindly been supplied by the Kenya Medical Department.)

Table I.

Year	*Cases*
1950	157
1951	107
1952	133
1953	124
1954	145
1955	66
1956	16
1957	21

Table II shows the number of cases treated from 1954 to 1957 in West Konyango, which is a location within the treated part of the Kuja–Migori area. Here, a similar drop occurs in 1955 and there is a corresponding slight rise in 1957.

Table II.

	1951	*1952*	*1953*	*1954*	*1955*	*1956*	*1957*
West Konyango	25	34	26	50	16	2	5

SUMMARY

G. palpalis fuscipes Newstead has been exterminated from more than 300 miles of the Kuja and Migori river systems, an area in South Nyanza in which periodic epidemics of sleeping sickness have occurred. The operation described above began in 1955.

In the first phases of the operation conducted in 1955, a Shell Chemicals' product, "Arkotine S.D. 18" (15% D.D.T.), diluted with water to 5% was applied four times to paths cut on both banks of the rivers at fortnightly intervals by means of knapsack sprayers. From January 1956 onwards, however, "Dieldrex 15" (an 18% Dieldrin emulsion) diluted to 1·8% with water, applied three times at three-weekly intervals, was used. Wherever re-infestation occurred, 5% Dieldrix was again applied.

By October 1957 only three *G. palpalis* were caught along more than three hundred miles of river and by the end of June 1958 one further fly was taken in the area lying within the scope of the present scheme.

Costs, including staff salaries, labour and transport, have worked out at about £120 per river mile. The average cost of bush-clearing to provide protective barriers to re-infestation was £150 per mile, whilst that for insecticides (including cutting paths) averaged £60 per mile.

There was a spectacular reduction in the number of cases of human trypanosomiasis treated in 1955, with a further considerable drop in 1956 and a slight, but insignificant, rise again in 1957.

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THE REARING OF *GLOSSINA PALPALIS* IN THE LABORATORY FOR EXPERIMENTAL WORK

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It has been known for many years that the easiest way to breed *Glossina* spp. is to keep each fly separately in a glass tube, covered with mosquito netting through which the tsetse can feed. Whilst this method is adequate for the scientist wanting to breed a few flies for his own use, it is quite inadequate for supplying the heavy demands of a research institute: if the tubes are bound into groups of ten, and the flies are given fifteen minutes to feed, one man will not be able to cope with more than forty flies an hour; then there is the initial labour of tubing the flies, followed by the periodic transfer of the flies to clean tubes. Since we have to keep a total stock which varies from 3,500 to 8,000 flies, the tube method would be quite impracticable.

In 1950, when the buildings of this Institute were sufficiently advanced, attention was immediately focused on methods of producing sufficient pupae at all times of the year, to provide uninfected flies for the research workers. Since for seven or eight months of each year the soil is too wet to enable pupae to be found in bush, and for six or seven months of the year the fly population is too low to permit of catching appreciable numbers of females for breeding purposes, it was clear that an uninterrupted supply of pupae could only be provided by devising a method of breeding flies on a scale adequate to keep the Institute going, even when field material is virtually unobtainable.

Glossina palpalis was the species selected because much data had already been collected in the field on its climatic requirements (Nash and Page, 1953), and also because Geigy (1948) had described a successful method for breeding this species on a large scale.

In October 1950 we put the Geigy method into operation and followed it in almost every detail, but were unable to keep the temperature constant at 26° C. with relative humidity at 85%. (Such control is not easy when the ambient temperature can range from 10° C. to 39° C. and the relative humidity from 15 to 98%.)

As a measure of reproductive efficiency we devised the unit Pupae per Female per Month (P.F.M.), care being taken to exclude in the calculation all females that were too young to have been able to produce a pupa before the end of the month. With the Geigy method, even when the mean monthly temperature was about 26° C., we failed to get a figure of over 1·4 P.F.M.

By the end of 1951 we found that guinea pigs, as used in Geigy's method, were not nearly such good hosts for *G. palpalis* as goats; if the flies were fed on goats, female longevity, reproduction rate and pupal weight were all increased. We also found that following the Geigy technique of placing six young males and eight young females together in a cage, about one-quarter were still virgin after fifteen days; the subject of fertilisation was then investigated by Nash (1955), and later Jordan (1958) studied the mating behaviour of the female.

Eventually we devised the following technique:

Housing

The flies are kept and fed in a room that is 12·2 × 6·1 × 4·0 metres high. The tsetse are kept in Bruce boxes, internal measurements 15·5 × 8 × 5 cm.; cotton mosquito-netting is used for the side panels instead of wire gauze, lest the fly's proboscis be damaged during feeding, by the goat struggling. Twenty Bruce boxes are kept standing upright, in a white-painted wooden tray; such trays are kept in racks, made of angle iron, and covered in hessian.

N.B.—Owing to a plague of earwigs (*Marava arachidis*), all wooden cupboards and shelving with their concommitant cracks and crevices have been done away with. (W.A.I.T.R. Ann. Rep., 1956).

Climatic Control

One of the big difficulties in breeding *G. palpalis* is to maintain the temperature as near the upper safe limit as possible, so as to get the maximum reproduction rate without reducing longevity excessively; 25–26° C. is believed to be the ideal, but we suspect that a certain amount of diurnal fluctuation may be beneficial, with the temperature falling to about 23° C. for a short time each night. On very hot days, when the ambient temperature rises to 35° C. or over, the situation is critical as, if the fly-room temperature rises above 28·3° C., a very heavy mortality will result. We believe that relative humidities fluctuating between 75 and 85% are optimal.

The fly-room is ventilated by means of an intake fan which sucks fresh air through a charcoal screen; by wetting the charcoal, the air can be humidified and cooled; there is an exhaust fan at the other end of the room. To supplement the humidifying action of the wet charcoal screen, or to replace it when cooling is not required, a controlled humidifier of our own devising is used: a simple atomiser automatically sprays the room with a fine water mist, whenever the relative humidity falls below 75% (Kitchen and Gall, 1953). Further cooling and humidifying can be produced by spraying the hessian rack-covers with water. If the temperature falls below 25° C., convection heaters are automatically switched on.

Combinations of such methods enable us to achieve a considerable degree of climatic control; however, our problem occurs on very hot days when in an endeavour to keep the temperature down we are forced to wet the sacking cupboards, thus producing excessively high humidity under conditions of high temperature—a combination which is believed to be very unfavourable to the fly.

We have now partitioned off the end of the room where the flies are housed, and plan to experiment with a household air-conditioning plant. This will reduce the temperature, but as it will also lower the humidity, we shall have to replace the moisture with our controlled humidifier; this should assist the plant by evaporative cooling.

Pupal Maintenance

The pupae are kept in 1-lb. jam jars whose bottoms have been cut off, thus making a container which is 8½ cm. high and 7 cm. in diameter. The top of the container is covered with fine filter-cloth made from spun rayon, which is kept in place with a rubber band which fits snugly into the neck-groove of such jars; this material is used because its loose weave permits ventilation, but would keep out the pupal parasite *Syntomosphyrum glossinae*, should it ever gain access to the fly-room. The bottom opening of the jar is also covered with this material which is attached with carpenter's glue and reinforced with a band of adhesive plaster: dry sand is poured in to a depth of 1·5 cm. and the pupae are placed on top.

These containers are kept in mating cages, which will be described later, but they have a perforated zinc floor, 7 cm. below which is a tray of wet sand which slides into the bottom of the cage. The very humid air above the sand percolates up through the loosely woven material into the dry sand in the bottom of the jars, so that the pupae are kept at a very high humidity without ever becoming wet.

Only 200 pupae are kept in each jar; it has been found that when very large numbers are kept in one container, many of the emergent flies are crippled—possibly this is due to lack of oxygen and to a high concentration of carbon dioxide forming within a jar, under conditions of very still air.

Undoubtedly, the method of pupal maintenance described above is outstandingly efficient. During the last twelve months the emergence rate from 33,000 fly-room bred pupae was 94%.

Mating Technique

It has been found that female *G. palpalis* are most willing to mate on the 3rd day of life, and that males are not fully potent until seven days old. Mating is undertaken in a special cage, 31 × 31 × 31 cm., which has a glass top and mosquito-gauze sides: including the space for the tray of wet sand, the cage stands 40·5 cm. high. Up to fifty, three-day-old females are placed in the cage with twice as many potent males. The cage is left in fair light on a table in the fly-room for the first five hours when most mating occurs, and for a further nineteen hours in one of the covered racks, where the light intensity is very low. By the end of twenty-four hours, tests show that a fertilisation rate of about 84% is achieved.

At the end of the mating period twenty " fertilised " females are placed in each Bruce box, and five seven-day-old males are added; this is the routine method employed. By dissecting samples, taken at random from the breeding cupboards on the sixteenth day of female life, it was found that 88% of the females were fertilised (Nash, 1955).

To facilitate this technique, the current pupal jars are opened daily in a mating cage and the newly emerged tsetse allowed to fly out. They are then caught singly in a tube; the females are liberated in a small cage without ever having been touched by hand, but all the males are marked with red oil paint, and housed separately. (Marking of the males facilitates separation of the sexes, after the twenty-four hour mating period.) The females are kept in a " virgin female " rack, on shelves marked 1, 2 and 3, the batches of cages being moved up one shelf each day until they have reached 3, when they are old enough for mating; similarly, males are kept in compartments in a " virgin male " rack, the batches being moved up one place each day until they reach the 7th compartment, when being seven days old they are transferred to the " stud-male " rack.

After completion of the mating period, all unmarked flies, i.e. females, are housed in Bruce boxes, and transferred to the " fertilised-female " rack; the marked males are returned to the " stud-male " rack. (There is rarely a surplus of males; large numbers are required for mating, and frequent handling reduces longevity.)

At short intervals, trays holding twenty Bruce boxes are made up, carrying initially 400 females and 100 males; at the end of 100 days, any survivors are destroyed as it has been found that the female reproduction rate decreases with age (Nash, 1955).

Fly Feeding Technique

Originally feeding was undertaken in a room lacking all climatic control, but it was found that it was much better if the tsetse were fed in the fly-room and not exposed to a sudden change of climate. Should the fly-room temperature have dropped in the early mornings of very cold weather, feeding is postponed until the temperature reaches 24° C.; in the very hot, dry weather, feeding starts before dawn, so as to get the boxes back into the racks before the temperature becomes too high.

We keep a stock of eighty goats for fly-feeding. Such a large number is needed because it has been found that unless the goats are used for only one week, and rested for two, their flanks become oedematous and many tsetse fail to feed. (Time after time we found that abnormal mortality could be reduced by a change of goat.) The flanks are never shaved as this leads to a hard, scaly dry skin, but sometimes the hair has to be reduced in length with scissors.

Small boys sit with their backs against the wall and their legs astride the recumbent goats; a block of four Bruce boxes is laid on each goat's side, and kept in position by a cloth; the cloth which covers the boxes has tapes which are tied round the goat. The boys place their hands on top of the boxes to keep them tightly down. Each block of boxes is left *in situ* for fifteen minutes; it follows, therefore, that if the boxes have been newly made up, a boy will be feeding up to 400 flies an hour. On one day all the goats' heads will be facing towards the right, exposing the left flank, and on the next day to the left; each flank is thus utilised on only three alternate days, before a rest period becomes due.

All flies are given a chance to feed every day, except Sunday; on this day only the newly emerged flies are fed. We tried feeding flies on alternate days, but gave it up when we found that the pupae from such flies were appreciably lighter than those obtained from flies fed daily.

Goat Maintenance

The goats are given a good diet of native foodstuffs to which is added mineral mixture; when they are not being used, they are daily herded in the open.

The goats' flanks are rubbed with lanolin on four occasions during the fortnight's rest period, when they are also dipped twice in an arsenical solution, free of all residual insecticides: they are well washed the day before the commencement of the next feeding period. The animals are wormed with phenothiamine at six-weekly intervals, at the beginning of a rest period.

Provided the above routine is followed, the goats keep in good condition despite the fly-feeding; some of them have been acting as blood donors for five years. Examination of haemoglobin and serum protein gave average values that were in no way inferior to those found in control village goats. Since this degree of fly-feeding does not result in anaemia, there can be no malnutrition in our flies due to this factor. (W.A.I.T.R. Ann. Rep., 1956).

On purchase, a beast is first examined for trypanosomes; if positive it is discarded, but even if negative it is treated with antrycide: the blood of each beast being used for fly-feeding is also examined daily before feeding starts. Such precautions are necessary, as on one occasion we got an infection in our fly colony and had to start building up a new one. Now each tray has its own three goats, one for each week of duty, so that should an infection ever arise it would mean sacrificing only that tray of flies.

Daily Maintenance of the Fertilised Female Stock

Daily, Sundays excepted, dead flies and pupae are removed from all Bruce boxes, by manipulation through the hole so that they fall on to mosquito-netting loosely stretched across a bowl; this prevents any jarring of the pupae, which are subsequently handled with teaspoons, and not by fingers. The numbers of dead flies are entered on special forms, as are the number of additions to stock provided by females that have just completed their mating period. At the end of the day's work, a balance is struck showing the final stock.

Experience has shown that, provided the daily mortality is below 2%, the stock is doing very well. This daily mortality figure is most valuable, as when figures of 3% or even 4% are recorded on several consecutive days, one knows that something is radically wrong. The mean mortality last year was 2·4% per day among the fertilised female stock, all of which is over four days old.

Disinfection of Boxes

The Bruce boxes are disinfected at about three-monthly intervals. They are soaked for twenty-four hours in a 1% solution of Centrimide B.P. and then for twenty-four hours in clean water; they are then hosed out, sun dried, and finally autoclaved. Centrimide has detergent, as well as bactericidal, properties and so loosens deposits of excrement; it also has no persistent smell.

EFFECTIVENESS OF THE METHOD DESCRIBED

The method employed for the mass breeding of *G. palpalis* has been described in some detail because we have undoubtedly made great advances over the last seven years. For example, the P.F.M. figure for the last eight months averaged 2·05, and ranged from 1·89 to 2·13, whereas the best monthly figure we ever got with the Geigy method was 1·4. However, we are still far from satisfied with our results.

Any method intended to supply sufficient pupae for a research institute's needs must be highly efficient, and undertaken on a large scale, as the following theoretical considerations will show.

When dealing with the tsetse which reproduces so slowly, there can be no hope of having an appreciable surplus of pupae unless the maximum rate of three pupae per female per month can be approached, i.e. each female on reaching the productive age, continues to larviposit at ten-day intervals.

We have found that when the mean maintenance temperature is 25·6° C. and mating is undertaken on the third day of female life, pupal production among a large batch of flies does not really start until the females are sixteen days old. The first two pupae produced by a female will certainly be needed to maintain stock, and if allowance is made for pupal mortality, failure to mate, infantile mortality, etc., it would be wiser to reserve the first three pupae for this purpose. If this is agreed, it follows that only females which have survived $16 + 10 + 10 + 10 = 46$ days can produce a surplus pupa which can be given away for research. Hence considerable longevity, as well as regularity of pupal production, is essential. Since Nash and Page (1953) found that even when *G. palpalis* were kept in separate tubes in the stream-bed, one-third were dead by the fortieth day, it is clear that a large stock would have to be kept for sufficient flies, forty-six days or older, to be available to pay a dividend.

With the installation of an air-conditioning plant we may get nearer the dual objective of long life and regular larviposition; however, there are probably other factors which could be important but are not readily reproducible, e.g. changes in blood source, satisfaction of hunger when stimulus arises, sunshine and flight.

It must be stressed that in our investigations priority has had to be given to supplying the Institute with uninfected healthy young flies or laboratory-bred unparasitised pupae. The obligation to supply the Institute, and many other workers, has been met, but its fulfilment has dictated both the nature and scope of the work, and has prevented undivided attention being given to the maintenance of a **self-contained** colony.

It is part of our policy to bring new blood into the breeding stock throughout the year lest we produce an atypical strain of tsetse which might give false results in, for example, transmission experiments. Nevertheless, it must be admitted that annual demands ranging from 8,000 to 13,000 laboratory-bred flies or pupae could never be met, unless we supplemented our own resources with much material which originated in the field.

The fly-room stock of fertilised females has its origin in the following three sources:

(*a*) From virgin females that were bred in the fly-room.

(*b*) From virgin females that emerged from pupae deposited by wild females captured in the field.

(*c*) From virgin females that emerged from pupae collected in the field.

Month	Mean monthly fertilised female stock	Origin of Stock (Virgin ♀s)		
		(*a*) From pupae deposited by fly-room females	(*b*) From pupae deposited by captured females	(*c*) From pupae collected in bush
		%	%	%
March, 1957	3,691	42	6	52
April	3,823	60	7	33
May	3,059	82	17	0
June	2,433	84	16	0
July	2,200	72	28	0
August	1,949	63	37	0
September	1,904	56	44	0
October	2,054	56	44	0
November	2,122	70	30	0
December	2,285	51	22	27
January, 1958	3,170	25	12	62
February	5,176	28	8	64
Average monthly stock	2,822	51	18	31
Total virgins		15,587	5,467	9,723

Sources (*b*) and (*c*) are brought in to supplement (*a*) at different seasons of the year. Source (*b*) has its own establishment, with its own feeding goats, as many of the wild flies are infected. Source (*c*) also has to have its own establishment, lest parasites from the wild pupae attack those bred in the fly-room.

The relative importance of these three sources in helping us to meet our obligations is exemplified in the table on preceding page.

Columns (*a*), (*b*) and (*c*) give in percentage form the origin of all the young flies that were added to the fertilised female stock in any given month, and do not indicate the composition of the stock in that month, which will depend considerably upon young flies added in previous months.

During the course of the whole year the fly-room (*a*) produces half the stock; during the first part of the rains (May to July) the Institute is virtually dependent on this source. Additions originating from captured females (*b*) are important in the latter half of the rains (August to October), and those from wild pupae (*c*) in the latter half of the dry season (January to March). It will be noted that no help can be got from source (*c*) for seven months of the year, and very little from source (*b*) for some six months.

It is hoped that what we have achieved so far in the way of technique will provide a foundation for those who contemplate undertaking research into the breeding of tsetse flies on a large scale.

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SOME OBSERVATIONS ON THE BREEDING OF *GLOSSINA MORSITANS* IN THE LABORATORY

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Buxton (1955) remarks that a tsetse fly in the laboratory is being kept under abnormal conditions, and that caution must be used in applying data from the laboratory to events in the field. Nevertheless, access to a self-supporting laboratory colony of tsetse flies greatly simplifies the work involved in approaching many of the problems of trypanosomiasis, and attempts have been made to maintain the flies in several laboratories. In West Africa *Glossina palpalis* has been maintained with considerable success (W.A.I.T.R., 1953–56), and Geigy (1946, 1948) has maintained the same species for many generations in a laboratory in Switzerland, but there has been little success in attempts to breed the East African savannah species of fly. Willett (1953), who was the first worker to attempt to " collect sufficient data to provide reliable assessments both of the results of any modifications of technique and of the general well-being of the populations at any given time ", recorded detailed laboratory findings on *G. swynnertoni*, *G. morsitans*, *G. pallidipes* and *G. austeni*. He maintained his flies in small cages, with ten flies to each cage, but Foster (1957) felt that more basic data could be obtained by maintaining the flies singly in 3 in. × 1 in. specimen tubes. Some earlier results with this method were published (Foster, 1957), and this present paper further records some of the reactions of the flies to modifications of technique.

One of the basic problems in keeping a laboratory colony of tsetse flies is whether to maintain the flies in a constant temperature and humidity and so attempt to regulate the vital processes whose speed is dependent on such factors (e.g. dehydration, pupa production), or to attempt to simulate the insect's natural environment by providing diurnal climatic variations. Although some workers have claimed that best results are obtained by the latter method, work in this laboratory has shown that *G. morsitans* prospers more under conditions of constant temperature. Comparative data are given in Table 1, where colony 1 represents flies kept under a diurnal variation of 74–80° F., and colony 2 a variation of 76–80° F. Colonies 3 and 4 were kept at a constant temperature of 79° F. The figures are derived from the first fifteen weeks after the establishment of the colonies. It is seen that the mean life of flies in the first two colonies was about forty days, compared with about seventy days in colony 3 (feeding methods were modified in colony 4, and the figures from this colony are not strictly comparable with those from the others). An interesting feature emerging from colony 1 was that newly emerged flies failed to tolerate a temperature of less than 74° F. The atmospheric humidity was 60–75% relative humidity, and the observation remains unexplained; in nature, the overnight temperature of the tsetse habitat frequently drops below 74° F., but this drop is usually accompanied by a rise in humidity to 80–100% R.H. This high humidity, and the ability to utilise microclimates, may enable the wild fly to survive low temperatures. In colony 2, the lower limit of the temperature variation was kept above 74° F., and a better survival of young flies was achieved; this led to a rise from 41% to 59% in the proportion of females which survived to reproductive age. Consequently 38% of the females produced pupae, against 27% in colony 1, and the mean number of pupae per female (for the fifteen-week period) of colony 2 was 1·2, compared with 0·8 in colony 1.

Foster (1957) commented that one reason for the low over-all pupa production of this colony flies was that many flies died before they were old enough to produce larvae, but this difficulty has now been largely overcome. As shown above, by reducing the limits of the diurnal temperature variation the proportion of females surviving to reproductive age was raised from 41% in colony 1 to 59% in colony 2. Colony 3 was maintained at a constant temperature of 79° F., and the survival figure rose dramatically to 84%. These flies were offered food every third day, but those of colony 4, kept under otherwise parallel conditions, were offered food every second day; this resulted in the proportion of females surviving to reproductive age being further raised to 92%. These improved survival rates led to 68% of the females of colony 4 producing pupae, as against 27% of those of colony 1. Consequently the mean number of pupae per female (for the fifteen-week period) has been raised form 0·8 in colony 1 to 2·1 in colony 4. As 65–75% successful emergence of pupae is recorded, this present pro-

Table 1.—*Glossina morsitans*: Summary of Colony Data (15-week periods)

	Colony 1	Colony 2	Colony 3	Colony 4
1. No. of male flies	259	234	155	169
2. No. of female flies	280	335	162	177
Longevity				
3. Mean life of males (days)	35	31	60	71
4. Mean life of females (days)	42	48	74	76
Fecundity				
5. Proportion of females living to reproductive age	41%	59%	84%	92%
6. Proportion of total females producing pupae	27%	38%	61%	68%
7. Proportion of females which survived to reproductive age which produced pupae	65%	64%	73%	74%
Pupa production				
8. Mean No. of pupae for all females	0·8	1·2	2·0	2·1
9. Mean No. of pupae per female of reproductive age	1·9	2·0	2·4	2·2
10. Mean No. of pupae per "producing female"	3·0	3·2	3·3	3·0
11. Mean interlarval period (days)	17·1	—	16·1	15·3

Table 2.—*Glossina morsitans* : Effect of Maximum Interval Without Food

Maximum Interval without food (days)	No. of cases	Mean interlarval period (days)
3	54	12·04
4	213	14·26
5	151	16·09
6	64	20·25
7	52	21·83
8	22	26·36
9	9	26·56
10	6	35·67
11	4	46·75
12	(2)	(37·50)
13	(1)	(30·00)

ductivity is still inadequate to maintain a self-supporting colony, and although some pupae are produced after this fifteen-week period, productivity declines markedly (see later). Furthermore, this level of productivity must be maintained in subsequent generations.

Satisfactory feeding, particularly of the females, is a vital factor in the laboratory maintenance of tsetse flies, affecting not only the size of the pupae, but also the rate of pupa production. The East African Tsetse Research Organisation (1955) has published a formula for calculating the length of the interlarval period. The formula allows temperature as the only variable, and although it may hold good in the field where a fly can, within the limits of availability, contact a host and feed whenever it wishes, it apparently does not apply to laboratory flies. It has been found that in laboratory colonies the duration of the interlarval period is directly correlated with the length of the maximum interval without food during the period (Foster, 1957). A typical example from colony flies is given in Table 2, which shows a progressive increase in the mean interlarval period from 12·04 days (maximum foodless interval three days) to 46·75 days (maximum foodless interval eleven days). Thus regularity of feeding (as distinct from the total intake of food) appears to be the prime object to be attained. The interval between feeds should be as short as is consistent with the taking of full feeds, as partial feeds lead to smaller larvae and more frequent abortions (Mellanby, 1937). From the present results it would appear optimal to offer food to the flies every third day; the flies of colony 4 were offered food every second day, and although this did not increase the proportion of partial feeds (about 5% of the total feeds), the pupa production of these flies was somewhat lower than those of colony 3, which were offered food every third day. The fact that the survival figures from colony 4 were slightly superior to those of colony 3 helped to equate the over-all pupa production figures of the two colonies (for the fifteen-week period covered, 2·0 pupae per female in colony 3 and 2·1 pupae per female in colony 4), but when the flies are maintained in individual tubes there is a considerable increase in the work involved in feeding them every two days instead of every three days, and the increased work is not offset by this slight increase in productivity. Further, a fly is less likely to feed on the second day than on the third day, and over a complete interlarval period the maximum foodless interval is often as great on a two-day system as on a three-day system. Neither does a two-day system produce significantly heavier pupae; 98 pupae from colony 3 showed a mean weight of 21·1 mgm., as against 22·2 mgm. for 190 pupae from colony 4.

An important problem is that laboratory flies tend to feed less often as their age increases, and the duration of the foodless intervals increases. Thus the interlarval periods become longer, and the rate of pupa production falls off. For example, in colony 3, the mean interlarval period was 12·7 days at a colony age of eight weeks, 13·8 days at eleven weeks, 14·4 days at 13 weeks, and 16·1 days at fifteen weeks as shown in Table 1. What we have termed the Pupal Index—the number of pupae per week per 100 females—showed a corresponding decline during the period; in colony 3 it reached a peak of thirty-six at a colony age of seven weeks, declining to twenty at fourteen weeks and six at twenty weeks.

The flies have all been fed on sheep; previous work has shown that pupa production is generally greater from flies fed on sheep than from flies fed on goat, rabbit or guinea pig. Feeding, however, is not consistently good even on sheep. It is necessary to change the sheep at frequent intervals, especially if a considerable number of flies are being fed. It seems that the constant feeding of flies causes some physiological change in the sheep blood, which leads to a refusal of many flies to feed further, and an inability to digest the blood meal in those flies which do feed. This change occurs before the skin of the sheep becomes obviously calloused, which is itself a factor necessitating new sheep. But even among new sheep, not previously exposed to tsetse flies, there seem to be differences in palatability. Flies offered certain sheep consistently showed a successful feeding figure of 80–90%, yet on other sheep only 40–50% of the same flies would feed. The reasons for these differences in palatability to flies are not apparent. They do not seem to be related to the colour, age, or outward physical appearance of the sheep, and preliminary blood examinations have failed to relate them to the haemoglobin content, red-cell count, white-cell count or any factor of the differential leucocyte count. In view of the importance of good and regular feeding, this problem merits further investigation.

An interesting feature has been noted concerning the pupae of the colony flies. These have been maintained at an atmospheric relative humidity of 60–70%, and 65–75% have emerged to give viable adults. Raising the humidity in which they were kept usually caused a fall-off in the emergence figures, and in no case has the figure of 75% been exceeded. Other workers, however, have successfully kept pupae in higher humidities, and achieved emergence figures of 80% and over.

One of the main problems still to be overcome is that of female flies which show occasional tendencies to continual abortions. These periods may follow, or be followed by periods of high productivity; feeding is not observably worse during many of these abortive periods, nor can any other cause be found. The phenomenon is also noticeable concerning the production of the first larva; although the mean time taken to produce this larva was about twenty-five days, some females, although feeding regularly, did nor produce it for ninety days or more, after which the produced subsequent larvae at the expected, short intervals.

In summary, it appears that critical temperature control is necessary for the maintenance of tsetse flies in the laboratory, and that frequent and regular feeding is necessary for a satisfactory rate of pupa production.

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THE DISTRIBUTION AND SIGNIFICANCE OF *GLOSSINA MORSITANS SUBMORSITANS* IN NORTHERN NIGERIA

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INTRODUCTION

There has been in recent years a tendency to underestimate the significance of *G. morsitans* to the livestock economy of Northern Nigeria. This is reflected in the opinions expressed by those not concerned with animal health in the Report of the Sixth Commonwealth Entomological Conference 1947 as follows:

> " Though flies of the morsitans group do occur in the dry woodlands of West Africa they are less widespread there, perhaps because the generally higher density of the human population tends to exclude the normal animal hosts. Thus the West Africa problem is for entomologists one of ridding the watercourses of *G. palpalis* and its relative *G. tachinoides* which are more sensitive to desiccation than *G. morsitans* and its allies."

Since then the advent of new trypanocidal drugs and new insecticides has given considerable impetus to the re-examination of the trypanosomiasis problem in livestock. This paper is an account of some of the more significant facts that have recently come to light concerning *G. morsitans*, and is an attempt to show that the view expressed at the Commonwealth Conference requires modification.

POSITION PRIOR TO 1954

Prior to 1954 the Veterinary Department had no direct concern with tsetse control. Observations on tsetse flies were pioneered in the territory by Moiser, B. (1912), Simpson, J. J. (1912) and MacFie, J. W. Scott (1912). Present workers are considerably indebted to the Tsetse Investigation which functioned at Sherifuri and Gadau in Katagum Division of Bauchi Province from 1925 to 1934 and associated with the names of Lloyd, Johnson, Buxton, Lewis, Lester and Nash.

These workers contributed greatly to our knowledge about *G. morsitans* but the fly was accorded less practical attention by those concerned with tsetse control for several reasons. The chief reason was that *G. morsitans* was not concerned as a vector of Gambian Sleeping Sickness and so was accorded little attention by the Sleeping Sickness Service of the Medical Department who were responsible for tsetse control in the field, and also it was deemed to be of less significance as a cause of trypanosomiasis in the livestock population than the riverine species.

In addition spectacular advances of *G. morsitans* with serious economic repercussions had not been recorded, and a practicable control technique for the fly in this territory had not been worked out.

Since then however the situation has changed considerably.

Advances by *G. morsitans* in Muri division and on the Kaduna–Jos road are referred to by Nash in " Tsetse Flies in British West Africa " (1948). The position at the latter place deteriorated further by 1952 and accordingly the Northern Nigeria Government, advised by the West African Institute for Trypanosomiasis Research, undertook, with the co-operation of the Sleeping Sickness Service, the first large-scale measures specifically against this fly in Northern Nigeria.

In addition a practical method of *G. morsitans* control in certain areas is now available. (Maclennan and Kirkby, 1958).

Previously, *G. morsitans* had been involved in the Sherifuri clearings together with *G. tachinoides* and in the Matyoro clearings with *G. palpalis* and *G. tachinoides*. Though the primary object of both Sherifuri and Matyoro appears to have been the control of human depopulation caused by sleeping sickness, control of all the species of tsetse present was attempted to permit of a prosperous livestock industry. In the cleared area at Sherifuri *G. morsitans* was not controlled but at the Matyoro clearings it was. Subsequently re-invasion in both cleared areas resulted from failure to settle in adequate human population to control regeneration.

THE DISTRIBUTION OF *G. MORSITANS* IN NORTHERN NIGERIA

Prior to 1954 Dr. Nash had accumulated all records of *G. morsitans* and entered them on the map of Northern Nigeria. Since that date additional records have been made by the Veterinary Department as a result of surveys carried out by the Tsetse Control Unit in areas where information was badly needed because of trouble from trypanosomiasis, or in other areas where the flies were no longer thought to be present. The findings since records commenced are set out on the attached map. Additional foci reported by the Sleeping Sickness Service in the course of their surveys have been inserted. On this map each dot indicates a place where *G. morsitans* has been caught, the solid lines indicate the boundaries of *G. morsitans* belts that have been established by survey and the dotted lines indicate conjectural boundaries of these belts not firmly established by recent survey. Thus the area of Northern Nigeria known to be infested with *G. morsitans* is about one-fifth of the whole but as survey progresses this figure expands.

DISTRIBUTION IN RELATION TO VEGETATION

With the publication by Keay of an " Outline of Nigerian Vegetation " (Keay, 1948) the differences in the vegetational zones that make up Northern Nigeria have been more readily appreciated. Investigations carried out by the Tsetse Unit of the Veterinary Department show that there are important differences in the distribution of the fly in the Sudan zone compared to the Guinea zone. The approximate boundary between these two zones of the savannah woodland is indicated on the map overleaf. Keay divides the Guinea zone into northern and southern parts but this division does not appear to affect tsetse distribution in any significant way. The boundary between the Sudan zone and the Guinea zone is indicated on the map by a line but it must be stressed that a clear-cut division does not exist and that the different elements that make up each of these zones overlap to varying degrees in different areas. This overlap may have an important bearing on tsetse advances and retreats in response to climatic trends.

Briefly the difference in vegetation in the two zones can be described as follows. In the Sudan zone in the upland the grass is usually short, does not sprout green before the rains, the boles of the trees are short and the crowns rounded. Owing to the less severe fires lateral branches start lower. Visibility thus tends to be rather limited in wooded areas. Refoliation after fire is delayed. In river flood plains, which are characteristic of the zone, large forest islands occur based on such trees as ebony (*Diospyros mespiliformis*) and African elm (*Celtis integrifolia*) supporting a tangled mass of creepers including the thorny *Acacia staxacantha* and with a dense under thicket of thorny *Ziziphus* spp. These islands form a variable but usually small proportion of the flood plain area. Lesser streams do not have the well-developed fringing forest seen in the Guinea zone.

In the Guinea zone the grass is much taller and the woodland is swept by fierce fires after which it is common for the grass and trees to sprout green again within ten days. Doka trees (*Isoberlinia* spp.) occur in communities in the upland varying from small clumps to extensive areas and in some areas these species are mingled diffusely with the other Guinea zone upland tree species. Development of riverine fringing forest is often pronounced and varies from a few yards wide in the northern parts of the zone to more extensive forests in the south. A definite ecotone at the margin of upland woodland and drainage line, even though this may be devoid of fringing forest, is of frequent occurrence. In the upland, refoliation, particularly of the doka, is rapid after the passage of fire, in marked contrast to the Sudan zone. The boles of the trees are taller and the crowns show a greater tendency to form a canopy which may be very well developed in stands of *Isoberlinia*. Thus, when the grass has been removed by fire visibility tends to be much further than in Sudan zone woodland.

DISTRIBUTION IN THE SUDAN ZONE

In the sandy areas of the Sudan zone, e.g. belts Nos. 5, 6, 7, 9 and 10, the experience has been that the primary *G. morsitans* foci are associated with river flood plains and that the upland savannah, even though it may be penetrated to a depth of several miles in the rains, is evacuated by the tsetse in the dry season. On occasions *G. morsitans* communities have been found based on exceptionally large " busugu " trees (*Ficus kawuri*) at the height of the dry season up to one mile from the margin of the river flood plain. Furthermore, in the second half of the dry season, when it is at its hottest, the bulk of the *G. morsitans* spend most of the day in the evergreen forest islands, very few being found in the intervening country of the flood plain. This retreat to forest islands has already been reported on in detail by Nash. This observation applies to most of the *G. morsitans* belts in the Sudan zone.

The picture in belt No. 34 differs. Here the country is rocky and though the larger rivers do have flood plains the tributaries are much more numerous than in the sandy region just described where indeed these hardly exist. These tributaries frequently hold pools of water and thickets encouraged by edaphic conditions, though the large evergreen forest islands encountered in the flood plains of rivers in the sandy area are absent. The latitude of this part of the Sudan zone is much lower and though the vegetation is classified as of the Sudan type it is not identical with that of the sandy area further north and it can be seen from the map that there is a belt of Guinea zone vegetation to the north of this belt. Another exceptional feature of this area is that there has been a very great increase in the range and density of the distribution of *G. morsitans* in recent years. Originally the fly was more closely associated with the river flood plains but they have recently spread up the tributaries already described. That the situation is not normal is illustrated by the exceptional female percentages encountered on this survey in the hot season ranging from 14% to 85%. Examples of *G. morsitans* were very scarce indeed in the dry season away from the watercourses.

The nature of *G. morsitans* belts Nos. 3, 4 and 13 in the Sudan zone has not yet been fully investigated but there is reason to believe that there also primary foci of the fly are associated with river flood plains or seasonal swamps and that in the hot season there is a retreat of the bulk of the *G. morsitans* population into evergreen forest islands. A description of the vegetation in a *G. morsitans* belt in the Sudan zone and an effective control method costing about £100 per square mile has been given by Maclennan and Kirkby (1958).

DISTRIBUTION IN THE GUINEA ZONE

In the Guinea zone it can be seen from the map that *G. morsitans* occupies extensive areas not closely associated with river flood plains as described for the Sudan zone. The picture here resembles more the *G. morsitans* infestation of the " miombo " woodlands of East Africa with which indeed the Guinea zone savannah woodland shows some features of similarity. In the northern parts of the Guinea zone there is a marked concentration of *G. morsitans* population along strips of riparian vegetation in the hot season and a marked concentration of breeding, which is scattered

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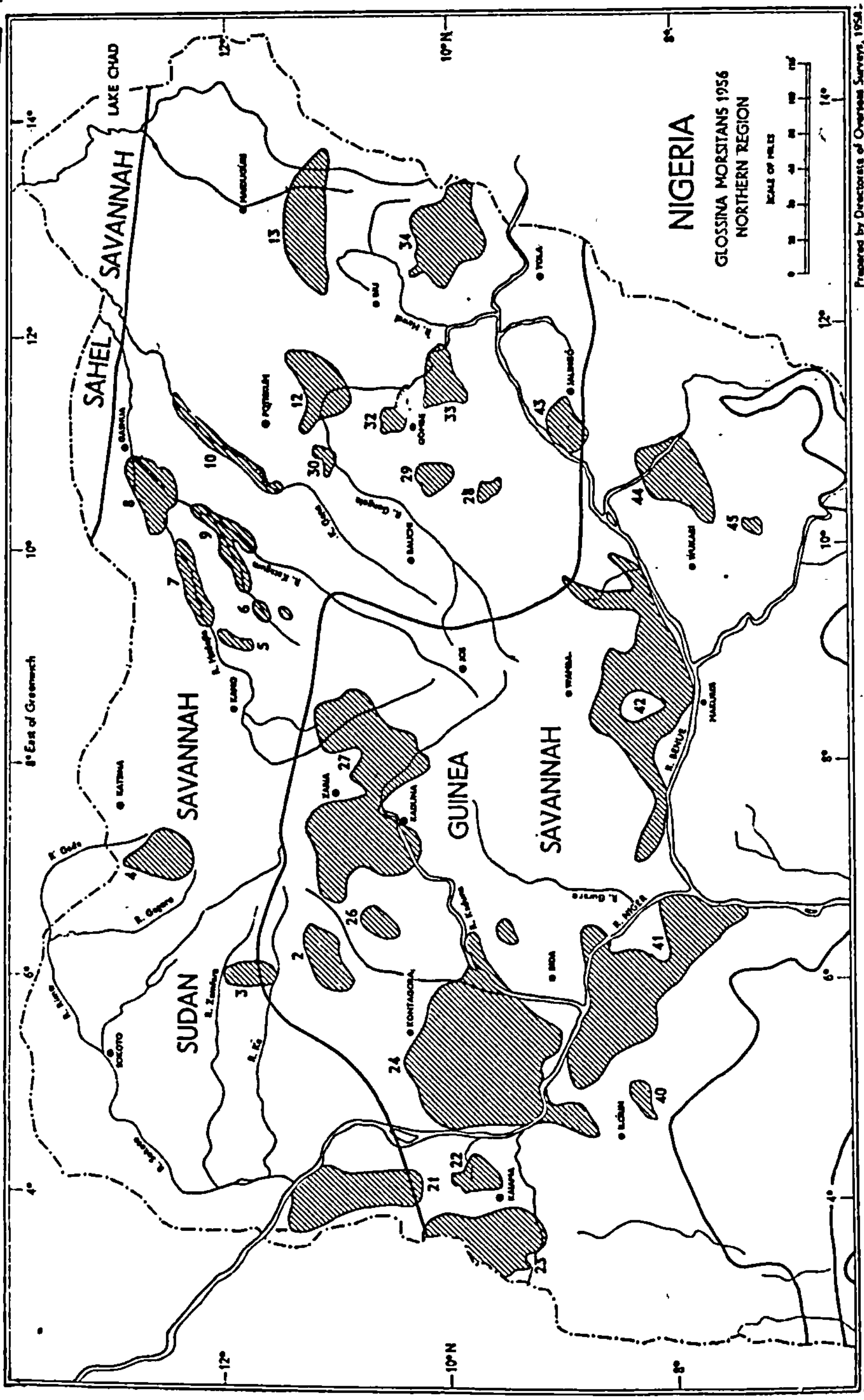
NIGERIA
GLOSSINA MORSITANS 1956
NORTHERN REGION
SCALE OF MILES
LAKE CHAD
SAHEL
SAVANNAH
SUDAN
SAVANNAH
GUINEA
SAVANNAH
8° East of Greenwich
R. BENUE
R. NIGER
Prepared by Directorate of Overseas Surveys, 1958
D.O.S. (Misc) 251

in the upland during the rains, in the vicinity of the drainage lines. Detailed investigations have been carried out in the northern parts of this zone at Shika, near Zaria, at Kontagora, and at Mokwa in the more southerly parts of this zone. As a result it can be stated that whereas in the Sudan zone, in the hot season, the bulk of the tsetse population is associated with forest islands, in the Guinea zone, though there is a variable concentration near drainage lines with riparian vegetation, this concentration decreases as one progresses southwards. In the **upland** of the Guinea zone it is areas of doka woodland that are most favoured by the flies and here the percentage of intermediate males is highest.

Even where the seasonal concentration is most noticeable it is by no means certain that the bulk of the tsetse population is in the vegetation along the drainage line. Whether this is so or not will depend on the degree of concentration and the relation of length of drainage line to area of upland infested. The apparent density of intermediate males in terms of distance is highest along the drainage lines where it is the ecotone of the upland that is most favoured, but more female flies and other categories of males are also caught here in contrast to the doka woodland where the catch is largely composed of intermediate males.

RECENT CHANGES IN THE DISTRIBUTION

There is reason to believe that *G. morsitans* belt No. 3 no longer exists as such and that there has been a regression in the northern limit of belt No. 2. A *G. morsitans* belt which existed at Wukari has disappeared. On the other hand there has been a very considerable extension of belt No. 34 and in the eastern boundaries of belt No. 27 in spite of barriers inserted to prevent this. Also of recent years comparatively small foci have been detected further upstream to foci 7, 8, 9 and 10 in the river valleys of the Sudan zone but are probably not new infestations.

This pattern suggests that without the interference of man there would be a widespread infestation in Northern Nigeria of the Guinea zone with linear extensions into the Sudan zone where the vegetation is suitable, that is, in the river valleys of the Chad system. It has been found that factors influencing the above changes include alterations in the pattern of human population with resultant interference of vegetation; also long-term climatic changes and movements of nomadic and trade cattle.

THE SIGNIFICANCE OF *G. MORSITANS* TO THE CATTLE POPULATION

Area affected.—As has been described about one-fifth of Northern Nigeria is occupied by *G. morsitans*. At present trypanosomiasis is the greatest single cause of loss to the livestock owner.

Significance in the Sudan zone.—In the Sudan zone *G. morsitans* prohibits the use of well-watered river valleys containing good grazing which could accommodate a significant proportion of the cattle which embark on seasonal migrations of as much as 300 miles in search of dry-season sustenance.

Significance in the Guinea zone.—In the Guinea zone *G. morsitans* is the major factor forcing the zebu cattle population to vacate wooded areas during the rains. Generally speaking it is only in enclaves where man has destroyed the necessary vegetational habitat that zebu cattle can survive during the rains in the Guinea zone. To illustrate this point the following examples of what has happened in areas originally free of *G. morsitans* in the dry season can be quoted.

At Shika Stock Farm west of Zaria, situated near the northern limit of the Guinea zone, the nearest primary foci of *G. morsitans* were eight miles away. Trypanosomiasis became a problem on the farm and continues to be after the drainage lines were cleared to control *G. tachinoides*. *G. morsitans* were then detected in low density (0·5 flies per patrol mile). Many viable *G. morsitans* puparia were found on the farm. Much of the farm was covered by regenerating mixed doka woodland of the Northern Guinea type, some of it fairly mature. Thus in the presence of only upland woodland vegetation the flies existed at all times of the year and were able to hang on in the Stock Farm as it was progressively cleared even when the remaining upland only amounted to about ten acres. They died out last dry season but re-established themselves during the rains. There were no warthog on the farm and small antelopes were very scarce indeed, the flies were therefore almost exclusively living on the cattle. The challenge was sufficient to cause the development of drug resistance to antrycide pro-salt. Close attention by the Veterinary Department enabled the stock to survive; a Fulani-owned herd under similar circumstances would have been decimated.

On Kontagora Land Settlement Scheme which is on the northern boundary of belt No. 24 *G. morsitans* established itself at an average apparent density of 1·5 flies per patrol mile on the introduction of an all season resident cattle population. Here again vegetation necessary for riverine species had been removed and the area included Guinea savannah woodland in which *G. morsitans* dispersal had not previously been detected. Again drug-resistant trypanosomes developed.

At Kaduna a laboratory herd of zebu cattle was established in an area of rather scrubby woodland on the margin of the cultivated area around the capital. The place where the cattle were kept was used by the Fulani as a dry season grazing area but evacuated by them during the rains. During two successive rainy seasons a *G. morsitans* community has established itself on the experimental herd and, though in low density, has caused a high rate of trypanosomiasis. The Fulani zebu herds that use this area in the dry season would have been decimated had they remained during the rains. Fulani herdsmen around Kaduna are well aware of this and only use areas that have been cleared of tree cover for wet season grazing. A common feature in all these episodes is the high rate of trypanosomiasis caused by a low challenge.

GENERAL SIGNIFICANCE

Concerning current trypanosomiasis in the Fulani-owned zebu cattle population it is impossible at present to be certain how much of this is due to riverine tsetse and how much to *G. morsitans*, but it is evident that the latter fly is of great significance. During the course of their seasonal migration to dry and wet season grazing areas the routes followed by many of these cattle passes through *G. morsitans* belts.

Degree of challenge and level of nutritional intake are very important factors in the incidence of clinical trypanosomiasis but within the limitations imposed by extremes in these two factors it is true to say that zebu cattle can be successfully reared by Fulani, with a varying degree of wastage, in areas infested with riverine tsetse but that such stock rearing is not possible in *G. morsitans* areas. The streams of most of the dry season grazing grounds used by the Fulani are infested by riverine tsetse with which the cattle come in contact when they are watered. In the absence of species other than riverine tsetse it may not be essential for the cattle to vacate the area in the rains to survive but if the area is infested by *G. morsitans*, or is capable of invasion during the wet season dispersal of this fly, zebu cattle that remain face disaster even though they may remain healthy, to outward appearances, in the dry season. In special instances it may be possible to preserve zebu cattle in such an area by chemotherapy but as yet there is no possibility of keeping peasant stock on a large scale in these circumstances.

Tolerant breeds.—Under certain circumstances Muturu (West African Shorthorn) and Kateku cattle can thrive in *G. morsitans* areas. In the Northern Region of Nigeria the former are kept as individuals or small groups by people who lack the degree of understanding of stock-raising in difficult circumstances held by the pastoral Fulani. Attempts to keep these cattle on a proper herd basis frequently encounter difficulty due to helminthiasis and ascariasis. There is reason to believe that the Kateku cattle which are kept by Fulani are a mixture of Muturu and Zebu. The blood of the latter is introduced to increase milk yield and carcass size and it is of interest to note that in the areas where these cattle are kept the degree of zebu blood that is introduced is inversely proportional to the challenge from *G. morsitans*. These Fulani have reduced the difficulties of helminthiasis and ascariasis mentioned above by their system of management and successfully keep their cattle on a non-migratory herd basis but it is interesting to note that they are only to be found in the vicinity of centres of human population. This is as likely to be due to the needs of the herdsmen themselves as to any high incidence of trypanosomiasis away from such areas; indeed the cattle graze in woodland.

SUMMARY

An account is given of some of the past and of some recent observations on the distribution and significance of *G. morsitans*. Differences in the two major vegetational zones—the Sudan zone and the Guinea zone—are mentioned, and an account is given of the differences that occur in general distribution and seasonal movements of *G. morsitans* in the two zones.

An account is given of the significance of this distribution for the indigenous cattle population. The majority of these cattle are zebu and it is evident that *G. morsitans* is a very important factor bringing about wet season evacuation of much of the Guinea zone by Zebu cattle. Mention is made of two trypanosome tolerant breeds.

ACKNOWLEDGMENT

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RECENT ADVANCES OF *GLOSSINA MORSITANS SUBMORSITANS* IN NORTHERN NIGERIA

By S. G. Wilson, C.B.E., Ph.D., B.Sc., M.R.C.V.S., Ministry of Animal Health and Forestry.

It has been recognised for some time that insufficient attention has been given to the distribution of *Glossina morsitans submorsitans* in Northern Nigeria and to its importance as a vector of disease. The chief reason for this neglect is that this species, not being a vector of human sleeping sickness, has been of minor importance to the medical entomologist as compared with *G. palpalis* and *G. tachinoides* (Maclennan, in press). Another important reason is that only one serious advance of *G. morsitans submorsitans* has been recorded between the years 1911 and 1950 (Nash, 1948 (*a*)) and there has therefore been no apparent cause for immediate alarm.

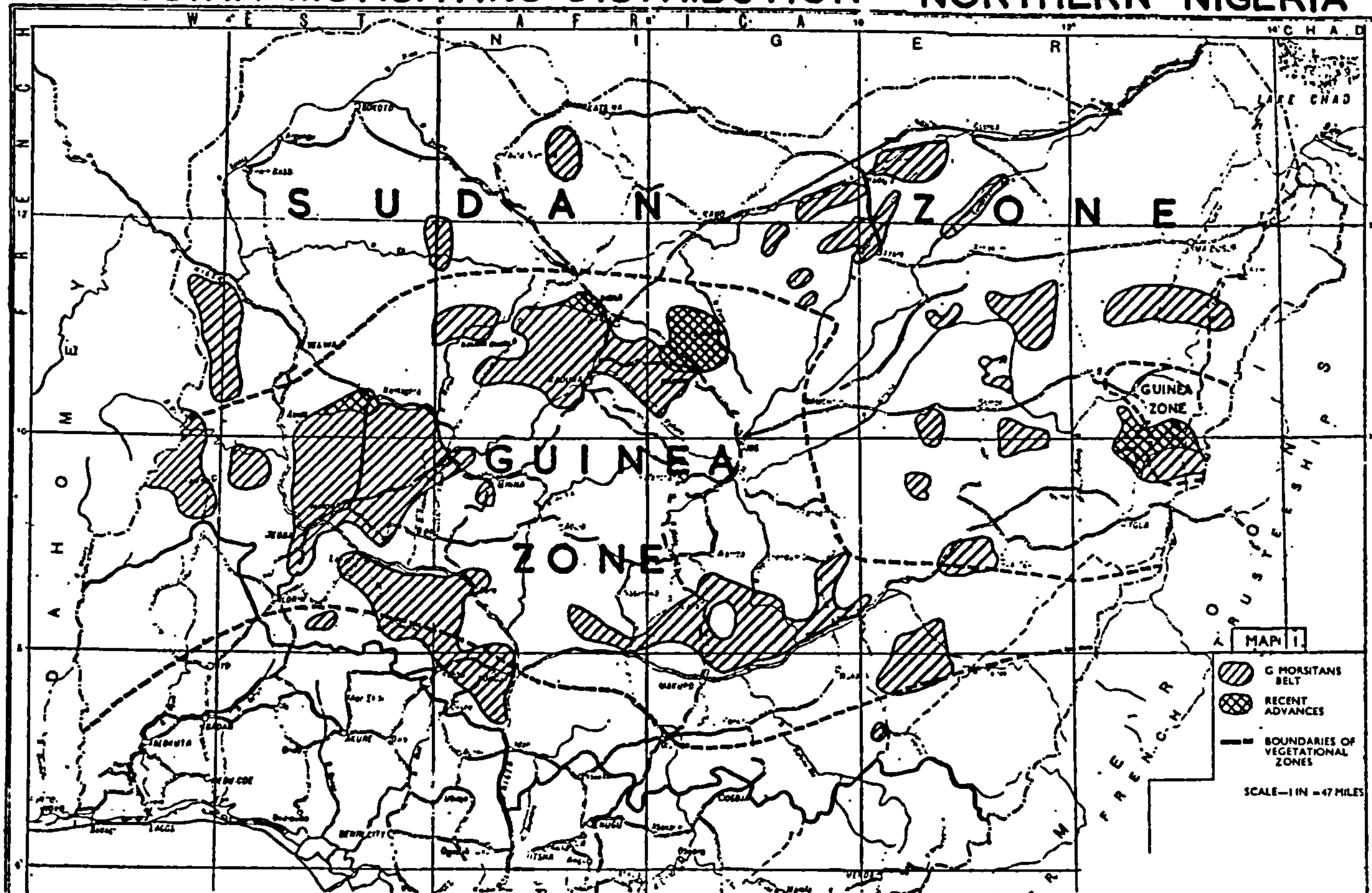
This attitude of *laissez faire* has recently had to be rapidly abandoned. The importance of bovine trypanosomiasis, of which *G. morsitans submorsitans* is an important vector, has been re-emphasised during the past five years by the excessive demands of the Fulani cattle owners for treatment of their herds by modern drugs (Wilson, 1958). In addition, recent striking advances of *G. morsitans submorsitans* have been noted both by Medical and Veterinary Tsetse Units. The purpose of this paper is to record these advances and analyse the possible factors which may have made them possible.

The present distribution of the *G. morsitans submorsitans* in Northern Region with the known recent advances are shown on Map I. For a true appreciation of the facts it is necessary, as always, to relate this distribution to the prevailing vegetation types.

The largest vegetation belt is that of the Guinea zone which covers most of the southern and central parts of the Northern Region, with forest remnants penetrating from the south, while in the north it merges into the dry Sudan vegetation zone. The vegetation of both these zones has been well described by Keay (1953) and by Rosevear (1953). There is little doubt that *G. morsitans submorsitans* occupied most of the Guinea zone vegetation at one time or other, especially the *Isoberlinia* woodlands, and this tsetse has been eradicated or advanced in any area as the agricultural activities of the local inhabitants increased or decreased. The penetration of this fly into the Sudan zone is more restricted and dependent on favourable local climatic conditions (Maclennan, in press).

The advances described in this article have in most instances occurred in the Guinea zone, the one notable exception being in the Song area of Adamawa where the Sudan zone is involved. They are therefore largely dependent on population movements, and where whole villages move out

GLOSSINA MORSITANS DISTRIBUTION - NORTHERN NIGERIA



of any area, an advance of *G. morsitans submorsitans* is almost certain. It is possible however that in the four cases recorded other factors have been operating and these possibilities will be discussed later in this article.

I

ADVANCES OF THE SONG AREA OF ADAMAWA
(Map II)

One of the most significant advances yet recorded by the Veterinary Tsetse Control Unit is that which occurred in the Song Area of Adamawa between the years 1940 and 1955. The area involved covers 2,500 square miles approximately and is drained by the Kilangi river system, and when surveyed early in 1955 the only tsetse species involved were *Glossina morsitans submorsitans* and *Glossina tachinoides* (Davies, unpublished report). Data only on the *G. morsitans* advance was collected.

Description of the Area

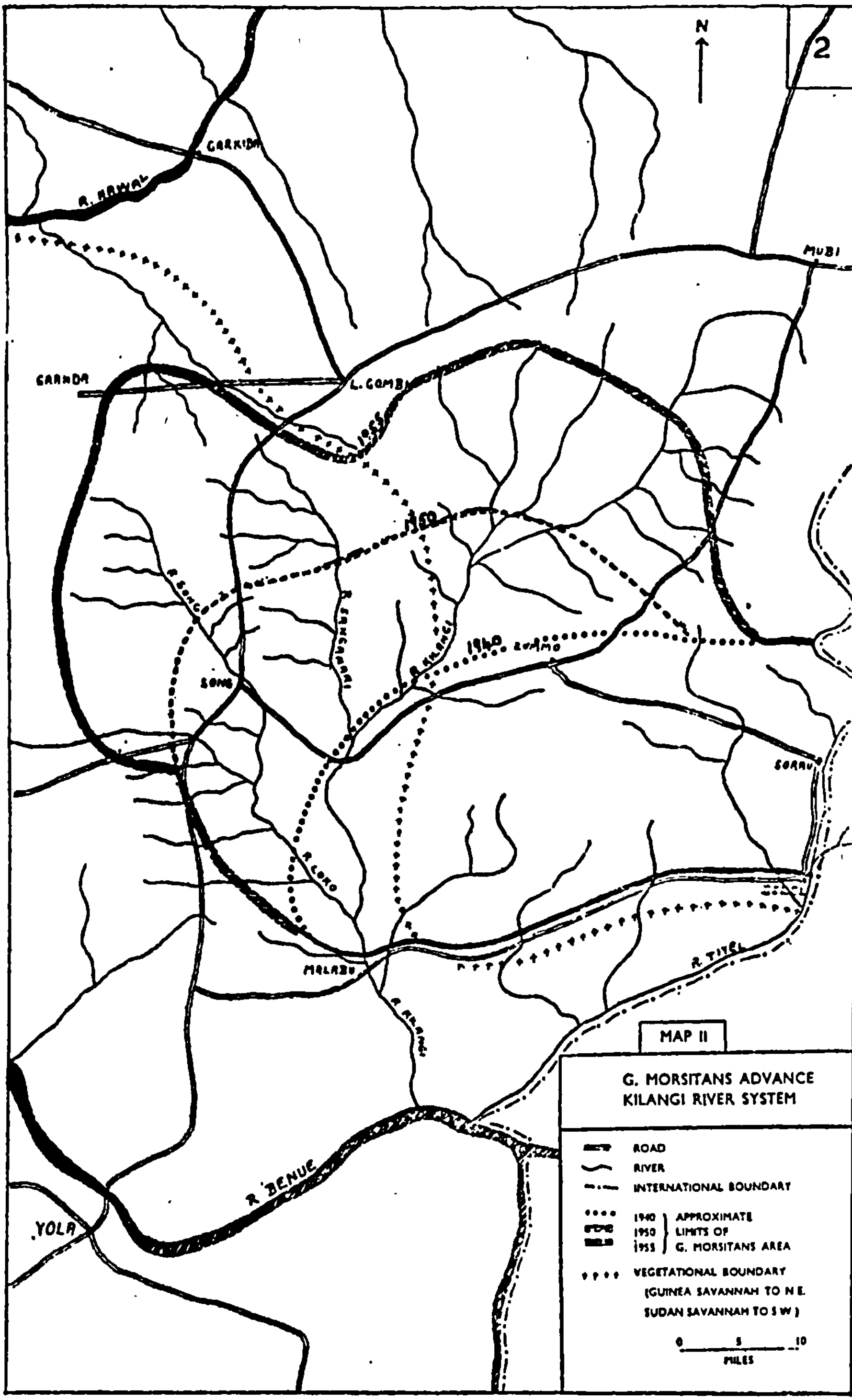
The area is drained by the Kilangi river and its three western tributaries, the Song, Loko and Sanganari streams. Except round the main villages much of the area is hilly undulating country with large areas relatively unfertile. Rainfall is within the 30 in. to 40 in. range and most of the rivers dry up during the height of the dry season in March and April when maximum temperatures range from 95° to 100° F. and relative humidity is very low.

The vegetation of the area is of interest in that there is an intrusion of Guinea savannah from the east surrounded by dry Sudan vegetation on the west and south (Map II). Travelling therefore from Song village towards Zummo, the dry *Acacia–Balanites–Ziziphus* vegetation changes to that of *Isoberlinia–Afzelia–Daniellia–Terminalia* type, to mention only a few of the dominant tree species.

Game has greatly decreased throughout the area and now chiefly consists of small herds of bushbuck, duiker and oribi, while warthog and baboons are prevalent.

Present Distribution of *G. morsitans submorsitans*

Glossina morsitans submorsitans is now well established over the entire Kilangi river system and dispersal occurs as far north as the Gombi–Mubi road. The only areas relatively clear and where settled cattle herds can be maintained are around the main villages on the periphery, where human settlement with cultivation has cleared considerable areas of vegetation. Breeding sites are widespread, chiefly along the river banks in the dry season and usually concentrated in favoured localities such as under a log in a river bed or between roots or buttresses of larger trees such as *Ficus*, *Diospyros* and *Vitex* spp., or alternatively under low bush.


N
2
GARKIDA
R. HAWAL
MUBI
GARADA
L. GOMBI
1955
1950
1940
R. SONG
SONG
SORAU
R. LOKO
MALABU
R. TIYEL
R. KILANGI
YOLA
R. BENUE
MAP II
G. MORSITANS ADVANCE
KILANGI RIVER SYSTEM
ROAD
RIVER
INTERNATIONAL BOUNDARY
1940 } APPROXIMATE
1950 } LIMITS OF
1955 } G. MORSITANS AREA
VEGETATIONAL BOUNDARY
(GUINEA SAVANNAH TO N E.
SUDAN SAVANNAH TO S W)
0 5 10
MILES

Previous History

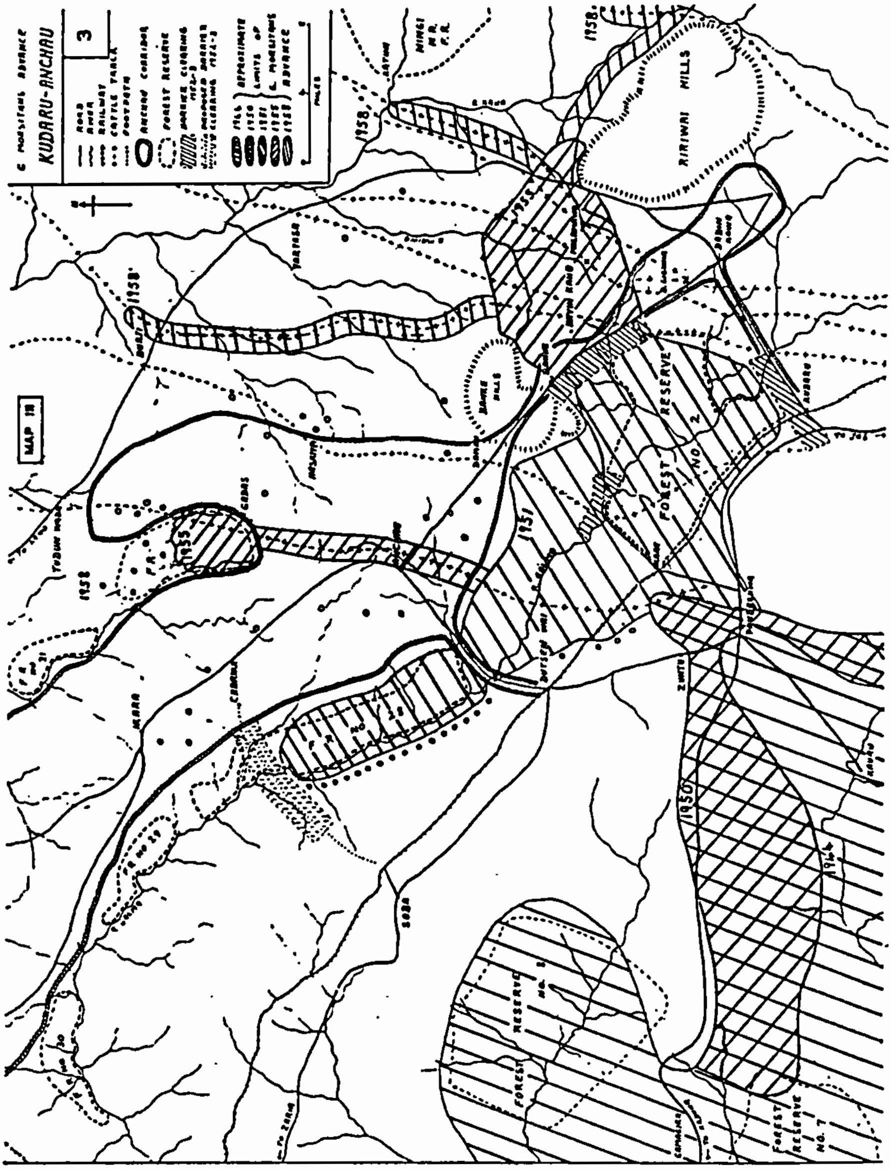
Previous detailed fly surveys and accurate distribution records are lacking in this as in most areas of Nigeria, but valuable local data was obtained during the 1955 survey (Davies, loc. cit.). The only previous recent survey was in 1952 when it was considered that the paucity of *G. morsitans* reported in north Adamawa (Song area) was not due to a lack of knowledge but " to the actual smallness in number and very local nature of the fly localities ". There has therefore been a rapid deterioration of the fly situation in the intervening three years.

Local evidence shows that prior to 1940 *G. morsitans* was well established in Sorau and Belel areas in the east, and westwards to Zummo and to the lower stretches of the Loko river. The invasion of the main Kilangi river and its western tributaries proceeded gradually between the years 1940 and 1950 with marked acceleration northwards and westwards between 1950 and 1955 (Map II). Although this advance cannot be plotted with accuracy owing to the lack of detailed entomological records, the evidence was substantiated by the recent history of the area as given by the local inhabitants, by the recent decrease in cattle population in the Song–Zummo area, by the increased incidence of trypanosomiasis in both settled and nomadic herds using this area, and by the recent complete evacuation by local farmers from certain heavily infested areas on the Song and Loko rivers.

The constant story given by the people was that " fly " arrived, and cattle began to die in the south around Belel 20 to 25 years ago, in the Zummo area 15 years ago and in the north-eastern areas near Gombi 2 to 5 years ago. The average cattle population at Zummo during the five-year periods 1940–44, 1945–49 and 1950–54 were 1,083, 312 and 42 head respectively, while at Song the relative figures during the same periods were 1,931, 1,032 and 530 head respectively. Human population figures show a very similar downward trend.

Probable Causes of this Fly Advance

No elaborate theory should be necessary to account for the advance of *G. morsitans submorsitans* through the Guinea vegetational zone, especially if it contains a high proportion of *Isoberlinia* woodland. The chief factors which operated were population movements away from the area, due both to the high incidence of human diseases such as onchocerciasis and sleeping sickness and to shifting cultivation on this relatively infertile soil which necessitated long periods of fallow. The incidence of onchocerciasis is high especially along the Loko river where 24% of all persons over thirty years were affected with blindness in some form and many villages are now completely evacuated. Also, in the absence of tribal war, the local pagan cultivators who are responsible for most of the bush destruction are tending to move away from the hills to the more fertile riverine plains near the



Benue. These factors are sufficient to cause an advance of *G. morsitans submorsitans* through Guinea zone vegetation and at the same time render most difficult any plans for future control or eradication of this tsetse.

The extension of *G. morsitans submorsitans* into the Sudan type of vegetation in the Song area is more difficult to explain. That this tsetse is not entirely happy in this area during the dry season is shown by the fact that even close to favoured breeding sites the female percentage in fly-catches may be as high as 30 to 50%. In this area, as in the Guinea zone, the prevalence of human diseases in driving people away from the area has an important bearing.

The effects of climatic factors such as increased rainfall with short dry seasons and favourable harmattan are more difficult to analyse and will be discussed later.

II

ADVANCES OF *GLOSSINA MORSITANS SUBMORSITANS* IN EAST ZARIA–SOUTH KANO PROVINCES

Glossina morsitans submorsitans had been known for many years to occupy a belt of Northern Guinea savannah woodland stretching across the central part of Zaria province from Kauru in the east to Birnin Gwari in the west (Map I). The exact limits of this belt were only known approximately and were constantly changing with increase or decrease of farmlands. Riverine infestations with *G. palpalis* and *G. tachinoides* were also prevalent, spreading far to the north and south of the *G. morsitans submorsitans* belt, and received prior attention because of their potential danger as vectors of *Trypanosoma gambiense*.

This was the general position until 1950 when detailed attention was drawn to this belt by two serious northerly advances, one in the Anchau–Banke area in the east and the other in the Doka–Shika area in the west. The history of both these advances is given below.

(A)

ADVANCES OF *G. MORSITANS SUBMORSITANS* IN THE ANCHAU–BANKE AREA

(Map III)

The area involved in this advance had been under close observation by medical entomologists for many years, including as it does the Anchau district which was the scene of a large-scale eradication scheme for riverine tsetse followed by resettlement of villages and rural development. A tsetse-free corridor was then created costing £70,000 (Nash, 1948 (*a*)).

Records of Fly Advances

The first remote indication of any threat to this Anchau area was when a few *G. morsitans submorsitans* were caught at old Pambeguwa village near mile 60 on the Kaduna–Jos motor road (Nash, 1948 (*b*)). The then nearest recognised fly-belt was thirty miles westwards crossing miles 20 and 30 on the Jos motor road and involving No. 8 Forest Reserve to the north of Gamagira village (Map III).

The first serious survey however for *G. morsitans submorsitans* in this area was made six years later in June 1950, when this tsetse was found well established in the *Isoberlinia* woodland south of the motor road at Pambeguwa and lightly dispersed northwards towards Zuntu village and eastwards towards the Jos railway line.

Surveys carried out fifteen months later over a wider area from September to December 1951 revealed a more serious situation and *G. morsitans submorsitans* was found across the railway line east of Kare and in Forest Reserve No. 2 threatening Kudaru in the east and Banke in the north. North-westwards tsetse were caught three miles south of Damau and therefore close to the Anchau Corridor, while westwards it was shown that Forest Reserve No. 28 west of Anchau, on the north-east bank of the Galma river, was lightly infested. The whole of this part of the Galma valley had therefore to be regarded as infested with *G. morsitans submorsitans* (Map III) and as most of this area had been known to medical entomologists for twenty years, and no savannah tsetse had previously been recorded, it was assumed that the occupation of this large tract of country by this tsetse had been relatively recent.

The importance from a veterinary point of view was that Fulani cattle tracks used by hundreds of thousands of nomadic cattle on their way to and from their traditional dry season grazing grounds were now tsetse infested and the incidence of trypanosomiasis in livestock both at Banke and in the Anchau corridor was already serious.

In addition to these fly records south of the corridor, a few *G. morsitans submorsitans* were found between Banke and Damau villages within the corridor, and two were caught six miles north of Hayin Kano to the north-east of the corridor.

Measures Taken to Stop this Advance

It was safely assumed in the face of this evidence that *G. morsitans submorsitans* was rapidly advancing throughout this area. Not only was the Anchau corridor in danger but a possible spread north-eastwards from Damau, if it had not already occurred, would threaten the sparsely populated areas in Tudun Wada and Burji districts of Kano and the Ningi district of Bauchi. An advance eastwards through farmland was less likely.

The action taken by the Northern Regional Government to deal with this threat was both prompt and vigorous. Based on a master plan (Nash, unpublished reports), a control campaign was organised, involving barrier clearings on the perimeters of the advance together with riverine clearings, game eradication, early grass burning and settlement within the area.

Clearing operations commenced in January 1952 and continued during the dry season of 1953 and during these two seasons 334 miles of river banks and thirteen and a half square miles of barrier were cleared (Map III).

At the same time pressure of tsetse on the barrier clearing at Banke was reduced by the use of insecticides in the forward areas both by regular fogging of vegetation along the roadways and grazing ninety head of cattle sprayed with D.D.T. emulsion throughout the woodland in front of the barrier.

The only complete failure in the plan was the impossibility of diverting the nomadic Fulani from their accustomed cattle tracks on their way northward in June and so the risk of carrying *G. morsitans* across the Banke barrier remained. Also the proposed barrier clearing on the Soba–Charika track was abandoned, and forest reserves were left untouched.

Immediate Effect of these Measures in 1953

During 1953 the density of *G. morsitans submorsitans* throughout the Galma valley was gradually increasing. The riverine clearings were based on the knowledge that during the dry season this tsetse was dependent on the denser riverine vegetation for breeding sites and, while this was largely true, these clearings were not being sufficiently effective to control the tsetse density. There was little, if any, increase in human population within the area and settlement along the barriers was proceeding slowly. Sporadic surveys however beyond the barriers failed to show any further spread and it was felt that the clearings had been largely successful in achieving their objective.

Subsequent Advances of *G. morsitans submorsitans* in 1954–1956

Methodical surveys north of the Banke barrier and as far east as Malamawa were carried out by the Veterinary Tsetse Control Unit late in 1954 and early in 1955. The most significant early finding was the discovery of a well-established colony of *G. morsitans submorsitans* on a small uncleared river on the north-east perimeter of the Banke barrier near the Hayin Kano–Burji cattle track. Five miles further north, on the same cattle track, a further focus of *G. morsitans submorsitans* was found on the Maiwa river crossing, while still further north dispersed flies were caught along the track up to fifteen miles north of the barrier. Eastwards a patch of *Isoberlinia* woodland on the east bank of the Maiwa river was lightly infested and further east a few tsetse were caught north of Malamawa on the Katini cattle track. Further to the west, and separate from these findings, scattered *G. morsitans submorsitans* were caught north and west of Gadas village which is ten and twelve miles north of Anchau within the corridor.

The position therefore by April 1955 as shown in Map III was that *G. morsitans submorsitans* was well established eight to ten miles north and east of the Banke barrier between the Banke and Ririwai hills with indications that the Anchau corridor had been infested around Gadas.

By December 1955 the Hayin Kano–Burji cattle track was completely infested as far north as the Kano motor road while further west *G. morsitans submorsitans* had spread right across the widest part of the Anchau fly-free corridor to the Forest Reserve west of Gadas (Map III).

During 1956, the fly populations in all these forward areas showed every sign of becoming well established especially along the two cattle tracks, one leading from Banke to Burji and one from Malamawa to Katini. Along this latter route, the flies rapidly advanced for a further five miles up to the Kano river crossing. Throughout 1956 and 1957, this river formed the eastern limit to *G. morsitans submorsitans* but recently, in April 1958, the Kano river has been crossed to the east of the Ririwai hills.

Discussion

The *Glossina morsitans submorsitans* advance in this whole area cannot be plotted in time with any exactitude in the absence of detailed surveys and of regular patrols in the Galma valley prior to 1951, and along the cattle tracks north and east of Banke prior to 1954. It is certain however that the surveys carried out late in 1951 revealed an advance of this tsetse in the Galma valley which, although relatively recent, must have been going on for some years. This advance had been influenced to a considerable extent by the movements of population out of the valley to avoid either enchocerciasis or sleeping sickness. Some of the people had moved to other districts and some had moved into the fly-free Anchau Corridor and signs of former human habitation are evident throughout this area with deserted villages and farmlands reverting to *Isoberlinia* woodland. *G. morsitans submorsitans* was therefore able to advance in 1951 up to the edge of the Anchau corridor along almost its entire south-western perimeter.

This was the position when control measures had hurriedly to be devised to prevent further advance. Barrier clearings are always difficult to site and are least reliable in a nomadic country with cattle tracks crossing the actual barrier area. It also seems likely, in light of recent findings, that the Banke barrier was in any case cut too close to the advanced front line of the *G. morsitans submorsitans* penetration. It is even probable that fly had already become established in small numbers north-east of the barrier in 1951 near Hayin Kano and that a small focus of *G. morsitans submorsitans* was establishing itself on the north-eastern side in 1952, not to be discovered until December 1954. By that time the fly was definitely on the advance and had crossed the Anchau corridor on a wide front and was being carried northwards especially along cattle tracks. Even the widest parts of the corridor had not proved an obstacle to this advance. It is significant that the Banke–Malamawa advances were in the first instances along two specific cattle tracks and other tracks going north to Yarayasa were not then infested.

Regular patrols were started in the Galma area in May 1953 first by the Medical Sleeping Sickness Service and later, in April 1955, by the Veterinary Unit. The results of a typical patrol, over the last three-year period, shown in fig. I, indicate a seasonally fluctuating settled population of *G. morsitans submorsitans* with no evidence that it will decrease without

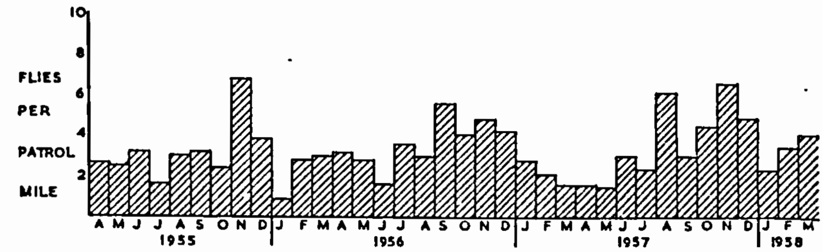


FIG 1

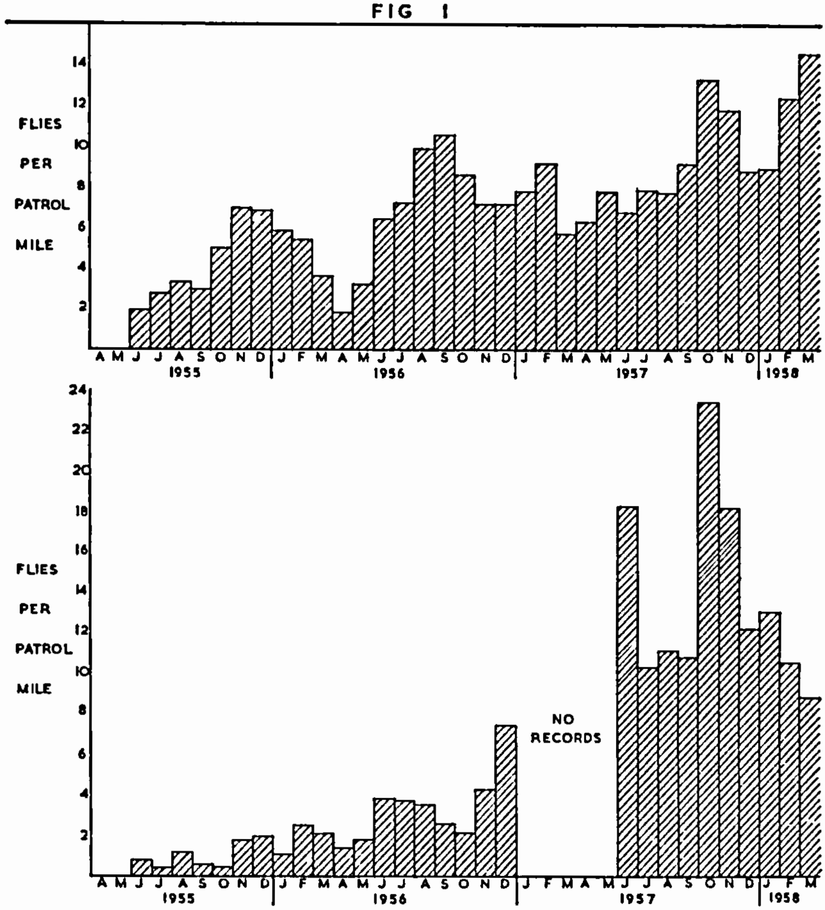


FIG 2

FIG. 1.—*Glossina morsitans submorsitans* caught per patrol mile by two tsetse assistants during weekly patrols along a definite route in the Galma river valley, from April 1955 to March 1958.

FIG. 2.—*Glossina morsitans submorsitans* caught per patrol mile (*a*) along the Hayin Kano–Burji cattle route and (*b*) along the Malanawa–Katsina cattle route from June 1955 to March 1958 showing the rapidly increased density of tsetse in both areas.

human intervention unless climatic conditions during the dry season are abnormally severe.

The results over the same three-year period in the advanced zone along the two cattle tracks, given in fig. II, indicate in contrast a rapidly increasing population with seasonal fluctuations becoming less obvious.

The penetration along the cattle tracks north of Banke is into an area of marginal vegetation merging into the Sudan vegetational zone. The establishment of a population in this area must depend, more than usual, on suitable vegetation and readily available food supply. In these instances either *Isoberlinia* woodland, or suitable riverine vegetation, or dense vegetation at the foot of the rocky hills, have all assisted in the establishment and spread of *G. morsitans submorsitans* along the cattle tracks while the readily available food supply from cattle using the track and to a lesser extent from game has turned a dispersal area into two permanently infested linear belts. The infestation at Gadas is more widespread throughout *Isoberlinia* woodland. Unfortunately, further advances in this area are frequently being recorded and no economic control measures have yet been devised.

(B)
GLOSSINA MORSITANS SUBMORSITANS ADVANCE IN THE DOKA-SHIKA AREAS
(Map IV)

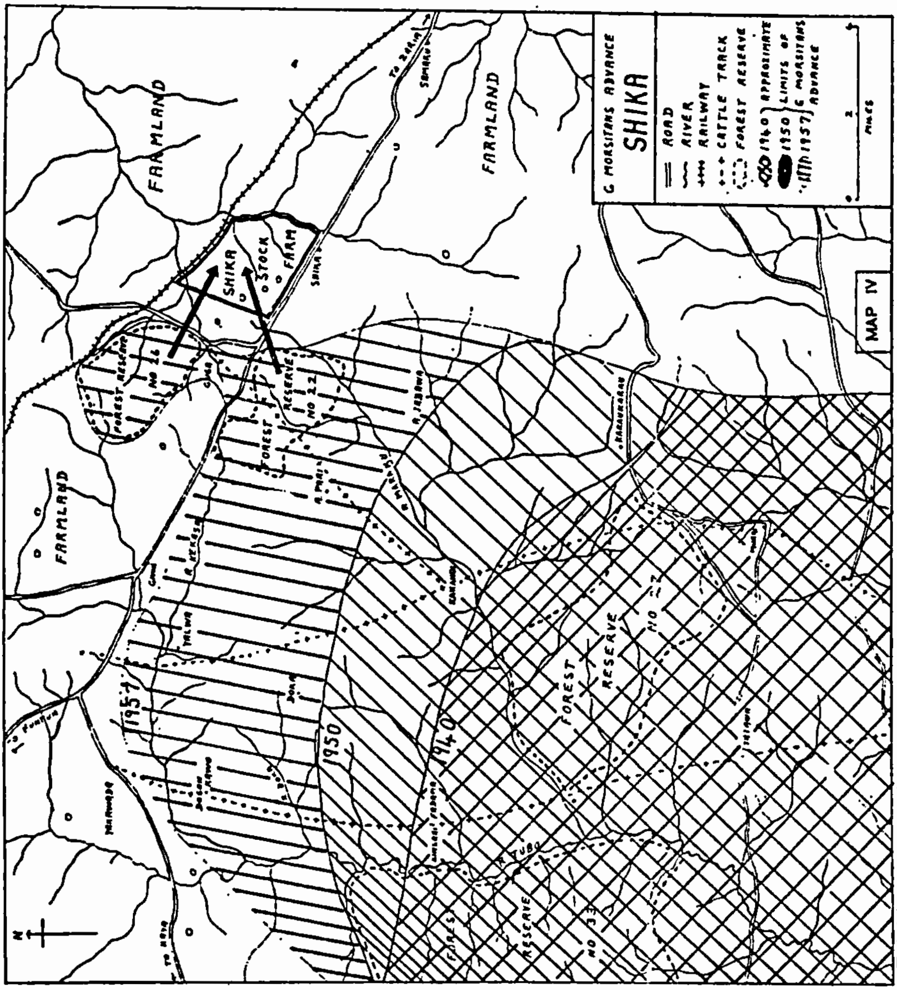
The area involved by this advance is the western wing of the central Zaria *G. morsitans submorsitans* fly-belt which has already been mentioned as being involved in the Anchau–Banke advance (Map I).

Description of Area

The vegetation of this area is of the Northern Guinea type with *Isoberlinia* woodland predominating in the forest reserves and uncultivated areas. The best farmlands serving Zaria township are to the north and east of the Zaria–Funtua road and here only the larger trees remain, such as *Parkia filicoidea*, and *Butyrospermum Parkii.* This area therefore constitutes an effective barrier to any spread of *G. morsitans submorsitans* to the east of the Funtua road. Much of the land however in the triangle west of the road, with the Tubo river as the western boundary and the Maraku river on the south, has poor, easily eroded soil, with well defined drainage lines. Small hamlets are scattered throughout the *Isoberlinia* woodlands but they all give the appearance of poverty with shifting cultivation prevalent and with a general tendency for families to move out of the area in search of better farms.

Previous History

The attention of the veterinarians was first drawn to this area between the years 1948 and 1950 by the serious incidence of trypanosomiasis in the


G MORSITANS ADVANCE
SHIKA
ROAD
RIVER
RAILWAY
CATTLE TRACK
FOREST RESERVE
1940
1950
1957
APPROXIMATE LIMITS OF G MORSITANS ADVANCE
MILES
MAP IV
FARMLAND
FARMLAND
FARMLAND
SHIKA
STOCK FARM
FOREST RESERVE NO 26
FOREST RESERVE NO 22
FOREST RESERVE NO 27
FOREST RESERVE NO 33
TO ZARIA
1957
1950
1940
N

herd of 650 cattle on the Agricultural Stock Farm at Shika. Previously, in 1944, a relatively heavy outbreak had occurred in this same herd, and, as the area was known to be infested with *G. tachinoides*, all the riverine vegetation on the farm was cleared and the outbreak subsided. Towards the end of 1948, however, 19% of the herd was infected, while in 1950 the infection rate had risen to over 30%. Between December 1950 and December 1952 the health of the herd was only maintained by regularly injecting all animals with Antrycide Methyl-sulphate.

At the same time, in 1950, complaints were also received that Fulani cattle, grazing during the dry season south of Yakawada village and near Giwa, were becoming infected with trypanosomes and the main cattle track along the east of the Tuba river was being avoided by nomadic cattle on their way south, as being too heavily infested with tsetse.

Glossina morsitans submorsitans Advances during 1950 to 1954

In all surveys during this period special attention was given to the Shika Stock Farm and environment as it was here, in the resident cattle herd, that trypanosomiasis was most serious. Until June 1953 the only fly caught were all *G. tachinoides*, but in July of that year one *G. morsitans submorsitans* was caught on the road near the western farm boundary. Within a few months flies were found consistently on the farm while Forest Reserve No. 22 was recognised as holding a small consistent population and parts of Forest Reserve 26 were also infested.

Towards the end of 1952 infection in the Shika farm herd was so serious that all the cattle were put on Antrycide pro-salt every two months.

This advance of *G. morsitans submorsitans* into Shika farm during the wet season of 1953 was first regarded as seasonal and liable to recede later in the year during the months of the dry harmattan. Fly, however, persisted in 1954, and further searches that year showed that *G. morsitans submorsitans* was actually breeding on the farm in very atypical bush and it seemed certain that the readily available food supply from the cattle herd was compensating for the difficult environmental conditions. In fact, the fly population on the farm actually increased until early in 1955, when all the secondary woodland on the farm was cleared and the area made unsuitable even for dispersal.

At the same time in 1953, detailed surveys were made to the west of the farm in the area drained by the Maraku and Kekasa rivers which flow westwards into the Tubo river (Map IV). *G. morsitans submorsitans* was found spread throughout this whole area, the greatest density being in the untouched or secondary *Isoberlinia* woodlands with a tendency to concentrate along the drainage lines towards the end of the dry season in March and April, when temperatures were at their maximum and relative humidity low. The *G. morsitans submorsitans* population was especially dense on the Maraku river and Kinsari and Doka streams flowing into the

Tubo river but fly was caught as far north as Yakawada and Giwa. No fly were found to the east across the motor road in the dense farming areas except on Shika farm and Forest Reserve No. 26.

General Picture of Advance

The general picture of *G. morsitans submorsitans* advance in this area, as given by the people themselves, was as follows. Prior to 1940, nomadic Fulani cattle remained throughout the dry season at Kakangi and Karau-karau villages but subsequent to that date tsetse advanced and drove all cattle out of the neighbourhood.

Further north, no savannah tsetse were found in the Doka village area until 1949 or 1950 and this area was, until then, popular with the Fulani cattle owners. Infestation of the drainage lines and *Isoberlinia* woodland north of Doka village occurred between 1950 and 1953 when fly came from the Fadama Kinsari drainage line. This latter area had been infested eight to ten years before 1950.

The advance eastwards across the Zaria road into Shika farm was undoubtedly assisted by the two adjacent forest reserves and the uncleared woodland left on the farm itself prior to 1955. The frequented cattle tracks which pass close to the farm and through Forest Reserve No. 22 have also contributed.

Since 1950, the main cattle track south of Kinsari has not been used. The people throughout this area have vivid memories of the cattle herds which came each season and manured their farms but now come no more. The frequent changes of hamlet sites and whole farms, the increasing poverty of the area with decreasing population, all speak of the relatively recent change in conditions. The prosperity of such villages on the periphery of the fly advance such as Yakawada in the north and Kaya in the west is actually in jeopardy.

Specific reasons for this advance are difficult to find but it does seem that a series of years of high rainfall with shortened dry seasons have favoured a build-up of tsetse population along the Maraku river system. This has encouraged a spread northwards towards Yakawada village and eastwards towards Shika farm where suitable vegetation existed for their survival.

III

GLOSSINA MORSITANS SUBMORSITANS ADVANCE IN THE KONTAGORA AREA

(Map V)

INTRODUCTION

For many years an extensive belt of *G. morsitans submorsitans* was known to occupy a large part of Niger Province, the southern limit of which included Mokwa and Jebba townships, while northwards it stretched towards Kontagora but stopped short of that town on a line through Auna and Kaboji villages. The eastern limits were approximately defined by the Bida Zungeru–Kontagora road, while to the west it reached close to the River Niger.

To the north of this belt there were departmental records of *G. morsitans* being caught at Kontagora by Simpson in 1910 and by Johnston and Lloyd in 1920 but there were no indications that these represented a permanent infestation.

Description of Area

The area covered by this tsetse belt is within the Guinea zone of vegetation and much of the area is uninhabited. This scarcity of population is due partly to the waterless, difficult nature of the country, but chiefly to the severe depopulating effect of repeated slave raids late in the nineteenth century.

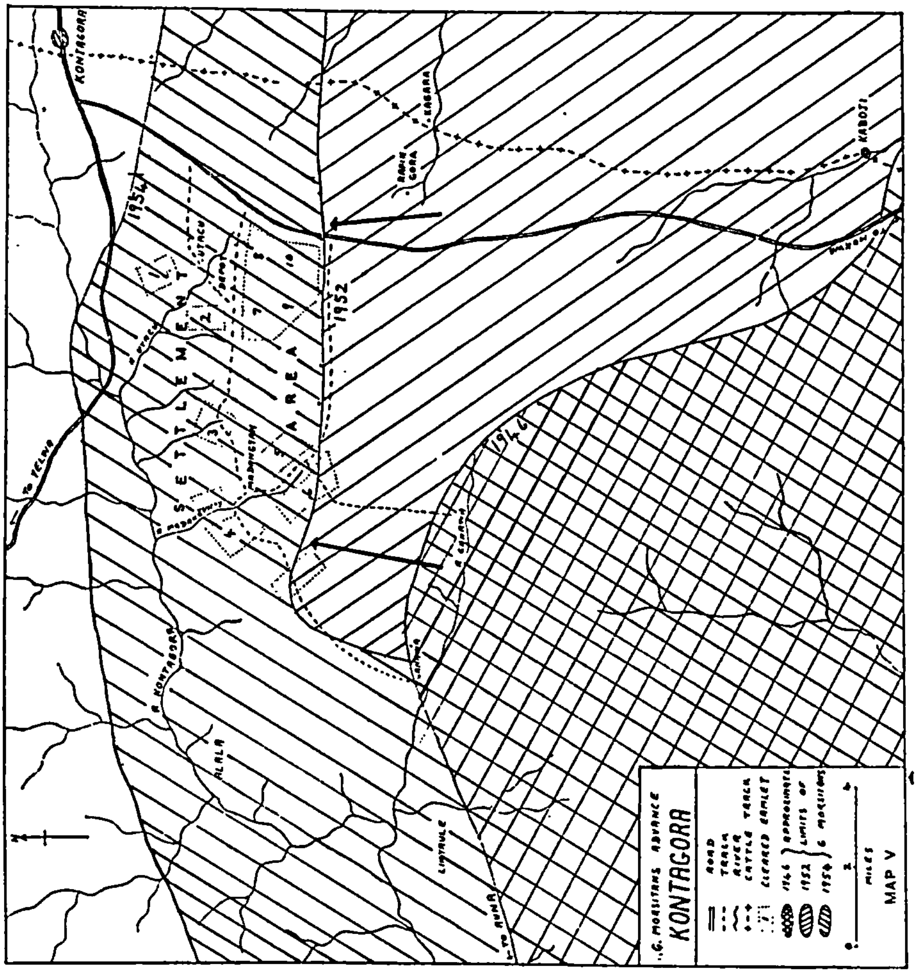
The motor road from Kontagora to Mokwa runs approximately north and south through the middle of this belt, and there are also two important trade cattle routes, one running parallel to the River Niger from Yelwa through Auna to Jebba while a second route passes through Kontagora and southwards through Kaboji village, close to the motor road, to Jebba.

Previous History

Attention was first drawn to this fly-belt in 1946 when plans were drawn up, firstly to improve the surface of the Kontagora–Jebba motor road and attract population and cultivation close to this route and secondly to make the trade cattle routes more safe for cattle passing southwards to the Ibadan and Lagos markets.

Two early tsetse surveys were therefore carried out along the cattle routes, one by the Medical Department in the wet season months of July and August 1946, when the tsetse were likely to be at their maximum dispersal range, and a second in February 1947 by the Veterinary Department, when the tsetse were likely to be more restricted. Both surveys confirmed that the northern limits of *G. morsitans submorsitans* were still slightly south of Auna and Kaboji villages and to the north of these hamlets only riverine tsetse were prevalent.

Further importance was given to the whole Kontagora area when in 1948 plans were made for a settlement scheme immediately to the north of the *G. morsitans submorsitans* fly-belt, west of Kontagora Town and south of the Kontagora–Yelwa road (Map V). Tsetse surveys of the settlement area were carried out again by both departments in 1948. Both surveys failed to find *G. morsitans submorsitans* but the survey carried out by the Medical Department in November 1948 was more thorough, and while confirming that the Kontagora river and the Utacu and Madangyan streams


KONTAGORA
MAP V
SETTLEMENT AREA
1954
1952
1946

were infested with *G. palpalis* and *G. tachinoides*, revealed a complete absence of *G. morsitans submorsitans* either along the rivers or in the surrounding bush and *Isoberlinia* woodland.

The proposed settlement area was then still very popular with the nomadic Fulani herdsmen, the semi-settled groups using the area as grazing grounds during December and January each year before moving off to make way for the true nomadic herds which arrived after the grass fires and stayed until the rains in April and May. These latter herds were forced to use water-holes along the Utacu and other streams and their chief complaint was of riverine tsetse which eventually forced them to move north again each year.

G. morsitans submorsitans Advance after Settlement

When the settlement scheme was eventually started in 1949, it was considered necessary to clear only the riverine vegetation to ensure the safety of the settlers and their cattle and these clearings were started in December 1948. During the next three years, nineteen miles of vegetation along the Kontagora river, thirty-five miles along the Utacu and Madangyan streams and five miles of the river Gora stream east of the settlement were cleared and the settlement area was rendered almost free of *G. palpalis* and *G. tachinoides*.

Cattle were introduced into the settlement during the first year, in 1949, and increased in numbers each year and early cases of trypanosomiasis were to be expected as the riverine tsetse were not then completely eradicated. During the next two years however deaths amongst cattle from this disease increased rather than decreased although the riverine clearings and preventive barriers on the Kontagora river were becoming more and more effective. Thus in 1949, five deaths from trypanosomiasis occurred amongst seventy-seven cattle at the depot and Hamlets 1 and 2 which represented 6·5% of the population while in 1951, forty-two deaths occurred amongst 305 cattle or 13·8%.

In 1952, with ever-increasing cattle mortality, the possibility that *G. morsitans submorsitans* were invading the area was first realised and in April of that year three tsetse assistants succeeded in catching three *G. morsitans submorsitans* in six hours along, or close to, the new motor road connecting Hamlet 6 to the Mokwa road along the southern perimeter of the settlement area.

Between May and June 1952, as the result of repeated surveys, one fly was caught well within the settlement area at Utacu depot while three were found along the Mokwa road and three in the R. Gora stream.

During September and October 1952, two flies were again caught near the Utacu stream while one fly was caught at each of Hamlets 3, 4 and 5 along the Madangyan stream and five further flies were caught on the Mokwa road, but Alala and Madangyan villages were still clear. A few weeks later however a focus of *G. morsitans submorsitans* was found on a path three to five miles south of Madangyan village on the way to Ganawa village where twenty flies were caught in two hours along two miles of path while ten flies were caught on the Mokwa road and thirty-two were collected on the R. Gora stream.

By the end of 1952, it was obvious that the whole *G. morsitans submorsitans* front had advanced north to the southern perimeter of the settlement, the chief thrusts being both along the Mokwa road where fly were now well established along the eastern boundary of the settlement and also from the Ganawa river towards Hamlet 6. From this advanced front individual flies were penetrating the settlement as far north as the Utacu stream.

During 1953, the numbers of cattle within the settlement area continued to increase and numbered 467 head by March 1954, when 4,000 acres of woodland had been cleared around the various hamlets. The health of these cattle was well maintained by Antrycide pro-salt injections every sixty to ninety days. Patrols and surveys however throughout the area continued to show that the settlement was being increasingly invaded by *G. morsitans submorsitans* but regular weekly patrols by trained tsetse assistants along defined routes were not organised until May 1954.

Fly-round No. 5 traversed the motor road from Hamlet 6 to the Mokwa road where fly were first found in April 1952, but it then required three tsetse assistants six hours to catch three flies. The catches along the route from April 1954 to December 1956 are given in Table I.

Table I.—Total Number of *G. morsitans submorsitans* Caught per Patrol along Patrol No. 5 for May 1954 to December 1956

	J.	*F.*	*M.*	*A.*	*M.*	*J.*	*J.*	*A.*	*S.*	*O.*	*N.*	*D.*
1954 .	—	—	—	—	0	2	1	1	3	4·5	7·5	1·5
1955 .	2	1·5	2	0	0·5	4	6·5	8	9·5	6·5	66	22
1956 .	1 ·6	2·5	1	1	3	6	4·5	5·5	12·5	16	4	6

It is evident that as soon as the rains broke in May each year fly density along the southern boundary of the settlement increased and in November 1955 reached invasion proportions.

Further north well within the settlement area on the Utacu stream where three fly were caught during 1952, catches along a regular patrol during the same period are given in Table II.

Table II.—Total Number of *G. morsitans submorsitans* Caught per Patrol along the Utacu Stream

	J.	*F.*	*M.*	*A.*	*M.*	*J.*	*J.*	*A.*	*S.*	*O.*	*N.*	*D.*
1954 .	—	—	—	—	1·5	0	0	0	2	1	2	0
1955 .	0	0	0	1·5	2	7	5·5	0	2·5	4	2	2
1956 .	0	0	3	8	3	3·3	2	0	0	2	3	2·5

It is obvious from these results that fly were regularly dispersing through the settlement area. Search for breeding sites however were largely unsuccessful except along the southern perimeter where a few scattered pupa cases were occasionally found.

Early in 1955, surveys to the south of Hamlet 6 disclosed a heavy concentration of *G. morsitans submorsitans* along the upper reaches of the Ganawa river and marked fly from this focus were found as far north as the boundary of the settlement. Experimental clearings carried out on this river during March and April 1956, while causing a marked reduction and disturbance of distribution of fly locally, had little effect on the numbers dispersing throughout the settlement. About the same time concentrations of fly were found along the cattle trade route to within a few miles of Kontagora.

During 1956, it was obvious that cattle farming in the settlement area would not be successful as over 50% of the cattle were being persistently positive to trypanosomiasis and a drug-resistant strain of *T. congolense* had developed. The Scheme was therefore closed in 1957, and the cattle sold for slaughter.

Discussion

The factors which influenced the advance of *G. morsitans submorsitans* into the Kontagora settlement area from 1951 onwards would, if properly understood, yield valuable information on the behaviour of this tsetse.

Prior to 1949 Fulani cattle used this area for grazing only during the dry season, retreating northwards to their traditional homes during the rainy season from May to November. In this way these cattle were largely able to avoid contact with *G. morsitans submorsitans* as during the dry season when the midday relative humidity was below 20% this tsetse tended to retreat towards such permanent rivers as the Ganawa.

From 1950 onwards, the density of human population increased within the settlement area, bush clearing was in progress around the hamlets and riverine vegetation had been cleared from all streams within the area. All these factors were directed towards making the area less attractive to *G. morsitans submorsitans*. The only apparently favourable factors were the opening up of the area with paths and roads with increased traffic and also groups of settlement cattle permanently resident in the area. Also considerable tracts of *Isoberlinia* woodland still remained untouched north and east of Hamlet 6 on relatively infertile land. These factors appeared to be sufficient to induce the tsetse to leave their usual haunts at Ganawa and invade the settlement area, especially in the wet season, in increasing numbers.

GENERAL DISCUSSION

The evidence as shown in the four areas discussed leave no doubt but that a movement northwards by *G. morsitans submorsitans* has occurred during the past ten years in all these fronts. No equivalent advance or increase in local density has been recorded for the riverine species, *G. tachinoides* and *G. palpalis*.

The simplest explanation of these local advances is based on the knowledge that if the human population leave any area in the Guinea zone the regenerating *Isoberlinia* woodland is most likely to be reoccupied quickly by *G. morsitans submorsitans*. This factor has been operative to some extent in the Song, Anchau and Doka areas but the reverse occurred in Kontagora, where population was actually increasing in the area of advance.

The same principle applies when forest reserves within the *morsitans* area create more favourable environmental conditions, increase fly density and make a tsetse advance more probable. If further forest reserves are placed along the periphery of the fly-belt they can act as stepping-stones to forward fly movements and thus act as a threat to fly-free areas. This has occurred at Shika where Forest Reserves Nos. 22 and 26 have become infested and threaten the infestation of Forest Reserves Nos. 2 and 28 and must have assisted in the final establishment of *G. morsitans submorsitans* along the whole Galma valley.

A general improvement of environment for *G. morsitans submorsitans* would also follow a series of short dry seasons associated with prolonged rainy season. In this way the period of stress on savannah tsetse would be shortened during the critical months of February to April when midday relative humidities normally fall below 20%. Meteorological data collected over the past twenty years still require detailed analysis but a very preliminary examination of the rainfall figures from Shika show that a rainfall cycle may exist, with alternate wet and dry periods. Thus if the rainfall figures at Shika over the past thirty-four years, when the average rainfall was 44·5 in., are divided in seven-year periods, the number of years in which rainfall was above the average in each period was as follows:

	1924–1930	*1931–1937*	*1938–1944*	*1945–1951*	*1952–1958.*
Years above average .	5	4	1	3	4

A "dry" period therefore occurred during the years 1938 to 1944 inclusive, during which a recession of *G. morsitans submorsitans* may have occurred. The present advances may, in some instances, be merely a recovery of lost ground due to increased density following a series of favourable years. A record rainfall of 56·12 in. fell in 1946.

While the early onset of rains in March causes a rise in relative humidity which favours the fly during a period when desiccation of the adult population is most likely, heavy prolonged rains in September also assists the *morsitans* economy by ensuring that pools on upper reaches of streams persist longer into the following dry season months of March and April.

The early onset of rains would also have a cooling effect, reducing maximum temperatures, and so increase longevity and fertility of the female fly and survival of the pupa.

Several additional local factors have reacted favourably on the fly advance. The provision of an easily available food supply in the form of permanent cattle herds has undoubtedly had an effect on the dispersal and establishment of *G. morsitans submorsitans* on Shika stock farm and also on the northward dispersal through the Kontagora settlement area. Also, in a country where nomadic herds form a permanent feature of the animal husbandry practice, it is most likely that these mass movements exercise some effect of fly dispersal. This has undoubtedly assisted in the dispersal of *G. morsitans submorsitans* in the Anchau–Banke area. In the same way the opening up of the Kontagora area by roads and increasing donkey traffic along roads and paths bringing produce to market, as in the Anchau area, must also have a considerable local influence.

It could be hoped that, if climatic factors were chiefly responsible for the present *G. morsitans submorsitans* advance, then a recession would take place in another seven to fourteen years period. But the evidence for this tide-like dispersal of tsetse until they reach the edge of their range followed by a retreat is not by any means definite, nor could it be relied upon in the absence of definite control measures.

Economic control measures for *G. morsitans submorsitans* in woodland country in the absence of population pressure from the surrounding countryside are difficult to formulate.

SUMMARY

Very little attention has been devoted in the past to recording the distribution and movements of *G. mortisans submortisans* in Northern Region Nigeria.

Four definite advances northward of this tsetse have recently been recorded, in the Song area of Adamawa province, in the Anchau–Banke area and in the Doka–Shika area of Zarina province, and in the Kontagora area of Niger province.

These four advances are described in detail and all have occurred since 1950 and, except in the Anchau area, have now appeared to have reached their maximum limits.

The factors which have influenced these advances during the past eight years are difficult to determine but movements of human population, climatic factors, and easily available food supply provided by herds of cattle grazed permanently near the limits of fly-belts, have all played a part.

Game have exercised a very minor role in these advances.

ACKNOWLEDGMENTS

Many thanks are due to the many officers of the Ministry of Health and Ministry of Animal Health and Forestry, whose records have been used so freely in compiling the history of these tsetse advances. More especially, my thanks are due to Mr. Howell Davies, of the Veterinary

Division, Ministry of Animal Health and Forestry, who carried out the detailed survey establishing the advance of *G. morsitans submorsitans* in the Song area of Adamawa, did much of the preliminary work at Kontagora, and has assisted me greatly in the preparation of this article.

Mr. K. J. R. Maclennan, M.B.E., of this Ministry was responsible for many of the more recent surveys in the Anchau area.

My thanks are also due to my Minister, Honourable Alhaji Dan Buram Jadah, M.H.A., for his continued interest and encouragement in this work.

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APPENDIX/ANNEXE

RECOMMENDATIONS OF THE SIXTH MEETING
RECOMMANDATIONS DE LA SIXIEME REUNION

SALISBURY, 1956

GENERAL REPORTS

REPORTS OF DISCUSSIONS ON METHODS OF CONTROL OF *GLOSSINA*

In conformity with Point 13 of the Resolutions of the Fifth Meeting the Committee discussed current methods of tsetse control which could be classified as follows :

(i) Direct Attack on *Glossina*

(*a*) Parasites and Predators

Attempts to control tsetse by the artificial breeding and release of local parasites has not met with success. Although such parasites exert a controlling influence on the size of the population, they cannot effect eradication.

(*b*) Hand Catching and Traps

Neither method has shown promise.

(*c*) Insecticides

Where complete isolation has been possible, aerial application of insecticides against *G. pallidipes* and *G. brevipalpis* has been entirely successful. In the absence of complete isolation, this measure can be applied to reduce the trypanosome challenge to man and animals in the early stages of settlement and economic projects.

Ground application to riverine vegetation of residual insecticide has proved successful against *G. palpalis* ; the speed with which the method can be applied make it a valuable measure in controlling epidemic sleeping sickness.

(ii) Starvation

(*a*) Game Elimination

It is not certain whether game elimination eradicates the tsetse solely by inducing starvation. Despite the specific food preferences demonstrated by Mr. Weitz, selective game destruction would not necessarily eliminate the fly, because of its ability to turn to other hosts when such are available.

(iii) Modification of the Habitat

(*a*) Sheer Clearing

As a means of halting advances of savannah species of tsetse this appears to be giving way to discriminative clearing in depth, because the latter is cheaper and requires little if any maintenance.

(*b*) Partial (Descriminative) Clearing

This measure is being more extensively used and refined for the reclamation of large areas of country.

N.B.—Work with arboricides is being undertaken with varying success.

(*c*) Human Occupation.

This measure has proved most successful in consolidating reclaimed areas, and settlement in sufficient density and under favourable conditions has eradicated tsetse from large areas infested by certain species of tsetse.

(iv) Auto-Sterilisation of the Tsetse Population

(*a*) Hybridisation

This measure has been tried, but without success.

(*b*) Sterilisation of Males by Gamma Rays

This measure is under investigation, but does not appear to be promising in the case of *Glossina*.

CHEMOTHERAPY OF HUMAN TRYPANOSOMIASIS

I. RECOMMENDED SCHEMES OF TREATMENT

A. *T. rhodesiense* Trypanosomiasis

(1) Haemolymphatic Stage

(*a*) Suramin (Antrypol, Moranyl, Bayer 205) 5 grammes intravenously, i.e. 5 × 1 gramme on the 1st, 3rd, 7th, 14th and 21st days, reducing the first few doses to 0·25 or 0·5 grammes in patients in poor condition.

(*b*) Pentamidine is considered less active but may be used in the dosage given below for *T. gambiense* infections.

(*c*) Mel B. Usual dosage : one series of three or four daily injections of 3·6 mg./kg. There is some indication that a single dose of 4 mg./kg. may prove effective. Neither of these treatments is recommended as a routine because of the toxicity of the drug.

Comments

Pentamidine and Suramin therapy should be reserved strictly for those cases in which there is no sign whatever of meningeal involvement.

(2) Nervous Cases

Mel B (Arsobal) at the same dosage as in the nervous stage of *T. gambiense* trypanosomiasis.

Comments

(*a*) The early doses should be reduced for individuals in a poor physiological state ;

(*b*) When the general condition is very poor, treatment by Mel B may be preceded by one to four injections of Suramin (Antrypol, Moranyl, Bayer 205) or tryparsamide.

B. *T. gambiense* Trypanosomiasis

The best drug at all stages of the disease is Mel B, but its use can only be recommended for cases treated in hospital.

(1) **Haemolymphatic Stage** (in the strictest sense)

(Not more than three cells per cubic mm. nor more than 25 mg. per 100 ml. of albumin in the C.S.F.)

Pentamidine

(*a*) Usual total dosage: 25 to 30 mg. (base)/kg., never exceeding 40 mg. (base)/kg.

(*b*) Routine of injections: either 10 × 3 or 4 mg. (base)/kg., intramuscularly, on 10 consecutive days,

or two series of five injections of 3 or 4 mg. (base)/kg., intramuscularly, every other day, separated by a rest of eight days.

Comments

(*a*) Pentamidine therapy should be reserved strictly for those cases in which there is no sign whatever of meningeal involvement.

(*b*) A single dose of 4 mg./kg. of Mel B gives excellent results in this stage.

(*c*) Suramin, and Pentamidine, alone or in combination with tryparsamide still give satisfactory results in certain territories.

(2) **Stage of Meningeal Involvement** (without clinical nervous symptoms)

The treatment should be the same as for the nervous stage.

(3) **Nervous Stage**

(*a*) Regions where no tryparsamide resistance is encountered. In those regions tryparsamide (alone or in association) still retains all the indications according to classical schemes of treatment.

(*b*) Regions where high tryparsamide resistance is encountered. Mel B is generally the only drug capable of curing the illness at this stage.

Dosage: According to the extent of changes in the C.S.F. and to the clinical signs, one or more series of three or four daily injections of 3·6 mg./kg. should be given, with intervals of eight days between series.

Comments

(*a*) The quantity of Mel B given at each injection should be calculated exactly according to the weight of the patient, except that a dose of 250 mg. (for a man of 70 kg.) should never be exceeded.

(*b*) Cases of Mel B resistance have been recorded with both *T. rhodesiense* and *T. gambiense.*

II. TREATMENT OF CASES OF *T. GAMBIENSE* RELAPSED FROM OTHER TREATMENTS

Mel B is the only trypanocide regularly used which gives any results and makes it possible to save some 35% to 40% of these cases.

III. NEW TRYPANOCIDES

(*a*) *Stylomycin* : Trials in animals and on man have given results inferior to those obtained with other drugs.

(*b*) *Nitrofurazone* (Furacin) : Trials in animals and on man have given some encouraging results.

(*c*) *Melarsen* : It would seem that a new preparation of melarsen used in Nigeria is of low toxicity and could be used with success in the field.

The Committee considers that trials of these drugs should be carried further.

IV. CHEMOPROPHYLAXIS

(1) *T. gambiense trypanosomiasis* : No communications have been received by the Committee. Chemoprophylactic campaigns are in progress in certain territories (Pentamidine).

(2) *T. rhodesiense trypanosomiasis :*

(*a*) Prophylactic campaigns with Pentamidine have been carried out with success in an area in Mozambique during an epidemic outbreak.

(*b*) It is known that some trials that have not been reported have been carried out in Bechuanaland and Ruanda-Urundi.

FINAL RESOLUTIONS

A. PROTOZOOLOGY

The Committee PROPOSES that the following problems should be further investigated :

(1) Search for the presence in West Africa of *T. uniforme* and a study of the course of the infection in ruminants.

(2) Revision of the *Congolense* group, with special reference to the status of *T. dimorphon* and related forms. (This study has already been started by Dr. Hoare.)

(3) More information is required on the distribution in Africa of *T. suis*, and of the clinical and epidemiological aspects of infections with this species in pigs.

(4) The study of factors governing the host-parasite relations in those intraspecific strains of trypanosomes which differ in virulence and host-range.

(5) In connection with papers by Dr. Willett (presented at the Sixth

Meeting) and by Dr. E. A. Lewis (at the Fifth Meeting), it would be desirable to carry out experiments on the effect of the species of *Glossina* vectors upon the virulence of the trypanosomes transmitted by them.

B. ENTOMOLOGY

1. The Committee NOTES the results obtained from serological methods developed by Mr. B. Weitz for the determination of the source of blood meals of *Glossina*, and wishes to record its appreciation of this most valuable work. It RECOMMENDS that the collection of material should be extended to as many parts of Africa as possible, with a view to determining the most important species of host for each species of tsetse.

2. The Committee EXPRESSED itself as satisfied that *Glossina pallidipes* had been eradicated from Zululand and with it epizootic trypanosomiasis and records its appreciation of the action of the Government of the Union of South Africa in carrying out the recommendations of Point 11 of the Resolutions of the Fifth Meeting.

3. The Committee NOTES the large scale successes achieved by game elimination in Southern Rhodesia and Uganda.

It would appear that in certain circumstances this measure may be an efficient and economical method for halting an advance of *G. morsitans* and achieving reclamation.

4. The Committee SUGGESTS that opportunity be taken, whenever possible, to utilise game killed in control operations to provide information on the incidence of trypanosomes in different species of the wild fauna. It NOTES that examination of blood films alone tends to be unsatisfactory and should be supplemented by all other measures which should be the subject of further study.

5. The Committee RECOMMENDS that entomologists should continue studies on the ecology of tsetse flies for the purpose of discovering methods of eradication which would cause less disturbance to the natural habitat than the methods at present in use, viz.: clearing, destruction of game or the use of non-selective insecticides.

6. The Committee RECOMMENDS that further studies should be made with a view to provide criteria for the differential diagnosis of trypanosome infections in glossinae.

C. ANIMAL TRYPANOSOMIASIS

(1) The Committee is of opinion that, while chemotherapy and chemoprophylaxis are very valuable aids in the control of trypanosomiasis in areas of low tsetse fly density, the application of active measures against the vectors remains essential.

(2) The Committee NOTES with satisfaction the promising results of the experiments carried out in West Africa with the suramin complexes in the chemoprophylaxis of animal trypanosomiasis and RECOMMENDS the

expansion of the study of chemoprophylaxis in general by controlled experiments under adequate veterinary supervision.

(3) The Committee RECOMMENDS that studies into the mechanism of tolerance to trypanosome infection in animals should be continued.

(4) The Committee, realising the limitation of existing drugs, RECOMMENDS that research be intensified to develop broad spectral trypanocidal drugs with a wider range of activity.

(5) In order to derive maximum benefit from the results obtained by research workers in the sphere of animal trypanosomiasis, this Committee RECOMMENDS that "rapporteurs" be appointed to the Seventh Meeting of I.S.C.T.R. to present a general appraisal of the present state of our knowledge on:—

(*a*) photosensitivity in animals;

(*b*) chemotherapy and chemoprophylaxis of bovine trypanosomiasis and also drug resistance;

(*c*) tolerance to trypanosome infection.

(6) The Committee REQUESTS the Governments of the Union of South Africa to deal with section (A), of the United Kingdom to deal with (B) and of French West Africa to deal with (C).

D. HUMAN TRYPANOSOMIASIS

The Committee RECOMMENDS that:

(1) Research should be continued on the true prophylactic value of Pentamidine and Suramin and on the frequency with which injections need to be given.

(2) Research should be undertaken on the risk of occult forms of both *gambiense* and *rhodesiense* trypanosomiasis following chemoprophylactic campaigns.

(3) Research should be continued:

(*a*) with a view to improving present trypanocides, in respect of activity and toxicity;

(*b*) to finding new trypanocides;

(*c*) to determining the value of therapeutic association and in particular the Pentamidine-Antrypol association at the haemolymphatic stage;

(*d*) to ascertaining the benefit that sleeping sickness can derive from non-specific treatment.

(4) Research should be continued to ascertain the percentage of patients treated with Pentamidine, in the blood-lymph stage, who develop nervous involvement.

(5) That a rapporteur should be appointed to take stock of the position in respect of chemoprophylaxis, and invites the Governments of France and Portugal to appoint a rapporteur for *T. gambiense* and *T. rhodesiense* sleeping sickness respectively.

E. MAPPING OF THE DISTRIBUTION OF GLOSSINAE AND TRYPANOSOMIASIS

(1) Maps of the distribution of tsetse flies to be kept up to date by the appropriate departments in the various territories ;

(2) The information contained in such maps to be made available to all interested parties, especially the B.P.I.T.T. on request ;

(3) The map compiled by Mr. Potts serves its purpose admirably and should be retained pending a revision ;

(4) The need for a revision of Mr. Potts' map to be decided by the I.S.C.T.R., as the only expert body competent to deal with matters concerning trypanosomiasis and its vectors. The revision is to be undertaken by the B.P.I.T.T. on the basis of the existing territorial maps (see 1 above).

(5) With regard to the mapping of the distribution of sleeping sickness the Committee has nothing to add to Resolution No. 3 of the Fifth Meeting of I.S.C.T.R.

FINAL GENERAL RESOLUTIONS

1. The Committee expresses the wish that the various branches concerned with trypanosomiasis control : i.e. medicine, veterinary medicine, entomology, botany, forestry, ecology, etc., should be appropriately represented at I.S.C.T.R. meetings.

2. The Committee decided to empower the Secretary, Dr. F. Evens, to edit and publish the final resolutions, after the closing of the meeting, on the understanding that amendments shall not affect the substance or the spirit of the resolutions.

3. The Committee took note with appreciation of the invitation extended by the Belgian Delegation to hold its next meeting in Brussels in 1958 at the time of the International Exhibition to be held in that city, accepts this invitation and requests the head of the Belgian Delegation to convey its thanks to his Government.

4. The Committee thanked Mr. J. K. Chorley for the very able manner in which he had conducted its work at the Sixth Meeting.

5. The Committee elected Dr. Neujean to take the Chair at the Seventh Session, in 1958.

6. The Committee expressed its thanks to Dr. Evens, Mr. Hendrickx, Mr. Grosse, Mr. Hewitson and the ladies of the Secretariat for their co-operation in the organisation and work of this Conference.

7. The Committee expressed its thanks and appreciation to the Government of the Federation of Rhodesia and Nyasaland for its hospitality and for all the arrangements which were made on the occasion of this meeting and in particular expressed its gratitude to the Speaker of the Southern Rhodesian Legislative Assembly for all the facilities provided.

8. The Committee expressed its thanks to the authors of all papers presented at this Session and to the B.P.I.T.T. for its assistance.

RAPPORTS GENERAUX

RAPPORTS DES DISCUSSIONS SUR LES METHODES DE LUTTE CONTRE LA *GLOSSINE*

Conformément au Point 13 des Résolutions de la 5ème Réunion, le Comité a discuté des méthodes courantes de lutte contre la tsé-tsé et qui pourraient être classées comme suit :

(i) Destruction directe

(*a*) Parasites et Prédateurs

Les tentatives de lutte contre la tsé-tsé par l'élevage et la libération de parasites locaux n'ont pas eu de succès. Bien que de tels parasites exercent une influence sur la grandeur de la population en la diminuant, ils ne peuvent cependant en provoquer l'éradication.

(*b*) Captures à la main et piégeage

Aucune de ces méthodes n'est prometteuse.

(*c*) Insecticides

Là où l'isolement complet a été possible, des applications aériennes d'insecticides contre *G. pallidipes* et *G. brevipalpis* ont été entièrement couronnées de succès. En l'absence d'un isolement complet, cette mesure peut être appliquée pour réduire la menace trypanosomique pour l'homme et les animaux, dans les stades initiaux de colonisation et dans des cas de projets économiques.

L'application sur la végétation riveraine d'un insecticide à effet rémanent faite du sol a été une réussite contre *G. palpalis* ; la rapidité d'application de cette méthode en fait une mesure de valeur dans la lutte contre une épidémie de maladie du sommeil.

(ii) Eradication par la faim

(*a*) Destruction du gibier

Il est certain que la destruction du gibier élimine la tsé-tsé uniquement en l'affamant. Malgré la préférence d'une nourriture spécifique démontrée par Mr. Weitz, une destruction sélective du gibier n'éliminerait pas nécessairement la mouche, à cause de sa capacité d'adaptation à d'autres hôtes quand ceux-ci existent.

(iii) Modification de l'habitat

(*a*) Déboisement total

Comme moyen destiné à arrêter l'invasion d'espèces de tsé-tsés de savane, cette méthode est abandonnée en faveur du déboisement sélectif en profondeur, parce que cette dernière méthode est plus économique et requiert peu ou pas d'entretien.

(*b*) **Déboisement partiel ou sélectif**

Cette méthode est plus communément utilisée et adaptée à la récupération de grandes surfaces de terrain.

N.B.— Des expériences avec les arboricides ont été faites avec des résultats variables.

(*c*) **Occupation par l'homme**

Cette mesure a connu le plus grand succès lors de la consolidation de régions récupérées et des colonisations suffisamment denses et dans des conditions favorables a éliminé la mouche tsé-tsé de grandes surfaces infestées par certaines espèces de tsé-tsés.

(iv) Autostérilisation de la population glossinienne

(*a*) **Hybridation**

Cette méthode a été essayée sans succès.

(*b*) **Stérilisation des mâles par rayons gamma**

Cette méthode fait l'objet de recherches, mais ne semble pas prometteuse dans le cas de la *Glossine.*

CHIMIOTHERAPIE DES TRYPANOSOMIASES HUMAINES

I. SCHEMAS DE TRAITEMENT RECOMMANDES

A. Trypanosomiase à *T. rhodesiense*

(1) **Stade lymphatico-sanguin**

(*a*) Suramine (Antrypol/Moranyl/Bayer 205) 5 gr. par voie intraveineuse soit 5×1 gr. le 1^er^, 3^e^, 7^e^, 14^e^ et 21^e^ jour, en réduisant les premières doses à 0,25 ou 0,5 gr. pour les patients en mauvais état physiologique.

(*b*) La Pentamidine est considérée comme étant moins active, mais peut être utilisée aux doses indiquées ci-dessous pour les infections à *T. gambiense.*

(*c*) Mel B. Dosage usuel : une série de 3 ou 4 injections quotidiennes de 3,6 mg./kg. Il y a des indications qu'une seule dose de 4 mg./kg. pourrait être efficace. Aucun de ces traitements n'est recommandé pour la routine à cause de la toxicité du médicament.

Commentaires

La thérapie à la Pentamidine et la Suramine doit être strictement réservée pour les cas où il n'y a pas de signe d'évolution nerveuse.

(2) **Stade Nerveux**

Mel B (Arsobal) aux mêmes dosages que dans la période nerveuse de la trypanosomiase à *T. gambiense.*

Commentaires

(*a*) Il y a lieu de réduire les premières doses chez les individus en mauvais état physiologique.

(*b*) Lorsque l'état général est très mauvais, il y a lieu de faire précéder le traitement au Mel B par 1 à 4 injections de Suramine (Antrypol, Moranyl, Bayer 205) ou tryparsamide.

B. Trypanosomiase à *T. gambiense*

Le meilleur trypanocide à toutes les périodes de la maladie est le Mel B, dont l'emploi ne peut être pourtant recommandé qu'en pratique hospitalière.

(1) **Période lymphatico-sanguine** (sensu stricto)

(pas plus de 3 cellules par cmm. ni de 25 mg. d'albumine dans le liquide rachidien.)

(*a*) Dosage total usuel 25 à 30 mgr. (base)/kg. sans jamais dépasser 40 mgr. (base)/kg.

(*b*) Rythme des injections : soit 10 × 3 × 4 mgr. (base)/kg. par la voie intramusculaire pendant 10 jours consécutifs, ou 2 séries de 5 injections de 3 à 4 mgr. (base)/kg. par la voie intramusculaire à jour passé, séparées par une période de repos de 8 jours.

Commentaires

(*a*) Les indications de la pentamidine devraient être strictement réservées aux cas où aucune réaction méningée ne peut être suspectée.

(*b*) Le Mel B à la dose unique de 4 mgr./kg. donne d'excellents résultats à ce stade.

(*c*) L'antrypol et la pentamidine seuls ou en association avec la tryparsamide donnent toujours de bons résultats dans certaines régions.

(2) **Stade de réaction méningée** (sans symptômes nerveux cliniques)

Même traitement que celui de la période nerveuse.

(3) **Période nerveuse**

(*a*) Régions sans tryparsamido-résistance : Dans celles-ci, la tryparsamide conserve toutes ses indications (seule ou en association) suivant les schémas de traitement qui ont fait leurs preuves.

(*b*) Régions à haute tryparsamido-résistance : Le Mel B est généralement le seul produit capable de guérir la maladie à ce stade.

Dosage : Suivant l'importance des altérations liquidiennes et des signes cliniques, il sera administré 1 ou plusieurs séries de 3 ou 4 injections quotidiennes de 3,3 mgr./kg. avec des intervalles de 8 jours entre les séries.

Commentaires

(*a*) La quantité de Mel B administrée lors de chaque injection doit être calculée exactement d'après le poids du malade, sans toutefois dépasser 250 mgr. (individu de 70 kgs.).

(*b*) Des cas de résistance au Mel B sont signalés tant pour *T. rhodesiense* que pour *T. gambiense*.

II. TRAITEMENT DANS LA TRYPANOSOMIASE DES MALADES A *T. GAMBIENSE* FAISANT UNE RECHUTE APRES D'AUTRES TRAITEMENTS

Le Mel B est le seul trypanocide utilisé régulièrement qui donne quelque résultat et permet de récupérer 35 à 40% de ces cas.

III. NOUVEAUX TRYPANOCIDES

(*a*) *Stylomycine* — des essais chez l'animal et chez l'homme ont donné des résultats inférieurs à ceux obtenus avec d'autres produits.

(*b*) *Nitrofurazone* (Furacin) — des essais pratiqués chez l'animal et chez l'homme ont donné des résultats encourageants.

(*c*) *Melarsen* — une nouvelle préparation de Melarsen utilisée en Nigéria possède une faible toxicité et pourrait être utilisée avec succès sur le terrain.

Le Comité estime qu'il y a lieu de poursuivre les essais avec ces produits.

IV. CHIMIOPROPHYLAXIE

(1) *Trypanosomiase à T. gambiense* : Aucune communication n'a été faite au Comité. Des campagnes de chimioprophylaxie sont poursuivies dans certains territoires (Pentamidine).

(2) *Trypanosomiase à T. rhodesiense.*

(*a*) Des campagnes de pentamidinisation ont été poursuivies avec succès dans une partie du Mozambique pendant une épidémie.

(*b*) Il est connu que certaines campagnes ont été effectuées au Bechuanaland et au Ruanda-Urundi, sans qu'elles fassent l'objet d'un rapport.

RESOLUTIONS FINALES

A. PROTOZOOLOGIE

Le Comité PROPOSE l'examen des problèmes suivants :

(1) La recherche en Afrique Occidentale de *T. uniforme* et l'étude de l'évolution de l'infection chez les ruminants.

(2) La révision du groupe *congolense*, spécialement en vue du statut de *T. dimorphon* et formes voisines. (Cette étude a déjà été entamée par le Dr. Hoare.)

(3) Il est nécessaire d'obtenir plus d'informations sur la distribution en Afrique du *T. suis* et sur les aspects cliniques et épidémiologiques de cette infection chez les porcs.

(4) L'étude des facteurs influençant les relations entre le parasite et son hôte chez ces souches intraspécifiques de trypanosomes qui diffèrent de par leur virulence et leur distribution chez les animaux.

(5) En rapport avec les travaux présentés par le Dr. Willett à la 6ème Réunion et par Mr. Lewis à la 5ème Réunion, il serait souhaitable que des expériences soient entreprises en vue de déterminer l'effet de l'espèce de glossine vectrice sur la virulence des trypanosomes transmis par elle.

B. ENTOMOLOGIE

1. Le Comité PREND NOTE des résultats obtenus par les méthodes sérologiques mises au point par Mr. B. Weitz pour identifier les repas sanguins des glossines, et CONSTATE que ces travaux présentent une très grande valeur. Il RECOMMANDE que du matériel soit rassemblé, dans le plus grand nombre possible de territoires africains, en vue de déterminer les espèces d'hôtes les plus importantes pour chaque espèce de glossine.

2. Le Comité CONSTATE que *Glossina pallidipes* a été éradiquée au Zoulouland et, par voie de conséquence, la trypanosomiase épizootique. Il loue l'effort accompli par le Gouvernement de l'Union de l'Afrique du Sud pour la mise en œuvre des Recommandations relatives au Point 11 des Résolutions de la 5ème Réunion.

3. Le Comité PREND NOTE des succès de grande envergure remportés grâce à la destruction du gibier en Rhodésie du Sud et en Ouganda.

Il semblerait que, dans certaines circonstances, ces mesures puissent constituer une méthode efficace et économique pour enrayer les progrès de *G. morsitans* et remettre les terres en valeur.

4. Le Comité SUGGERE que, dans la mesure du possible, on tire parti du gibier abattu au cours des opérations de lutte antiglossinienne pour obtenir des indications sur l'incidence des trypanosomes chez les différentes espèces de la faune sauvage. Il PREND NOTE du fait que l'examen microscopique du sang ne suffit pas, à lui seul, et qu'il y a lieu d'y adjoindre toutes autres mesures qui devront faire l'objet de plus amples études.

5. La Comité RECOMMANDE que les entomologistes poursuivent leurs études sur l'écologie des glossines en vue de déterminer des méthodes d'éradication susceptibles de troubler moins l'équilibre naturel du milieu, que ne le font les méthodes actuellement appliquées (déboisement, destruction du gibier, emploi d'insecticides non-sélectifs).

6. Le Comité RECOMMANDE que les études soient poursuivies en vue de fixer les critères du diagnositic différentiel des infections à trypanosomes chez les glossines.

C. TRYPANOSOMIASES ANIMALES

(1) Le Comité ESTIME que, s'il est vrai que la chimiothérapie et la chimioprophylaxie constituent des procédés valables pour la lutte contre les trypanosomiases dans les zones à faible densité de tsé-tsé, l'application de mesures contre les vecteurs n'en demeure pas moins essentielle et effective.

(2) Le Comité NOTE avec satisfaction les résultats encourageants des expériences poursuivies dans l'Ouest Africain avec les complexes à base de suramine en matière de chimioprophylaxie des trypanosomiases animales, et RECOMMANDE que les études sur la chimioprophylaxie en général soient développées grâce à une expérimentation sous contrôle vétérinaire adéquat.

(3) Le Comité RECOMMANDE que les études concernant le mécanisme de la trypano-tolérance chez les animaux soient poursuivies.

(4) Etant donné le nombre limité de médicaments existants, le Comité RECOMMANDE que les recherches pour mettre au point des produits possédant un large spectre trypanocide soient intensifiées.

(5) Afin que soient exploités au maximum les résultats obtenus en matière de trypanosomiases animales par les chercheurs, le Comité RECOMMANDE que des rapporteurs soient désignés pour la VIIème Réunion de l'I.S.C.T.R., pour présenter une revue d'ensemble de nos connaissances sur :

(*a*) la photosensibilisation chez les animaux,

(*b*) la chimiothérapie et la chimioprophylaxie des trypanosomiases bovines, et la résistance aux trypanocides,

(*c*) la trypano-tolérance.

(6) Le Comité INVITE le Gouvernement de l'Afrique du Sud à traiter de la Section (A), le Gouvernement du Royaume-Uni à traiter de la Section (B) et le Gouvernement de l'A.O.F. à traiter de la Section (C).

D. TRYPANOSOMIASES HUMAINES

Le Comité RECOMMANDE :

(1) que des recherches soient poursuivies pour déterminer la valeur prophylactique réelle de la Pentamidine et de l'Antrypol et la fréquence des injections à donner ;

(2) que des recherches soient entreprises sur le risque que présentent les campagnes de chimioprophylaxie dans l'apparition des formes occultes tant chez la trypanosomiase à *T. gambiense* que chez celle à *T. rhodesiense* ;

(3) que des recherches soient continuées en vue

(*a*) d'améliorer les trypanocides actuels au point de vue activité et toxicité,

(*b*) de trouver de nouveaux trypanocides,

(*c*) de déterminer la valeur des associations thérapeutiques et notamment l'association Pentamidine-Antrypol à la période lymphatico-sanguine,

(*d*) de rechercher le bénéfice que peuvent retirer les malades du sommeil de traitements non-spécifiques ;

(4) que des recherches soient continuées pour déterminer le pourcentage des malades traités à la Pentamidine au stade lymphatico-sanguin en évolution au stade nerveux ;

(5) qu'un rapporteur soit désigné pour faire le point en matière de chimioprophylaxie et invite les Gouvernements de la France et du Portugal à désigner un rapporteur respectivement pour la maladie du sommeil à *T. gambiense* et à *T. rhodesiense*.

E. CARTES DE REPARTITION DES GLOSSINES ET DES TRYPANOSOMIASES

(1) Les cartes de répartition des glossines sont à tenir à jour par les services appropriés des différents territoires.

(2) Les informations contenues dans ces cartes sont à tenir, sur demande, à la disposition de toutes les parties intéressées, spécialement à la disposition du B.P.I.T.T.

(3) La carte présentée par Mr. Potts continue admirablement à rendre des services et devrait être retenue en attendant une révision.

(4) La décision de la nécessité d'une révision de la carte de Mr. Potts appartient au C.S.I.R.T., en tant que suel comité d'experts compétents en matière de trypanosomiase et ses vecteurs. La révision doit être entreprise par le B.P.I.T.T. sur la base des cartes territoriales existantes (voir 1 plus haut).

(5) En ce qui concerne la carte de la distribution de la maladie du sommeil, le Comité n'a rien à ajouter à la Résolution No. 3 de la 5ème de Réunion du C.S.I.R.T.

RESOLUTIONS GENERALES FINALES

1. Le Comité exprime le vœu que les diverses disciplines intéressées à la lutte contre la trypanosomiase : médecine, médécine vétérinaire, entomologie, botanique, forêts, écologie etc. soient représentées de façon appropriée aux réunions du C.S.I.R.T.

2. Le Comité a décidé de charger le Secrétaire, le Dr. F. Evens, d'éditer et de publier les résolutions finales après le clôture de la réunion, sous réserve que les amendements n'affecteront ni la substance ni l'esprit des résolutions.

3. Le Comité prend note avec satisfaction de l'invitation de la Délégation belge à tenir sa prochaine réunion à Bruxelles en 1958 au moment de l'Exposition internationale qui doit avoir lieu dans cette ville, accepte cette invitation et demande au chef de la Délégation belge de transmettre ses remerciements à son Gouvernement.

4. Le Comité remercie M. J. K. Chorley de l'efficacité avec laquelle il s'est acquitté de sa tâche au cours de la VIème réunion.

5. Le Comité élit le Dr. Neujean président de la VIIème Réunion de 1958.

6. Le Comité exprime ses remerciements au Dr. Evens, à M. Hendrickx, à M. Grosse, à M. Hewitson et au personnel féminin du secrétariat pour l'esprit de coopération dont ils ont fait preuve dans l'organisation et le fonctionnement de la Conférence.

7. Le Comité exprime ses remerciements au Gouvernement de la Fédération de la Rhodésie et du Nyassaland pour son hospitalité et pour tous les arrangements qui ont été pris à l'occasion de cette réunion et, en particulier, exprime sa gratitude au Président de l'Assemblée Législative de la Rhodésie du Sud pour toutes les facilités mises à sa disposition.

8. Le Comité exprime ses remerciements aux auteurs de tous les documents présentés à cette réunion et au B.P.I.T.T. pour son aide.

C.C.T.A.

Secrétariat C.C.T.A./C.S.A.
Secretariat C.C.T.A./C.S.A.

Europe
Abbey House, 2–8, Victoria Street, London, S.W. 1

Afrique
B.P. 949, Bukavu, Congo Belge

BUREAUX ET COMITES TECHNIQUES
TECHNICAL BUREAUX AND COMMITTEES

FONDATION POUR L'ASSISTANCE MUTUELLE EN AFRIQUE AU SUD DU SAHARA
FOUNDATION FOR MUTUAL ASSISTANCE IN AFRICA SOUTH OF THE SAHARA
C.C.T.A./C.S.A. Secretariat, Abbey House, 2–8, Victoria Street, London, S.W. 1. Tel. Abbey 3920.

FONDS INTERAFRICAIN DE LA RECHERCHE
INTER-AFRICAN RESEARCH FUND
C.C.T.A./C.S.A. Secretariat, Abbey House, 2–8, Victoria Street, London, S.W. 1. Tel. Abbey 3920.

BUREAU INTERAFRICAIN DES SOLS ET DE L'ECONOMIE RURALE (B.I.S.)
INTER-AFRICAN BUREAU FOR SOILS AND RURAL ECONOMY (B.I.S.)
57, rue Cuvier, Paris V^{e}. Tel. Port Royal 36–25.

SERVICE PÉDOLOGIQUE INTERAFRICAIN (S.P.I.)
INTER-AFRICAN PEDOLOGICAL SERVICE (S.P.I.)
c/o I.N.E.A.C., Yangambi, Congo Belge.

COMMISSION PHYTO-SANITAIRE
PHYTO-SANITARY COMMISSION
c/o The Commonwealth Institute of Entomology, 56, Queen's Gate, London, S.W. 7, Tel. KNI 7501.

COMITÉ CONSULTATIF INTERAFRICAIN SUR LES EPIZOOTIES (I.A.C.E.D.)
INTER-AFRICAN ADVISORY COMMITTEE ON EPIZOOTIC DISEASES (I.A.C.E.D.)
Muguga, P.O. Kikuyu, Kenya.

BUREAU INTERAFRICAIN DES EPIZOOTIES (I.B.E.D.)
INTER-AFRICAN BUREAU FOR EPIZOOTIC DISEASES (I.B.E.D.)
Muguga, P.O. Kikuyu, Kenya.

BUREAU PERMANENT INTERAFRICAIN POUR LA TSÉ-TSÉ ET LA TRYPANOSOMIASE (B.P.I.T.T.)
TSETSE FLY AND TRYPANOSOMIASIS PERMANENT INTER-AFRICAN BUREAU (B.P.I.T.T.)
c/o B.P. 557, Léopoldville, Congo Belge. Tél. 3388.

COMITÉ SCIENTIFIQUE INTERNATIONAL DE RECHERCHES SUR LES TRYPANOSOMIASES (I.S.C.T.R.)
INTERNATIONAL SCIENTIFIC COMMITTEE FOR TRYPANOSOMIASIS RESEARCH (I.S.C.T.R.)
C.C.T.A./C.S.A. Secretariat, Abbey House, 2–8, Victoria Street, London, S.W. 1. Tel. Abbey 3920.

INSTITUT INTERAFRICAIN DU TRAVAIL (I.L.I.)
INTER-AFRICAN LABOUR INSTITUTE (I.L.I.)
B.P. 2019, Brazzaville, A.E.F. Tél. 32–80.

COMITÉ CONSULTATIF INTERAFRICAIN DU TRAVAIL
INTER-AFRICAN LABOUR ADVISORY COMMITTEE
COMITÉ CONSULTIVO DO INSTITUTO INTER-AFRICANO DO TRABALHO
c/o Ministério do Ultramar, Lisboa, Portugal.

COMITÉ INTERAFRICAIN POUR LES SCIENCES HUMAINES
INTER-AFRICAN COMMITTEE FOR SOCIAL SCIENCES
57, rue Cuvier, Paris V^{e}. Tél. Gobelins 71–98.

Comité Interafricain du Logement
Inter-African Committee on Housing
c/o South African Council for Scientific and Industrial Research, P.O. Box 395, Pretoria, South Africa. Tel. 4–5931.

Comité Interafricain des Statistiques (C.I.E.)
Inter-African Committee on Statistics (C.I.E.)
Comissão Inter-Africana de Estatistica (C.I.E.)
c/o Secção de Relações Internacionais, Ministério do Ultramar, Apartado No. 20/52, Lisboa, Portugal.

Comité Interafricain sur la Mécanisation de l'Agriculture
Inter-African Committee on the Mechanisation of Agriculture
C.C.T.A./C.S.A. Secretariat, Abbey House, 2–8, Victoria Street, London, S.W. 1. Tel. Abbey 3920.

Comité Consultatif Interafricain sur les Cartes et les Services Topographiques
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Comités Régionaux pour la Conservation et l'Utilisation du Sol
Regional Committees for the Conservation and Utilisation of the Soil
Afrique Méridionale — Southern Africa (S.A.R.C.C.U.S.)
P.O. Box 965, Pretoria, South Africa.
Afrique Occidentale — Western Africa (C.R.O.A.C.U.S.)
c/o Bureau des Sols, Dakar, Afrique Occidentale Française.
Afrique Orientale — Eastern Africa (C.R.E.A.C.U.S.)
c/o E.A.A.F.R.O., P.O. Box 21, Kikuyu, Kenya.
Afrique Centrale — Central Africa (C.R.A.C.C.U.S.)
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Sud-Central — Southern-Central
Est-Central — East-Central.

Comité Régional Ouest-Africain pour les Epizooties
West African Regional Committee on Epizootic Diseases
C.C.T.A./C.S.A. Secretariat, Abbey House, 2–8, Victoria Street, London, S.W. 1. Tel. Abbey 3920.

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Panel of Education Correspondents
c/o C.C.T.A., Abbey House, 2–8 Victoria Street, London, S.W. 1. Tel. Abbey 3920.

Réseau de Correspondants pour la Nutrition
Panel of Nutrition Correspondents
P.O. Box 170, Pretoria, South Africa. Tel. 36158.

Réseau de Correspondants pour l'Utilisation des Radio-isotopes dans l'Agriculture
Panel of Correspondents for the Use of Radio-isotopes in Agriculture
c/o B.I.S., 5, rue Cuvier, Paris V^e^.

Réseau de Correspondants en Matière d'Informations Économiques
Panel of Correspondents on Economic Information
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Panel of Correspondents for the Use of Radio-isotopes in the Medical Field
c/o B.P.I.T.T., B.P. 557, Léopldville, Congo Belge.

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Correspondant Scientifique Interafricain pour l'Anthropologie

Inter-African Scientific Correspondent for Anthropology

Prof. J. Hiernaux, Recteur de l'Université Officielle du Congo Belge et du Ruanda-Urundi, B.P. 1825, Elisabethville, Congo Belge.

Correspondant Scientifique Interafricain pour la Protection des Archives

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Correspondant Scientifique Interafricain pour la Climatologie

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Correspondant Scientifique Interafricain pour la Géologie

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Inter-African Scientific Correspondent for Geomagnetism

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Correspondant Scientifique Interafricain pour l'Histoire et l'Ethno-histoire

Inter-African Scientific Correspondent for History and Ethno-history

Prof. Dr. Silva Rego, Instituto Superior de Estudos Ultramarinos, Lisboa, Portugal.

Correspondant Scientifique Interafricain pour l'Ionosphère

Inter-African Scientific Correspondent for Ionosphere

c/o O.R.S.T.O.M., 47, bd des Invalides, Paris VIIème.

Correspondant Scientifique Interafricain pour les Rayons Cosmiques

Inter-African Scientific Correspondent for Cosmic Rays

Prof. J. P. Andrews, Professor of Physics, Makerere College, Kampala, Uganda.

Correspondant Scientifique Interafricain pour la Séismologie

Inter-African Scientific Correspondent for Seismology

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Correspondant Scientifique Interafricain pour les Tests Psychotechniques

Inter-African Scientific Correspondent for Psychotechnical Tests

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COMITE SCIENTIFIQUE INTERNATIONAL DE RECHERCHES SUR LES TRYPANOSOMIASES

Origines et Historique

Les " Conclusions " adoptées en 1949 à la 1ère Réunion du Comité constituent le document de base du C.S.I.R.T.

Une Conférence africaine sur la Tsé-Tsé et la Trypanosomiase, qui s'était réunie à Brazzaville du 2 au 8 février 1948, avait approuvé deux recommandations tendant respectivement à créer un Bureau Permanent (le B.P.I.T.T.) et un Comité Scientifique International. Des propositions avaient déjà été faites en 1946 à une Conférence internationale sur la Trypanosomiase en vue d'inviter les Institutions et Services à procéder à des échanges d'informations sur la mouche tsé-tsé et sur les problèmes que pose la trypanosomiase humaine et animale.

Depuis, des réunions ont eu lieu à intervalles réguliers dans les territoires des Gouvernements Membres, notamment à Londres, à Anvers, en A.O.F., en Afrique-Orientale Portugaise, en Union Sud-Africaine, dans la Fédération de la Rhodésie et du Nyassaland, et à Bruxelles.

Attributions et Pouvoirs

Les attributions du Comité, à la révision desquelles les Gouvernements Membres procèdent actuellement, consistent à examiner les résultats des travaux en laboratoire et sur le terrain, à susciter de nouvelles recherches, encourager les échanges entre organisations scientifiques et chercheurs et coordonner leurs efforts, et à ménager régulièrement des confrontations sur les problèmes relatifs à la tsé-tsé et à la trypanosomiase ainsi que des comptes rendus de nouvelles expériences et découvertes.

Composition

Le Comité comprend des représentants des pays membres de la C.C.T.A. Son Secrétariat est au siège de la C.C.T.A. à Londres.

Membres Actuels de la C.C.T.A.

Sont actuellement membres de la C.C.T.A., la Belgique, la Fédération de la Rhodésie et du Nyassaland, la République Française et Communauté, le Ghana, la République de Guinée, le Libéria, le Portugal, l'Union Sud-Africaine et le Royaume-Uni.

Stephen Austin & Sons Ltd

1958

SEVENTH MEETING

COMMISSION FOR TECHNICAL CO-OPERATION IN AFRICA SOUTH OF THE SAHARA