

INTER-AFRICAN BUREAU FOR ANIMAL HEALTH
BUREAU INTERAFRICAIN DE LA SANTE ANIMALE

**BULLETIN OF
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OF AFRICA**

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Les articles devront être suivis d'un résumé, portant uniquement sur les faits, qui devra contenir l'essentiel de l'article et en faire ressortir tous les renseignements nouveaux et les principales conclusions.

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VOLUME 17

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CONTENTS/SOMMAIRE

	Page
EDITORIAL	4/5
I. ORIGINAL ARTICLES/ARTICLES ORIGINAUX	
Principes de production d'un vaccin mixte associé Anti-bovipestique-Antipéripneumonique inoculé en un seul temps—A. PROVOST	7
Contagious Bovine Pleuropneumonia: Comparison of serological tests and post-mortem observations in cattle with resolving lung lesions—S. S. STONE and A. C. BYGRAVE ..	11
Contagious Bovine Pleuropneumonia vaccination in East Africa—G. DAVIES and F. R. GILBERT	21
Clinical course and physical changes of blood in Foot-and-Mouth S.A.T.2 type infection in cattle—F. VOHRADSKY ..	27
Diagnosis of African swine fever by fluorescent antibody staining of blood films and buffy coat smears—G. S. COLGROVE	39
The protection of 60 Nigerian trade cattle from trypanosomiasis—using Samorin—B. K. NA'ISA	45
Variations in tick species and populations in the Bugisu district of Uganda. Part I. The tick survey—M. W. SMITH ..	55
Variations in tick species and populations in the Bugisu district of Uganda. Part II. The effects of altitude, climate, vegetation and husbandry on tick species and populations—M. W. SMITH	77
Problèmes du Nomadisme au Mali—I. KONATE et Hama Ag MAHAMOUD	107
Reflections on sheep diseases in Kenya—J. G. WANDERA ..	121

<i>Continuation/Suite</i>	Page
2. BUREAU INFORMATION/INFORMATIONS DU BUREAU	
Geographical distribution maps of animal diseases in Africa, 1968/Cartes de distribution géographique des maladies animales en Afrique, 1968:	
No. 205 (A1) —Foot-and-Mouth Disease/Fièvre aphteuse ..	127
No. 206 (A2) —Rabies/Rage	128
No. 207 (A4) —Rinderpest /Peste bovine	128
No. 208 (A11)—Newcastle Disease/Maladie de Newcastle ..	129
No. 209 (B1) —Cont. Bov. Pleuropneumonia/Péripneumonie Cont. Bov.	129
No. 210 (C4) —East Coast Fever/Theileriose "East Coast Fever" ..	130
3. ABSTRACTS/ANALYSES	
Subject Index/Table des Matières	131/132
Abstracts Nos. 1-32/Analyses Nos. 1-32	133

EDITORIAL

This Volume XVII of the *Bulletin of Epizootic Diseases of Africa*, marks the third year of Africanisation of the Inter-African Bureau for Animal Health (IBAH), which is one of the four Bureaux of the Scientific Technical and Research Commission (STRC)—Organisation of African Unity (OAU).

As readers would judge, the Africanisation has not affected the International attitude of the *Bulletin*. Our old authors are generously providing us with their articles, and new authors from all nationalities are also contributing. A considerable number of African authors have proved their efficiency as well, and French speaking authors have started to publish in our *Bulletin*.

The Editor and Staff of IBAH are very glad to attain this result, promise to save no effort for the continuation of success and development; and wish all authors, subscribers and readers all the best in the new year 1969.

OSMAN,
Vet. Brigadier (retd.),
EDITOR.

EDITORIAL

Ce volume XVII du *Bulletin des Epizooties en Afrique* marque la troisième année de l'Africanisation du Bureau Interafricain de la Santé Animale (IBAH), qui est l'un des quatre bureaux de la Commission Scientifique Technique et de la Recherche de l'Organisation de l'Unité Africaine (CSTR/OUA).

Comme pourront en juger les lecteurs, l'Africanisation n'a pas du tout affecté le standing international du *Bulletin*. Nos anciens auteurs continuent très généreusement de nous pourvoir en articles, et de nouveaux auteurs de toute nationalité contribuent eux aussi. Un nombre considérable d'auteurs africains ont prouvé leur efficacité et des auteurs francophones commencent à publier dans notre *Bulletin*.

L'Editeur et le personnel de l'IBAH sont très heureux d'avoir atteint ce but et s'engagent à tout mettre en œuvre pour poursuivre dans cette voie, l'améliorer même, et ils souhaitent aux auteurs, suscripteurs et lecteurs leurs vœux les meilleurs pour l'année 1969.

OSMAN,
Gén. de Brig. Vét. (retraité),
EDITEUR.

PRINCIPES DE PRODUCTION D'UN VACCIN MIXTE ASSOCIÉ ANTIBOVOPESTIQUE-ANTIPÉRI-PNEUMONIQUE INOULÉ EN UN SEUL TEMPS

A. PROVOST

*I.E.M.V.T., Laboratoire de Recherches Vétérinaires de Farcha,
Fort-Lamy, Tchad*

CONCEPTION DU VACCIN MIXTE

Il est inutile d'avancer des arguments justifiant l'utilité d'un tel vaccin. Tout au contraire peut-on regretter qu'il n'ait pas été mis au point avant le début des opérations du P.C. 15 en Afrique centrale et occidentale.

Les travaux de différents chercheurs avaient montré que la vaccination antipestique à l'aide du vaccin capripésteque gênait ou même abolissait totalement l'immunogénèse antipéri-pneumonique tout comme celles d'autres antigènes bactériens. Tout au contraire, Macadam puis Brown montraient que le vaccin antipestique de cultures tissulaires pouvait être inoculé impunément en même temps qu'un vaccin antipéri-pneumonique, pourvu néanmoins qu'on l'appliquât en des lieux d'inoculation différents et avec des seringues séparées; les antibiotiques contenus dans le vaccin de cultures cellulaires se montraient microbicides pour *M. mycoïdes*, microorganisme qui doit être vivant dans le vaccin antipéri-pneumonique.

Le pas capital — celui de l'association possible des deux antigènes — était franchi; il ne restait plus qu'à améliorer le procédé de vaccination. Il tombe sous le sens qu'il serait en effet beaucoup plus pratique d'utiliser le vaccin mixte en un seul temps d'inoculation plutôt que procéder à 2 inoculations en deux lieux différents.

C'est cette association qui fut réclamée au Laboratoire de Farcha en Janvier 1966, où elle était encore au stade expérimental, par le service de l'Élevage du Tchad, à la suite d'incidents de vaccination consécutifs à l'emploi mal contrôlé d'un vaccin antipéri-pneumonique d'ovoculture.

En ces circonstances, il fut décidé d'utiliser à l'avenir la souche péri-pneumonique KH3J dont on pouvait garantir l'innocuité à défaut d'une immunité de valeur inconnue pour le bétail tchadien.

PROBLÈMES DE PRODUCTION DU VACCIN MIXTE

Il en existait au moins deux, importants:

— devoir incorporer une culture vivante de *M. mycoïdes* (culture qui doit rester viable) à des liquides de cultures cellulaires contenant un mélange polyantibiotique dont trois constituants au moins étaient notoirement connus comme mycoplasma-cides;

— étant donné les dilutions successives et pertes en unités viables que subirait la culture de *M. mycoïdes* lors de sa préparation puis de son emploi, obtenir des cultures primaires très riches de KH3J.

Les réponses à ces deux problèmes ont été apportées de la manière suivante:

1^o Sélection d'un clône de KH₃J. On pouvait, sans grands risques, n'incorporer aux liquides de cultures cellulaires après la phase de croissance des cellules que deux antibiotiques: pénicilline et streptomycine. Ce dernier seulement possède une activité sur *M. mycoïdes*, bien que ce soit une question de souches et qu'il existe des mutants. En exposant la souche KH₃J à des concentrations croissantes de streptomycine, on obtient un mutant qu'il est alors aisé de clôner et qui se montre totalement résistant à la streptomycine sans être pour cela streptomycino-dépendant; il a été baptisé KH₃J-SR. Il est à noter, ce qui peut être intéressant en certains cas, que cette streptomycino-résistance totale peut constituer un "marqueur" de souche.

On pouvait se demander si ce mutant avait les mêmes propriétés immunigènes que la souche KH₃J d'origine. La réponse, positive, sera donnée plus loin.

2^o Augmentation de la richesse des cultures. Profitant des recherches effectuées en Australie sur le métabolisme de *M. mycoïdes* et de nos propres observations, un milieu de croissance a été mis au point (milieu "F-66", décrit dans le tome 2 du Rapport annuel du Laboratoire de Farcha, année 1967).

En suivant avec précision la culture du mutant KH₃J-SR, on établit une courbe de croissance qui indique qu'avec le milieu F-66 et un inoculum standardisé la récolte doit intervenir entre la 66ème et la 70ème heure. Dès la 78ème heure, la richesse diminue et quelques heures plus tard il n'y a plus que quelques unités viables. Ce sont certes des conditions très strictes de culture mais qui permettent d'obtenir des récoltes titrant 10¹¹ organismes/ml. (10¹² en quelques occasions).

Le vaccin mixte est préparé en mélangeant à parties égales:

— les récoltes diluées des liquides de cultures cellulaires infectées depuis 4 à 5 jours avec la souche bovine RPKO-BK de Plowright et Ferris et entretenues dans un milieu ne contenant que pénicilline et streptomycine comme antibiotiques; ces récoltes sont diluées extemporanément au 1/10 avec de la peptone à 11 p. 100 en eau distillée, pH: 7,2.

— La culture du mutant KH₃J-SR âgée de 66 à 70 heures. Les mélanges sont répartis sous le volume de 5 ml. en flacons de 20 cc. et lyophilisés selon un cycle de 48 heures dont les 24 premières se font le produit étant à —25–30° C. Le flacon contient 100 doses de produit lyophilisé dont la teneur par dose est d'au minimum 10^{2.7}DCP₁₀ de virus bovine et de 10⁸ du mutant KH₃J-SR. En pratique, les titrages donnent des chiffres bien supérieurs.

La technique de production est, on le voit, très simple. Elle ne met en oeuvre aucune opération fastidieuse de centrifugation. Le succès, croyons-nous, est dû au volume important du ballast de lyophilisation. Peut-être y a-t-il là des progrès à accomplir.

UTILISATION DU VACCIN MIXTE AU TCHAD

Dès Mars 1966, le vaccin mixte, auquel le nom de code de Bisec avait été donné, a été utilisé au Tchad lors de la première année suivant la phase I du P.C. 15, puis lors des opérations de la phase 3 (Est du Tchad). Au total, de Mars 1966 à Novembre 1968, 4.661.300 doses ont été fournies par le Laboratoire de Farcha.

Il n'y a pas eu de réactions post-vaccinales locales ni générales sauf sur une vingtaine d'animaux répartis dans trois troupeaux vaccinés par la même équipe de vaccination: on suppose que dans ces cas il y a eu confusion de vaccin. La vaccination a été parfaitement acceptée des propriétaires qui, dans l'ensemble non prévenus de la double opération, ne présentaient leurs animaux qu'à la vaccination antipestique.

Sur le terrain, ceci sans vouloir crier victoire totale, les résultats paraissent très bons.

La péripneumonie existait au Tchad sous forme enzootique dans une bande transversale du Nord-Est au Sud-Ouest, allant en gros d'Abéché à Fianga, en passant par Mongo; un très gros foyer d'infection était la préfecture de Fianga dans le Sud-Ouest du pays.

Il est apparu au bout de deux ans d'utilisation que le nombre des foyers déclarés avait très fortement baissé; le tableau suivant donne quelques chiffres.

1965: 148 foyers

1966: 87 foyers

1967: 28 foyers avec 409 malades et 44 morts

1968: 22 foyers

Par foyers, il faut entendre troupeaux de propriétaires différents et non pas points géographiques au sens de l'IBAH, ce qui revient en fait à diminuer le nombre des foyers; en 1967 et 1968, ils ont été inférieurs à 10.

On se doit, évidemment, d'être extrêmement circonspect quant à la valeur absolue de ces chiffres car d'une part ils peuvent ne pas refléter l'entière vérité étant donné des facteurs socio-politiques existant dans le pays, et d'autre part il est bien connu que l'épizootologie de la péripneumonie fait que cette maladie présente des rythmes cycliques et qu'en conséquence l'on puisse se trouver en ce moment au creux d'une vague. Prévaut néanmoins l'impression parmi le personnel du Service de l'Élevage du Tchad que la vaccination a été efficace. Dans la région de Fianga, on n'a pas rapporté l'existence de foyer de péripneumonie depuis 18 mois. A l'abattage de vieilles vaches il se peut que l'on trouve des lésions, mais elles semblent être anciennes.

Il paraît important de faire remarquer que pratiquement tout le bétail tchadien sauf celui d'un département où n'existait pas la maladie a été vacciné au moins deux fois et que le succès peut tenir à la large couverture vaccinale ainsi réalisée.

EPREUVE D'IMMUNITE AU LABORATOIRE

Ayant en mémoire les restrictions apportées plus haut, le laboratoire se devait de contrôler la valeur de la résistance conférée par la vaccination. Afin d'apprécier cette valeur dans la pratique, telle qu'elle est dans les troupeaux après les opérations vaccinales conduites par un personnel à encadrement assez lâche, il a paru intéressant d'éprouver des bovins primo-vaccinés en brousse dont le laboratoire se rendait acquéreur; un nombre égal de bovins de même âge non vaccinés (il s'en trouve encore, difficilement) servait de témoins. La méthode d'infection était une adaptation locale de la méthode australienne par contamination directe avec des bovins intubés.

Deux contrôles ont ainsi été réalisés, l'un 9 mois après la primovaccination, l'autre 13 mois. Le tableau rend compte des résultats.

Contrôle après 7 à 9 mois:67% de protection
Contrôle après 11 à 13 mois:62% de protection

La protection n'est donc pas totale; elle est du même ordre à 9 et 13 mois. On remarquera que les résultats sont comparables à ceux qui ont été acquis en Australie avec la souche KH₃J inoculée sans adjuvant.

Conclusion

Le vaccin mixte antipestique-antipéripleurmonique a été conçu et produit par le laboratoire de Farcha pour répondre à des problèmes locaux de prophylaxie. Tel qu'il est, ce vaccin n'a pas la prétention de s'imposer au continent africain. Ce que l'on peut néanmoins retenir, *c'est le principe de l'association et les solutions indiquées pour y parvenir*. C'est pour des raisons très particulières au Tchad qu'a été choisie la souche KH₃J. Rien n'interdirait de la remplacer par une autre au gré de l'utilisateur (T₁, V₅) à laquelle on ferait subir le traitement à la streptomycine.*

Tel qu'il est actuellement, il paraît donner satisfaction aux autorités vétérinaires tchadiennes et tient apparemment sous contrôle la péripleurmonie aux moindres frais. C'était bien là le but que l'on s'était proposé lorsque son étude a été ébauchée.

* Un mutant streptomycino-résistant de la souche T₁ a été cloné.

Communication faite par l'auteur lors de la reunion de P.C. 15 Nairobi 14-15 Novembre, 1968.

(Received for publication 31 December 1968)

SUMMARY

The bisec, the mixed vaccination against rinderpest and pleuropneumonia has been processed and produced by the Farcha Laboratory to solve local prophylactic problems. There is no attempt to impose this vaccine on the whole of the African continent. Nevertheless, it is interesting to note the **principle of combination and the solutions shown to obtain it**. A strain KH₃J has been chosen; this is due to reasons peculiar to Chad. All users could at will choose other strains (T₁, V₅) which could be processed with streptomycin.*

Under its present state, this mixed vaccine appears to satisfy the Chad veterinary authorities and it seems to control the pleuropneumonia economically. This was the purpose of the research.

* The streptomycin-resistant mutant of T₁ strain has been cloned.

Paper presented by the author during the P.C.15 meeting at Nairobi, 14-15 November 1968.

CONTAGIOUS BOVINE PLEUROPNEUMONIA: COMPARISON OF SEROLOGICAL TESTS AND POST-MORTEM OBSERVATIONS IN CATTLE WITH RESOLVING LUNG LESIONS

S. S. STONE* and A. C. BYGRAVE†

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and
Veterinary Research Laboratory, Kabete

The diagnosis of contagious bovine pleuropneumonia (C.B.P.P.) offers no obstacle in the face of an outbreak of the disease or shortly thereafter. In the acute cases of the disease, both antibody and antigen can be readily detected (Gourlay, 1965, Shifrine and Gourlay, 1967). These authors found good correlation between serological and postmortem findings.

Detailed data on the comparative results of serological tests and post-mortem observations are not available from cattle which have survived a natural outbreak of C.B.P.P., except for the limited observations reported by Campbell and Turner (1936), Parker (1960), Turner and Etheridge (1963) and Huddart (1966).

These studies evaluated six available serological tests in identifying cattle with chronic C.B.P.P. lesions with reference to sequestered lesions containing viable *M. mycoides* persisting 18 months after a natural C.B.P.P. outbreak.

MATERIALS AND METHODS

Cattle

Involved in this study were Zebu cattle surviving a natural C.B.P.P. infection which occurred during 1966, in the Archer's Post area, Isiolo District, Kenya. At the time of slaughter the herd had no evidence of active C.B.P.P. as judged by deaths and clinical signs during the previous 18 months.

The cattle were identified by serially numbered plastic ear tags (Tip-Tags) and hot-iron brands.

Three weeks before slaughter, blood samples were obtained from individual cattle and the sera tested by the field modification of the complement fixation test (C.F.T.) as described by Huddart (1963). Blood samples were also obtained from the jugular vein. The collected serum was refrigerated and transported to the laboratory where it was stored at -20°C . until used.

Three weeks after serum collection the cattle were slaughtered at the Kenya Meat Commission Abattoir, Mombasa. The lungs of all cattle were examined for lesions characteristic of C.B.P.P. According to the type of lesion found on post-mortem, specimens were divided into five groups:

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† Field Epizootiologist, Joint Project 16.

1. Fibrosed sequestrated lesions with overlying pleural adhesions.
2. Cicatricial scars with associated pleural adhesions indicative of sequestral resolution.
3. Extensive pulmonary fibrosis involving the local area of the costal pleura adjacent to the lung fibrosis.
4. Minimal pulmonary fibrosis and costal pleural adhesions.
5. No gross visible lesions.

Isolation procedure for *M. mycoides*

For isolation of *M. mycoides*, samples of lung tissues, lesions and corresponding bronchial lymph nodes, were cut with a sterile scalpel and placed in tryptose broth containing penicillin 100 IU/ml., thallium acetate 1:2000, sulphamezathine 1:2000 and polymyxin 500 IU/ml. Confirmation of *M. mycoides* was made by growth inhibition tests (Davies and Read, 1968) after two sub-passages.

Serological tests

Besides the field modification of the C.F.T. (a), the sera were tested for antibodies to C.B.P.P. by a laboratory C.F.T. (b) (Shifrine *et al.*, 1968). This test employed an overnight fixation period at 5°C.

Two agglutination tests for detecting antibody were used. The first was the slide agglutination serum test (S.A.T.) (c) as described by Turner and Etheridge (1963) and modified by Gourlay (1964). The other was an indirect hemagglutination (I.H.A.G.A.L.) (d) in which sheep erythrocytes were coated with a galactan isolated from *M. mycoides* (Hudson *et al.*, 1967) and used as described by Cottew (1960).

The test for the detection of circulating antibody was the agar gel diffusion (A.G.T.) procedure as outlined by Shifrine and Gourlay (1967) except that the *M. mycoides* antigen was prepared by sonic disruption.

The A.G.T. was also used for detecting antigen (Shifrine and Gourlay, 1967). This procedure was modified by using pig anti-*M. mycoides* serum capable of detecting as little as 1 µg of antigen/ml. of serum. In this test the reaction was controlled using purified galactan F (Hudson *et al.*, 1967). All of the other serological tests were controlled using normal sera and broth culture. All sera were stored at -20°C. and heated to 56°C. before testing.

RESULTS

Two of the 50 sera tested by the rapid field C.F.T. were positive, 10 were doubtful, and the remaining 38 sera were negative (Table I). In the laboratory C.F.T., 28 sera had titres ranging from 1:10 to 1:160, and two were anticomplementary. The remaining 20 sera were negative.

Except for one animal (36) all sera were negative for agglutinating antibody detectable by the S.A.T.

There were no sera without a titre in the I.H.A.G.A.L. test and the titres ranged from 1:10 to > 1:1280 with 14 sera having agglutination titres of 1:160 or greater.

In view of the large number of high titres obtained with the I.H.A.G.A.L. test, 191 serum samples from healthy cattle originating from a C.B.P.P.-free area were tested by this method and the results detailed in Table III. Only 15 sera had undetectable titres, and 160 had titres ranging from 1:10 to 1:80. The remaining 16 had titres ranging from 1:160 to 1:5120 with three sera having titres of 1:5120.

Table I.—Comparison of serological tests in detecting resolving lesions persisting for 18 months after a natural outbreak of contagious bovine pleuropneumonia

Sera No.	Field CF	Lab. CF	SAT	IHAGAL	AGT-ANT	AGT-Ab	Lungs at Post-mortem
1	—	—	—	20	—	—	NVL —5
2	—	—	—	40	—	—	FRL —4
3	—	10	—	320	—	—	NVL —5
4	—	10	—	80	—	—	NVL —5
5	—	20	—	40	—	—	FRL —3
6	—	40	—	160	—	—	FRL —3
7	—	10	—	40	—	—	NVL —5
8	—	—	—	>1280	—	—	FRL —3
9	—	10	—	40	—	—	NVL —5
10	—	20	—	1280	—	—	FRL —4
11	—	—	—	40	—	—	FRL —4
12	—	10	—	40	—	—	NVL —5
13	—	—	—	40	—	—	FSL* —1
14	—	—	—	10	—	—	NVL —5
15	D	80	—	80	—	—	FRL —3
16	—	—	—	40	—	—	FRL —4
17	—	—	—	40	—	—	NVL —5
18	—	AC	—	160	—	—	FSL*+ —1
19	—	—	—	40	—	—	FRL —3
20	—	—	—	80	—	—	FRL —4
21	D	40	—	40	—	—	FRL —3
22	—	10	—	40	—	—	NVL —5
23	—	10	—	80	—	—	FRL —3
24	D	—	—	80	—	—	FRL —3
25	D	80	—	40	—	—	FRL —3
26	—	—	—	40	—	—	FRL —4
27	—	10	—	>1280	—	—	FRL —2
28	—	—	—	80	—	—	FRL —2
29	D	—	—	80	—	—	NVL —5
30	—	10	—	160	—	—	NVL —5
31	—	—	—	80	—	—	FRL —4
32	—	20	—	80	—	—	FRL —4
33	—	—	—	160	—	—	FVL —5
34	D	20	—	80	—	—	FRL —3
35	—	80	—	40	—	—	FRL —4
36	D	80	+	80	—	—	FRL —3
37	—	10	—	40	—	—	FRL —2
38	—	—	—	160	—	—	FRL —2
39	—	80	—	10	—	—	FRL —3
40	+	AC	—	80	—	—	FRL —3
41	—	20	—	>1280	—	—	FRL —2
42	—	20	—	160	—	—	FRL —4
43	—	10	—	40	—	—	FRL —4
44	D	40	—	320	—	—	FRL —3
45	—	—	—	640	—	—	NVL —5
46	—	160	—	40	—	—	FRL —3
47	D	40	—	20	—	—	FSL*+ —1
48	+	160	—	20	—	—	FRL —4
49	—	—	—	80	—	—	FRL —3
50	D	—	—	160	—	—	FRL —3

Field CF = Field Complement Fixation Test
 Lab. CF = Laboratory Complement Fixation Test (overnight fixation)

SAT = Slide Agglutination Test
 IHAGAL = Indirect Hemagglutination Test using *M. mycoides* Galactan F coated RBC

AGT-ANT = Agar gel diffusion precipitin test for antigen

AGT-Ab = Agar gel diffusion test for antibody

D = Doubtful test, partial fixation at 1:10 serum dilution

— = No fixation at 1:10

+ = 75% or more at 1:10

AC = Anticomplementary

NVL = No visible lesion

FRL = Fibrosed resolved lesion

FSL = Fibrosed sequestrated lesion

* = isolation of *M. mycoides* from lesion

1, 2, 3, 4, 5 = evaluation of lesion, 1—fibrosed sequestrated lesion, 5—no visible lesion

The tests for circulating antibody or antigen using the A.G.T. procedures were all negative.

In three cattle, fibrosed sequestrated lung lesions were present. In each, *M. mycoides* was isolated from the inspissated necrotic material. *M. mycoides* was not isolated from the bronchial lymph nodes or macroscopically normal lung tissue from these three cattle.

Of the 34 cattle with fibrosed resolved C.B.P.P. lesions (detailed in Table II), five were in group 2; 17 in group 3; and 12 in group 4. It was impossible to differentiate between these groups of lesions serologically. The remaining 13 cattle had no visible lung lesions.

DISCUSSION

There was some correlation in our results between the field and the laboratory C.F.T. Except for serum 40, which was anticomplementary in the laboratory C.F.T., the positive and seven of the doubtful (D) reactions obtained with the field C.F.T. showed C.F.T. titres ranging from 1:20 to 1:160 in the laboratory test. However, in sera 24, 29 and 50, which had doubtful "trace" reactions (d) in the field C.F.T., no detectable titre was obtained in the laboratory C.F.T.

The one positive S.A.T. was also positive in the laboratory C.F.T. and doubtful in the field C.F.T.

All tests for circulating antigen were negative. This finding was indicative of recovered animals and would, therefore, not be expected to influence tests for C.B.P.P. antibody as suggested by Turner and Etheridge (1963). Hudson *et al.* (1967) has shown that galactan F, extracted from *M. mycoides* and inoculated at the dose of 0.63 mg./kg. body weight, had a level of 1 µg per ml. serum five weeks later. In actual infection with *M. mycoides* it can be presumed that the galactan level may have exceeded that reached experimentally by Hudson *et al.* (1967) as serum titres as high as 1:512 can be obtained (Masiga and Stone, 1968). Therefore, galactan would be expected to remain in the circulation for a longer time as suggested by Shifrine and Gourlay (1967). This was not the case with the sera in this study, and it is surprising that we were unable to detect the presence of circulating galactan in the three cattle from which an isolation of *M. mycoides* was made. It, therefore, becomes apparent that in the cattle from which an *M. mycoides* isolation was made, the fibrotic tissue surrounding the sequestrated lesions, had precluded the free passage of this antigen into the serum.

The finding that the I.H.A.G.A.L. test for antibodies is not specific would have been expected as this test only detects antibody directed against the carbohydrate fraction of *M. mycoides*, and this carbohydrate has common antigenic groupings with several bacteria (Shifrine and Gourlay, 1967; Stone and Shifrine, 1968).

Published data on the applicability of serological tests for detecting C.B.P.P. from a natural outbreak in Zebu cattle have been obtained during the active stage. In these studies where active cases of C.B.P.P. occur, either serum antibody or circulating antigen, or both, can be readily detected by the appropriate use of the C.F.T., S.A.T. and A.G.T. As a result, a close correlation is reported for the various tests and post-mortem findings (Gourlay, 1965) and (Shifrine and Gourlay, 1967). Under these circumstances, the C.F.T. remains the most reliable single test for use in the living animal, although Shifrine and Gourlay (1967) stated that the results for the S.A.T., taken in conjunction with the A.G.T. for antigen, will detect 100% of cattle naturally infected with C.B.P.P. during the active stage of the disease.

Table II.—Results of post-mortem examination

<i>Serum Reference Number</i>	<i>Lesion</i>	<i>Lesion Classification</i>
2	Localized pleural adhesion (2.5 × 3.75 cm.) overlying completely resolved lesion in left diaphragmatic lobe.	4
5	Excessively fibrosed lesion involving left cardiac lobe (6.3 × 3.75 cm.), extensive pleural adhesions involving the base of apical, cardiac and diaphragmatic lobes.	3
6	Fibrosed resolved lesion involving the first division of the right apical lobe (5.0 × 2.5 cm.), with associated pleural adhesions.	3
8	Fibrosed lesion (5.0 × 7.6 cm.) involving anteroventral aspect of the right diaphragmatic lobe with associated pleural adhesions.	3
10	Circumscribed fibrosed lesion (2.5 × 2.5 cm.), right cardiac lobe with localized pleural adhesion.	4
11	Localized fibrosed lesion (3.75 × 3.75 cm.) at ventral extremity of right cardiac lobe with adhesions to pericardium and costal pleura.	4
13	Excessively fibrosed lesion (5.0 × 2.5 cm.) involving right cardiac lobe and containing five necrotic foci up to 5 mm in size. Extensive adhesions involving the ventral extremity of of the second sub-division of the apical lobe, cardiac lobe, and antero-ventral aspect of the diaphragmatic lobe.	1
15	Fibrosed resolved lesion (2.5 × 3.75 cm.) ventral aspect of right diaphragmatic lobe with associated diaphragmatic adhesions. Localized fibrosed lesion ventral extremity of left cardiac lobe with pleural and peri-cardial adhesions.	3
16	Fibrosed lesion (5.0 × 2.0 cm.) medial aspect of left cardiac lobe, adhered to pericardium.	4
18	Sequestered lesion (6.2 × 3.7 cm.) involving the right cardiac lobe. Fibrosed lesion affecting both divisions of the apical lobe. Extensive pleural adhesions overlying the apical, cardiac and anterior third of the diaphragmatic lobe.	1
19	Fibrosed lesion (5.0 × 5.0 cm.) antero-ventral aspect of left diaphragmatic lobe with associated pleural adhesions.	3
20	Small depressed fibrosed lesion (3.75 × 2.5 cm.) right diaphragmatic lobe with localized pleural adhesions.	4
21	Fibrosed lesion (3.75 × 3.75 cm.) left diaphragmatic lobe with extensive pleural adhesions.	3
23	Fibrosed lesion (5.0 × 2.5 cm.) base of left diaphragmatic lobe with associated diaphragmatic adhesions.	3
24	Fibrosed lesion (10.0 × 12.5 cm.) left diaphragmatic lobe with adhesions.	3
25	Left lung—fibrosed to varying degrees in all lobes with extensive pleural adhesions. Right lung—adhesions present along the ventral aspect of all lobes and extending over the antero medial aspect of the diaphragmatic lobe.	3
26	Fibrosed lesion (2.5 × 3.75 cm.) right diaphragmatic lobe with pleural adhesions.	4

<i>Serum Reference Number</i>	<i>Lesion</i>	<i>Lesion Classification</i>
27	Cicatrix (3.5 × 3.0 cm.) right diaphragmatic lobe—slight pleural adhesion.	2
28	Stellate cicatrix (3.75 × 3.75 cm.) right diaphragmatic lobe with localized pleural adhesions.	2
31	Fibrosed lesion (2.5 × 3.75 cm.) right diaphragmatic lobe with pericardial adhesions.	4
32	Fibrosed lesion (2.5 × 2.5 cm.) left apical lobe—slight pleural adhesions.	4
34	Fibrosed lesion (6.2 × 2.5 cm.) left cardiac lobe with pleural and pericardial adhesions.	3
35	Fibrosed lesion (2.5 × 2.5 cm.) right cardiac lobe with pericardial adhesions.	4
36	Fibrosed lesion (5.0 × 7.6 cm.) antero ventral aspect right diaphragmatic lobe with pleural adhesions.	3
37	Fibrosed cicatrix (2.5 × 1.3 cm.) in second division of right apical lobe with localized pleural adhesions.	2
38	Fibrosed cicatrix (2.5 × 2.5 cm.) left cardiac lobe with localized pleural adhesions.	2
39	Extensive fibrosed lesion (10.2 × 10.2 cm.) right diaphragmatic lobe with pleural adhesions.	3
40	Fibrosed lesion (5.0 × 2.5 cm.) right anterior division of the apical lobe; and fibrosed lesion (3.75 × 2.5 cm.) cardiac lobe. Both lesions associated with extensive pleural adhesions.	3
41	Cicatrix (3.75 × 3.75 cm.) left diaphragmatic lobe with pleural lesions.	2
42	Fibrosed lesion (3.75 × 2.5 cm.) left cardiac lobe with pleural adhesions.	4
43	Pleural adhesions right diaphragmatic and cardiac lobes; no visible fibrosed lung lesions.	4
44	Fibrosed lesion (5.0 × 5.0 cm.) right cardiac lobe with pleural adhesions.	3
46	Fibrosed lesions (5.0 × 5.0 cm.) left apical lobe; pleural adhesions involving apical and cardiac lobes.	3
47	Sequestrum (3.75 × 3.0 cm.) right diaphragmatic lobe with localized pleural and diaphragmatic adhesions.	1
48	Fibrosed lesion (2.5 × 2.5 cm.) right diaphragmatic lobe with localized adhesions.	4
49	Fibrosed lesion (5.0 × 5.0 cm.) left diaphragmatic lobe with localized diaphragmatic adhesions.	3
50	Fibrosed lesion (7.6 × 7.6 cm.) left diaphragmatic lobe with pleural and diaphragmatic adhesions.	3

1 = Sequestered lesion containing viable *M. mycoides*.

2 = Cicatrix—indicative of sequestral resolution.

3 = Excessive fibrosed resolved lesions.

4 = Resolved lesions with minimal fibrosis.

Table III.—Indirect haemagglutination titres using *M. mycoides* galactan-coated r.b.c. on 191 sera samples obtained from cattle originating from a C.B.P.P.-free area in Kenya

Titre.		No. of Sera.
0	**** **** ****	15
1:10	**** **** **** **** **** ****	30
1:20	**** **** **** **** **** **** **** **** **** **** III	48
1:40	**** **** **** **** **** **** **** **** **** **** **** **** III	58
1:80	**** **** **** **** **** IIII	24
1:160	III	3
1:320	III	3
1:640	I	1
1:1280	IIII	4
1:2560	II	2
1:5120	III	3

Turner and Etheridge (1963) compared the slide agglutination test (S.A.T.), slide agglutination blood test (S.A.B.T.) and the C.F.T. in 57 cattle in Australia involved in a natural outbreak of C.B.P.P. Five had fibrosed resolved lung lesions. All five were negative in the C.F.T. but positive to the S.A.T. In other experimentally infected cattle, the efficacy of the S.A.T. fell to 60% when sequestered lesions had been present for approximately eight weeks and the C.F.T. was influenced to a lesser degree. However, both tests became progressively less reliable in detecting cattle with this type of lesion.

The decline in detectable C.F.T. titres associated with lesion resolution has been noted by Campbell and Turner (1936), Hindmarsh *et al.* (1943), and Parker (1960) in naturally infected cattle. However, the diagnosis of C.B.P.P. in cattle which had resolving sequestered and resolved fibrosed C.B.P.P. lesions of long duration has not been recorded.

Campbell and Turner (1936) found that cattle with sequestered lesions normally retained a low intermittent C.F.T. titre for the duration of their observations.

Huddart (1966) reported the results of C.F.T. tests performed 6–8 months after clinical C.B.P.P. In a group of 18 cattle, 10 were C.F.T. positive and on post-mortem, six had resolving lung lesions. Five of the eight remaining cattle that were C.F.T.-negative also had lung lesions. It was possible to culture *Mycoplasma* from three of four lung lesions in both the C.F.T.-positive and C.F.T.-negative cattle. This indicates that the C.F.T. was not a reliable indicator of either residual lesions or residual infections.

Johnston and Simmons (1963) examined lungs from 12 cattle with sequestered C.B.P.P. lesions of unknown duration. Four of the 10 available sera from these 12 cattle gave a positive C.F.T. titre. He was able to isolate *M. mycoides* from four of the lung lesions. Only two of these isolates of viable *Mycoplasma* were made from cattle that had a positive C.F.T. titre.

Evidently, all current serological tests for C.B.P.P. become progressively less reliable in detecting cattle with resolving C.B.P.P. lesions. No current serological tests or group of tests can differentiate *in vivo* between sequestered lesions present for 18 months or longer and containing viable *M. mycoides* and sterile fibrosed lesions remaining within the lung tissue after complete resolution.

Any control measures using serological tests to diagnose C.B.P.P. lesions in the live animal must be applied rapidly after the cessation of clinical disease. If the serological testing is delayed and sequestered lesions have persisted for six

months or longer, no currently available serological test will detect all cattle harbouring viable *M. mycoides* within such lesions.

Although it can be concluded that the present serological tests for C.B.P.P. in cattle are inadequate, the possibility exists that a specific test may be forthcoming. Stone and Shifrine (1968) showed that an antigenic fraction is present in *M. mycoides*, apparently unrelated to those found in *E. coli*, which strongly cross-reacts with *M. mycoides* antibody in cattle sera.

SUMMARY

Six current serological tests were performed in an attempt to identify cattle with chronic contagious bovine pleuropneumonia (C.B.P.P.) lung lesions which may have persisted 18 months after a natural C.B.P.P. outbreak. The tests were as follows: the field modification of the complement fixation test, a laboratory complement fixation test, slide agglutination serum test, gel diffusion tests for antibody and antigen, and indirect haemagglutination test.

No test or combination of tests was capable of differentiating between the type of C.B.P.P. lesion found on post-mortem examination.

Current serological tests in the field control of C.B.P.P. appear to be limited unless applied immediately after the cessation of clinical C.B.P.P. within infected herds. If testing is delayed, the progressive loss in reliability of the tests preclude any logical control measures aimed at the elimination of cattle harbouring *M. mycoides* within sequestered lesions.

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Résumé

Six épreuves sérologiques courantes ont été effectuées afin d'essayer d'identifier le bétail atteint de lésions pulmonaires dues à la pleuropneumonie bovine contagieuse chronique (PPBC) qui peuvent avoir persisté pendant 18 mois après une résurgence naturelle de PPBC. Les tests étaient les suivants: la modification en campagne du test de fixation de l'alexine, un test de fixation de l'alexine en laboratoire, un test de sérum agglutination sur lame, tests de diffusions en gélose des anti corps et antigènes et test d'hémagglutination indirect.

Aucun test ni aucune combinaison de test ne pouvait différencier entre les types de lésion PPBC découverts lors de l'autopsie.

Les épreuves sérologiques actuelles pour l'éradication en campagne du PPBC semblent être limitées, à moins d'être appliquées immédiatement après la cessation du PPBC clinique dans les troupeaux infectés. Si l'on retarde le moment du test, la perte progressive de fiabilité des tests empêche toutes mesures logiques de contrôle destinées à l'élimination du bétail vecteur de *M. mycoides* dans des lésions séquencées.

CONTAGIOUS BOVINE PLEUROPNEUMONIA VACCINATION IN EAST AFRICA

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The existence of pleuropneumonia (CBPP) in East Africa is recorded in the reports of the then British East Africa Agricultural Department as early as 1907. European settlers first reached this area in any numbers in the years 1902-03 (Sorrenson, 1968), and it seems probable that CBPP existed before their arrival and was not introduced by trek oxen from South Africa as has often been suggested. Thomson (1885), who journeyed through Kenya in 1883, mentioned examining carcasses of Masai cattle that had died in an epidemic in the Laikipia area. He recorded that "the heart . . . seemed a revolting mass of dirty yellow fat and both sides of the ribs . . . had the appearance of being rotten", and Sir Arnold Theiler (1910) considered this as evidence of CBPP.

The disease was widespread in East Africa after the first world war, and inoculation of infected pleural fluid into the tail was used as a means of vaccination until Walker produced the first culture vaccine in 1920. Its administration involved an initial course of three doses at intervals of three weeks followed by a single annual booster dose. It is interesting to note that when Walker devised this vaccine, he used a simple form of in-contact trial to assess its potency (Walker, 1920).

Walker's culture vaccine was used for over 30 years but in 1952 Sheriff and Piercy published details of their egg vaccine. This consisted of the T₁ strain of *Mycoplasma mycoides* (the causative organism of CBPP) which had been isolated from a natural case of CBPP in Tanganyika and which seems to have been relatively avirulent even when first isolated. The production and development of the vaccine has been described in a series of papers (Sheriff and Piercy, 1952; 1953; Piercy and Knight, 1956, 1957, 1958). The vaccine was used for 10 years (1952-1962) in East Africa but, towards the end of this period, reports began to accumulate suggesting that recently vaccinated cattle were contracting CBPP (Anon., 1957; Hammond and Branagan, 1965). There is no satisfactory published account of the difficulties encountered at this time, but it seems that three phenomena were observed in the field:

1. occasionally vaccinated cattle contracted CBPP, probably as a direct result of vaccination;
2. severe local reactions occurred in an appreciable proportion of cattle;
3. in some areas anaphylactic reactions occurred in cattle that were being vaccinated with egg vaccine for the second and third time.

* Seconded from the Ministry of Agriculture, Fisheries and Food, U.K.

These problems led to a loss of confidence in the vaccine, and in later years it was little used. The CBPP problem in Masailand was growing and it was finally decided to use the egg passaged T_1 strain as seed material for a broth vaccine. This broth vaccine, produced at the East African Veterinary Research Organization (EAVRO) laboratory at Muguga, is now the only one used in East Africa. Its production has been described by Brown, Gourlay and Macleod (1965).

The T_1 Broth Vaccine

(a) **Potency:** In the last two years, a large part of the work of the division of bacterial diseases at EAVRO has been devoted to evaluating this vaccine. Apart from Walker's early experiments, all previous CBPP vaccines in East Africa had been tested for potency by subcutaneous challenge of a virulent strain of *M. mycoides*. Whilst this method has certain advantages in time and cost, there is no published evidence demonstrating the connection between the results of subcutaneous challenge and of the natural challenge that a vaccine has to undergo in the field. It was decided to test the T_1 broth vaccine by contact challenges modelled on those of Hudson and Turner (1963), and a cattle shed was built for this purpose in 1966. The first trial was carried out in late 1966, and details of this and further trials have been published (Davies, Masiga, Shifrine, and Read, 1968) or are in preparation (Gilbert, 1969). So far groups of cattle have been subjected to contact challenge at one month, six months and 12 months after vaccination. In the case of the one-month and six-month trials, none of the vaccinated cattle has shown any bacteriological or pathological evidence of CBPP when slaughtered at the termination of the experiments, but occasional animals have shown some slight ($< 1/160$) CF titres during the trial which appeared to be an anamnestic response. The results of the twelve-month trial have still to be fully evaluated, but it appears that the resistance to infection is still substantial. It therefore seems that the T_1 broth vaccine confers a solid immunity for at least twelve months and that it can form the basis of a vaccination programme at annual intervals. Extensive field experience with the vaccine in Uganda supports this claim (Huddart, 1967a).

The dose of vaccine used at present contains between 2×10^8 and 2×10^9 viable units, but there is no information available to indicate the number of viable units necessary to confer protection. Evidence on this point is needed, not only to allow the vaccine to be used with the utmost economy, but also as basic information for developing it into a lyophilised product. An experiment has begun in which three groups of cattle have been vaccinated with doses of vaccine containing either 10^9 , 10^7 , or 10^5 viable units. These animals are being contact challenged six months after vaccination.

(b) **Safety:** The T_1 broth vaccine has been used in Uganda, Tanzania and Kenya for the last four years at the rate of one million doses a year injected into the tip of the tail and, so far, there have been no reports of the vaccine causing clinical disease, and few reports of local reactions at the inoculation site. In the Loliondo area of Tanzania, out of 17,000 cattle vaccinated in 1967, only two were reported to have lost their tails. Huddart (1967b) found that there were no reactions if the vaccine was used in healthy cattle at intervals of more than six months. However, he did record hard circumscribed swellings up to 6 inches in length in quarantine cattle that were heavily infected and had been subjected to several vaccinations at monthly intervals.

To supplement this field information, an experiment was devised to trace the

persistence of the vaccinating organism in the host body. A group of 10 cattle was slaughtered serially at intervals after vaccination, and a thorough bacteriological examination carried out on the carcasses. The results of this experiment are about to be published (Davies, 1969a) and they show that the organism was confined to the lymph nodes draining the vaccination site and was recoverable for only 14 days after vaccination. In one animal, *M. mycoides* was isolated from the trachea, but none of the nasal swabs taken at regular intervals from these animals yielded the organism. This experiment was repeated with a group of cattle that had elevated temperatures due to a recent caprinised rinderpest vaccine inoculation. The distribution of organisms was the same as in the group of normal cattle, and the only effect of the stress appeared to be a lengthening of the period during which the organism could be cultured from the body.

In a further experiment, the T_1 vaccine strain has been passaged in cattle by means of endobronchial intubation (Davies, 1969b), and the strain reverted to full virulence after five such passages.

The results of these experiments suggest that the vaccinating organism may reach the respiratory tract and be exhaled on rare occasions but that the chances of its reverting to virulence in this way by natural serial passage are virtually non-existent especially if the cattle population is largely immune as a result of vaccination.

(c) **Further Development:** The present vaccine is delivered in 8 oz. bottles containing 200 ml., i.e. 400 doses. It is cheap (five East African cents per dose) and easy to use. Its main drawback is its short field life of three weeks. Under refrigerated conditions its life is, in fact, at least five weeks (Gourlay and Macleod, 1966), but this is not long enough even in East Africa where communications are good.

The first attempt at extending the shelf life of the T_1 vaccine involved lyophilisation. It was felt that after the difficulties with the egg vaccine, any product containing an adjuvant would be unacceptable in East Africa, and thus the work was devoted to drying the unmodified broth culture. The vaccine is used for mass inoculations in areas where the cattle are kept in large herds, and it was thus desirable that each ampoule of vaccine should contain at least 100 doses. This necessitated either (a) increasing the titre of the present culture, or (b) concentrating the present vaccine.

Attempts at increasing the titre of the present vaccine have failed. It has a maximum titre of 4×10^9 viable units per ml. (Davies, 1969b), and this is similar to that achieved by Buttery (1967) with his Panmede medium B. Aerating the culture by magnetic stirrers or by rocking mechanisms failed to increase the titre. Attempts at concentrating the culture have also failed. Whilst a "Lister" cream separator concentrated the organisms, it was impossible to maintain sterility in this way, and a continuous flow high speed centrifuge gives a yield of organisms totally inadequate for the production of large amounts of vaccine. Depositing agents have been investigated, and Provost's findings (1967) that carboxymethyl-cellulose fails to deposit *M. mycoides* even when used in a range of different pH conditions have been confirmed.

Because of these difficulties, the work on a lyophilised product has been abandoned temporarily, and attention devoted to improving the keeping qualities of the wet vaccine. Work carried out in Australia (Campbell, 1938; Hudson, 1968) has shown that broth vaccines can retain their titre of viable organisms for

long periods at high ambient temperatures provided they are suitably buffered. Work has started on growth studies on the T_1 strain in various media, and it is hoped eventually to produce a wet vaccine with a shelf life of three months.

Use of the T_1 Vaccine

CBPP in East Africa is not the major economic problem that it is in parts of West Africa. In the three countries served by the East African Community (Uganda, Tanzania and Kenya), CBPP exists in three areas, (a) the north eastern area of Kenya, where it occurs in cattle being trekked southward from parts adjoining the Ethiopian and Somali frontiers; (b) the Karamoja region of Uganda, where outbreaks have occurred in areas near the frontier with Sudan; (c) Kenya and Tanzania Masailand, an isolated focus of infection.

The first two areas present problems in an eradication policy in that infection can easily be reintroduced across a national border in an area where complete control of stock movements is very difficult to achieve. It is possible that concerted action by government veterinary departments will solve this problem in time. The other infected area—Masailand—does not have these disadvantages. It is a compact area surrounded by cultivated lands which have been free of CBPP for some time. There is, therefore, little chance of the reintroduction of the disease. For various reasons a policy of serological testing followed by the slaughter of reactors is unacceptable in Masailand and mass vaccination in this area is being considered, initially in conjunction with the JP-15 rinderpest campaign.

There are reasons for believing that a mass vaccination campaign carried out with the T_1 vaccine will succeed. It was mentioned previously that vaccinated cattle used in contact trials did not appear to harbour *M. mycoides* even after prolonged contact with infective cattle. It therefore follows that there should be little risk of a carrier state existing in vaccinated cattle, and that the only infective cattle will be those that have contracted the disease naturally. The results of the Australian and East African contact trials (Hudson and Turner, 1963; Davies *et al.*, 1968) suggest that, in the majority of naturally infected cattle which survive, lesions resolve or develop into sequestra within a few weeks. Studies on the distribution of organisms in the respiratory tract of infected cattle shown that, where the lesions appear to have resolved or have become sequestered, *M. mycoides* can only be recovered from the sequestra or the regional lymph nodes (Davies, unpublished observations) so that most cattle are infective for only a limited period. Although the persistence of the disease and the occurrence of new outbreaks is often attributed to the breakdown of old infected sequestra, it is more likely that infection is maintained in areas such as Masailand by the constant mixing of acutely infected and susceptible animals which occurs in the large mobile cattle populations kept by semi-nomadic tribes.

The probable absence of an infective carrier state in vaccinated cattle and the short infective period may provide the circumstances leading to eradication by mass vaccination as long as the vaccination cover is extensive enough to reduce the chances of infective cattle meeting susceptibles to a minimum.

SUMMARY

CBPP has been recorded in East Africa since the beginning of the century. Vaccination was originally by the inoculation of infected pleural fluid, but Walker in 1920 developed the first culture vaccine, and this was used until the 1950's,

when the T₁ strain was passaged in embryonated eggs and the 44th passage used as a freeze-dried vaccine. Difficulties with this vaccine led to the production of the T₁ broth vaccine.

Contact trials designed to evaluate the potency of the T₁ broth vaccine show that it provides an immunity for at least 12 months. Safety experiments have shown that the vaccinated organism localises in the regional lymph nodes and that it is very unlikely to reach the respiratory tract and be exhaled. Field reports indicate that reactions at the site of vaccination do not occur.

Difficulties have been encountered in developing a freeze-dried vaccine, and present work is concentrating on the development of a wet vaccine with a shelf life of three months. Further work includes trials designed to give an estimate of the number of vaccinating organisms needed to induce a satisfactory immunity. The use of the T₁ vaccine in the field is discussed.

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Résumé

Le PPBC a été signalé en Afrique orientale depuis le début du siècle. La vaccination se faisait à l'origine par l'inoculation de fluide pleural infecté et en 1920 Walker mit au point le premier vaccin sur culture, dont on se servit jusqu'aux années 1950. Alors, on fit passer la souche T₁ par des œufs embryonnés et le 44ème passage servit de vaccin lyophilisé. Les difficultés qui résultèrent de ce vaccin menèrent à la production du vaccin de culture en bouillon.

Des épreuves de contact destinées à évaluer l'activité du vaccin de bouillon T₁ montrent qu'il assure une immunité pendant au moins 12 mois. Des expériences sur

la sûreté ont montré que l'organisme vacciné se localise dans les ganglions lymphatiques régionaux et qu'il a très peu de chances d'atteindre les voies respiratoires et d'être expiré. Les rapports en campagne indiquent qu'il n'y a pas de réaction à l'emplacement de la vaccination.

Des difficultés ont été éprouvées lorsqu'il s'est agi de mettre au point un vaccin lyophilisé et les travaux actuels se concentrent sur la mise au point d'un vaccin humide d'une durée de conservation de trois mois. Des travaux ultérieurs indiquent qu'il faudrait faire des épreuves pour évaluer le nombre d'organismes de vaccination nécessaires pour provoquer une immunité satisfaisante. La communication examine l'usage du vaccin T₁ en campagne.

CLINICAL COURSE AND PHYSICAL CHANGES OF BLOOD IN FOOT-AND-MOUTH S.A.T.₂ TYPE INFECTION IN CATTLE

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Ghana is one of the countries which is enzootically infected by F.M.D. Various types of virus have been isolated. Over the past ten years the following types of the virus have been identified from materials sent to Pirbright: Type O, 1958; Type A, 1960, 1961, 1967; Type S.A.T.₂, 1961, 1962, 1965, 1968 (Oppong, 1968). It is evident that S.A.T.₂ type was the most frequent cause of the F.M.D. outbreaks in this country. Similarly Shahan (1956) stated that S.A.T. types were identified more often at Pirbright Research Institute in the past years. The comparison of antigenic differences of S.A.T. types virus was done by Hyslop *et al.* (1963) and the immunity study by Vojnov and Zagrobyan. The story of an outbreak of F.M.D. caused by S.A.T., was described by Viljoen (1964) and the clinical course of F.M.D. caused by S.A.T. types by McKenzie and Simpson (1956). The course of the disease in indigenous breeds is not more serious than when other strains of virus are responsible, but in exotic breeds may have a fatal course.

MATERIALS AND METHODS

This experiment was conducted at the Agricultural Research Station (Nungua), Faculty of Agriculture, University of Ghana, Legon. The Station is located 20 miles east of Accra in a gently rolling country of low elevation typical of the western Accra Plains. The annual average rainfall is 32 inches with double peaked monsoon rainfall regime—June and September.

The outbreak of foot-and-mouth disease appeared on the station on 28 June 1968 in the herd of bulls and bullocks. The number of animals in this herd was 62 and 15 animals were found showing clinical symptoms such as salivation, dullness, fever and aphtae on the inner surface of the lips and tongue. These animals were kept on the pastures about three miles from the station. According to a decision of the Animal Health Department, Ministry of Agriculture, all the cattle (total no. 540 head) at the station were artificially infected by swabbing the infectious material into the mucous membrane of the mouth cavity on 29 June 1968.

Nine animals from the herd located at the station, which did not show any alteration of clinical status were selected for further experiment:

West African Shorthorn cows Nos. 51, 50, 105,

Ndama cow No. 12,

Jersey × West African Shorthorn F₂ cows Nos. SS 6, SS 20,

Jersey × West African Shorthorn F₁ cows Nos. JS 21, JS 16,

Sokoto Gudale cow No. 62.

These animals were swabbed orally with cotton wool swabs soaked in the buffered glycerin saline containing the pooled virus obtained from clinical lesions of animals in the bulls and bullocks herd. A fresh swab was used for each animal.

The clinical status including temperature, pulse, respiration and development of mouth and hoof changes and the general clinical picture was observed daily for a period of 28 days after infection.

Blood examination was performed every other day (R.B.C. and W.B.C. improved Neubauer counting chamber, P.C.V. microhamatocrit, HB% M.R.C. grey wedge photometer, white cell differential counts; anticoagulant used, double oxalate mixture).

Examination and bleeding of animals were done from 7 to 8 o'clock in the morning and blood examined the same day.

The experimental animals were kept inside the clinic paddock with a possibility of grazing and drinking *ad lib*.

The main herd grazed on the pastures around the station.

RESULTS

Clinical symptoms in artificially infected cattle were:

Cow WAS 51:

- 1st day: Reddening of mucous membrane of the mouth cavity, sensitive to touch.
- 2nd day: Aphtha on the inner left side of the lower lip 2×1.5 cm.
- 3rd day: Irregular pulse, mucopurulent discharge from the nostrils, aphtha on the left side of the lower lip burst surface covered with necrotic masses, another aphthae on the middle of the inner side of the lower lip and on the tip of the tongue 2×2 cm.
- 4th day: Aphthae on the lower lip and on the tip of the tongue not yet burst, the first aphtha covered with necrotic masses, mucopurulent discharge from the nostrils, irregular pulse.
- 5th day: Aphthae on the lower lip and tip of the tongue burst and the surface covered with necrotic masses (Fig. 2) irregular pulse, reddening of the skin of interdigital space on both hind legs, limping.
- 6th day: Lesions in the mouth cavity granulating, difficult movement and obvious pains of the hind legs. Irregular pulse.
- 7th-16th day: Lesions in the mouth granulating. Limping stopped on the 10th day; no changes on the hoofs developed.
- 17th day: Lesions in the mouth cavity healed, fresh scars visible.

Cow WAS 50:

- 1st day: Profuse salivation, two vesicles on the inner side of the lower lip 2×2 cm.
- 2nd day: Vesicles on the lower lip burst, two vesicles on the left and right inner sides of the upper lip. Irregular pulse.
- 3rd day: All lesions in the mouth cavity burst, covered with necrotic masses. Pulse irregular.
- 4th day: Inner side of the lower and upper lips covered with necrotic masses, both lips swollen and very painful.
- 5th day: Lesions in the mouth cavity the same, swelling of the lips reduced.
- 6th-11th day: Granulation of the lesions.

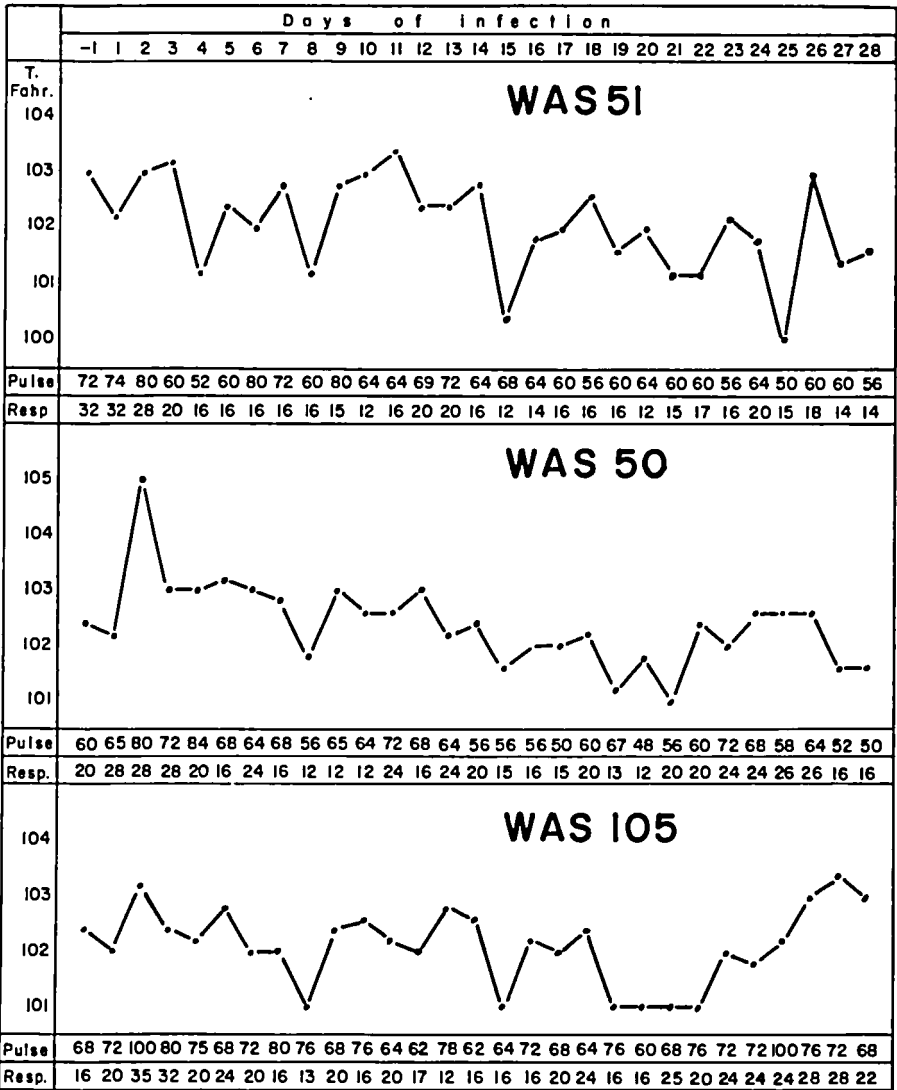


FIG. 1.—Body temperature, pulse and respiration in artificially infected animals.

- 12th day: Granulation continues, inflammation of the skin of interdigital space and coronet of the hind legs swollen, limping.
- 13th–15th day: Limping and swelling reduced. Lesions on the upper lip healed, on the lower lip deep ulcers granulating.
- 16th–22nd day: No changes on the legs developed, lesions on the lower lip granulating.
- 23rd day: Lesions on the lower lip in the form of 3 cm. long scar.

WAS 105:

- 1st day: Reddening of the mucous membrane of the mouth cavity. Salivation.
- 2nd day: Aphtae on the right and left side of the tongue. Salivation.
- 3rd day: Both aphtae burst, covered with necrotic masses.
- 4th-16th day: Ulcers gradually granulating. Limping for two days, but no hoof changes developed.
- 17th day: Lesions in the mouth cavity healed.

ND 12:

- 1st and 2nd day: Salivation, mucous membrane of the mouth cavity red and sensitive to touch.
- 3rd day: Two aphtae on the right inner side of the lower lip, two on the inner side of the upper lip (2×1.5 cm.).
- 4th day: Aphtae burst covered with necrotic masses.
- 5th day: Mucopurulent discharge from the nostrils. Necrosis of the inner side of the upper lip and hard palate. Ulcers on the lower lip slightly granulating.
- 6th day: The same picture.
- 7th day: Inflammation and swelling of the interdigital space of front and right hind legs, limping. Movement very difficult. Lesions on the upper lip still necrotic; the lower lip granulating.
- 8th-18th day: Lesions in the mouth cavity healing. Still limping but no ulcers on the legs developed.
- 19th day: Lesions in the mouth cavity healed. Limping on right hind leg. The coronet sensitive to touch, but no visible changes.
- 27th day: Limping stopped.

SG 62:

- 1st-6th day: Salivation.
- 7th day: Reddening and swelling of the muzzle and nostrils.
- 8th day: Aphtae on the muzzle and inside the right nostril.
- 9th day: The muzzle and the nostrils covered with scabs, after their removal bleeding.
- 10th-19th day: Lesions on the muzzle and nostrils healing.
- 23rd day: Healed completely in a form of a scar in the middle of the muzzle.

SS 6:

- 3rd day: Salivation.
- 6th day: Salivation stopped. No lesions in mouth and on the hooves developed during the experimental period.

SS 20:

- 2nd day: Salivation. Aphta on the inner left side of the lower lip.
- 3rd day: Salivation. Mucopurulent discharge from the nostrils. Lower lip swollen. Necrosis of the mucous membrane of the lower lip. Aphtae on the inner side of the upper lip.

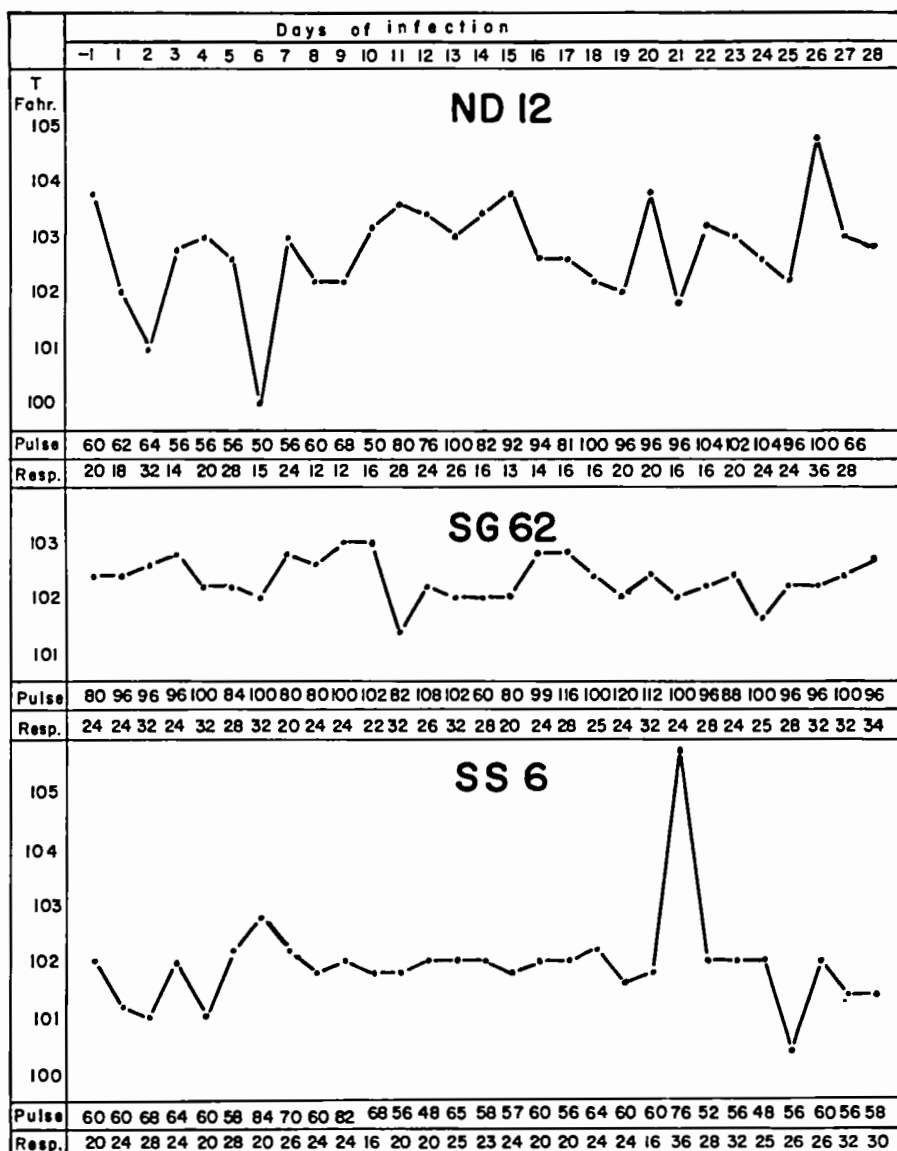


FIG. 1.—(cont.)

- 4th day: Salivation. Mucopurulent discharge from the nostrils. Necrosis of the mucous membranes of the lower and upper lip.
- 5th day: Lesions on the lower lip granulating but covered with necrotic masses. Lesions on the upper lip bleeding.
- 6th–11th day: Lesions on the lower lip healed. Upper lip granulating well.
- 12th–26th day: All lesions healed completely.

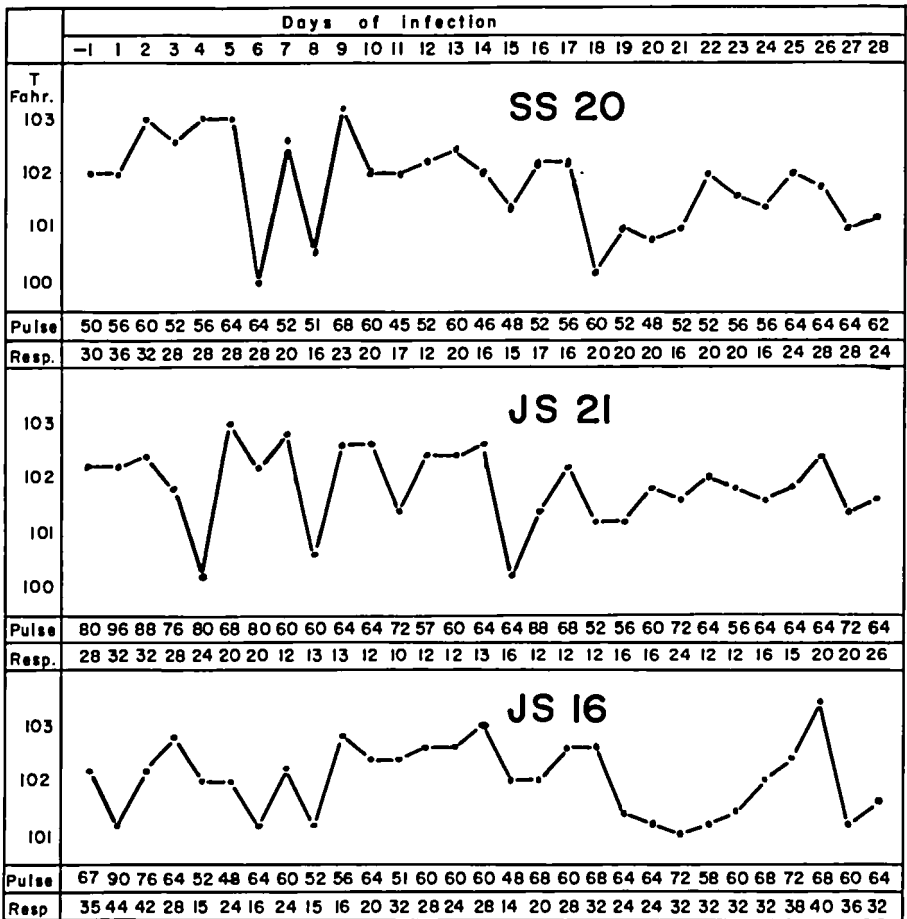


FIG. 1.—(cont.)

JS 21:

- 2nd day: Salivation.
- 3rd day: Aphthae on both edges of the tongue (2×1.5 cm.), one on the left inner side of the lower lip, upper lip and hard palate. (Fig. 3).
- 4th day: Aphthae burst and covered with necrotic masses.
- 5th day: Mucopurulent discharge from the nostrils. Necrosis of the mucous membrane of the upper lip and hard palate.
- 6th day: Granulation started under the necrotic masses.
- 7th day: Granulation continues. Ulcers along the coronet and in the interdigital space on all legs. Limping, difficult movement.
- 8th–16th day: Lesions in the mouth granulating well. Lesions on the legs almost healed.
- 17th–25th day: All the lesions in the mouth and on the legs healed.

JS 16:

- 2nd day: Salivation.
- 3rd day: Aphtae on the inner side of the lower lip, upper lip and hard palate.
- 4th day: Ulcers on the lower and upper lip, necrosis of the mucous membrane of the hard palate. Large blister on the tip of the tongue.
- 5th day: Mucous membrane of the tip of the tongue fell off (Fig. 4). Lesions on the lower and upper lips and hard palate granulating but covered with necrotic masses.
- 8th day: The lesions on the lips and hard palate granulating. The tip of the tongue covered with purulent exudate. Small ulcers on the interdigital space of the left front leg. Limping.
- 9th–20th day: Lesions in the mouth healing well. No necrotic changes on the legs developed.
- 21st day: Lesions on the lips and hard palate healed completely. Tip of the tongue still not healed.
- 27th day: Tip of the tongue healed leaving numerous scars on the surface.

The highest loss of weight (Table I) was in the first 13 days after infection. This is of course in direct relation with changes in the mouth cavity which prevented the animals feeding well. From the third week when the changes were healing the loss of body weight stopped and in two cases increased. At the end of the experiment the loss of weight varied from 14 to 54 lb.

The thermal reaction appeared in three animals on the 2nd day after infection (Fig. 1). It is most probable the first rise in temperature was a few hours after infection which unfortunately was not recorded. The variations of temperature, pulse and respiration are due to the stage of clinical changes.



FIG. 2.—Cow WAS 51: ruptured vesicles on the lower lip and tip of tongue, with necrosis. (5th day).



FIG. 3.—Cow JS 21 : vesicles on tongue, upper and lower lips and hard palate (3rd day).



FIG. 4.—Cow JS 16 : the mucous membrane of the tip of the tongue has detached : lesions on the upper and lower lips and hard palate are granulating but covered with necrotic material.

Table I.—Live weight of experimental animals (in lb.)

No. of Animal	Days after infection					
	-1	7	13	18	23	28
WAS 51 .	437	396	406	406	406	403
WAS 50 .	640	591	576	572	589	586
WAS 105 .	703	682	688	686	689	670
ND 12 .	486	456	438	437	438	440
SG 62 . .	836	810	800	796	811	816
SS 6 . .	695	673	677	677	650	662
SS 20 . .	720	636	656	678	699	706
JS 21 . .	626	527	544	578	592	604
JS 16 . .	544	530	482	450	480	505

The physical changes of blood during 28 days observation period are included in Table II. The erythrocytes number varied considerably and the minimal values were below the data published (Schalm 1961), but on average the erythrocyte counts showed gradual decrease throughout the course of observation. The lowest values were found at the end of the fourth week after infection. Similarly haematocrit values were on the lowest level at the end of the experiment. Haemoglobin content dropped but not so much as the erythrocytes and haematocrit. The number of leucocytes is within the published data but varies considerably; the number of



FIG. 5.—Severe necrotic lesions of the hoofs of animals in the main herd.

Table II.—Mean haematological values in experimental animals

Days of after infection	RBC/mill cu.mm.			PCV/%			Hb/g, 100 ml			WBC/1000 cu.mm.			Lymphocytes/%			Neutrophils/%			Monocytes/%			Eosinophils/%		
	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min
— 1	6.32	7.85	4.85	34	42	29	12.53	14.06	9.92	9.30	11.35	6.65	61	78	40	34	47	13	0.4	2	0	5.2	12	0
2	5.72	7.75	3.84	32	38	27	11.51	13.32	9.32	9.63	11.75	6.40	69	75	61	29	37	23	0.1	1	0	1.3	5	0
4	5.88	6.15	3.78	31	38	26	11.10	14.06	9.32	8.90	12.00	6.15	72	93	55	27	45	7	0.0	0	0	1.1	4	0
6	5.30	6.35	4.40	33	42	27	11.73	14.06	9.92	7.91	11.15	4.80	81	97	55	15	37	3	0.2	2	0	4.6	11	0
8	5.14	6.20	4.20	32	43	27	10.26	14.06	7.99	9.07	12.45	6.20	60	85	44	34	50	7	0.2	1	0	5.4	12	0
10	5.08	5.70	3.95	33	43	25	11.53	14.06	9.47	8.94	13.55	6.20	60	75	35	29	49	11	1.4	3	0	9.0	28	0
12	5.16	6.96	3.79	30	39	22	10.87	13.76	8.73	9.63	15.55	7.40	60	84	39	34	50	14	0.2	1	0	5.4	14	0
14	5.07	6.65	4.31	31	40	26	11.51	14.06	9.47	9.63	14.25	6.70	55	85	41	39	56	14	0.0	0	0	5.8	10	0
16	4.86	6.12	3.16	31	40	23	11.77	14.06	8.88	10.02	16.80	7.60	63	87	32	33	66	13	0.1	1	0	3.9	11	0
18	4.84	5.69	3.49	29	40	23	10.84	14.06	8.29	8.99	11.50	6.80	55	80	31	36	54	10	0.3	2	0	8.7	15	2
20	4.85	5.95	3.36	30	40	21	11.05	14.36	8.58	9.72	12.40	7.90	51	68	30	36	66	16	0.9	2	0	12.7	24	0
22	4.50	5.95	3.10	28	37	21	10.90	12.88	9.62	9.34	14.45	3.35	51	71	37	33	49	21	0.7	3	0	15.7	34	5
24	4.41	5.93	3.52	27	36	21	10.13	12.58	8.14	7.99	11.35	2.90	65	83	50	24	48	3	0.1	1	0	10.7	22	0
26	4.30	6.07	3.10	27	38	19	9.88	13.32	6.96	7.70	9.90	3.25	60	84	45	28	52	8	0.8	3	0	10.8	19	0
28	4.73	7.08	3.56	28	38	22	9.95	12.58	7.10	8.37	10.30	4.50	61	80	49	29	45	7	0.7	2	0	9.7	15	4

lymphocytes and neutrophiles were not influenced by the infection as well as monocytes whilst a number of eosinophiles dropped within the first four days after infection and was above average from 20th to 28th day.

DISCUSSION

Incubation period varied from one to three days, and in one case the first clinical symptoms appeared on the 6th day after infection and in one other case no clinical signs appeared at all. Healing of the lesions in the mouth cavity took 17 to 27 days, a similar course to the healing process of the mouth cavity of the rest of the herd, and it was interesting that in the nine animals observed no severe hoof lesions developed. In three animals only reddening, wetting and slight inflammation of the skin in interdigital space and around the coronet was noticed, whilst in the main herd severe necrotic lesions on the hoofs developed (see Fig. 5). The most probable explanation was that the animals under observation were kept in a separate paddock which was relatively dry, whilst the main herd grazed on the pastures some of which were flooded and muddy because of the heavy rainfalls during this period. Approximately 30% of the animals developed the hoof lesions. The healing was prolonged and lasted on average five weeks but in very complicated cases seven weeks. The loss of body weight was most excessive in the first two weeks when the animals were unable to feed adequately. Of the 500 animals infected only one animal died and two of them (two bullocks over one year) were slaughtered in emergency because of necrotic arthritis of the hoof-joints.

Concerning the low erythrocyte counts, Edwards *et al.* (1955) working on sheep in Ghana came to a similar conclusion and considered that this low number of erythrocytes was due to the inheritance of lower haematological values in these animals of this territory or that they suffered from the effects of some anaemia producing factor or factors so far undiscovered.

The problem of F.M.D. in tropical countries of Africa is most serious. The control measures, common in other countries, are sometimes hardly applicable. It is usually difficult and sometimes even impossible to isolate the infected area and to prevent spreading of the disease. Vaccination cannot usually be done because of lack of vaccines and also because of high expenditures involved. The most common methods of what remains is aptization of the whole herd. Viljoen (1964) does not recommend aptization as a control measure because of the difficulty of preventing contact with susceptible game. He finally achieved control by vaccination in spite of breakdown of immunity of certain cases.

The station was closed because of F.M.D. for eight weeks. The direct losses by death were negligible but indirect ones resulting in loss of condition, drop in milk yield, loss of the milk market etc. were quite remarkable. The first drop in milk yield appeared the first day after infection (1.14 lb. per animal) and continued decreasing throughout the observation period so that the difference between the uninfected animals and the same animals on 28th day after infection was 3.83 lb. in average per animal. The 45th day after infection the milk yield was at the normal level again.

The disease was not transmittable to other domestic animals in spite of close contact of sheep, goats and pigs with infected cattle on the pastures.

SUMMARY

The clinical course and physical changes of blood in foot-and-mouth S.A.T.₂ infection in cattle are described.

The onset of clinical lesions appeared on the 1st and 3rd day after infection and the mouth lesions healed in 17 to 27 days. The foot lesions in experimental animals did not develop into the necrotic stage but 30% of the main herd showed severe foot lesions that healed in five to seven weeks. Only one animal died and two were slaughtered in emergency. Other domestic animals were not affected.

The blood examination revealed gradual decrease of erythrocyte numbers with the lowest counts at the end of the fourth week. Haematocrit and haemoglobin levels dropped during the observation period. The other haematological values were not affected by the infection, only the eosinophil percentage increased from 20th to 28th day.

The F.M.D. infection at the station influenced in negative sense the general body condition of infected animals and milk yield of the milking herd.

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Résumé

Description de l'évolution clinique et des changements physiques du sang dans une infection du bétail par la fièvre aphteuse S.A.T.2.

Les lésions cliniques commencent à apparaître les 1er et 3ème jours après l'infection et les lésions buccales se sont guéries en 17 à 27 jours. Les lésions du pied chez les animaux d'expérience n'apparurent pas à l'étape nécrotique, mais 30% du troupeau principal manifestèrent de graves lésions du pied, qui se guérirent en 5 à 7 semaines. Une seule bête mourut et deux furent abattues d'urgence. Les autres animaux domestiques n'étaient pas infectés.

L'examen du sang révélait une diminution graduelle du nombre d'érythrocytes, la numération la plus basse étant celle de la fin de la 4ème semaine. La teneur en globules rouges à l'hématocrite et celle de l'hémoglobine baissèrent pendant la période d'observation. Les autres valeurs hématologiques n'étaient pas affectées par l'infection: seul le pourcentage d'éosinophilie augmenta du 20ème au 28ème jours.

L'infection par la fièvre aphteuse à la station influença d'une manière négative l'état général de l'organisme des animaux infectés et le rendement en lait du troupeau laitier.

DIAGNOSIS OF AFRICAN SWINE FEVER BY FLUORESCENT ANTIBODY STAINING OF BLOOD FILMS AND BUFFY COAT SMEARS

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The diagnosis of African swine fever (ASF) by fluorescent antibody (FA) staining of tissue sections (Boulanger *et al.*, 1966) and tissue impression smears (Heuschele, Coggins and Stone, 1966) has been reported. More recently, immunofluorescence was described in circulating leukocytes of pigs infected with ASF virus (Colgrove, 1968). The ease of obtaining blood samples as well as the relative simplicity of the FA technique suggested that the demonstration of fluorescent antigen in leukocytes might find application as a rapid method of identifying the disease in pigs prior to death. Studies were therefore undertaken to assess the reliability of FA staining of blood films and buffy coat smears in the diagnosis of ASF.

MATERIALS AND METHODS

Animals

Sixteen Large White pigs, eight to nine months of age, were separated into four groups, and each group of four pigs was orally infected with a different isolate of ASF virus. Animals were bled and temperatures recorded each day following infection.

Virus and infection procedure

The following isolates of ASF virus were used: Hinde WH II†; Kitale (Heuschele, Stone and Coggins, 1965); Uganda (DeTray, 1960); and Tengani (Cox and Hess, 1962). Infection was accomplished by feeding each pig approximately 50 grams of minced spleen and liver, containing $10^{6.0}$ to $10^{7.0}$ hemadsorption₅₀ units of virus per gram of tissue.

Collection of blood and preparation of smears

Blood was collected from the anterior vena cava of each pig, employing approximately 1 mg. EDTA (disodium salt) per ml. of blood as anticoagulant. Blood films were prepared on glass slides as for routine hematologic studies, air dried and fixed in acetone for 10 minutes at room temperature. Buffy coat smears were prepared in the following manner. Blood was drawn into capillary (microhematocrit) tubes and centrifuged for 10 minutes. The capillary tubes were then broken at the level of the buffy coat, the leukocytes smeared on a glass slide, air dried and fixed as above.

* Employed by the United States Department of Agriculture, Agricultural Research Service, Plum Island Animal Disease Laboratory, Box 848, Greenport, Long Island, N.Y. 11944, U.S.A.

† Hinde WH II virus was isolated from a wart hog near Nanyuki, Kenya, by Dr. D. E. DeTray in 1959.

Fluorescent antibody technique

Fluorescent antibody was prepared according to the method outlined by Heuschele, Coggins and Stone (1966), utilizing the serum of a pig which survived infection with Hinde WH II virus. The globulin fraction of the serum was conjugated with 0.025 mg. fluorescein isothiocyanate per mg. protein, concentrated by forced dialysis and lyophilization, and stored at -20°C . until use. The lyophilized conjugate was diluted 1:5 with distilled water prior to application. Blood films and buffy coat smears were stained with labeled antibody for 30 minutes in a moist chamber at 37°C ., then washed 10 minutes in phosphate buffered saline (pH 7.0). Preparations were mounted with 10% glycerol in phosphate-buffered saline and examined with an ultraviolet microscope.* The specificity of fluorescent staining was confirmed by (1) the absence of fluorescence in blood films and buffy coat smears of uninfected control animals, (2) absence of fluorescence in preparations treated with fluorescein isothiocyanate-labeled normal pig serum, and (3) inhibition of fluorescence in infected preparations treated with unlabeled ASF virus antiserum prior to the application of fluorescent antibody.

Preparations were stained and examined within one to three hours after collection of blood. Blood samples from immunofluorescence-positive animals were then placed in the refrigerator and stored for 24 hours, after which time additional blood films and buffy coat smears were prepared and examined.

RESULTS

The demonstration of immunofluorescence in circulating leukocytes of 16 pigs infected with ASF virus is summarized in Table I. The earliest appearance of specific fluorescence in blood films and buffy coat smears occurred at three days post infection (DPI) in three pigs. Over half the pigs examined were positive by the FA test at four DPI, and at five DPI immunofluorescence was seen in the leukocytes of 14 of 16 animals. Fluorescent antigen was found in the blood of all 16 pigs at least once during the course of the experiment.

Fluorescent cytoplasmic inclusions were observed primarily in monocytes, and in buffy coat preparations immunofluorescence-positive cells were present in sufficient numbers to facilitate rapid diagnosis. In some whole-blood films, however, large areas of the slide had to be searched before specific fluorescence was found, particularly during the first one or two days in which immunofluorescence was demonstrated. In a few cases positive cells were not seen in several hundred high-dry (200 X) fields, and diagnosis was based on the finding of fluorescent cells in buffy coat smears. In later stages of infection, when numbers of cells involved had increased, fluorescent leukocytes were commonly found in whole-blood films at a rate of approximately one cell per five or six high-dry fields.

The first febrile responses were noted at 3 DPI in five pigs, and the remaining animals became febrile at 4 DPI. Table II relates the first appearance of immunofluorescence in blood films and buffy coat smears to the onset of fever. Fluorescent antigen was detected in the leukocytes of only two pigs prior to the first rise in temperature, while over half the animals became positive by the FA test on the second day of fever. After the initial detection of specific fluorescence in preparations from individual animals, the blood of each pig remained positive until the time of death. The first deaths occurred at 6 DPI, and the longest survival time

* Model GFL, Carl Zeiss, Oberkochen, Wurttemberg, Germany.

Table I.—Immunofluorescence in circulating leukocytes of pigs infected with ASF virus

Virus	Pig No.	Days Post Infection									
		1	2	3	4	5	6	7	8	9	10
Hinde	1940	—	—	—	— ^f	+	++	+++	D		
	1943	—	—	— ^f	+	++	+++	D			
	1946	—	—	—	— ^f	+	++	++	D		
	1947	—	—	—	— ^f	+	+	++	++	++++	D
Uganda	1936	—	—	—	— ^f	+	++	++	D		
	1938	—	—	—	— ^f	—	—	++	D		
	1942	—	—	—	— ^f	—	+	+	+++	D	
	1944	—	—	—	— ^f	+	+	+++	D		
Kitale	1948	—	—	—	+++ ^f	++	D				
	1963	—	—	— ^f	+	+++	D				
	1972	—	—	— ^f	++	+++	D				
	1973	—	—	+ ^f	++++	++	++++	D			
Tengani	1957	—	—	—	+++ ^f	++	D				
	1958	—	—	+	+++ ^f	++	+++	D			
	1959	—	—	— ^f	+	++	++	D			
	1971	—	—	+	+++ ^f	++	+++	D			
No. pigs positive		0	0	3	9	14	11	8	2	1	
No. pigs surviving		16	16	16	16	16	12	8	2	1	

f = first day of fever (over 103° F).
 — = buffy coat (BC) smears and blood films negative.
 + = BC positive; 0-2 pos. cells/100 fields (200 X) in blood films.
 ++ = BC pos.; 3-10 pos. cells/100 fields in blood films.
 +++ = BC pos.; 11-20 pos. cells/100 fields in blood films.
 ++++ = BC pos.; over 20 pos. cells/100 fields in blood films.
 D = Died.

Table II
Relation between onset of fever and first appearance of fluorescent antigen in leukocytes

<i>Febrile Response</i>	<i>No. of Pigs Showing Specific Fluorescence for First Time</i>
Before Fever	2 (12.5%)
1st Day of Fever . . .	3 (18.7%)
2nd Day of Fever . . .	9 (56.3%)
3rd Day of Fever . . .	1 (6.25%)
4th Day of Fever . . .	1 (6.25%)

was nine days. The time from first appearance of fluorescent antigen in leukocytes until death varied from one to five days, with an average time of three days in which diagnosis of ASF could be made by the method outlined.

Blood films and buffy coat smears prepared and stained after blood samples had been stored in the refrigerator for 24 hours proved satisfactory for the demonstration of specific fluorescence, although a high percentage of disintegrated leukocytes were encountered in many preparations.

DISCUSSION

The identification and slaughter of all infected and exposed swine is essential for the control and eradication of ASF. A rapid and simple method for detecting subclinical or incubating infection in ASF-suspect areas would expedite the prompt initiation of control measures. While sensitive and specific diagnostic tests for ASF already exist (Malmquist and Hay, 1960; Coggins and Heuschele, 1966), the advantages of simplicity and speed inherent in the FA method would facilitate early diagnosis of the disease if sensitivity of the immunofluorescence technique proved satisfactory. It was previously reported that fluorescent antigen appeared in the blood as early as 2 DPI (Colgrove, 1968), suggesting that the sensitivity of the FA test might be adequate for detection of incubating cases of ASF. With this background in mind, the current studies were undertaken to test the diagnostic reliability of fluorescent staining of ASF viral antigen in circulating leukocytes.

The method described herein has the advantage of speed and facility in obtaining, preparing and examining samples; time elapsed from collection of blood to examination of preparations may be less than an hour in the case of blood films and only slightly longer when buffy coat smears are used. Alternatively, blood may be stored at refrigerator temperatures for at least 24 hours before slides are prepared and examined, with satisfactory results obtained. The concentration of leukocytes in buffy coat smears enabled rapid detection of fluorescent antigen when the numbers of involved cells were relatively low, and this method was therefore considered preferable to the FA staining of whole-blood films.

Earlier evidence (Heuschele, Coggins and Stone, 1966) and results of this experiment indicate that immunologically related antigens are common to a number of strains of ASF virus. Labeled antibody to the Hinde WH II strain of virus successfully stained four different ASF virus isolates in this experiment, suggesting that a single serum conjugate would have diagnostic application over a wide range of virus strains. In tissue culture experiments, 11 different isolates have been stained by labeled antibody to a single strain of ASF virus.*

* Coggins, L., and Colgrove, G. S. (1967). Unpublished data.

The disadvantages in applying FA staining of leukocytes to the diagnosis of ASF are several. Results obtained herein indicate that the FA test is not sufficiently sensitive to detect incubating or subclinical cases of ASF. Studies on the pathogenesis of ASF virus (Colgrove, Haelterman and Coggins, 1969) have shown that viremia occurs before the onset of fever in infected animals. In the present experiment, viral antigen was demonstrated in the leukocytes of only two of 16 pigs prior to the febrile response, and blood samples of over half the pigs examined did not become immunofluorescence-positive until the second day of fever. In the previously reported study (Colgrove, 1968) in which fluorescent leukocytes were observed at 2 DPI, experimental pigs ranged in age from three days to three weeks. It has subsequently been found (Colgrove, Haelterman and Coggins, 1969) that growth and dissemination of ASF virus occur more rapidly in younger than in older pigs, which would account for the later appearance of immunofluorescence in the blood of pigs used in the present study.

Fluorescent cells were demonstrated for a relatively short time preceding death in the blood of most animals. While viral antigen was detected in stained preparations from one pig for a total of five days, the average time from first appearance of specific fluorescence until death was only three days, giving a rather narrow period of time in which diagnosis could be made.

Finally, recent investigations (Colgrove, Haelterman and Coggins, 1969) have established that the hemadsorption test (Malmquist and Hay, 1960) is more sensitive in the detection of ASF virus than the FA test, particularly in early stages of infection when virus titers are relatively low. In a series of experiments employing both techniques, specific immunofluorescence was not detected in blood and tissues of infected swine until relatively high titers of virus, as determined by 50% hemadsorption endpoints, were present.

Despite these limitations, the technique described herein may be a useful adjunct to other tests for the diagnosis of ASF, especially when numerous animals in a herd can be examined.

SUMMARY

Blood films and buffy coat smears from pigs infected with ASF virus were stained by the direct FA technique and examined for the presence of viral antigen in leukocytes. Time from infection to first appearance of specific fluorescence in circulating leukocytes varied from three to seven days, and immunofluorescence then persisted until death of the animal. The application of this technique to the diagnosis of ASF is discussed.

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Résumé

Des films de sang et tampons de caillots blancs de porc infectés par le virus ASF ont été colorés au moyen de la technique FA directe et examinés pour y découvrir la présence d'antigène viral dans les leucocytes. Le temps qui s'écoulait entre l'infection et la première apparition de la fluorescence spécifique des leucocytes en circulation variait de 3 à 7 jours et l'immunofluorescence continuait alors jusqu'à la mort de la bête. L'application de cette technique au diagnostic ASF est examinée.

THE PROTECTION OF 60 NIGERIAN TRADE CATTLE FROM TRYPANOSOMIASIS USING SAMORIN*

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INTRODUCTION

The use of drugs to protect trade cattle against trypanosomiasis in Nigeria has been a subject of discussion in various publications including Unsworth and Birkett (1952), WAITR Annual Report for 1963 and Jones-Davies (1967). This degree of interest reflects the importance of the trade cattle business in the country. Large numbers of trade cattle (cattle sold for slaughter) from the Northern States of Nigeria and neighbouring territories are trekked along well established trade cattle routes, provided with watering points and night stops, to consumer areas in the Southern States. The routes run roughly from the tsetse free north to the tsetse infested riverine areas and the Eastern and Western States which lie further south.

Roughly 200,000 trade cattle are railed annually from the Northern States to the Southern States and approximately the same number of cattle have to cover the same distances on the hoof. In doing so they travel through extensive *Glossina morsitans* belts interspersed with areas infested with the riverine tsetse flies *G. tachinoides* and *G. palpalis* (see Map 1).

The traditional method of transport on the hoof, although time consuming and apt to become uneconomical with distance (severe body weight loss occurring on treks when fodder and water are in short supply) is likely nevertheless to persist for a long time to come, (Werhahn *et al.* 1964).

Hence the importance of these drug protection trials against trypanosomiasis.

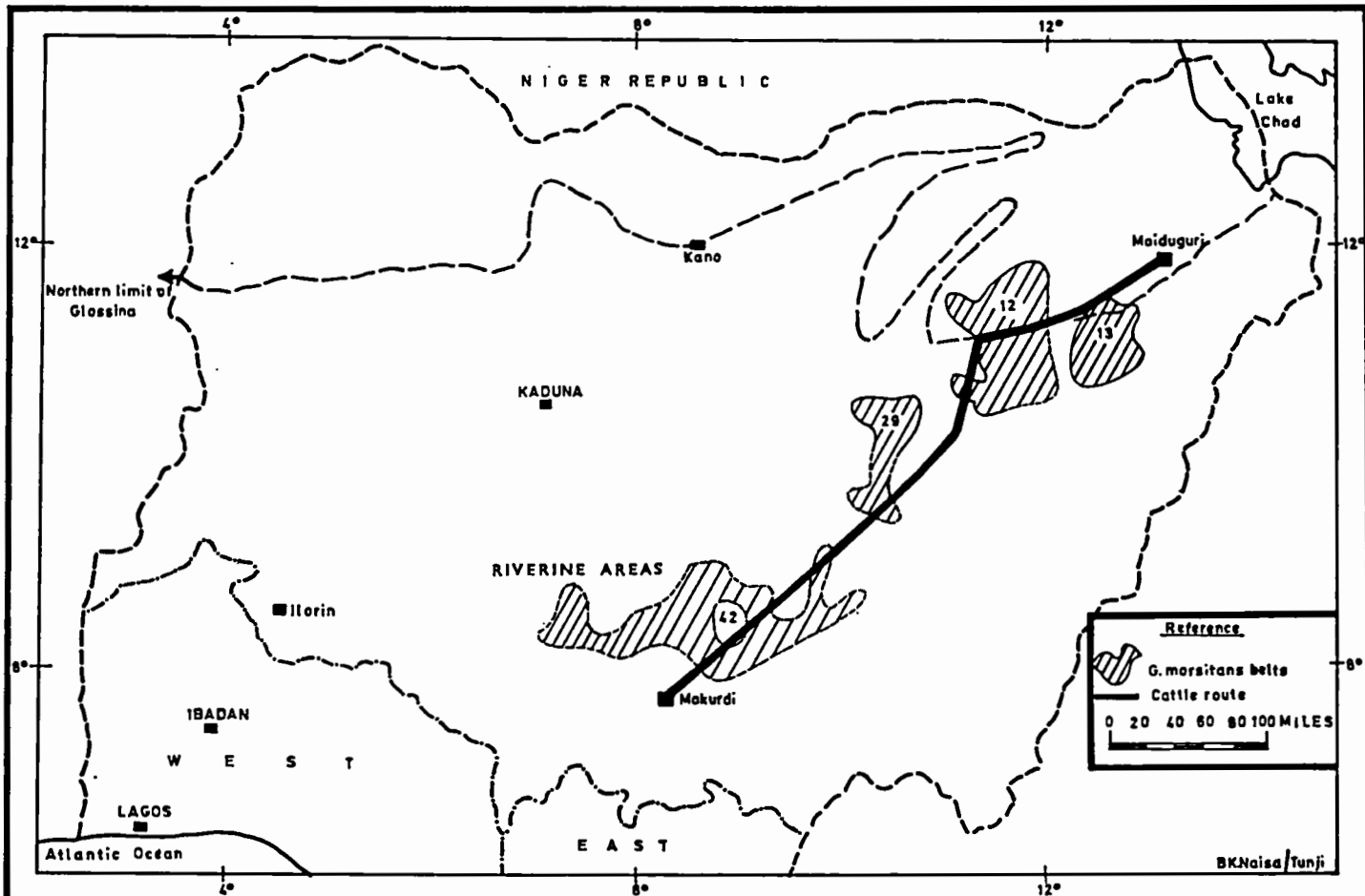
The present experiment was carried out between March-May, 1968 in collaboration with May and Baker Ltd., who supplied Samorin free of charge and who were also kind enough to meet most of the incidental expenses. The aim of the exercise was to determine if Samorin at the two dose rates employed affected the health of 60 mature trade cattle following a trade cattle route 575 miles long. This route, which traverses areas of tsetse infestation, runs from Maiduguri 13° 10' E., 11° 50' N., to Makurdi 8° 32' E., 7° 44' N., via Gombe 11° 07' E., 10° 17' N., and Wase 9° 59' E., 9° 06' N.

MATERIAL AND METHODS

A. The Cattle

Eighty mature trade cattle were provided by cattle traders at Maiduguri, the starting point of the trek. They were divided into three groups.

* Samorin—M. and B. isometamidium chloride.



B. Treatments

All animals were weighed using a "Farmer's Boy"* weighband and ear tagged before the beginning of the trek and weighed again at intervals along the route (see Tables IIIa, IIIb, and IIIc). Faecal samples were also taken and examined before the trek began but only one sample out of the 80 was found to contain helminth eggs (300 strongyle eggs per gram of faeces). In this experiment and for all practical purposes the weighband method of estimating the weight of the animals was considered accurate enough for the purposes of drug administration. Samorin was given once only at the beginning of the trek (see Table I). The drug was freshly prepared at a 1% solution in filtered water and injected intramuscularly into the middle third of the lateral aspect of the neck dorsal to the vertebrae on one or both sides, depending on the volume to be injected. Duplicate thick and thin blood smears were taken on the day of weighing and ear tagging before treatment and also at intervals of three to four days along the route. They were stained by Giemsa according to the method of MacLennan (1957). Post-mortem examinations were carried out by the staff of Veterinary Tsetse Division, who accompanied the cattle—and the findings recorded.

C. The Trek

The route from Maiduguri to Makurdi, a distance of 575 miles traversed three *Glossina morsitans* belts namely Belts 12, 29 and 42, separated by a predominantly *G. tachinoides* infestation (Map 1). The route has a limited number of watering points and night stops and trade cattle are checked at control posts established at intervals along the route. The cattle were accompanied by four drovers employed by the cattle traders and by two laboratory technicians and three labourers of the Tsetse Division. The herd averaged 22.7 miles per day from Maiduguri–Gombe, 21.1 miles per day from Gombe–Wase and 16.1 miles per day from Wase–Makurdi. The average distance covered per day for the whole journey (Maiduguri–Makurdi) was 20.5 miles. Although the trek occupied 31 days the actual number of days spent on travelling was 28. The Samorin treatment was administered on 27 March 1968 and the journey commenced on 2 April 1968 and ended on 3 May 1968.

D. The Tsetse Risk

Records were kept of all the tsetse flies seen along the route and although no riverine tsetse were recorded, it is known from records of surveys that as from the third day of the trek the herd entered an area of *G. tachinoides* infestation.

On the eighteenth day of the trek the cattle received a heavy challenge from *G. morsitans* for a distance of 15 miles while they were travelling along the edge of Yankari Game Reserve (Belt 29) and although no more flies were seen thereafter, it is known from available records that from the twenty-fifth day of the trek up to the end the cattle were in an area of *G. morsitans* infestation. The flies encountered on the eighteenth day of the trek were caught by means of a net either by Field Assistants using themselves as bait or by trapping flies directly off the trade cattle.

Results

A. The fate of the animals

1. Reaction to drug

Local reactions to Samorin were observed in 34 out of the 60 cattle treated.

* Farmer's Boy weighband—Dalton Supplies Ltd., Oxon., U.K.

Table I

Group	No. of Cattle	Treatment	No. infected with trypanosomes and species of tryps.	Average period between treatment date and appearance of tryps. in blood. Range in days	Number arrived at Makurdi	Number and causes of death or selling		Number lame en route and fate
						Died	Sold	
1	20	CONTROLS	11 6 <i>T. congolense</i> 5 <i>T. vivax</i>	8.6 days (8-19) 33.8 days (33-36)	8	11 died 4 showed trypanosomes in bloodsmears. 7 did not and died from <i>samberu</i> ?	1 It showed tryps. in bloodsmears	None was lame en route or had to be sold because of lameness.
2	30	SAMORIN 0.25 mg./kg.	5 2 <i>T. vivax</i> 3 <i>T. congolense</i>	0 (infected before treatment) 8 days	10	0 on the way, one of which showed tryps. in bloodsmears 1 died at Makurdi Total death = 7 0 died from <i>samberu</i> ?	8 very weak from <i>samberu</i>	None was lame en route or had to be sold because of lameness.
3	30	SAMORIN 0.5 mg./kg.	1 <i>T. congolense</i>	8 days	14	10 1 showed Anaplasma the rest died from <i>samberu</i> ?	0 1 showed trypanosomes in blood	2 (No. 04 and 240). No. 04 died from <i>samberu</i> poisoning. No. 240 was sold on point of death from <i>samberu</i> poisoning also.

N.B.—Average period between treatment and parasitaemia is given and *not* the prepatent period (i.e. period between the date of infection and date of parasitaemia) because the actual date of infection is not known.

The first reactions were observed in four animals, eight days after treatment. Of 34 cattle that showed these reactions, 10 were still showing them at the end of the trek (see Table II). The reactions were not serious. They appeared at autopsy as slight muscle fibrosis in some of the animals and as gelatinous fluid infiltration of muscle fibres with fibrosis in others. Externally they took the form of flat swellings usually less than four inches across.

2. The appearance of trypanosomes

Group I

Controls—20 animals

Eleven out of the 20 animals used as control became infected with trypanosomes as recorded in Table I. Of the eight animals that reached Makurdi, five showed

**Table II.—Animals that had their site of injection swollen
Group II 0.25 mg./kg. Samorin**

Animal No.	Date First Observed	Duration
97	4.4.68	up to 30.4.68 when animal was sold
10	5.4.68	up to Makurdi when it died on 5.5.68
198	4.4.68	up to time of sale on 2.5.68
13	5.4.68	disappeared by 24.4.68
19	5.4.68	up to time of death on 21.4.68
72	5.4.68	up to time of sale on 29.4.68
79	5.4.68	disappeared by 24.4.68
237	5.4.68	disappeared by 24.4.68
238	5.4.68	up to time of sale on 30.4.68
241	5.4.68	up to time of death on 2.5.68
5	22.4.68	up to time of sale on 24.4.68
77	22.4.68	up to time of sale on 27.4.68
232	22.4.68	disappeared by 3.5.68
96	22.4.68	up to Makurdi sold on 6.5.68
247	15.4.68	up to time of sale at Makurdi on 6.5.68
88	15.4.68	up to time of sale at Makurdi on 6.5.68
248	15.4.68	up to time of sale at Makurdi on 6.5.68

Group III 0.5 mg./kg. Samorin

Animal No.	Date First Observed	Duration
24	4.4.68	disappeared by 24.4.68
94	4.4.68	up to time of death on 26.4.68
2	5.4.68	disappeared by 24.4.68
17	5.4.68	up to time of sale at Makurdi on 6.5.68
16	5.4.68	up to time of sale on 26.4.68
73	5.4.68	up to time of sale at Makurdi on 6.5.68
92	5.4.68	up to time of death on 25.4.68
799	5.4.68	up to time of death on 2.5.68
243	5.4.68	up to time of death on 26.5.68
240	11.4.68	up to time of death on 30.4.68
21	22.4.68	up to time of sale on 1.5.68
246	22.4.68	disappeared before 3.5.68
99	22.4.68	up to time of sale on 26.4.68
90	22.4.68	disappeared by 3.5.68
9	15.4.68	up to time of sale at Makurdi 6.4.68
235	15.4.68	up to time of sale at Makurdi 6.4.68
200	15.4.68	up to time of sale at Makurdi 6.4.68

N.B.—All the cattle were treated on 27.3.68.

Table IIIb.—Group on 0.25 mg./kg.

Animal No.	Weight at Maiduguri	Weight at Gombe	Weight at Wase	Weight at Makurdi	Tryps. species and date bloodsmears taken	Fate of the Animal	Remarks
1	573 lb.	564 lb.	571 lb.	Sold on the way (570 lb.)	Nil	Sold on the way	—
5	628 „	639 „	609 „	Sold on way (600 lb.)	Nil	Sold on way—very weak	—
8	489 „	489 „	489 „	Died on way (480 lb.)	Nil	Died—swollen stomach	—
10	538 „	547 „	556 „	Died Matakurdi (547 lb.)	Nil	Died—Control Post Makurdi	Gained 9 lb.
13	437 „	419 „	428 „	445 lb.	Nil	Sold—Makurdi	Gained 8 lb.
15	507 „	498 „	Died at Wase (490 lb.)	—	Nil	Died— <i>samberu</i>	—
19	582 „	573 „	Died on way (500 lb.)	—	Nil	Died— <i>samberu</i>	—
20	498 „	498 „	481 lb.	Sold on way (498 lb.)	Nil	Sold on way—very weak	—
23	628 „	639 „	628 „	650 lb.	T.V. 20.3.68	Sold at Makurdi	Gained 22 lb.
71	556 „	573 „	564 „	582 „	Nil	Sold—Makurdi	Gained 26 lb.
72	547 „	564 „	564 „	Sold on way (556 lb.)	Nil	Sold—unable to walk	—
77	573 „	481 „	507 „	Sold on way (481 lb.)	T.C. 4.4.68	Sold—unable to walk	—
79	639 „	639 „	639 „	650 lb.	T.C. 4.4.68	Sold at Makurdi	Gained 11 lb.
82	575 „	591 „	591 „	600 „	Nil	Sold at Makurdi	Gained 25 lb.
83	717 „	703 „	717 „	730 „	Nil	Sold at Makurdi	Gained 13 lb.
88	631 „	628 „	639 „	639 „	Nil	Sold—Makurdi	Gained 8 lb.
89	664 „	677 „	Died on the way (600 lb.)	—	Nil	Died	—
93	547 „	538 „	538 lb.	564 „	Nil	Sold—Makurdi	Gained 17 lb.
96	591 „	591 „	600 „	609 „	Nil	Sold—Makurdi	Gained 18 lb.
97	564 „	564 „	582 „	Sold on way (569 lb.)	Nil	Sold on way—very weak	—
106	507 „	528 „	518 „	500 lb.	Nil	Sold—Makurdi	Lost 7 lb.
108	564 „	564 „	564 „	Sold on way (564 lb.)	Nil	Sold—cannot walk	—
232	507 „	518 „	529 „	529 lb.	Nil	Sold—Makurdi	Gained 22 lb.
233	609 „	617 „	628 „	609 „	Nil	Sold—Makurdi	The same
237	617 „	639 „	628 „	628 „	Nil	Sold—Makurdi	Gained 11 lb.
238	437 „	437 „	437 „	Sold on way (430 lb.)	Nil	Sold—weak	—
241	703 „	703 „	717 „	Died on way (700 lb.)	T.V. 20.3.68	Died	—
242	556 „	566 „	Died on way (550 lb.)	—	Nil	Died	—
247	617 „	600 „	609 lb.	628 lb.	Nil	Sold—Makurdi	Gained 11 lb.
248	573 „	556 „	547 „	600 „	T.C. 4.4.68	Sold—Makurdi	Gained 27 lb.

patent *T. vivax* trypanosomiasis on arrival (Nos. 18, 95, 76, 245 and 250). The periods that elapsed before infections became patent are shown in Table I. Animal No. 22 had *T. congolense* infection which persisted for 23 days out of the 31 days taken to complete the trek. Thereafter smears taken from it were

Table IIIc.—Group on 0.5 mg./kg.

Animal No.	Weight at Maiduguri	Weight at Gombe	Weight at Wase	Weight at Makurdi	Tryps. species and date bloodsmears taken	Fate of the Animal	Remarks
2	538 lb.	538 lb.	547 lb.	556 lb.	Nil	Sold—Makurdi	Gained 18 lb.
4	582 „	582 „	582 „	600 „	Nil	Sold—Makurdi	Gained 18 lb.
9	504 „	528 „	529 „	556 „	Nil	Sold—Makurdi	Lost 8 lb.
11	538 „	529 „	538 „	556 „	Nil	Sold—Makurdi	Gained 18 lb.
249	489 „	408 „	454 „	400 „	Nil	Died on the way	—
14	573 „	582 „	582 „	Died on the way (580 lb.)	Nil	Died— <i>samberu</i>	—
16	556 „	556 „	547 „	Sold on way (540 lb.)	Nil	Sold due to <i>samberu</i>	—
17	600 „	582 „	591 „	628 lb.	Nil	Sold—Makurdi	Gained 28 lb.
21	582 „	582 „	591 „	Sold on way (582 lb.)	Nil	Sold—very weak	—
24	498 „	507 „	518 „	518 lb.	Nil	Sold—Makurdi	Gained 20 lb.
25	609 „	609 „	600 „	Died on way (600 lb.)	Nil	Died—swollen stomach	—
73	498 „	518 „	547 „	529 lb.	Nil	Sold—Makurdi	Gained 31 lb.
78	628 „	617 „	617 „	Died on way (600 lb.)	Nil	Died <i>samberu</i>	—
81	600 „	609 „	582 „	617 lb.	Nil	Sold—Makurdi	Gained 17 lb.
85	628 „	604 „	Died on way (600 lb.)	—	Nil	Died	—
86	617 „	628 „	639 lb.	Sold on way (630 lb.)	Nil	Sold—very weak	—
90	628 „	628 „	640 „	650 lb.	Nil	Sold—Makurdi	Gained 22 lb.
92	529 „	538 „	547 „	Died on way (529 lb.)	Nil	Died	—
94	628 „	617 „	650 „	Died on way (650 lb.)	Nil	Died	—
98	529 „	538 „	547 „	547 lb.	Nil	Sold—Makurdi	Gained 18 lb.
99	591 „	582 „	582 „	Sold on way (589 lb.)	T.C. 4.4.08	Sold—weak	—
197	507 „	498 „	509 „	529 lb.	Nil	Sold—Makurdi	Gained 18 lb.
799	564 „	564 „	573 „	Died (550 lb.)	Nil	Died	—
200	609 „	591 „	504 „	617 lb.	Nil	Sold—Makurdi	Gained 8 lb.
235	507 „	518 „	529 „	538 „	Nil	Sold—Makurdi	Gained 31 lb.
236	677 „	664 „	677 „	Sold on way (617 lb.)	Nil	Sold on way—very weak	—
240	650 „	664 „	677 „	Sold on way (664 lb.)	Nil	Sold on way—very weak	—
243	463 „	454 „	463 „	Died on way (460 lb.)	Nil	Died	—
244	690 „	677 „	690 „	Died on way (690 lb.)	Nil	Died	—
246	591 „	591 „	600 „	609 lb.	Nil	Sold—Makurdi	Gained 18 lb.

average weights of the groups from Maiduguri to Makurdi during the trek among those animals that survived the journey, was observed only in the control group and amounted to 1.6%. Groups on 0.25 and 0.5 mg./kg. Samorin showed increase of 2.4 and 3.4% respectively.

4. Cause of death

Group I (Controls)

Eleven animals died out of the 20 used. One was sold on the way in extremis. The animal sold en route together with four out of the 11 that died showed trypanosomes in blood smears from time to time and could have died from trypanosomiasis alone or from a combined effect of trypanosomiasis and *samberu* plant poisoning. The other seven did not show any blood parasite in blood smears taken up to the time of death and it is concluded that they died from plant poisoning alone (Table IIIa).

Group II Samorin 0.25 mg./kg.

Six animals died and eight more had to be sold on the way, as they were at the point of death. Of six animals that died only one (No. 241) showed trypanosomes in its blood smear. The other five and the eight that were sold on the point of death must have eaten the poisonous plant *samberu* which they came across mostly between Wase and Makurdi (Table IIIb). Animal No. 10 died at Makurdi but it completed the journey. Total number of deaths is thus seven.

Group III 0.5 mg./kg. Samorin

Ten animals out of the 30 used in this group died and six more had to be sold on the way. Of the 10 animals that died none showed trypanosomes in blood smears during the journey. One animal (No. 244) showed anaplasma in its blood smear three days before it died and could have died from anaplasmosis. Of the six animals that had to be sold No. 99 showed trypanosomes in blood on a single occasion only. (4 April 1968). The other nine and five animals that died and had to be sold respectively are assumed to have eaten the poisonous plant.

It was not known that mortality from *samberu* poisoning on this particular trek route occurred before the experiment was started. Later, after the trouble had started and other trade cattle following the same route were also dying, it was learnt from the villagers that *samberu* poisoning was an established occurrence especially on that part of the route between Wase and Makurdi. The usual way to protect the cattle is to burn the plant every two years but it was learnt that this had not been done though it had been overdue.

DISCUSSION

Although the poisonous plant *samberu* has limited the scope of what could have been achieved, it was possible in some degree to determine whether Samorin at the two doses employed, influenced the health of the cattle treated with it, and subsequently trekked for a distance of 575 miles under adverse conditions. Of the 30 animals that reached the destination (out of the 60 that set forth), 28 had gained weight at the time of arrival whilst in the control or untreated group, four out of the eight that survived the journey had lost weight on arrival and five of the eight had patent trypanosomiasis on arrival (Table IIIc).

Nine *T. congolense* and three *T. vivax* infections had become apparent by the eighth day after treatment, one *T. vivax* and four *T. congolense* of these being in the control group. These infections, it is felt, could not have resulted from any tsetse risk encountered after the treatment date and the explanations for most of these infections, which were of a fleeting nature in the treated groups, are not apparent. It is known, however, that four animals (Nos. 3, 23, 241 and 22) were infected before treatment, this having been established by blood smears taken the day before. It may be that the others were also infected but were at the prepatent stage, the stress of the trek causing their appearance later. If this was so then these trypanosomes that appeared by the eighth day after treatment (two days after commencement of the trek) and which were all *T. congolense* must either have had certain degree of resistance to Samorin or were strains which succeeded in establishing and maintaining parasitaemia in cattle which would otherwise prove unreceptive, having previously been treated with some chemotherapeutic substance.

The fact that 30 out of the 60 protected cattle either died or had to be sold on the way could not be attributed exclusively to trypanosomiasis, since, though some of them were infected (one from 0.5 mg./kg. group and three from 0.25 mg./kg. group) they stopped showing trypanosomes in subsequent blood smears long before they died. The immediate cause of death of these animals from the protected groups and some from the control group was in all probability the ingestion of *samberu* which they came across during the trek. The symptoms exhibited by the cattle that ate it were dyspnoea, distended stomach, salivation, running nose and sunken eyes in the case of the acute form followed by death within minutes of the animal going down. In the sub-acute form blood-stained watery diarrhoea was observed and the affected animal sometimes recovered.

In his paper on Samorin protection of immature trade cattle Jones-Davies (1967) found that he obtained better results with Samorin at 0.5 mg./kg. than at 0.25 mg./kg. But in that experiment the cattle were kept for a further 57 days after reaching their destination and it would be expected that the higher dose would give a longer protection. This proved to be so since four of the five animals so treated survived the experiment, whereas, though all beasts treated at 0.25 mg./kg. arrived at the destination, only one survived the experiment. Under normal circumstances however, trade cattle would not be held for so long after arrival, before slaughter. It is felt therefore, that Samorin, at 0.25 mg./kg. would give enough protection against trypanosomiasis to enable trade cattle to reach their destination and remain there for up to seven days before slaughter—a delay not likely to be exceeded in practice.

In the present experiment 16 out of the 30 animals treated at 0.25 mg./kg. arrived at the destination (15 of them having put on weight before arrival) whilst 14 out of 30 animals treated with Samorin at 0.5 mg./kg. reached the destination (13 of them having gained weight also).

Thus comparable results were achieved and in the absence of any additional advantage attaching to use of the higher dosage, economic considerations would suggest the selection of the lower.

SUMMARY

Eighty mature cattle were trekked along a very difficult trade cattle route from Maiduguri-Makurdi (a distance of 575 miles) in 28 days. They were divided into three groups of 30, 30 and 20 cattle each. The group with 20 cattle was used as control while the other two groups of 30 cattle were treated with Samorin at

0.25 mg./kg. and 0.5 mg./kg. respectively, administered intramuscularly in the lateral aspect of the neck.

Heavy casualties occurred and these were attributed to various causes including trypanosomiasis (in untreated cattle) plant poisoning, anaplasmosis and general privation. It proved necessary to salvage, en route, several animals which deteriorated to the point of prostration.

It is concluded that as far as trade cattle are concerned, (i.e. cattle sold for slaughter—which are usually killed shortly after reaching their destination) Samorin at 0.25 mg./kg. body weight is just as effective, in preventing trypanosomiasis and maintaining weight gain, as Samorin at 0.5 mg./kg.

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Résumé

Quatre-vingts têtes de bétail adultes suivirent une route d'acheminement du bétail très pénible de Maiduguri à Makurdi (distance de 925 km.) en 28 jours. Les bestiaux étaient divisés en trois groupes de 30, 30 et 20 têtes chacun. Le groupe comportant 20 têtes servait de témoin, tandis que les deux autres groupes de 30 têtes furent traités au Samorin à 0,25 mg./kg. et 0,5 mg./kg. respectivement. L'injection se faisait intramusculairement sur le côté du cou.

Il y a eu de très fortes pertes, qui étaient attribuées à diverses causes, y compris la trypanosomiase (chez le bétail non-soigné) l'empoisonnement par des plantes, l'anaplasmosse et les carences générales. Il fut nécessaire de récupérer en cours de route plusieurs bêtes qui s'étaient détériorées au point de s'abattre.

L'on conclut qu'en ce qui concerne le bétail commercial (c'est-à-dire les bêtes vendues pour l'abattoir, qui sont généralement tuées peu de temps après l'arrivée à destination) le Samorin à 0,25 mg./kg. de poids vif et tout aussi efficace pour empêcher la trypanosomiase et maintenir l'augmentation de poids que le Samorin à 0,5 mg./kg.

VARIATIONS IN TICK SPECIES AND POPULATIONS IN THE BUGISU DISTRICT OF UGANDA

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PART I

The tick survey

INTRODUCTION

General

Since the work of Dr. S. G. Wilson in 1953, very little has been done in the way of field investigation and research on tick numbers and species prevalent in the Bugisu district of Uganda.

Verbal statements have been made from time to time by local members of Veterinary Department staff concerning the presence or absence of certain ticks at particular altitudes or places at different times of the year, but it has not been possible to find information to substantiate these statements. As a result it was decided to try to get some idea of the true picture, taking into consideration the effects of altitude on tick populations as well as other factors such as rainfall, humidity, vegetation, temperature and methods of husbandry.

The slopes of Mount Elgon have a wide range of conditions within a relatively small area and Bugisu district therefore lends itself to this type of investigation.

Other reasons for undertaking this study were:

- (a) The introduction of European livestock into the area.
- (b) The organisation of cattle upgrading schemes.
- (c) The beginning of tick eradication schemes in the area.
- (d) The attempted extension of tick control schemes.

For all these livestock projects, there was a need for more tick population data.

Lewis (1939) was one of the first workers to undertake a detailed study of tick populations and ecology in East Africa. Later work was done by Wilson (1953) and more recently by Yeoman (1964), and Yeoman and Walker (1967) and Hampshire (1956) in Tanzania.

Wilson (1953) in his "Survey of the distribution of tick vectors of East Coast Fever in East and Central Africa" suggested that the *Rhipicephalus appendiculatus*/*Amblyomma variegatum* association of ticks is prevalent in Uganda, and that this in turn appears to be related to a minimum annual rainfall of 30 inches. Bugisu certainly fulfils this condition since, in all areas, rainfall exceeds 30 inches.

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It appeared from a superficial examination of a number of cattle that Wilson's contention was correct, but it was obvious that information concerning relative numbers and also other species of ticks present, would not be obtainable except by carrying out complete collections from a number of animals, at various altitudes and at different times of the year.

Bugisu District: A description of the area

Bugisu, Uganda, is situated on the western slopes of Mount Elgon in the Eastern Region (see Fig. 1). In relation to other parts of Uganda, Bugisu district is very heavily populated with more than 700 people per square mile in some parts.

In the past, the area was largely forest but below 6,500 ft. it is now heavily cultivated, mostly with permanent crops of bananas and coffee. (Below 4,000 ft. the main cash crop is cotton.) Maize, millet and sorghum, together with ground-nuts, beans, sweet potatoes, English potatoes, cassava and green vegetables are also grown in many places at various altitudes.

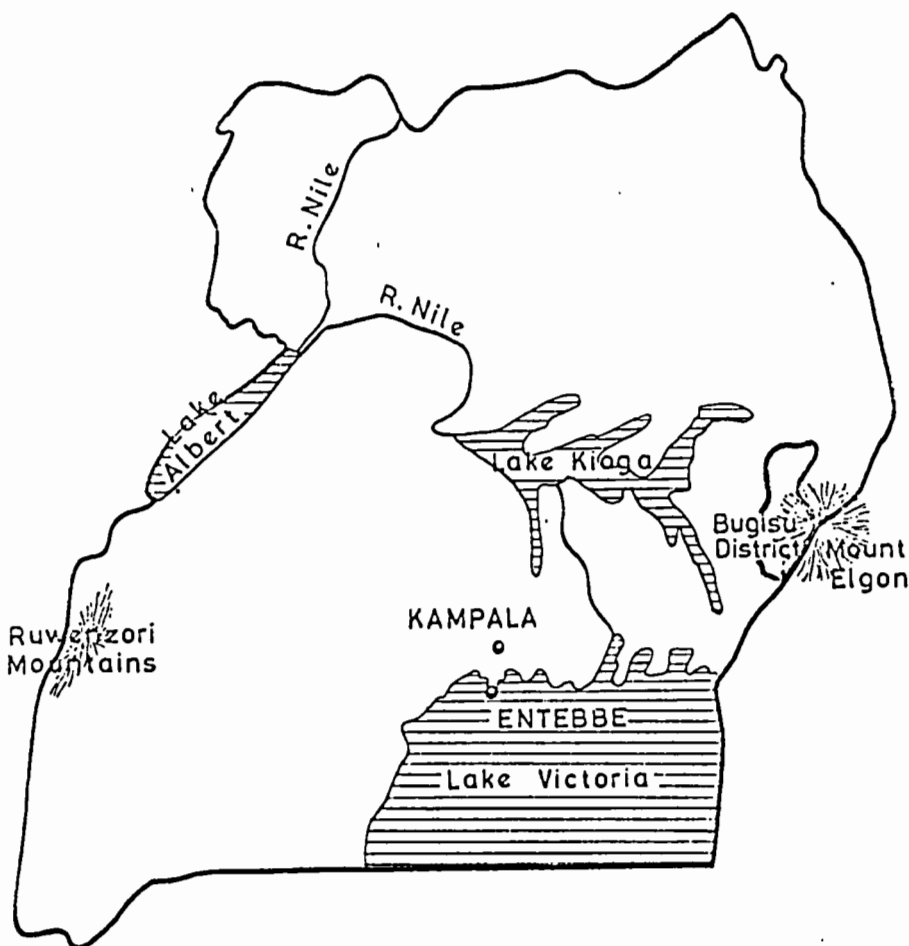


FIG. 1.—Outline map of Uganda showing Bugisu district.

Bugisu lies at altitudes between about 3,600 ft. and 14,000 ft. (the top of Mount Elgon) but there are few human settlements over about 6,000 ft. Rainfall in all parts exceeds 40 inches and can rise as high as 80 inches (over 2,000 mm.) at the higher altitudes, depending on the time of year. Relative humidity is also high and rarely falls below 75%. Temperature never falls below 15°C. and can exceed 32°C. at the upper limits. Climatic factors will be dealt with in greater detail in a subsequent paper.

Despite heavy population and close cultivation in most areas, stock populations are also high. The stocking rate is approximately one acre per livestock unit.*

There are two main systems of management:

- (a) Free grazing with herdsmen on the extensive pastures and swamps of the plains areas.
- (b) Tethering of stock on the small patches of grass still left in the hill areas. Supplementary feeding (mainly with split banana stems and banana leaves) is also practised widely in the hills where grazing is restricted.

These systems are gradually being changed by the increase in land enclosure, and the desire for tick eradication is encouraging the spread of land enclosure.

MATERIALS AND METHODS

General

Complete collections of ticks were made from cattle at three different altitudes in North, Central and South Bugisu. These collections were made at intervals over a complete seasonal cycle, i.e. wet season to wet season.

The altitudes selected were 3,600 ft., which is about the lowest altitude in the district, 4,500 ft., an approximately medial altitude in the area under investigation and 5,000–6,000 ft., which is just below the upper limit of human (and cattle) habitation on the mountain. This upper limit also approximates to the lower limit of the Mount Elgon forest reserve.

For reasons which will be explained later, collections were made from three cattle at each site (with the exception of Bugema, where only two cattle were used). Three sites were selected at each altitude. This gave a total of nine cattle at each altitude, with the exception of the 3,600 ft. level where only eight were dealt with at each collection. Tick collections began in May 1964 (first rains 1964) and were repeated in June/July 1964 (mid-year drier period), September/October 1964 (second rains), December 1964/January 1965 (dry season proper) and April/May 1965 (first rains 1965).

Choice of Collecting Sites (see Fig. 2)

An altimeter was not available and it was therefore necessary to select sites near clearly marked places on the newest Uganda Survey Maps, in such a way that the sites could be related to a particular contour line at a known altitude. Other factors also had to be considered such as:

- (a) The availability of cattle owned by farmers prepared to co-operate.
- (b) That since a number of collections were to be taken from the same cattle, the sites had to be near all-weather roads in order to enable collections to be made at any time.

* A livestock unit may be considered as equivalent to 1 adult bovine, 2 calves or 4 sheep or goats.

- (c) Sites had to be as near as possible to a rainfall recording point at the same altitude.
- (d) Tick collecting sites had to be in areas not involved in any tick control programme.

Choice of Animals and Methods of Tick Collection

Since it was intended to make complete collections from the same animals, it was necessary to make sure that the animals selected could be identified at the subsequent collections, and it was decided to mark the cattle used, either with a

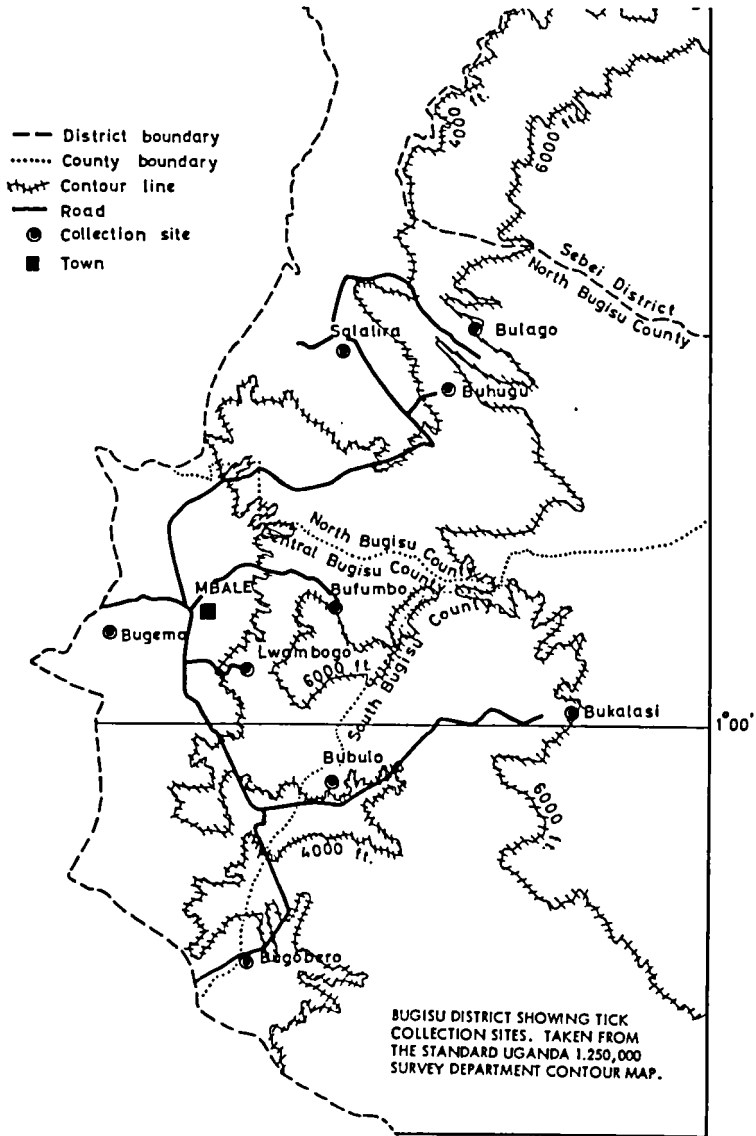


FIG. 2.

brand or a tattoo, or ear clip. This idea had to be abandoned because of opposition from the owners. Thus it was necessary to select cattle with some natural colour mark or feature which could be quickly spotted at a subsequent visit. Preference was given to animals which had not been recently introduced into the herd or which were not due to be sold or given away for dowry purposes.

Collections were made only from adult animals because of the possibility that variations in husbandry within the calf population might affect tick infestations on calves. Old animals were avoided also because of the possibility that they might be more resistant to tick infestation.

Where animals used were changed for any reason between collections, every attempt was made to select other animals of similar weight, size and if possible sex and colour. All animals used were given serial or code numbers for record purposes. To make sure that the actual collection of ticks was thoroughly done, all animals were cast with ropes and held securely by two men (usually the farmer himself and a relative). The animal's body was then searched for ticks following a definite pattern of sections, each section being dealt with in the same order at each collection.

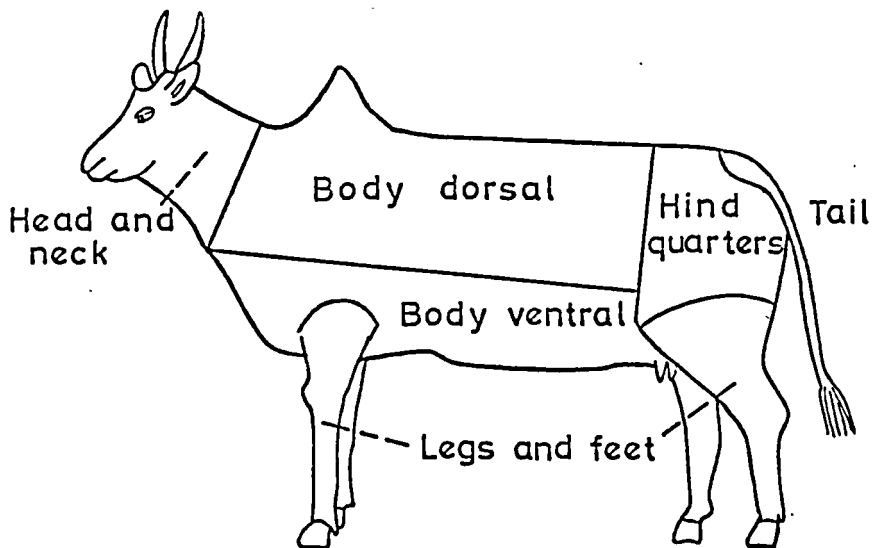


FIG. 3.—Outline drawing showing arbitrary subdivisions of the body for tick collection purposes.

After completing collections on one side, the animal was carefully turned over to make collections from its other side.

Tick collection days had to be carefully selected to make sure that both animals and soil were reasonably dry. Otherwise animals cast under muddy conditions became filthy on one side, thus preventing complete tick collections from being taken. Ticks were picked off with small dressing forceps to avoid damage. All ticks were killed by placing them in collecting bottles partially filled in advance with Boardman's solution (97 parts 20% alcohol and 3 parts ether). This caused the ticks to die with their legs outstretched, thus making later examination of the ventral surfaces easier. Ticks collected in this manner heavily contaminated the killing fluid with blood, serum, dirt and hair, so that at the end of the day's collection, all fluid in the bottles was changed several times using 70% alcohol.

It was originally intended to make collections from at least eight animals at each site, but three was the practicable maximum. In most cases collections had to cease before midday, when heavy rain normally prevented further collections that day. Also, owners (who in any case were unco-operative, suspicious and frightened by the whole operation) tended to become increasingly unco-operative and, in some instances, hostile as they became tired from holding down cattle.

The attacks of biting flies (usually *Stomoxys* and *tabanid* species) also made the work very difficult and by the time the third animal had been dealt with both cattle and owners were becoming rather fractious. At one site, Bugema in Central Bugisu, cattle owners refused assistance with more than two cattle and it was not possible to spend more than one day at a time collecting at any one site.

RECORDS

Initial tick collection figures were recorded on specially prepared sheets showing the parts of the body from which ticks were collected (Table I). Only a sample table is recorded here as the full records total over 100 pages. Collection figures were subsequently condensed onto tick data abstract sheets (Table II). In this way it was possible to put average figures for one site (but for all collections) on one sheet of paper.

Identification of Material

Specimens of all ticks likely to be met within the area under investigation were supplied by Miss Jane Walker (at that time working at the East African Veterinary Research Organisation Laboratories in Muguga, Kenya). These ticks were used as reference specimens, in conjunction with this workers published papers (Walker 1959, 1962).

All tick specimens were identified with a low power Zeiss stereoscopic dissecting microscope. As far as possible ticks were examined in batches on a culture plate with a clear white background.

RESULTS

Species of ticks found

The species found on cattle were:

- Amblyomma variegatum* Fabricius 1794
- Boophilus decoloratus* (Koch 1844)
- Rhipicephalus appendiculatus* Neumann 1901
- Rhipicephalus evertsi evertsi* Neumann 1897
- Rhipicephalus simus simus* Koch 1844
- Rhipicephalus tricuspis* Donitz 1906

Descriptions of all the tick species found have been published in the book *African Ixodoidea*, Volume I: "Ticks of the Sudan" by H. Hoogstraal. Original collection record sheets are available, at the Sub-department of Veterinary Parasitology, Liverpool School of Tropical Medicine.

Predilection Sites of Attachment:

The original tick collection record sheets demonstrated the predilection sites for each species of tick found (Table I) as follows:

Sample Sheet of Original Collection Figures

Table I

COLLECTION No. I

DISTRICT : Bugisu		COUNTY : Central Bugisu		ALTITUDE : 3,600 ft.	PLACE NAME : Bugema		DATE : 16.5.64
Number and Description of Animal	Head	Body Dorsal	Body Ventral	Hind Quarters	Legs and Feet	Tail	Species Totals
No. 3 Young black and white bull	<i>Rhipicephalus appendiculatus</i> MM . 89 FF . 41 NN . 17 L . 1 <i>Amblyomma</i> spp. probably <i>variegatum</i> NN . 2 LL . 2 <i>Boophilus decoloratus</i> NN . 2 Unidentified (crushed or broken) MM . 2 F . 1 L . 1	<i>Rhipicephalus appendiculatus</i> M . . 1 Unidentified crushed N . . 1	<i>Rhipicephalus appendiculatus</i> MM . 3 FF . 3 NN . 15 LL . 0 <i>Amblyomma variegatum</i> MM . 63 FF . 6 <i>Amblyomma</i> sp. probably <i>variegatum</i> NN . 2 LL . 2 <i>Boophilus decoloratus</i> F . . 1 N . . 1 MM . 2 Unidentified (crushed) NN . 3 LL . 5	<i>Rhipicephalus appendiculatus</i> N . . 1 <i>Rhipicephalus evertsi</i> M . . 1 <i>Amblyomma variegatum</i> MM . 4 <i>Amblyomma</i> spp. probably <i>variegatum</i> LL . . 4 <i>Boophilus decoloratus</i> F . . 1	<i>Rhipicephalus appendiculatus</i> F . . 1 N . . 1 <i>Rhipicephalus simus</i> M . . 1 <i>Amblyomma variegatum</i> MM . 4 FF . 3 <i>Amblyomma</i> spp. probably <i>variegatum</i> LL . . 2	<i>Rhipicephalus appendiculatus</i> MM . 3 F . . 1 N . . 1 <i>Rhipicephalus evertsi</i> M . . 1 <i>Rhipicephalus tricuspis</i> M . . 1 F . . 1	<i>Rhipicephalus appendiculatus</i> MM . 96 FF . 46 NN . 35 LL . 7 — 184 <i>Amblyomma variegatum</i> MM . 71 FF . 9 — 80 <i>Amblyomma</i> sp. probably <i>variegatum</i> MM . 4 LL . 10 — 14 <i>Rhipicephalus evertsi</i> MM . 2 <i>Rhipicephalus tricuspis</i> M . . 1 F . . 1 — 2 <i>Boophilus decoloratus</i> MM . 2 FF . 2 NN . 3 — 7 <i>Rhipicephalus simus</i> M . . 1 Unidentified (crushed) MM . 2 FF . 2 NN . 4 LL . 6 — 13
Totals	158	2	112	11	12	8	Total No. of ticks 303

A. variegatum

This species occurred mainly on the brisket, axilla, abdomen, udder (or scrotum) and inguinal region. Immature stages were found on the same sites and also on the dewlap, legs and feet. In the present state of knowledge, it is not possible to differentiate the species of the immature forms of the genus *Amblyomma*. However, since all the adult *Amblyomma* ticks found on cattle during this survey were *A. variegatum*, it was considered reasonable to assume that the immature stages found were also *A. variegatum*. For this reason, immature forms in the original collection sheets (see Table I), were labelled "*Amblyomma* species, probably *variegatum*" whilst in the abstract sheets they were placed under "*A. variegatum*" without further qualification.

B. decoloratus

Here the main predilection sites were the dewlap and brisket, with a few others scattered over the abdomen. Isolated adults were found on the flanks, hindquarters and back. Nymphs were most common on the abdomen, but were also found on the ear flap, the latter also being the usual site for larvae.

R. appendiculatus

This was the most commonly found species and occurred mainly on the head and neck, especially along the fringes of the ears, the eyelids and sometimes the base of the horns. Some ticks were also found on other parts of the body, such as the flanks, genitalia and tail, but the occurrence and numbers of these depended on the degree of crowding of the ticks inside and outside the ear flaps and other parts of the head. Immature stages were found on the ears and face and also on the neck and dewlap.

R. evertsi

This tick was found only in very small numbers, and when present, was restricted largely to the area underneath the root of the tail, especially around the anus and between the caudal folds. At many collections the tick was absent. Immature forms were not found.

R. simus

Only one example of this species was found. The specimen was a male, found on the lower leg of an animal at Bugema in Central Bugisu. Immature stages of the tick were not found on cattle.

R. tricuspis

This species of tick was again found only in very small numbers and when present was always on the tail, especially the tail brush. Ticks were often found singly or sometimes in pairs of male and female together. Immature stages were not found on cattle.

Tick Populations (General)

Of the ticks collected, 73% were *R. appendiculatus*, 21% were *A. variegatum* and just over 1% were *B. decoloratus*. 4.4% of all ticks examined were not completely identified, due to being crushed or broken when examined. Of this 4.4% approximately two-thirds were nymphs and larvae.

Table IIa.—Tick data abstract sheet

COUNTY : Dubulo (S. Bugisu)				PLACE NAME : Bugobero			ALTITUDE : 3,600 ft.			ANIMAL SERIAL NUMBERS : 41, 42, 43						
Collection No. and Date		Rhipicephalus appendiculatus Av. ticks per animal	Species Total Av. per animal	Amblyomma variegatum Av. ticks per animal	Species Total Av. per animal	Rhipicephalus evertsi Av. ticks per animal	Species Total Av. per animal	Boophilus decoloratus Av. ticks per animal	Species Total Av. per animal	Other Spec. Total Av. per animal	Other Spec. Total Av. per animal	Other Spec. Total Av. per animal	Other Spec. Total Av. per animal	Other Spec. Total Av. per animal	Total Tick Av. per animal All Species incl. unidentified ticks	
I 29.5.64	MM FF NN LL	100-00 29-00 68-00 7-66	} 204-66	3-00 1-66 18-66 2-33	} 25-66	0-33 Nil Nil Nil	} 0-33	Nil 3-66 1-00 Nil	} 4-66	R. tricuspis 0-33	(1)	(2)	(3)	(4)	(5)	244-33
II 8.7.64	MM FF NN LL	96-66 26-33 52-66 4-00	} 179-66	4-66 2-33 20-33 36-33	} 63-66	0-33 0-33 Nil Nil	} 0-66	0-33 0-66 0-66 0-33	} 2-00	1-00						260-33
III 11.11.64	MM FF NN LL	107-66 33-33 34-00 9-33	} 184-33	9-00 1-66 30-33 11-66	} 52-66	1-66 1-00 Nil Nil	} 2-66	Nil 1-33 0-33 Nil	} 1-66	0-66						250-66
IV 0.1.65	MM FF NN LL	110-33 46-66 91-00 19-33	} 277-33	5-33 3-66 51-00 59-33	} 119-33	0-33 Nil Nil Nil	} 0-33	2-66 3-66 3-00 1-00	} 10-33	0-33						428-66
V 0.4.65	MM FF NN LL	73-33 26-33 8-00 1-00	} 108-66	15-00 8-00 11-33 0-66	} 22-33	1-00 0-33 Nil Nil	} 1-33	Nil 1-00 Nil Nil	} 1-00	0-66						153-66

REMARKS: MM = Males; FF = Females; NN = Nymphs;
10.8.66 LL = Larvae.

Numbers not separated into males, females, nymphs and
larvae. *R. tricuspis* = *Rhipicephalus tricuspis*.

Table IIB.—Tick data abstract sheet

COUNTY : Central Bugisu				PLACE NAME : Bugema				ALTITUDE : 3,600 ft.				ANIMAL SERIAL NUMBERS : 1, 2, 3				
Collection No. and Date		Rhipicephalus appendiculatus Av. ticks per animal	Species Total Av. per animal	Amblyomma variegatum Av. ticks per animal	Species Total Av. per animal	Rhipicephalus evertsi Av. ticks per animal	Species Total Av. per animal	Boophilus decoloratus Av. ticks per animal	Species Total Av. per animal	Other Spec. Total Av. per animal	Other Spec. Total Av. per animal	Other Spec. Total Av. per animal	Other Spec. Total Av. per animal	Other Spec. Total Av. per animal	Total Tick Av. per animal All Species incl. unidenti- fied ticks	
I 16.5.64	MM FF NN LL	164.33 51.33 17.60 6.00	} 230.33	38.00 5.33 9.60 24.33	} 71.33	0.66 Nil Nil Nil	} 0.66	0.66 0.66 1.00 Nil	} 2.33	<i>R. tricuspis</i> 2.33	(2)	(3)	(4)	(5)	336.33	
II 3.7.64	MM FF NN LL	97.00 35.00 47.00 3.50	} 182.50	1.00 1.00 34.00 19.00	} 55.00	0.50 Nil Nil Nil	} 0.50	0.50 1.50 0.50 Nil	} 2.50						253.50	
III 22.10.64	MM FF NN LL	121.00 49.50 46.50 14.50	} 231.50	4.50 1.50 35.50 27.50	} 69.00			Nil 0.5 2.0 Nil	} 2.50						302.00	
IV 8.1.65	MM FF NN LL	112.50 40.50 72.50 22.50	} 248.00	2.50 Nil 39.50 76.00	} 118.00			Nil Nil 1.00 Nil	} 1.00						400.00	
V 13.4.65	MM FF NN LL	53.00 15.50 43.50 5.50	} 117.50	6.00 2.50 11.00 6.50	} 26.00	1.00 Nil Nil Nil	} 1.00	1.00 1.50 2.50 Nil	} 5.00						157.00	

REMARKS: MM = Males; FF = Females; NN = Nymphs;
10.8.66 LL = Larvae.

Numbers not separated into males, females, nymphs and larvae. *R. tricuspis* = *Rhipicephalus tricuspis*.

Table IIc.—Tick data abstract sheet

COUNTY : North Bugisu				PLACE NAME : Salalira				ALTITUDE : 3,000 ft.				ANIMAL SERIAL NUMBERS : 26, 27, 28				
Collection No. and Date		Rhipicephalus appendiculatus Av. ticks per animal	Species Total Av. per animal	Amblyomma variegatum Av. ticks per animal	Species Total Av. per animal	Rhipicephalus evertsi Av. ticks per animal	Species Total Av. per animal	Boophilus decoloratus Av. ticks per animal	Species Total Av. per animal	Other Spec. Total Av. per animal	Other Spec. Total Av. per animal	Other Spec. Total Av. per animal	Other Spec. Total Av. per animal	Other Spec. Total Av. per animal	Total Tick Av. per animal All Species incl. unidentifed ticks	
I 26.5.64	MM FF NN LL	10.66 5.66 0.66 Nil	}17.00	2.00 0.33 4.33 2.00	}8.66			0.33 Nil Nil Nil	}0.33	(1) <i>R. tricuspis</i> 0.66	(2)	(3)	(4)	(5)	27.33	
II 26.6.64	MM FF NN LL	8.00 6.00 0.33 Nil	}14.33	0.66 Nil 0.66 Nil	}1.33			Nil 0.33 Nil Nil	}0.33						16.00	
III 10.9.64	MM FF NN LL	23.66 11.66 1.66 Nil	}37.00	1.00 Nil 0.66 1.33	}3.00										40.00	
IV 14.1.65	MM FF NN LL	28.33 8.66 9.00 2.00	}48.00	5.33 1.33 17.66 1.00	}25.33			0.66 Nil 0.33 Nil	}1.00						70.66	
V 14.4.65	MM FF NN LL	48.00 12.66 0.33 Nil	}59.00	10.33 8.33 6.00 Nil	}30.66					0.66					91.33	

REMARKS: MM = Males; FF = Females; NN = Nymphs;
10.8.66 LL = Larvae.

Numbers not separated into males, females, nymphs and larvae. *R. tricuspis* = *Rhipicephalus tricuspis*.

Table III.—Tick data abstract sheet

COUNTY : North Bugisu			PLACE NAME: Buhugu				ALTITUDE : 4,500 ft.			ANIMAL SERIAL NUMBERS: 21, 22, 23					
Collection No. and Date		Rhipicephalus appendiculatus Av. ticks per animal	Species Total Av. per animal	Amblyomma variegatum Av. ticks per animal	Species Total Av. per animal	Rhipicephalus evertsi Av. ticks per animal	Species Total Av. per animal	Boophilus decoloratus Av. ticks per animal	Species Total Av. per animal	Other Spec. Total Av. per animal	Other Spec. Total Av. per animal	Other Spec. Total Av. per animal	Other Spec. Total Av. per animal	Other Spec. Total Av. per animal	Total Tick Av. per animal All Species incl. unidentified ticks
I 20.5.64	MM FF NN LL	2-68 0-33 0-33 Nil	}3-33	6-33 Nil 1-00 5-33	}12-66					(1)	(2)	(3)	(4)	(5)	16-33
II 20.6.64	MM FF NN LL	0-66 0-33 Nil Nil	}1-00	0-33 Nil 0-66 Nil	}1-00										2-33
III 11.9.64	MM FF NN LL	Nil Nil 0-66 Nil	}0-66	0-66 Nil 0-33 0-33	}1-33			Nil 0-33 Nil Nil	}0-33						2-33
IV 13.1.65	MM FF NN LL	0-33 0-66 Nil Nil	}1-00	Nil Nil 1-00 Nil	}1-00										2-00
V 13.4.65	MM FF NN LL	Nil 0-33 Nil Nil	}0-33	2-00 Nil Nil Nil	}2-00										2-33

REMARKS: MM = Males; FF = Females; NN = Nymphs;
10.8.66 LL = Larvae.

Numbers not separated into males, females, nymphs and larvae.

Table IIg.—Tick data abstract sheet

COUNTY : South Bugisu			PLACE NAME : Bukalasi				ALTITUDE : 6,000 ft.			ANIMAL SERIAL NUMBERS : 36, 37, 38					
Collection No. and Date		Rhipicephalus appendiculatus Av. ticks per animal	Species Total Av. per animal	Amblyomma variegatum Av. ticks per animal	Species Total Av. per animal	Rhipicephalus evertsi Av. ticks per animal	Species Total Av. per animal	Boophilus decoloratus Av. ticks per animal	Species Total Av. per animal	Other Spec. Total Av. per animal	Other Spec. Total Av. per animal	Other Spec. Total Av. per animal	Other Spec. Total Av. per animal	Other Spec. Total Av. per animal	Total Tick Av. per animal All Species incl. unidentified ticks
I 19.5.64	MM FF NN LL	Nil Nil 0.33 Nil	} 0.33	0.33 Nil Nil Nil	} 0.33					(1)	(2)	(3)	(4)	(5)	0.60
II 19.9.64	MM FF NN LL	0.33 0.33 Nil Nil	} 0.60					Nil 1.00 0.33 Nil	} 1.33						2.00
III 24.9.64	MM FF NN LL	0.33 Nil Nil Nil	} 0.33	0.33 Nil Nil 0.33	} 0.60										1.00
IV 5.1.65	MM FF NN LL	0.60 Nil Nil Nil	} 0.60												0.60
V 5.4.65	MM FF NN LL	Nil 0.60 Nil Nil	} 0.60					Nil 0.33 Nil Nil	} 0.33						1.00

69

REMARKS: MM = Males; FF = Females; NN = Nymphs;
10.8.66 LL = Larvae.

Numbers not separated into males, females, nymphs and larvae.

Table III.—Tick data abstract sheet

COUNTY : Central Bugisu				PLACE NAME : Bufumbo				ALTITUDE : 5,500-6,000 ft.			ANIMAL SERIAL NUMBERS : 12, 13, 15				
Collection No. and Date		Rhipicephalus appendiculatus Av. ticks per animal	Species Total Av. per animal	Amblyomma variegatum Av. ticks per animal	Species Total Av. per animal	Rhipicephalus evertsi Av. ticks per animal	Species Total Av. per animal	Boophilus decoloratus Av. ticks per animal	Species Total Av. per animal	Other Spec. Total Av. per animal	Other Spec. Total Av. per animal	Other Spec. Total Av. per animal	Other Spec. Total Av. per animal	Other Spec. Total Av. per animal	Total Tick Av. per animal All Species incl. unidentified ticks
I 6.5.64	MM FF NN LL	1-66 1-00 Nil Nil	} 2-66	2-00 0-33 Nil Nil	} 2-33					(1)	(2)	(3)	(4)	(5)	5-00
II 30.6.64	MM FF NN LL	0-33 0-33 Nil Nil	} 0-66												0-66
III 12.9.64	MM FF NN LL			0-33 Nil Nil 16-33	} 16-66										18-00
IV 8.1.65	MM FF NN LL	Nil Nil Nil 0-33	} 0-33	Nil Nil 3-00 1-33	} 4-33										4-66
V 10.4.65	MM FF NN LL	0-33 Nil Nil Nil	} 0-33	0-66 0-33 0-33 Nil	} 1-33										1-66

REMARKS: MM = Males; FF = Females; NN = Nymphs;
 10.8.66 LL = Larvae.

Numbers not separated into males, females, nymphs and larvae.

Table III.—Tick data abstract sheet

COUNTY : North Bugisu				PLACE NAME : Bulago				ALTITUDE : 6,000 ft.			ANIMAL SERIAL NUMBERS : 16, 17, 18				
Collection No. and Date		Rhipicephalus appendiculatus Av. ticks per animal	Species Total Av. per animal	Amblyomma variegatum Av. ticks per animal	Species Total Av. per animal	Rhipicephalus evertsi Av. ticks per animal	Species Total Av. per animal	Boophilus decoloratus Av. ticks per animal	Species Total Av. per animal	Other Spec. Total Av. per animal	Other Spec. Total Av. per animal	Other Spec. Total Av. per animal	Other Spec. Total Av. per animal	Other Spec. Total Av. per animal	Total Tick Av. per animal All Species incl. unidentified ticks
I 26.5.64	MM FF NN LL	Nil 0-33 Nil Nil	} 0-33	0-33 Nil Nil Nil	} 0-33					(1)	(2)	(3)	(4)	(5)	0-66
II 25.8.64	MM FF NN LL	Nil Nil Nil Nil	} Nil	Nil Nil Nil Nil	} Nil										Nil
III 26.9.64	MM FF NN LL	Nil Nil 0-33 Nil	} 0-33												0-33
IV 12.1.65	MM FF NN LL	Nil 0-33 Nil Nil	} 0-33												0-33
V 10.4.65	MM FF NN LL	0-33 Nil Nil Nil	} 0-33												0-33

REMARKS: MM = Males; FF = Females; NN = Nymphs;
10.8.66 LL = Larvae.

Numbers not separated into males, females, nymphs and larvae.

Male ticks exceeded female ticks in the two major species present, but not in the case of *B. decoloratus*. With *R. appendiculatus* the ratio of male to female ticks varied from 2.0:1 to 3.0:1 in all but four collecting sites. In these four, Buhugu at 4,500 ft. and all three 6,000 ft. sites, tick numbers were too low to justify such a comparison. The ratio was widest at those sites where ticks were most numerous. For *A. variegatum*, the ratio varied from 1.8:1 to 5.2:1 at those sites where numbers were large enough to justify a comparison of this type. *B. decoloratus* was present only in small numbers at any one site, but a consideration of its total numbers indicates a male/female ratio of 0.4:1.

Table III shows the minimum and maximum numbers of ticks found per animal at different sites, including unidentified ticks. This table also shows a breakdown into species and the numbers of collections at which each was found.

DISCUSSION

Ticks found

The dominant species found were *A. variegatum* and *R. appendiculatus*, which is in agreement with the suggestion of Wilson (1953). Wilson also found *B. decoloratus* in Bugisu, but only at the lowest altitudes. It was expected that *R. evertsi* would be much more widespread than was found to be the case, and *R. simus simus* and *R. tricuspsis* are recorded from Bugisu for the first time.

Predilection sites of attachment

For *A. variegatum*, *R. appendiculatus*, *R. evertsi* and *B. decoloratus* the predilection sites were as expected for those species and were in agreement with the findings of Yeoman and Walker (1967). *R. tricuspsis* was found only on the tail brush, whereas Yeoman and Walker (1967) found this species on both the tail brush and on other parts of the body sometimes in relatively large numbers.

In the past, few quantitative tick vector studies have been carried out, for obvious practical reasons, but a comparison of total numbers of *R. appendiculatus* with the sites on the host on which it is found shows that the number of sites and the concentration of ticks at those sites increases as the total number of ticks on the host rises. This would appear to be self-evident, but it explains why one worker finds a tick on certain sites on the host, whilst another worker finds the same tick in other sites also.

Tick Populations (General)

Although a large part of Bugisu is climatically suitable for both *R. appendiculatus* and *A. variegatum*, *R. appendiculatus* occurs on cattle in much larger numbers than *A. variegatum*. Possible reasons for this are:

- (a) There may be a greater death rate amongst the immature stages of *A. variegatum* than amongst those of *R. appendiculatus*.
- (b) There is a more severe skin reaction to the bites of *A. variegatum* than to *R. appendiculatus*, and this could reduce the density of a tick population in a particular skin area.
- (c) *A. variegatum* is a larger tick than *R. appendiculatus*, and the female especially, takes a much larger blood meal than does the female of *R. appendiculatus*. This suggests that individual *A. variegatum* ticks require a larger area of skin from which to feed.

Table III.—Numbers (minimum and maximum) of different species of ticks found and their occurrence at different sites

Site	Altitude	Average Rainfall	R a	Collections when found	A v	Collections when found	R e	Collections when found	B d	Collections when found	R t	Collections when found	Total ticks per animal
Bugobero	3,600 ft.	1147 mm 45·15 in.	100-300	five	20-120	five	1-3	five	1-10	five	0-1	five	154-430
Bugema	3,600 ft.	1179 mm 46·37 in.	100-250	five	25-120	five	0-1	three	1-5	five	0-3	one	157-400
Salalira	3,600 ft.	1044·1 mm 41·11 in.	15-60	five	2-30	five	Nil	Nil	0-1	three	0-1	two	10-92
Bubulo	4,500 ft.	1317·1 mm 51·85 in.	90-180	five	5-50	five	Nil	Nil	0-5	four	Nil	Nil	80-219
Lwambogo	4,500 ft.	1317·1 mm 51·85 in.	7-130	five	1-45	five	0-1	two	2-9	three	Nil	Nil	8-142
Buhugu	4,500 ft.	1454·9 mm 57·27 in.	1-4	five	1-13	five	Nil	Nil	0-1	one	Nil	Nil	2-17
Bukalasi	6,000 ft.	1651·0 mm 65·0 in.	0-1	five	0-1	two	Nil	Nil	0-2	two	Nil	Nil	1-2
Bufumbo	5,500- 6,000 ft.	1693·4 mm 66·6 in.	0-3	four	1-17	four	Nil	Nil	Nil	Nil	Nil	Nil	2-18
Bulago	6,000 ft.	2026·0 mm 79·7 in.	0-1	five	0-1	one	Nil	Nil	Nil	Nil	Nil	Nil	0-1

Key to tick species: R a = *Rhipicephalus appendiculatus*; A v = *Amblyomma variegatum*; R e = *Rhipicephalus evertsi*;
B d = *Boophilus decoloratus*; R t = *Rhipicephalus tricuspis*.

The presence of larger numbers of males than females amongst the dominant tick species, is in keeping with the tendency of male ticks of these species to stay on the host longer than the females. The females drop off as soon as they have had a blood meal.

In *B. decoloratus* the female ticks are slightly more common than the males and it is possible that males of this species may have a shorter life expectancy.

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SUMMARY

1. An outline of the background to this work is followed by a brief summary of work done elsewhere in East Africa on tick populations and ecology.
2. A general description is given of the geography and climate of Bugisu district.
3. Total tick collections were made from three cattle at nine different sites throughout the district, five collections being made between May 1964 and May 1965. It was not possible for various reasons, to make more frequent collections. Three collection sites were at 3,600 ft., three at 4,500 ft. and three at 5,500-6,000 ft.
4. All ticks collected were killed in Boardman's solution, preserved in 70% alcohol and identified using a Zeiss dissecting microscope.
5. Ticks found on cattle were *Amblyomma variegatum*, *Boophilus decoloratus*, *Rhipicephalus appendiculatus*, *Rhipicephalus evertsi evertsi*, *Rhipicephalus simus simus* and *Rhipicephalus tricuspis*.
6. *Rhipicephalus appendiculatus* and *Amblyomma variegatum* were the major tick species found (73% and 21% respectively of all the ticks). Only small numbers of *Boophilus decoloratus* were found (1%).
7. Male ticks exceeded female ticks except with *Boophilus decoloratus* where female ticks were slightly in excess.
8. Predilection sites for the ticks found were largely in keeping with the findings of other workers.
9. Suggestions are made concerning the possible reasons why *Rhipicephalus appendiculatus* is normally present in greater numbers than *Amblyomma variegatum*.

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Résumé

1. Le cadre de ce travail étant d'abord situé, un bref résumé est fait des travaux effectués ailleurs en Afrique orientale sur la population et l'écologie de tiques.
2. Descriptions générales de la géographie et du climat du district du Bugisu.
3. Cueillette totale des tiques qui fut effectuée sur trois têtes de bétail à neuf emplacements différents dans le district. Cinq des cueillettes furent effectuées entre mai 1964 et mai 1965. Pour diverses raisons, il n'était pas possible d'effectuer des cueillettes plus fréquentes. Trois des lieux où cette opération se déroula étaient situés à 1.100 mètres, trois à 1.400 mètres et trois entre 1.700 et 1.800 mètres.
4. Toutes les tiques qui furent trouvées furent tuées dans une solution de Boardman, conservées dans l'alcool à 70° et identifiées au moyen d'un microscope de dissection Zeiss.
5. Les tiques trouvées sur le bétail étaient: *Amblyomma variegatum*, *Boophilus decoloratus*, *Rhipicephalus appendiculatus*, *Rhipicephalus evertsi evertsi*, *Rhipicephalus simus simus* et *Rhipicephalus tricuspis*.
6. *Rhipicephalus appendiculatus* et *Amblyomma variegatum* étaient les principales espèces de tiques trouvées (73% et 21% respectivement de toutes les tiques). On ne trouva que de très faibles nombres de *Boophilus decoloratus* (1%).
7. Il y a davantage de tiques males que femelles, sauf dans le cas du *Boophilus decoloratus*, où il a légèrement plus de tiques femelles.
8. Les sites de prédilection des tiques confirmaient dans l'ensemble les conclusions d'autres chercheurs.
9. Des suggestions sont formulées au sujet des raisons possibles pour lesquelles *Rhipicephalus appendiculatus* se trouve normalement en plus grand nombre qu'*Amblyomma variegatum*.

VARIATIONS IN TICK SPECIES AND POPULATIONS IN THE BUGISU DISTRICT OF UGANDA

M. W. SMITH *

PART II

The effects of altitude, climate, vegetation and husbandry on tick species and populations

INTRODUCTION

In the first of these two papers,† a description was given of the tick survey completed in the Bugisu district of Uganda, during 1964-5. The survey which was carried out at three different altitudes and at nine separate sites, demonstrated the prevalent species of ticks on cattle in the area. *Rhipicephalus appendiculatus* and *Amblyomma variegatum* were shown to be the two dominant species. Further results and conclusions concerning tick populations and the relationships between and within species were also described and discussed. During the survey, all available climatic information was collected concerning rainfall, temperature and relative humidity, vegetation, crops and husbandry methods.

Probably the most important investigations concerning tick ecology have been carried out by Theiler (1948) and her co-workers in South Africa, and Yeoman and Walker (1967) in Tanzania, in the form of nationwide surveys of tick distribution. Both groups were handicapped by the enormous areas to be covered, which precluded repeated total seasonal tick collections on the same animals. Other workers such as Lewis (1931) and Hampshire (1958) were also at a disadvantage in that erratic dipping and spraying was being carried out in the areas in which they were working. Yeoman (1967) working in Sukumaland, Tanzania, was able to carry out repeated seasonal collections of ticks on the same animals, and was able to show that for *R. appendiculatus* the degree of vegetational cover was an important ecological factor controlling the numbers of this tick.

Description of the area

A general description of the area was given in the first paper. Details of individual collection sites are included in Tables Ia to Ii and the positions of collection sites have also been superimposed in Map 2, showing the main vegetational areas of Bugisu.

Up to an altitude of between 4,000 and 4,500 ft. above sea level, the natural vegetation in Central and North Bugisu is either a *Combretum-Terminalia-Albizia-Hyparrhenia* savannah, or, in areas where drainage is impeded, an *Acacia-Setaria* or *Acacia-Imperata* savannah. In South Bugisu within the same altitude range the natural vegetation is either a *Combretum-Hyparrhenia-Cymbopogon* savannah

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† The two papers form the subject of a thesis presented for the Degree of M.V.Sc. in the University of Liverpool.

Table Ia.—Record sheet of collection sites

District: BUGISU

County: BUBULO (SOUTH BUGISU)

Site: BUGOBERO	Map Ref.: 34° 13' E by 0° 52' N	Altitude: 3,600 ft.	Rainfall: 45"
<i>Local name of place where applicable:</i> NAMAKHONGE BULAKO	<i>Types of vegetation crops-cultivation, etc.:</i> Post cultivation community— Cymbopogon, Imperata, Eragrostis, Chloris, Hyparrhenia. Cynodon, Digitaria and Sporobolus. Also Annual Weeds. Crops are mostly cotton, groundnuts, sorghum, sweet potatoes, some maize and cassava.	<i>Names of owners including changes with reasons:</i> DAUDI WASAKINI (May and July series) YOMA WESSWA (Later series) Wasakini had sold some of his cattle and it was therefore necessary to collect from fresh animals.	<i>Serial numbers of cattle and descriptions with changes and reasons for changes:</i> <i>Serial No. 41</i> —Grey bull. <i>Serial No. 42</i> —Black heifer. <i>Serial No. 43</i> —Black heifer with white spots. <i>Series for Nov. and thereafter</i> <i>Serial No. 41</i> —Black bull with white spots on scrotum. <i>Serial No. 42</i> —Brown heifer. <i>Serial No. 43</i> —Black heifer with white underbelly.
<i>Collectors:</i> M. W. Smith Mr. Kauka			
<i>Collection dates:</i> 1st : 29.5.64 2nd : 8.7.64 3rd : 11.11.64 4th : 6.1.65 5th : 6.4.65	<i>Method of husbandry:</i> Communal grazing in small groups with herd boys. Night kraals. Some tethering on post cultivation resting land.		
<i>Remarks:</i> June collection delayed to July. September collection delayed to Nov. due to non co-operation of cattle owners.			

Table Ib.—Record sheet of collection sites

District: BUGISU

County: CENTRAL BUGISU

Site: BUGEMA	Map Ref.: 34° 09' E by 1° 03' N	Altitude: 3,600 ft.	Rainfall: 46"
<i>Local name of place where applicable:</i> BUKASAKYA	<i>Types of vegetation crops-cultivation, etc.:</i> Moist Combretum Savanna Terminalla-Albizia-Hyparrhenia rufa. Open grazing land scattered trees swampy in parts. Some maize and small millet	<i>Names of owners including changes with reasons:</i> DISONI WANGWE (1st series done in May) Later collections refused by owner. ASUMANI MUDEBO (Later series)	<i>Serial numbers of cattle and descriptions with changes and reasons for changes:</i> <i>Serial No. 1</i> —Small brown bullock. <i>Serial No. 2</i> —Grey cow with brown hindquarters. <i>Serial No. 3</i> —Young black and white bull. <i>Series for June and thereafter</i> <i>Serial No. 1</i> —White heifer. <i>Serial No. 2</i> —Black cow with white spot on head. Owner refused to assist with third animal. No other owners would assist with their cattle in this area. Collections therefore only possible (after May) on two animals in this group and not three as planned.
<i>Collectors:</i> M. W. Smith Mr. Mutambo Mr. Muiyiyi			
<i>Collection dates:</i> 1st : 16.5.64 2nd : 3.7.64 3rd : 22.10.64 4th : 8.1.65 5th : 13.4.65	<i>Method of husbandry:</i> Free grazing with herdsmen. Cattle in groups of 20-30 H/C. Night kraals.		
<i>Remarks:</i> June collection delayed to July and Sept. collection delayed to Oct. owing to non co-operation of cattle owners.			

Table Ic.—Record sheet of collection sites

District: BUGISU

County: NORTH BUGISU

Site: SALALIRA	Map Ref.: 34° 17' E by 1° 16' N	Altitude: 3,600 ft.	Rainfall: 41"
<i>Local name of place where applicable:</i> BUKISE	<i>Types of vegetation crops-cultivation, etc.:</i> Moist Combretum Savannah Terminalia, Albizia, Hyperrhenia rufa. Little cultivation. Some Acacia and Evergreen Shrubs. Heavy overgrazing and some patchy sheet erosion.	<i>Names of owners including changes with reasons:</i> James Katamba	<i>Serial numbers of cattle and descriptions with changes and reasons for changes:</i> Serial No. 26—Brown and White Heifer. Serial No. 27—Brown Heifer with light underside. Serial No. 28—Grey cow.
<i>Collectors:</i> Mr. Smith Mr. Kalukusu Mr. Bwayo			
<i>Collection dates:</i> 1st: 20.5.64 2nd: 26.6.64 3rd: 10.9.64 4th: 14.1.65 5th: 14.4.65	<i>Method of husbandry:</i> Free grazing during day. Herded by children. With night kraals.		
<i>Remarks:</i>			

Table Id.—Record sheet of collection sites

District: BUGISU

County: BUBULO (SOUTH BUGISU)

Site: BUBULO	Map Ref.: 34° 16' E by 0° 58' N	Altitude: 4,500 ft.	Rainfall: 52"
<i>Local name of place where applicable:</i> WALANGA, BUTTA, BUNUKIZI	<i>Types of vegetation crops-cultivation, etc.:</i> Dry Combretum savanna—Combretum, Hyparrhenia, Acacia. Little or no cultivation.	<i>Names of owners including changes with reasons:</i> WELIKE	<i>Serial numbers of cattle and descriptions with changes and reasons for changes:</i> Serial No. 31—Cream coloured heifer. Serial No. 32—Black cow. Serial No. 33—Black heifer with white spots.
<i>Collectors:</i> M. W. Smith Mr. Bweri			
<i>Collection dates:</i> 1st: 20.5.64 2nd: 19.6.64 3rd: 8.10.64 4th: 7.1.65 5th: 7.4.65	<i>Method of husbandry:</i> Free grazing with herdsmen. Night kraals.		
<i>Remarks:</i> Sept. collection delayed to Oct. by non-co-operation of cattle owner.			

Table Ie.—Record sheet of collection sites

District: BUGISU

County: CENTRAL BUGISU

Site: LWAMBOGO	Map Ref.: 34° 13' E by 1° 02' N	Altitude: 4,500 ft.	Rainfall: 52"
Local name of place where applicable: BUNKOKO	Types of vegetation crops-cultivation, etc.: Medium Altitude Forest. Savanna Mosaic. Bananas with some coffee, sorghum, maize, sweet potatoes and vegetables.	Names of owners including changes with reasons: NAKAYI MULEKWA (First series done in May) ERUKANA WAKABIRI (Later series) In Jan. No. 7 changed again. Last animal sold. WADIKA WAKADIYA In Jan. and thereafter No. 6 replaced by animal belonging to Wakadiya.	Serial numbers of cattle and descriptions with changes and reasons for changes: Serial No. 6—Brown and white cow. Serial No. 7—Brown and white heifer. Serial No. 8—Large black cow. Owner refused further assistance. June and Sept. Series Serial 6—Black cow with light underside. Serial 7—Dark brown and white underneath cow. Serial 8—Light brown and white bull. January and April Series Serial 6—Black and white heifer. Serial 7—Brown and white heifer. Previous cow taken for dowry and sold. Serial 8—As in June and Sept. series.
Collectors: M. W. Smith Mr. Wasagala Mr. Mutambo	Method of husbandry: Tethering on short overgrazed pasture and post cultivation land. Supplements of split banana stems. Sometimes taken to plains for grazing.		
Collection dates: 1st : 6.5.64 2nd : 18.6.64 3rd : 28.9.64 4th : 11.1.65 5th : 9.4.65			
Remarks: Very very few bulls in this area and no bullocks seen.			

Table If.—Record sheet of collection sites

District: BUGISU

County: NORTH BUGISU

Site: BUHUGU	Map Ref.: 84° 19' E by 1° 12' N	Altitude: 4,500 ft.	Rainfall: 57"
Local name of place where applicable: BUMALIMBA	Types of vegetation crops-cultivation, etc.: Forest—savanna mosaic at medium altitudes. Area heavily cultivated with bananas, coffee, sorghum, maize, vegetables.	Names of owners including changes with reasons: BENEKADADE KADE (No. 21) LUSEWEGA MAKESE (No's. 22 and 23)	Serial numbers of cattle and descriptions with changes and reasons for changes: Serial No. 21—Black heifer daughter of Tul. Serial No. 22—White and brown heifer. Serial No. 23—White cow.
Collectors: M. W. Smith Mr. Bwayo	Method of husbandry: Tethering on small areas overgrazed pasture. Supplementary feeding with split banana stems.		
Collection dates: 1st : 29.5.64 2nd : 29.6.64 3rd : 11.9.64 4th : 13.1.65 5th : 13.4.65			
Remarks:			

Table Ig.—Record sheet of collection sites

District: BUGISU

County: MANJIYA (SOUTH BUGISU)

Site: BUKALASI	Map Ref.: 34° 25' E by 1° 01' N	Altitude: 6,000 ft.	Rainfall: 65-70"
Local name of place where applicable: BUKALASI COFFEE STORE	Types of vegetation crops-cultivation, etc.: Pygeum moist montane forest bordering on high altitude savanna mosaic. Heavily cultivated, mostly coffee and bananas. Most of original forest cut down.	Names of owners including changes with reasons: LUKA MUSHII	Serial numbers of cattle and descriptions with changes and reasons for changes: Serial No. 36—Black and white heifer. Serial No. 37—Light and dark brown heifer. Serial No. 38—Black bull.
Collectors: Mr. Smith Mr. Walyaula			
Collection dates: 1st: 10.5.64 2nd: 10.6.64 3rd: 24.9.64 4th: 5.1.65 5th: 5.4.65	Method of husbandry: Cattle herded by children on grass verges or tethered on small areas of short overgrazed pasture. Some supplements of split banana stems.		
Remarks: Very few bulls or bullocks available.			

Table Ih.—Record sheet of collection sites

District: BUGISU

County: CENTRAL BUGISU

Site: BUFUMBO	Map Ref.: 34° 17' E by 1° 04' N	Altitude: 5,500-6,000 ft.	Rainfall: 65-70"
Local name of place where applicable: BUFUMBO	Types of vegetation crops-cultivation, etc.: High altitude forest. Savanna mosaic. Cross cultivation, bananas, coffee, vegetables, sorghum, maize.	Names of owners including changes with reasons: ABDU WABIRI (No. 12) KASIMU WAMUMDU (No. 13) WAMUNDU WAKWABA (No. 15)	Serial numbers of cattle and descriptions with changes and reasons for changes: Serial No. 12—Black and white cow. Serial No. 13—Black cow.
Collectors: Mr. Smith Mr. Wasagala			
Collection dates: 1st: 6.5.64 2nd: 30.6.64 3rd: 12.9.64 4th: 8.1.65 5th: 10.4.65	Method of husbandry: Cattle herded by children on grass verges or small areas. Short overgrazed pasture. Sometimes tethered. Some supplementary feeding with split banana stems.		
Remarks: No bulls or bullocks found in this particular area.			

Table II.—Record sheet of collection sites

District: BUGISU

County: NORTH BUGISU

Site : BULAGO	Map Ref.: 24° 23' E by 1° 15' N	Altitude : 6,000 ft.	Rainfall : 79"
Local name of place where applicable: GOMBOLA HEADQUARTERS	Types of vegetation crops-cultivation, etc.: High altitude forest/savanna mosaic. Mostly cultivated with bananas and coffee interspersed with patches of bush and forest trees.	Names of owners including changes with reasons: Fabiano Wettaka	Serial numbers of cattle and descriptions with changes and reasons for changes: Serial No. 16—White and light brown cow. Serial No. 17—Black cow. Serial No. 18—Black bull.
Collectors: M. W. Smith Mr. Kalukusu Mr. Mwawule			
Collection dates: 1st : 20.5.64 2nd : 25.6.64 3rd : 26.9.64 4th : 12.1.65 5th : 12.4.65	Method of husbandry: Tethering on very small patches of short overgrazed pasture. Supplementary feeding split banana stems.		
Remarks:			

with some *Acacia* or a post-cultivation community of grasses including species of *Cymbopogon*, *Imperata*, *Eragrostis*, *Chloris*, *Cynodon*, *Digitaria* and *Sporobolus*, together with annual weeds.

Throughout the district above this altitude, the vegetation changes to a medium altitude forest savannah mosaic, and eventually as altitude increases, to high altitude forest. The rich volcanic soil at these higher altitudes, together with higher rainfall, makes the area very suitable for growing bananas and coffee. This is one of the reasons why so much of the natural vegetation has given way to cultivated crops.

There is a wide range of rainfall in the district, varying from 41–46 inches (1041–1168 mm.) at 3,500 ft. and 52–57 inches (1321–1448 mm.) at 4,500 ft. to 65–80 inches (over 2000 mm.) at 5,500–6,000+ ft. This gives a total range from 41 inches to 80 inches over an altitude increase of approximately 2,500 ft.

Only two sets of mean temperature and relative humidity figures are available for Bugisu, at Mbale (3,800 ft.) and Nabumali (4,000 ft. to 4,500 ft.). These have been considered as representative of the 3,600 ft. and 4,500 ft. altitude levels respectively. At Mbale the mean maximum temperature fluctuates between 27.3° C. and 32.2° C., giving a range of approximately 5.0° C. Mean minimum temperature varies between 15.5° C. and 17.2° C. At Nabumali the mean maximum temperature fluctuates between 25.3° C. and 30.9° C. giving a range of 5.1° C. Mean minimum temperature fluctuates between 15.9° C. and 18.8° C. The difference between the mean maximum and mean minimum temperatures at the two altitudes is at no time greater than two degrees.

At Mbale the mean relative humidity at 09.00 hours varies from 78% to 93% whilst at Nabumali it normally varies from 79% to 89%. Although there are no figures available for higher altitudes, tentative deductions may be made by interpolation from existing figures for lower altitudes. It is highly unlikely that the mean maximum and minimum temperatures at 6,000 ft. would be more than (say) 3.0° C. lower than at 4,500 ft. whilst the mean relative humidity would be unlikely to fall below 70–75% at the higher altitudes, especially since there is an increase in rainfall at the higher levels.

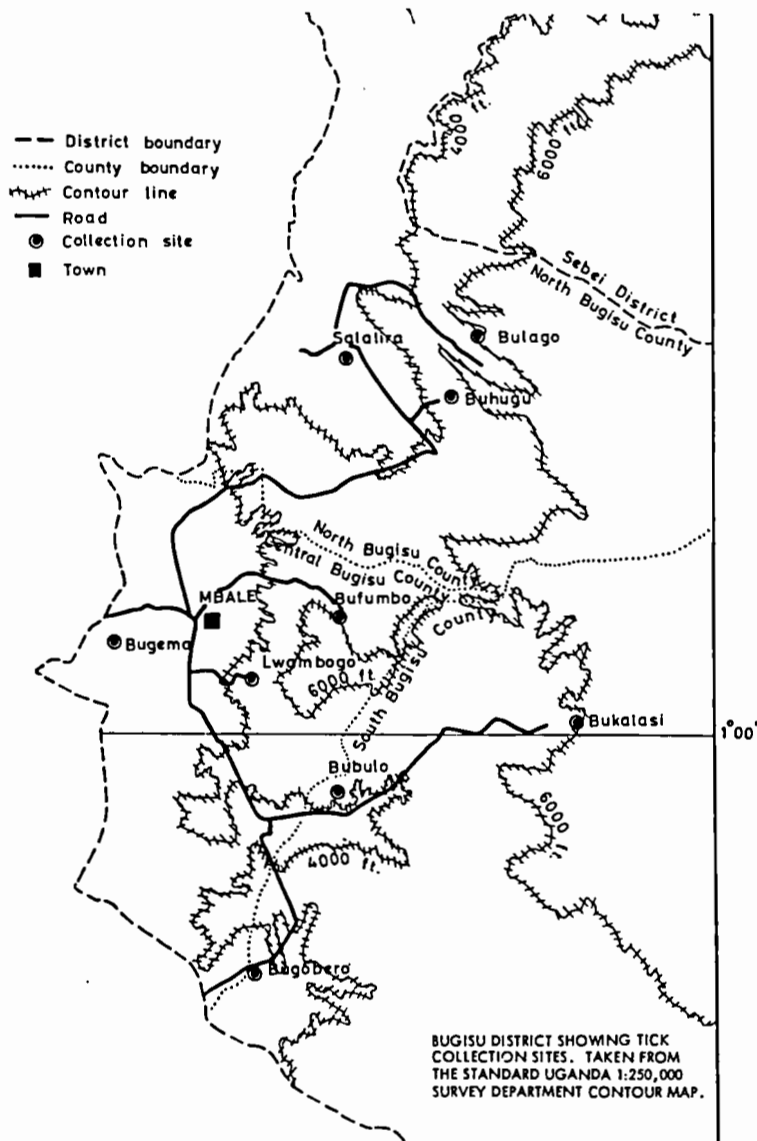
MATERIALS AND METHODS

Site Positions and Altitudes

These were plotted on the standard 1:250,000 Uganda Survey Department contour map. (Map 1).

Rainfall

Detailed rainfall figures were obtained from the summaries of rainfall in Uganda published by the East African Meteorological Department using figures from numbered rainfall recording points situated close to the tick collection sites.



MAP 1.

In the case of the Bukalasi collection site, no figures were available, except the annual totals for 1964 and 1965 obtained by interpolation from existing data by the Meteorological Department. For the Bufumbo collection site there were no average monthly or average annual figures available, since the recording site was only established in 1964.

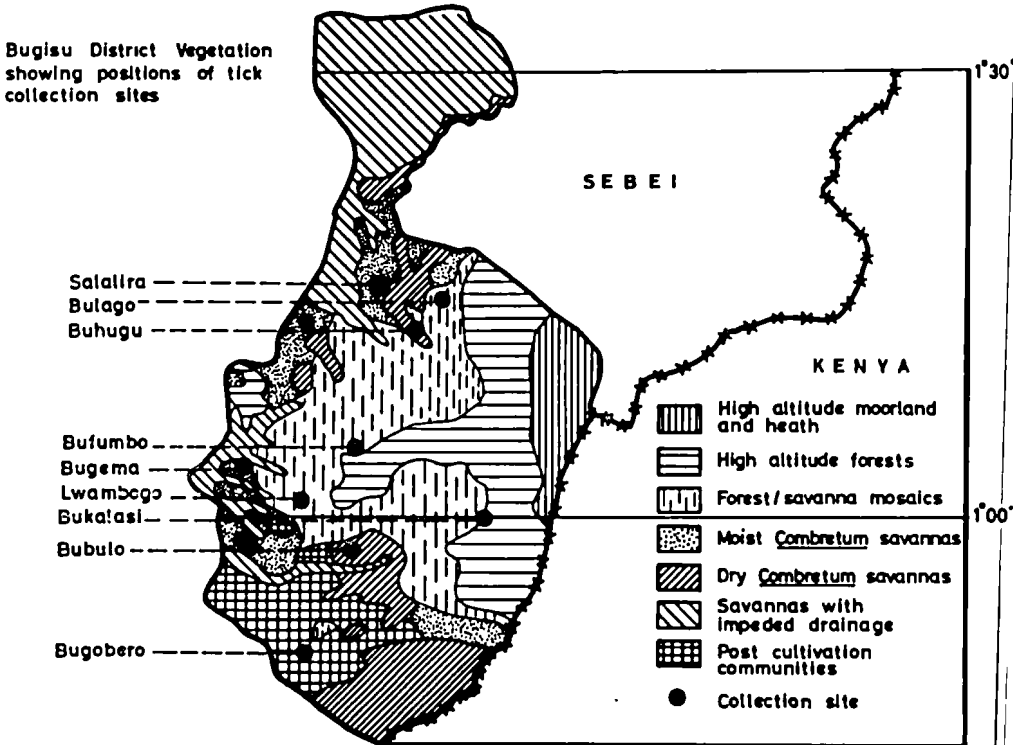
Mean Temperature and Relative Humidity (Table II)

As already stated, these figures were available only for two places, Mbale (at 3,800 ft.) and Nabumali (at between 4,000 and 4,500 ft. altitude), both in Central Bugisu. This information was also obtained from the East African Meteorological Department.

Vegetation, Crops and Husbandry Methods

This information was obtained from various sources:

- (a) The Vegetation of Uganda by Langdale Brown, Osmaston and Wilson (1964).
- (b) The Grasses of Uganda by Harker (1961).
- (c) The Vegetation Map 1:500,000 produced by the Uganda Department of Lands and Surveys (Map 2).



MAP 2.—Taken from the Uganda Survey Dept. Vegetation Map of Uganda.

Table II

Available relative humidity figures for Mbale and Nabumali						Available temperature figures for Mbale and Nabumali						
Mean relative humidity for 09.00 and 15.00 hrs. local time 1965						Monthly temperature average Mbale for 20 years up to 1965 Nabumali 1964 and 1965 only						
Mbale (3,800 ft.)			Nabumali (4,000-4,500 ft.)			Mbale (3,800 ft.)			Nabumali (4,000-4,500 ft.)			
Month	0900 hrs.	1500 hrs.	Month	0900 hrs.	1500 hrs.	Month	Mean max. °C	Mean min. °C	1964		1965	
									Mean max. °C	Mean min. °C	Mean max. °C	Mean min. °C
January . .	78%	89%	January . .	79%	72%	January . .	32.2	15.7	29.8	10.7	29.6	10.4
February . .	84%	95%	February . .	58%	58%	February . .	31.7	16.4	30.0	20.7	30.9	16.7
March . . .	80%	99%	March . . .	85%	70%	March . . .	30.9	16.9	27.4	18.2	29.3	17.2
April . . .	93%	91%	April . . .	87%	84%	April . . .	28.9	17.2	26.6	18.8	27.5	17.1
May	83%	95%	May	83%	72%	May	27.9	16.9	27.3	17.4	27.3	16.6
June	82%	90%	June	85%	90%	June	27.8	16.3	27.4	17.0	27.8	15.9
July	86%	92%	July	82%	70%	July	27.3	16.1	25.3	16.2	27.1	16.1
August . . .	93%	92%	August . . .	87%	N.R.	August . . .	27.5	15.8	26.4	16.7	27.0	16.2
September .	80%	93%	September .	89%	74%	September .	28.2	15.5	26.6	16.1	27.2	17.0
October . . .	N.R.	N.R.	October . . .	86%	74%	October . . .	28.8	15.8	26.5	16.2	26.0	17.6
November . .	N.R.	N.R.	November . .	80%	71%	November . .	29.9	15.9	28.0	16.3	25.8	17.7
December . .	N.R.	N.R.	December . .	82%	N.R.	December . .	30.4	15.8	27.3	15.9	27.7	16.7
Remarks	Mbale (altitude 3,800 ft.) and Nabumali (altitude 4,000-4,500 ft.) are the only two places in Bugisu for which temperature and relative humidity figures are available. It is intended that these figures should be considered as representative of the 3,600 ft. and 4,500 ft. levels respectively. Assessment of 6,000 ft. figures may be obtained by interpolation.											

(d) Frequent personal visits to the sites and consultations with H. Osmaston (see (a) above) and K. Harker (see (b) above).

Photographs of each site were also taken to give some idea of the vegetational cover, the types of cattle and the type of husbandry.

Figures and tables

From the tick survey data, graphs were constructed to show the seasonal variations in numbers, of all stages of the two dominant tick species (Figs. 1-7). Histograms of monthly rainfall were superimposed on the graphs, to demonstrate the relationships between rainfall distribution and the seasonal variations of tick numbers. For reasons of brevity, not all figures could be included in this paper and only representative examples have been inserted.

A table was also prepared (Table III) showing the maximum and minimum numbers of all species of ticks at each collection site, and for comparison purposes, altitude and annual rainfall figures were included in the table. A second table (Table II) shows the available figures for monthly mean relative humidity and monthly mean temperatures in Bugisu district.

Photographs

Using a small Polaroid camera, photographs were taken of each collection site to show the relative amounts of vegetational cover. These pictures also illustrated some aspects of crop and animal husbandry at each site. Again there are too many photographs for all to be used, but representative examples have been included to show the main differences between certain sites and altitudes (Figs. 1-7).

RESULTS

Seasonal variations in numbers of *A. variegatum*

1. Elevation 3,600 ft.

Site: Bugobero

There was a constant but relatively low level of adult tick activity all the year round. Immature ticks were usually in excess of adults, with a major increase in the numbers of immatures during the main dry season of January/February. During the mid-wet season drier period between July and August, there was a minor increase in the immature stages of the tick which was largely restricted to larvae. There was, however, a gradual increase in nymphae throughout the wet season. During July 1964 the ratio of immature ticks to adults was 8:1. During January 1965, the ratio of immature ticks to adults was 13:1.

Thus, although adult tick numbers were relatively constant throughout the year, new generations of larval ticks hatched out in two major batches in July and January with a six months interval (Fig. 1).

Site: Bugema

At this site the picture was very similar to that at Bugobero except that the relative number of immature ticks was very much greater. There was a much greater increase in immatures in January than at Bugobero and the ratio of immatures to adults in January was 47:1. In July it was 26:1.

Site: Salalira

Total tick numbers were much lower. There was a relatively constant level of adults throughout the year but at a lower level than at Bugobero or Bugema.

Table III

Numbers (minimum and maximum) of different species of ticks found and their occurrence at different sites													
Site	Altitude	Average Rainfall	R a	Collections when found	A v	Collections when found	R e	Collections when found	B d	Collections when found	R t	Collections when found	Total ticks per animal
Bugobero	3,600 ft.	1147 mm 45·15 in.	100-300	five	20-120	five	1-3	five	1-10	five	0-1	five	154-430
Bugema	3,600 ft.	1179 mm 40·37 in.	100-250	five	25-120	five	0-1	three	1- 5	five	0-3	one	157-400
Salalira	3,600 ft.	1044·1 mm 41·11 in.	15- 60	five	2- 30	five	Nil	Nil	0- 1	three	0-1	two	16- 92
Bubulo	4,500 ft.	1317·1 mm 51·85 in.	90-180	five	5- 50	five	Nil	Nil	0- 5	four	Nil	Nil	80-210
Lwambogo	4,500 ft.	1317·1 mm 51·85 in.	7-130	five	1- 45	five	0-1	two	2- 9	three	Nil	Nil	8-142
Buhugu	4,500 ft.	1454·9 mm 57·27 in.	1- 4	five	1- 13	five	Nil	Nil	0- 1	one	Nil	Nil	2- 17
Bukalasi	6,000 ft.	1651·0 mm 65·0 in.	0- 1	five	0- 1	two	Nil	Nil	0- 2	two	Nil	Nil	1- 2
Bufumbo	5,500- 6,000 ft.	1693·4 mm 66·6 in.	0- 3	four	1- 17	four	Nil	Nil	Nil	Nil	Nil	Nil	2- 18
Bulago	6,000 ft.	2026·0 mm 79·7 in.	0- 1	five	0- 1	one	Nil	Nil	Nil	Nil	Nil	Nil	0- 1

Key to tick species: R a = *Rhipicephalus appendiculatus*; A v = *Amblyomma variegatum*; R e = *Rhipicephalus evertsi*;
B d = *Boophilus decoloratus*; R t = *Rhipicephalus tricuspis*.

Immature ticks were much reduced in numbers and so few larvae were found that they were not plotted on the graph. Although numbers of nymphs were much lower, there was still a noticeable slight increase in the dry season in January. The ratio of immatures to adults was only 3:1. There was a general depression of breeding activity, and an overall reduction in tick numbers at this site (Fig. 3).

2. Elevation 4,500 ft.

Site: Bubulo

The general picture at Bubulo was similar to that at Bugobero at 3,600 ft. (Fig. 1) but tick numbers were lower throughout the year. There were two peaks in the numbers of immature ticks, one between July and August and another between November and April, which is the main dry season. The ratios between immature and mature ticks were 2:1 in July and 4:1 in January (Fig. 4).

Site: Lwambogo

Adult tick numbers here were lower than at Bubulo. This lower level continued throughout the year with a slight increase in March/April 1965. There was a similar increase in numbers of immature ticks in the dry season from November to April.

No graph was prepared for *A. variegatum* at the Buhugu collecting site or at the 6,000 ft. collection sites as tick numbers were too low (Fig. 6).

Seasonal variations in numbers of *R. appendiculatus*

1. Elevation 3,600 ft.

Site: Bugobero

The seasonal variation was similar to that in Bugema for *R. appendiculatus*, except that an exceptionally high and unusual amount of rainfall in December 1964 was accompanied by a continuation of adult tick activity. Adult tick numbers then fell during the drier months of January, February and March 1965.

Site: Bugema

The largest numbers of adult ticks were present during the first and second parts of the main rainy season. There was some depression in numbers during the July/August drier period and a considerable drop in numbers throughout the dry season proper between November 1964 and March 1965. Immature ticks began at a low level during the first part of the rains but gradually increased in numbers from July onwards, reaching a peak during the dry season. There were more adults than immatures (Fig. 2).

Site: Salalira

Tick numbers were lower throughout the year than at Bugema or Bugobero. No larvae were found and very few nymphs, although these slightly increased in numbers during the dry season (Fig. 3).

2. Elevation 4,500 ft.

Site: Bubulo

The cycle began with a high number of adults at the beginning of the 1964 wet season. Numbers then gradually fell until October, rising again at the end

of the main rains and continuing to rise until reaching a peak again during the 1965 rains in April. There was a marked reduction in immature ticks during the rains and then a rise to a sudden peak during the only really dry month of January.

Site: Lwambogo

Adult tick numbers were depressed throughout the major part of the year, with highest numbers being found between November and April/May. Immature ticks were present in small numbers during most of the period, with a small increase to a peak in numbers during January in the main dry season (Fig 5).

No graphs were plotted for Buhugu collecting site for *R. appendiculatus*, as rainfall was very high and tick numbers very low. Similarly, no graphs could be prepared for the collecting sites at the 5,500 and 6,000 ft. elevations. Comparisons of these figures, with those at other sites, are given in Table I (see also Fig. 7).

Effects of altitude

Within the limits of altitude dealt with, it was not possible to detect any clear correlation between altitude and tick population.

Effects of rainfall

Figures 1-7 show a relationship between seasonal variations of all stages of the main species of ticks and rainfall distribution.

Effects of temperature and relative humidity

It was not possible to show any correlation between the small variations of temperature and humidity prevalent in Bugisu, and the variations in tick populations and species.

Vegetation, Crops and Husbandry

The effects of vegetation, crops and husbandry are best dealt with under the heading of " Discussion."

DISCUSSION

Tick populations (seasonal variations)

In Figs. 1-7, the graphs have been interpreted as a general indication of the true picture. It was possible to carry out only five collections during the period of the investigation.

A. variegatum

Elevation 3,600 ft. Sites: Bugobero, Bugema, Salalira

At this altitude there was a constant excess of immature ticks over adults, with the ratios tending to be widest at the drier parts of the year. The ratios of immature ticks to adults at Bugema during July 1964 and January 1965 were more than three times those at Bugobero, but if one considers larvae alone, the Bugobero graph shows that there were two main hatches of larvae during the year whilst at Bugema there was only one. This was almost certainly related to differences in rainfall distribution at the two sites.



FIG. 1a.—Bugobero. South Bugisu (3,600 ft.) Typical appearance of grazing in areas of natural bush not suitable for cultivation.

Rainfall histogram showing superimposed tick numbers for *Amblyomma variegatum* at collecting site Bugobero, South Bugisu. Altitude 3,600 ft.

1964 total rainfall 1138.3 mm. = 44.42 in.
Average rainfall 1147.0 mm. = 45.15 in.

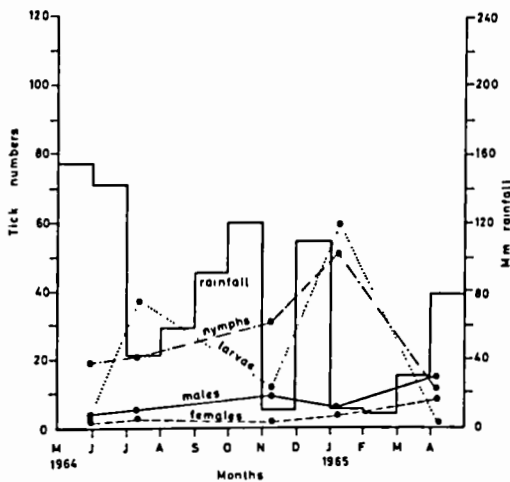


FIG. 1b.—Seasonal variations of *Amblyomma variegatum* in an area with good grass cover and definite wet and dry seasons.



FIG. 2a.—Bugema. Central Bugisu (3,600 ft.) Here there is also good grass cover mostly *Hyparrhenia rufa*. This is one of the better drained areas.

Rainfall histogram showing superimposed tick numbers
for *Rhipicephalus appendiculatus* at collecting site
Bugema, Central Bugisu. Altitude 3,600 ft.

1964 total rainfall 1377.8 mm. = 54.24 ins.
Average rainfall 1179.0 mm. = 46.37 ins.

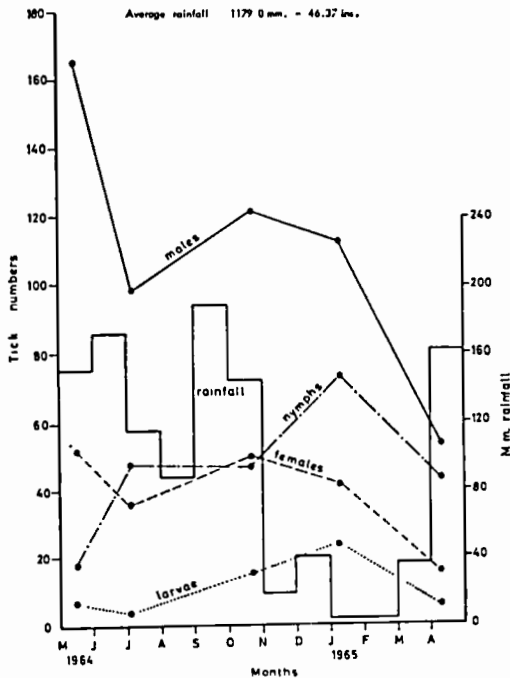


FIG. 2b.—Seasonal variations for *Rhipicephalus appendiculatus* under favourable conditions.

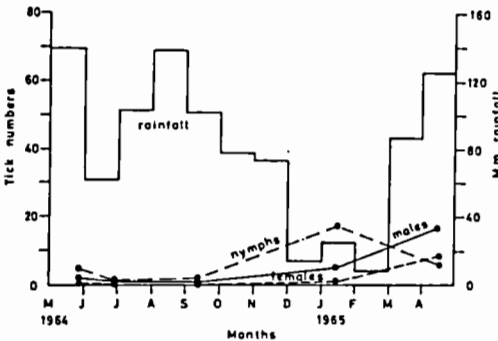


FIG. 3a.—Salalira. South Bugisu (3,600 ft.). Potentially a good grazing area but is overstocked and overgrazed. Note the beaten down appearance of the grass cover. Bare eroded patches are present but not visible in this photograph. Leafless broken stalks of *Hyparrhenia rufa* are visible near the camera.

Rainfall histogram showing superimposed tick numbers for *Amblyomma variegatum* at collecting site Salalira, North Bugisu. Altitude 3,600 ft.

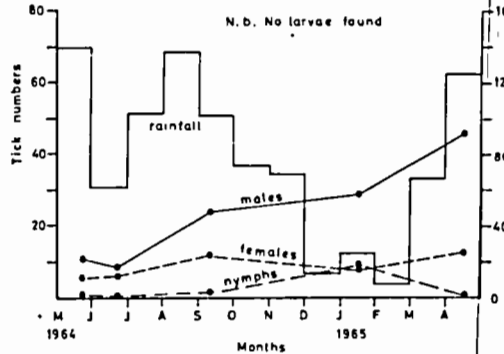
1964 total rainfall 1132.5 mm. = 44.85 ins.
Average rainfall 1044.1 mm. = 41.11 ins.

NB. Larvae not plotted - very few found.



Rainfall histogram showing superimposed tick numbers for *Rhipicephalus appendiculatus* at collecting site Salalira, North Bugisu. Altitude 3,600 ft.

1964 total rainfall 1132.5 mm. = 44.58 ins.
Average rainfall 1044.1 mm. = 41.11 ins.



FIGS. 3b and 3c.—Depressed seasonal cycles of *Amblyomma variegatum* and *Rhipicephalus appendiculatus*.



FIG. 4a.—Bubulo. South Bugisu (4,500 ft.). Bush covered slopes not suitable for cultivation. Good natural cover but the grasses are shorter and less dense. Rainfall is higher than at 3,600 ft. and better distributed. Dry season is very short.

Rainfall histogram showing superimposed tick numbers for *Amblyomma variegatum* at collecting site Bubulo, South Bugisu. Altitude 4,500 ft.

1964 total rainfall 1263.8 mm. = 50.4 ins.
Average rainfall 1317.1 mm. = 51.85 ins.

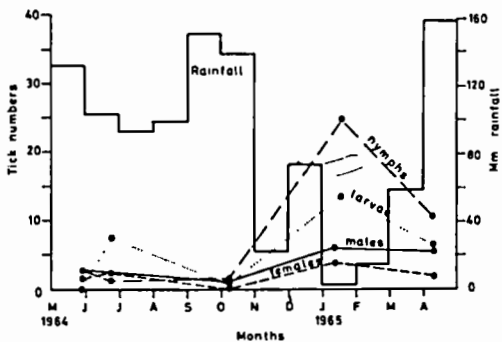


FIG. 4b.—Seasonal tick cycles are similar to those at lower altitudes but total numbers are reduced.



FIG. 5a.—Lwambogo. Central Bugisu (4,500 ft.). Grazing conditions here show a transitional stage between those at Bubulo in South Bugisu and those at Buhugu in North Bugisu.

Rainfall histogram showing superimposed tick numbers
for *Rhipicephalus appendiculatus* at collecting site
Lwambogo, Central Bugisu. Altitude 4,500 ft.

1964 total rainfall 1283.8 mm - 50.4 ins.

Average rainfall 1317.1 mm - 51.85 ins.

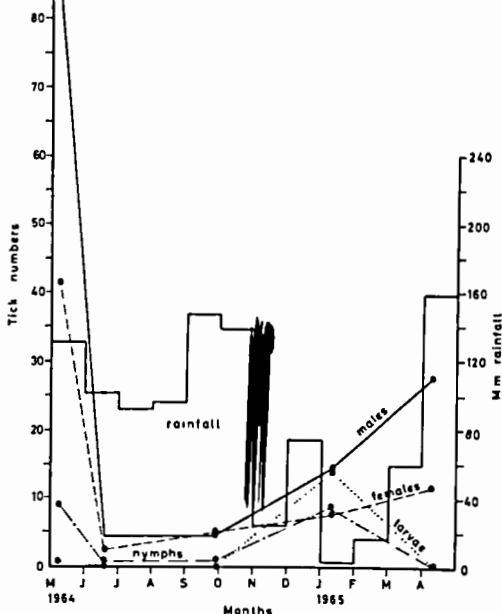


FIG. 5b.—Seasonal variations of ticks (characterized by *Rhipicephalus appendiculatus*) showing low tick numbers between June and November when cattle are kept almost exclusively in the hills.



FIG. 6.—Buhugu. North Bugisu (4,500 ft.). Here soil and rainfall combine to produce conditions almost identical with all 6,000 ft. sites. Cattle are tethered on small areas of short grass and given supplementary fodder. Tick numbers are too few to plot.

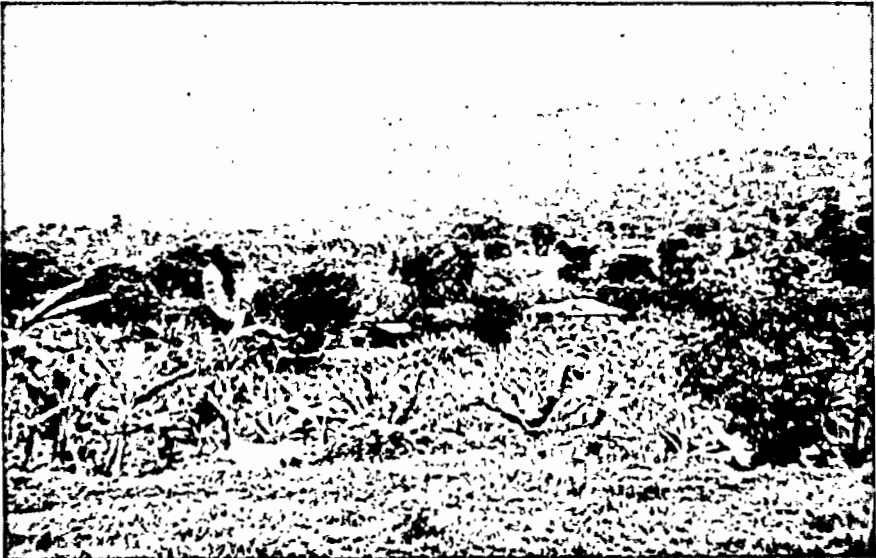




FIG. 7.

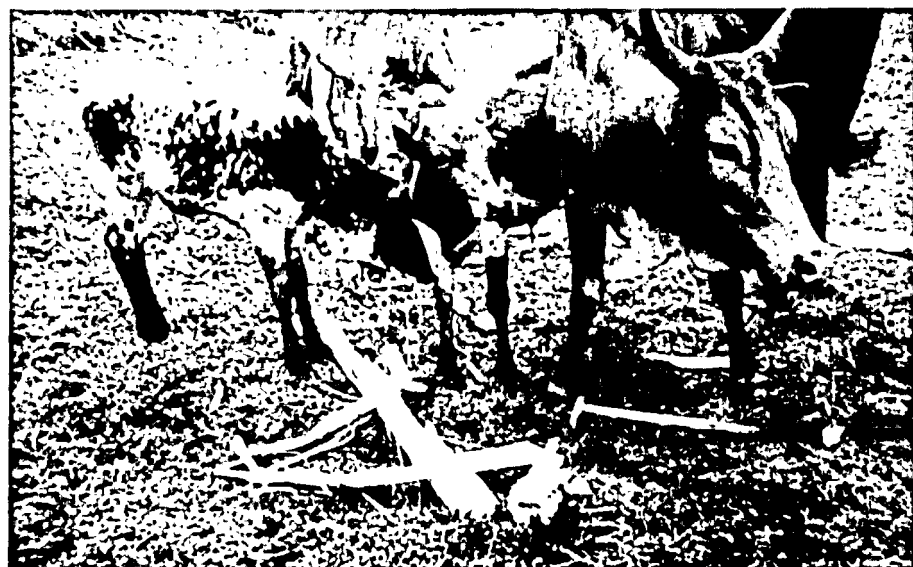


FIG. 7.



FIG. 7.—Typical appearance of grass cover at 6,000 ft. sites. Overgrazing is severe and supplementary feeding is practised. Ticks are either absent or too few to plot on a graph.

At Salalira the overall depression of tick numbers throughout the year could not be related either to rainfall or altitude differences and some other factor or factors must have been responsible, vegetational cover being the most likely. Considering that the immature stages of *A. variegatum* also feed on birds and small mammals, there must be a high death rate amongst immature ticks, to produce the wide ratio apparent between immatures and adults.

The overall picture for *A. variegatum* at this elevation was one of a relatively constant number of adult ticks throughout the year, with a slight increase in numbers at the beginning of each wet season. Immature ticks were always present in much larger numbers than adults, but reached their highest levels during the drier periods of July and January. At Salalira, although seasonal variations tended to follow the same general pattern, tick numbers were very much lower than elsewhere and the reduction could not be related to season, rainfall or altitude.

Elevation 4,500 ft. Sites: Bubulo, Lwambogo

Seasonal variations at these sites, although similar in pattern to those at 3,600 ft., were much less clear cut. At Lwambogo, an increase in the number of immature ticks did not occur in July. This illustrates the overall depression of tick numbers at this site as compared with Bubulo. A ratio between immature and adult ticks could not be determined in the main dry season, as no adults were found at that time. The figures for Lwambogo were to some degree distorted by a tendency of the farmers involved to take cattle to the plains for grazing.

R. appendiculatus

Elevation 3,600 ft. Sites: Bugobero, Bugema, Salalira

In contrast to *A. variegatum*, there was at these sites a lower number of

immature stages than adults. If one considers nymphs alone, these were at most times of the year in excess of adult females. The immature stages, especially larvae, prefer to feed on other small mammals and this would explain why the total numbers of immature ticks found on cattle were lower than the totals of adults.

With *R. appendiculatus* there was only one main hatch of larval ticks during the year, in the dry season between January and March. At Salalira there was a marked reduction in the number of ticks as compared with Bugobero and Bugema, and seasonal variations were very much less clear cut. This reduction in tick numbers and seasonal fluctuations could not be related to differences in altitude or rainfall and again some other factor or factors must have been responsible.

In summary, at this altitude, the numbers of adult *R. appendiculatus* rose during periods of increased rainfall and fell during the dry season. Immature ticks were at their maximum during the dry season between January and April. At Salalira tick numbers were very much lower than at the other two sites at 3,600 ft. The seasonal variations for both main species of ticks at this altitude are similar to those recorded by Matthyse (1954) in Northern Rhodesia, now Zambia.

Elevation 4,500 ft. Sites: Bubulo, Lwambogo

The seasonal cycle of adult ticks at Bubulo was similar to those at 3,600 ft. elevation up to the end of December 1964. At this point, following an unusually early start to the main rains, tick numbers began to increase again.

In Fig. 5, representing the Lwambogo site, the expansion of the left hand ordinate showing tick numbers, although necessary to show the seasonal variations more clearly, does give a distorted appearance of the magnitude of the drop in tick numbers between May and July 1964. Nevertheless the graph does reflect the habit of the local farmers in taking their cattle to the plains for grazing between the months of November and April/May. During the wet season the cattle remain almost exclusively in the hills and tick numbers are generally low. Thereafter tick numbers increase proportionately, depending on how frequently the cattle are taken to the plains for grazing, in areas where tick populations are higher.

Figures 1-7 show that the seasonal variations for the two main species of ticks appeared to be related to rainfall (see under "Effects of Rainfall"), but that factors other than rainfall must also be considered when attempting to interpret the overall level of activity at any particular site. The more obvious variations tended to become less apparent as tick numbers decreased. The total numbers of ticks per animal at any given site will be dealt with again under headings dealing with the effects of altitude, rainfall, vegetation and husbandry.

Other species of ticks

R. evertsi and *B. decoloratus* showed no significant signs of seasonal periodicity, possibly due to the fact that they were present in such small numbers and also that they are not three host ticks. This is in agreement with Theiler (1949, 1950) and Yeoman (1964).

R. tricuspis was found at all times of the year at one or other of the three lower collecting sites, whereas Wilson (1946) found that *R. tricuspis* was only present on cattle in the rainy season. The tick was only found in small numbers and it was not possible to detect any significant degree of seasonal variation.

Effects of altitude on tick species and populations (see Table III)

R. appendiculatus

In total numbers this was the most numerous of all ticks found. It was found at all sites and at all collections except for one at Bufumbo. The largest numbers per animal were found at the 3,600 ft. altitude, whereas Lewis (1939) and Wiley (1953) considered the tick to be most numerous between 4,800 ft. and 7,000 ft. At this elevation there was a considerable reduction in numbers at the Salalira site which could not have had anything to do with altitude. At the opposite extreme tick numbers at 6,000 ft. were uniformly very small and there would appear to have been a reduction in tick numbers related to altitude.

If, however, one considers the 4,500 ft. elevation these three sites showed a gradation in tick numbers varying from a total similar to that at 3,600 ft. to a total similar to that to be found at 6,000 ft. In Bubulo, for instance, there were relatively large numbers per head of cattle (90-180). At Lwambogo in Central Bugisu, average numbers were reduced to between seven and 136 per animal, whilst at Buhugu in North Bugisu, numbers were reduced further still to between one and four per animal. The reduction in numbers at 4,500 ft. was very similar to the reduction which could be seen between 3,600 ft. and 6,000 ft., and yet it occurred within the same altitude level of 4,500 ft. and could not, therefore, be attributed to altitude change.

These figures suggested that altitude as such was not the direct cause of the difference in numbers of this tick between 3,600 ft. and 6,000 ft.

A. variegatum

A. variegatum was second in numerical importance. It was present at all altitudes within the area under investigation and was present at all collections up to the 4,500 ft. level. At 5,500 ft.-6,000 ft., the tick was found at four collections in Bufumbo, two collections at Bukalasi and only one collection at Bulago. At 3,600 ft. the tick showed a similar distribution to that of *R. appendiculatus*, but in relatively smaller numbers. *A. variegatum* was normally outnumbered by between two and six to one by *R. appendiculatus*. There was a similar drop in numbers at Salalira unrelated to altitude.

Again at 4,500 ft. elevation there was a fall in tick numbers progressing from Bubulo collection site to Lwambogo and Buhugu collection sites in Central and North Bugisu respectively. These changes could not be attributed to altitude, since they occurred at the same altitude and yet reproduced the changes in tick numbers to be seen between sites at 3,600 ft. and 6,000 ft.

At 5,500 ft.-6,000 ft. the numbers of this species of tick per animal at Bufumbo collection site were similar to those at Buhugu at 4,500 ft. whilst numbers at 6,000 ft. at Bulago and Bukalasi sites were somewhat lower (0-1). It was not possible to detect any clear cut relationship between the incidence of *A. variegatum* and altitude within the limits of the altitudes studies. The work of Lewis (1931) is not really comparable here since the lowest altitude he considered was 6,000 ft.

B. decoloratus

The third most numerous tick was found at all altitudes and all sites except Bufumbo and Bulago at 6,000 ft. *B. decoloratus* was not found at all individual collections throughout the season except at Bugobero and Bugema collection sites

at 3,600 ft. At those collections where ticks were found, numbers were at all times very low. It was not possible to detect any significant variations relative to altitude and since only small numbers of this species were present at all altitudes and nearly all sites, one must assume that another factor or factors was responsible for the small numbers found.

R. evertsi

The species was found at 3,600 ft. at Bugobero and Bugema collecting sites in very small numbers (0-3) per animal. It was also found at 4,500 ft. at Lwambogo collecting site in Central Bugisu, also in very small numbers. It was not possible to determine any relationship with altitude. It is evident, however, from the work of Theiler (1950) that in South Africa, altitude was not a limiting factor for this tick. It would seem, therefore, that in Bugisu another factor other than altitude must be responsible for the small numbers present.

R. tricuspis

R. tricuspis was found at 3,600 ft. altitude collecting sites only. Numbers found were in all cases very small. It was found at all collections in Bugobero and Bugema, but at three collections only at Salalira. It was not possible to determine any relationship between tick numbers and altitude and again some other factor or factors must be considered as controlling numbers or occurrence. Certainly in the experience of Yeoman and Walker (1967) in Tanzania, altitude was not a limiting factor for *R. tricuspis*.

R. simus

R. simus was only found on cattle as a single sample at one site at 3,600 ft., but it was also present in side collections made from dogs at Bulago at 6,000 ft.

In general within the altitudes studied in Bugisu district, altitude as such did not appear to be a direct controlling factor for *R. appendiculatus*, *A. variegatum* and *B. decoloratus*. This is in agreement with the findings of Theiler (1949) with respect to *R. appendiculatus* and *B. decoloratus*. No conclusions in relation to effects of altitude could be drawn concerning *R. evertsi* and *R. tricuspis*. It was necessary to consider, therefore, factors other than altitude in attempting to decide on the reasons for the very small numbers of both ticks on cattle in Bugisu.

Effects of Rainfall on Tick Species and Populations

The relationship of tick numbers to rainfall at different times of the year is illustrated in Figs. 1-7. Graphs were prepared only for *R. appendiculatus* and *A. variegatum*, since these were the only species present which showed any demonstrable evidence of variation throughout the year. Annual rainfall averages are also set out in tabular form in conjunction with total tick numbers per animal in Table III. In the histograms rainfall has been entered in mm. only, on the right-hand ordinate, but annual totals have been shown in mm. and inches.

The histograms show that the main rainy season began normally in March/April and continued until October/November the same year. There was a drier period in the middle of the main rains, during the period June to August (the exact period and intensity depending on the situation of the tick collecting site). The main dry season was between November/December and February/March the following year.

For the two major species of ticks, the seasonal variations could be correlated quite closely with fluctuations in rainfall, and it was apparent that the consideration of annual rainfall totals alone was not sufficient when attempting to interpret variations in tick populations over the period of a year. The distribution of rainfall throughout the year must also be taken into account.

Changes in the tick populations could not be wholly explained by differences in rainfall levels or distribution. At Salalira collecting site, for instance, the rainfall was only 127 mm. or five inches less than at Bugema and yet the numbers of ticks of the two major species were from four to 10 times less than those at Bugema or Bugobero at the same altitude. Even the monthly rainfall figures did not show a great deal of difference when compared with similar monthly totals for Bugobero and Bugema. Furthermore, total rainfall at Salalira at an average of 1044 mm. or approximately 41 inches was well within the range of 30 to 50 inches suggested by Wilson (1953) as suitable for the optimum activity of *A. variegatum* and *R. appendiculatus*. Theoretically, therefore, both main species of ticks should have been numerous at Salalira, but were not. It was necessary, therefore, to consider other ecological factors besides rainfall in determining the cause of the drop in numbers of the major species of ticks at Salalira.

If one studies the figures for the 4,500 ft. elevation, there was here a general rainfall level 152 to 254 mm. or six to 10 inches in excess of the averages at 3,600 ft. This was accompanied by a drop in tick numbers. This drop was most marked at the Buhugu tick collecting site in North Bugisu, where tick numbers were as low or almost as low as at 6,000 ft.

At Buhugu also, average rainfall was in excess of both the other 4,500 ft. tick collecting sites by 152 mm. or six inches. This particular year (1964) the rainfall exceeded that of the other two 4,500 ft. sites by 432 mm. or 17 inches. The actual total of rainfall here in 1964 was 1745.9 mm. or well over 68 inches. This was 291 mm. or over 11 inches in excess of the average.

Nevertheless the relative decrease in total tick numbers of both main species at Buhugu (as compared with other 4,500 ft. sites) was very much larger than the relative increase in rainfall, but a study of the distribution of rainfall at Buhugu shows that the dry season is virtually eliminated. In June 1964, rainfall at Buhugu was more than double that at other 4,500 ft. collecting sites. In July it was one-third more and in September almost double. Even in August, rainfall was in excess of the other two sites.

During what should have been the dry season proper between November 1964 and March 1965, rainfall at Buhugu never went below 24 mm. or one inch of rain per month and for all except one month was more than this figure. This is reflected in the very low tick population in general and the fact that the seasonal increases in immature ticks did not occur to any demonstrable extent.

At the 6,000 ft. elevation collecting sites, the situation was rather similar to that at Buhugu, except that rainfall levels were even higher. This would partly explain both the similarity of the tick populations at Buhugu and the higher altitude sites and also the general uniformity and low level of the tick populations at the higher altitude sites themselves. It does not however, explain the differences between the tick populations at Bubulo and Lwambogo, since here rainfall totals and distribution were the same at both sites, although at a lower level than Buhugu. Neither does it explain the low tick populations at Salalira.

One must, therefore, conclude that although rainfall distribution does have a

very strong influence on tick populations, some other factor or factors is also involved which must be considered in conjunction with rainfall. Furthermore, there are the possible secondary effects of rainfall on tick populations and species, through its effects on vegetation, crops, husbandry and human population.

Considering *R. evertsi*, *B. decoloratus* and *R. tricuspis*, here it was not possible to demonstrate changes or fluctuations of tick populations under the effects of rainfall variations. There was, however, a strong possibility that the rainfall totals in Bugisu were at or near the upper limits of tolerable rainfall for these three ticks. *R. tricuspis*, for instance, did not occur anywhere where rainfall exceeded 1143 mm. or 45 inches. *R. evertsi* did not occur in areas with rainfall above 1270 mm. or 50 inches per annum. *B. decoloratus* did not occur in areas with rainfall above 1651 mm. or 65 inches per annum.

In conclusion it is suggested that from the available evidence tick populations are strongly influenced by rainfall levels and distribution. In Bugisu it could be seen that for *R. appendiculatus* and *A. variegatum*, total rainfall was not so important as seasonal distribution. With the remaining ticks, i.e. *R. tricuspis*, *R. evertsi* and *B. decoloratus*, these appeared to be affected by the total levels of rainfall in Bugisu, i.e. one must consider for certain groups of ticks not only a lower rainfall toleration limit, but also an upper rainfall toleration limit. This is in agreement with the findings of Yeoman and Walker (1957). Furthermore, any predictions one might make about the tick populations in any area on a basis of average rainfall must be tempered by a consideration of rainfall distribution also.

Tick populations are not static but in a dynamic association with the variable aspects of climate, such as rainfall. This is illustrated by the dramatic changes in the tick borne disease picture which can follow the extreme changes in rainfall levels and distribution in "wet" or "dry" years.

Effects of Temperature and Humidity on Tick Species and Populations

Table II shows the annual temperature and relative humidity figures available for Bugisu district. This table illustrates that there was very little variation in either temperature or humidity in Bugisu during 1964/5 at the altitudes given. It was not possible to show any correlation between the very small variations in temperature and relative humidity and the variations in tick populations or species.

If by interpolation one estimated the mean maximum and minimum temperatures at 6,000 ft. as approximately two to three degrees lower than those at 4,000-4,500 ft., this still does not give temperatures low enough to have any great effect on the variability of the tick populations. Similarly the relative humidity at 6,000 ft. would not be low enough to have any appreciable effect on those ticks known to be vulnerable to desiccation. Certainly at no time did the known relative humidity fall below 58% and for most of the year was between 70% and 90% for those areas from which figures are available. It was, therefore, not possible to show any correlation between tick populations and relative humidity within the range prevalent in Bugisu.

Effects of Vegetation, Crops and Types of Husbandry on Tick Species and Populations

In Map No. 2 the tick collection sites are marked on the Uganda 1:250,000 Vegetation Map to show the basic vegetation areas within which each site was

located. But the collection site records in Tables Ia to Ii, and also the photographs, show that the original vegetation has in parts of Bugisu given way to cultivated crops. These crops are often permanent crops such as bananas and coffee. In the hill areas especially this has had a great effect on the amount of grazing available for livestock and the type of cattle husbandry in use.

Cattle in these areas have had to be tethered to avoid crop damage. In turn, tethering has been the cause of severe overgrazing on the already depleted and overstocked pasture land available. The provision of banana leaves and banana stems as a supplementary feed has hence become common practice in the overgrazed hill areas (see photographs).

From the tick collection and site data it will be seen that the common factor noticeable at the sites where tick numbers were so low as to be insignificant, was that they were all areas suitable for heavy cropping with permanent crops of bananas and coffee. This had been accompanied by the expected dense human population and severely reduced grazing for cattle with the results already explained above. Engorged female ticks from tethered animals are only able to drop off the cattle within the overgrazed area. Not only are the engorged females unlikely to find sufficient protective vegetation but any larvae which do hatch out are exposed to the direct effects of the sun and rain.

The spread of ticks from infested to non-infested areas is also severely limited in those areas where permanent tethering of cattle in the same place is practised. Even in areas not suitable for permanent crops, any severe overgrazing for whatever reason has a similar effect and results if maintained, in a reduction of tick numbers following the exposure of the tick microclimatic environment to direct strong sunlight and heavy erosive rainfall.

This would explain why tick numbers were so low at Salalira compared with Bugema and Bugobero. For the period of this survey, Salalira was an overstocked, overgrazed area with small eroded patches here and there. Bugema and Bugobero on the other hand both had very good grass cover and plenty of tree-bush and scrub.

The degree of vegetational cover plus the presence of considerable permanent crops and some tethering of the cattle would also help to explain the reduction in tick numbers at Lwambogo when compared with Bubulo at 4,500 ft. The Bubulo site was located in a *Combretum* savannah area with some *Hyperrhenia* and *Acacia* and a good rainfall of 1270 mm. or 50 inches plus. The soil being stony, the site was not suitable for cropping and the original vegetation prevailed with a good grass and bush cover. This afforded a good habitat for ticks in contrast to the Lwambogo site.

Conclusions

Vegetation in itself is a true reflection of the total climatic forces in any area and as suggested by Hornby (1934) the degree of vegetational cover is a good indication of the possible level of activity of *R. appendiculatus* and *A. variegatum*. This was shown to be true for *R. appendiculatus* by Yeoman (1967) in Tanzania.

In general it would be true to say that in this district the most important factors affecting tick numbers and the variations in populations and species were:

- (a) Rainfall distribution,
- (b) Vegetational cover (which is closely tied in with the stocking rate).

Other factors were:

- (c) The total annual rainfall,
- (d) Types of husbandry, crops and density of human population.

None of these factors can be considered as an entity in itself since all are interacting to produce the total tick environment but they also affect each other to some extent and thus may exert a secondary "pressure" on the tick habitat.

SUMMARY

1. This is the second of two papers devoted to a study of the effects of altitude, climate, vegetation and husbandry on the tick populations of the Bugisu district of Uganda.
2. A brief outline is given of the results of the survey recorded in the first paper together with further details of the climate and geography of the area.
3. Tick collection sites are marked on the Uganda 1:500,000 vegetation map and the 1:250,000 contour map. All relevant information concerning each site is recorded separately. All available data for the district, concerning rainfall, temperature, and relative humidity is also recorded separately.
4. Seasonal variations in the numbers of the two major ticks, *R. appendiculatus* and *A. variegatum* are shown graphically. Overall, the graphs for *R. appendiculatus* show a general increase in immature ticks during the dry months of January/February and a reduction in the numbers of immature ticks, with an increase in adult ticks during the wet months from May to October.

The graphs for *A. variegatum* show a relatively constant level of adult ticks all the year round. Immature ticks were present in greater numbers than adults at most times of the year, with peaks of activity during the dry months of January/February and sometimes in July also.

5. *R. evertsi*, *R. tricuspis* and *B. decoloratus* were only found in small numbers and there was no evidence of seasonal variation. Only one sample of *R. simus* was found.
6. Seasonal variations of *R. appendiculatus* and *A. variegatum* ticks are shown to be related to rainfall fluctuations, by plotting monthly rainfall (as histograms), against the numbers of ticks. For *R. evertsi*, *R. tricuspis* and *B. decoloratus*, no such relationship could be demonstrated and it is considered that these ticks, although present in Bugisu, were experiencing conditions approaching the upper tolerable limits of rainfall for these species. For the major species of ticks present, seasonal variations and distribution of rainfall were of much greater importance than annual totals.
7. It was not possible to relate variations in the species and populations of ticks to changes in altitude within the range of altitudes studied in Bugisu. This means that between 3,600 ft. and 6,000 ft., altitude did not in itself have any controlling influence over the cattle ticks present in the district.
8. It was not possible to relate variations in the species and populations of ticks to changes in temperature or relative humidity, both factors remaining fairly constant throughout the year.
9. The two major species of ticks are shown to be sensitive to reductions in vegetational cover which in turn are related to seasonal rainfall, stocking rate, types of crops and methods of husbandry in use.

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Résumé

1. Il s'agit ici de la deuxième de deux communications consacrées à une étude des effets de l'altitude, du climat, de la végétation et des méthodes agricoles sur les populations de tiques du district du Bugisu en Ouganda.
2. Bref aperçu des résultats de l'enquête décrite dans la première communication, avec de plus amples détails sur le climat et la géographie de la région.
3. Les emplacements où des tiques ont été recueillies sont marqués sur la carte de la végétation au 1:500.000 de l'Ouganda, ainsi que sur la carte hypsométrique au 1:250.000. Toutes les informations appropriées sur chaque emplacement sont énumérées séparément. Toutes les données disponibles sur le district, concernant les précipitations atmosphériques, la température et l'humidité relatives, sont également notées séparément.
4. Variations saisonnières du nombre des deux principales tiques: *R. appendiculatus* et *A. variegatum* sont indiquées sous forme de graphiques. D'une façon générale, les graphiques relatifs à *R. appendiculatus* montrent une augmentation générale des jeunes tiques pendant les mois secs de janvier/février et une réduction du nombre des jeunes tiques, avec une augmentation des tiques adultes pendant les mois humides de mai à octobre.

Les graphiques d'*A. variegatum* montrent un niveau relativement constant de tiques adultes pendant toute l'année. Les jeunes tiques étaient plus nombreuses que les adultes pendant presque toute l'année, avec des crêtes d'activité pendant les mois secs de janvier/février et parfois aussi en juillet.

5. *R. evertsi*, *R. tricuspis* et *B. decoloratus* ne se trouvent qu'en petit nombre et ils ne semblent pas y avoir de variation saisonnière. On ne trouva qu'un seul échantillon de *R. simus*.

6. On peut voir que les variations saisonnières des tiques *R. appendiculatus* et *A. variegatum* sont fonction des fluctuations pluviométriques, ainsi que l'indique le tracé des précipitations mensuelles (sous forme d'histogrammes) contre le nombre de tiques. Pour *R. evertsi*, *R. tricuspis* et *B. decoloratus*, on ne pouvait démontrer aucun rapport et l'on pense que ces tiques, tout en étant présentes à Bugisu, subissaient des conditions approchant des limites maximum tolérables de précipitations atmosphériques pour ces espèces. Dans le cas des espèces principales de tiques présentes, les variations saisonnières et la distribution des pluies étaient de plus grande importance que les totaux annuels.
7. Il n'a pas été possible de déterminer une relation entre les variations des espèces et des populations de tiques d'une part et les changements d'altitude dans le cadre des altitudes étudiées au Bugisu. Ceci signifie qu'entre 11.000 et 18.000 mètres, l'altitude en soi n'a pas une influence déterminante sur les tiques du bétail qui se trouvent dans ledit district.
8. Il n'a pas été possible d'effectuer une corrélation entre les variations des espèces et des populations de tiques et les changements de température ou d'humidité relative, les deux facteurs demeurant assez constants pendant toute l'année.
9. Les deux principales espèces de tiques sont sensibles aux réductions de la couverture végétale qui, elles-mêmes, dépendent de la pluviosité saisonnière, du nombre de bêtes pour une superficie donnée, du type de récolte et des méthodes culturales employées.

PROBLEMES DU NOMADISME AU MALI*

I. KONATE † et Hama Ag MAHAMOUD ‡

Le code forestier du Mali admet comme limite Sud de nos zones arides, le 15^{ème} parallèle Nord. Les zones arides situées au Nord de cette limite couvrent 830.000 km.², soit 67% de la superficie totale du Mali.

Le Sahel malien ou rivage du Sahara est une large bande sablonneuse, parsemée de dunes, comprise grosso-modo entre les 15 et 18^{ème} parallèles Nord.

Couvrant environ 460.000 km.², soit 39% de la superficie totale, le Sahel malien se distingue par des caractéristiques physiques, économiques et humaines bien marquées. En outre il soulève des problèmes particuliers dont les solutions retiennent toute l'attention de notre Pays.

I. DONNEES GEOGRAPHIQUES ET DEMOGRAPHIQUES

La zone Sahélienne au Mali peut être divisée en deux parties:

— la zone Sahélienne Nord avec moins de 300 mm. d'eau par an, présente quelques caractères Sahéliens. C'est une zone de dunes fixées et de steppe à mimosées. Le disparition du had (*Cornulaca monacantha*) apprécié du chameau en indique la limite Sud.

— la zone Sahélienne Sud avec 300 à 500 mm. de pluie, d'une durée de 3 mois présente une végétation herbacée plus fournie et végétation arbustive constituée surtout d'acacia.

Par ailleurs la zone Sahélienne d'Ouest en Est comprend (voir Fig. 1).

— le Sahel Soudanais à l'Ouest,

— le Delta Central Nigérien au centre,

— le Plateau Central Nigérien et la boucle du Niger à l'Est.

Le Climat: Le Sahel malien est caractérisé par un climat sec avec de grands écarts de température. Deux saisons se partagent l'année: la saison sèche d'Octobre à Juin et la Saison pluvieuse la plus courte, de Juillet à Septembre. Les précipitations diminuent au fur et à mesure que l'on remonte vers le Nord: au Sud il tombe en moyenne 400 mm./an; Tessalit au Nord enrégistre 50 mm./an.

Végétation: L'existence des deux zones signalées entraîne celle des zones de végétation.

Dans le Nord Sahélien, la végétation est clairsemée et présente des caractères tropophiles accusés: grand développement des parties ligneuses et épineuses, feuilles très réduites.

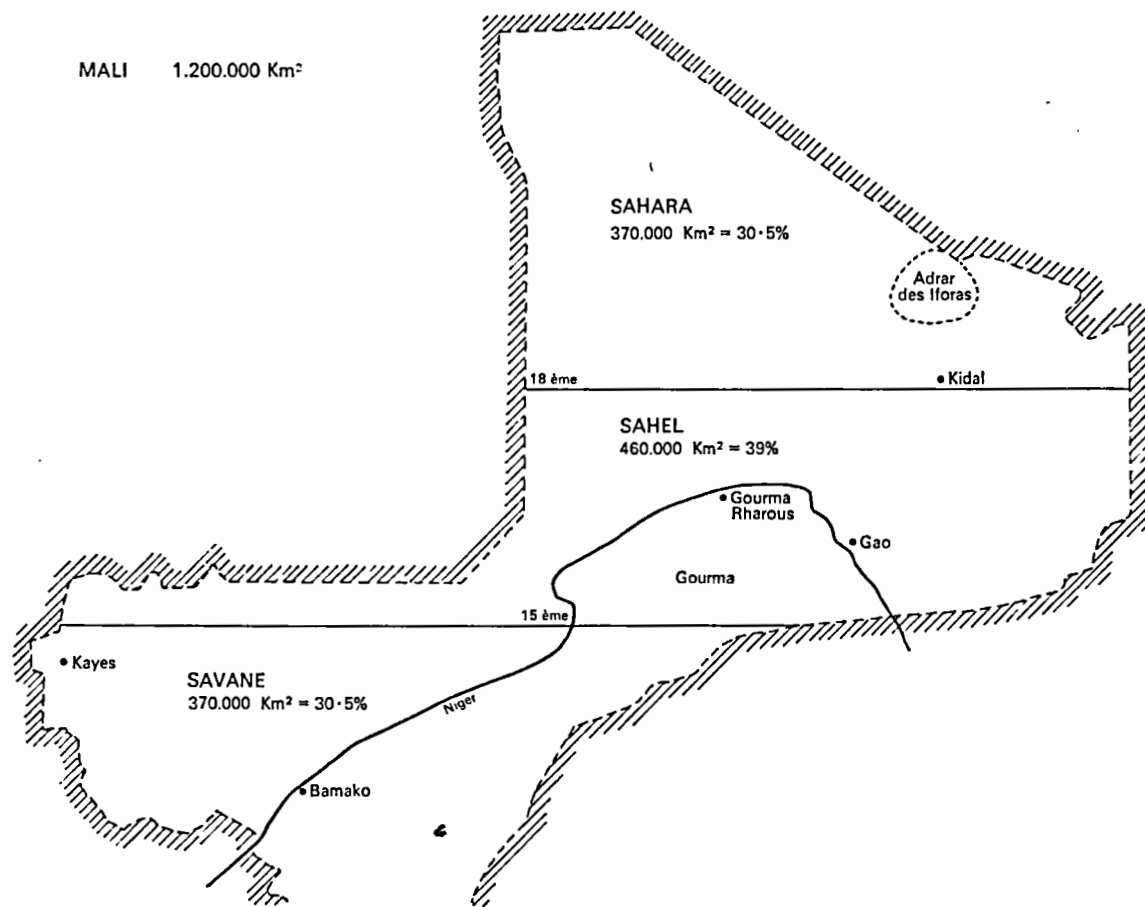
La zone Sud présente une végétation moins tropophile avec un tapis herbacé plus abondant où les graminées dominent.

Dans le Sahel Soudanais le terrain est parfois accidenté avec des plissements

* Rapport présenté à la réunion sur les problèmes du nomadisme dans la région sahélienne en Afrique, organisée par le Bureau International du Travail, à Niamey (9-20 Septembre, 1968).

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rocheux. Dans le Delta Central le sol est principalement constitué par des alluvions et des sédiments avec quelques affleurements de latérite ferrugineuse et de grès siliceux. Il présente de nombreux lacs qui s'épanouissent au Nord du Plateau Dogon sur les deux rives du fleuve. L'ensemble forme un lacs de chenaux inextricable transformé en marécage lors de l'inondation annuelle.

Le Plateau Central Nigérien et la boucle du Niger ne sont fécondés que par le fleuve Niger, qui coule sur une largeur de 4 à 5 km. selon les régions.

La rive gauche est bordée par le Haoussa et la rive droite encercle le Gourma.

Au Nord et au Nord-Est de Tombouctou, l'Azaoud constitue un vaste ensemble de Hamadas et d'ergs qui va se perdre dans le Sahara.

Au Nord-Est de Bourem le massif montagneux de l'Adrar des Iforas d'une altitude de 500 à 1.000 m. forme un flot à climat Sahélien au milieu de la zone Saharienne.

A l'Est de la branche descendante du Niger se trouvent quelques vallées vestiges d'anciennes rivières, telles sont les vallées du Tilemsi aboutissant à Gao; la vallée d'Indeliman aboutissant à Tabango; la vallée de l'Azaouack près de Ménaka. Celles de l'Azaouack et de l'Assaraké qui sont les plus importantes descendent vers la mare permanente d'Anderamboukane.

II. DONNEES DEMOGRAPHIQUES

Le Sahel malien est occupé par des sédentaires, des nomades et sémi-nomades.

Les Nomades

1^o) — **Les Touaregs:** de race blanche et d'origine berbère islamisés, sont les descendants des tribus berbères Godala, Lemtouna, Lemta. Dans le passé, tous n'étaient pas entièrement nomades car on leur doit la fondation de grandes villes du Moyen âge africain telles que Tombouctou, Takeda, Tadmeka, Araouane. Actuellement ils s'adonnent entièrement à l'élevage transhumant à travers toute la 6ème région économique du Mali. Aussi loin que remontent les données historiques, ils firent partie intégrante de cette zone géographique. Ils furent tour à tour sous domination Mandingue, Songhoï, Marocaine, Peulh. Ils reprirent leur autonomie après l'effondrement de ces hégémonies et rétablirent leur autorité sur la boucle du Niger, jusqu'à la conquête française.

2^o) — **Les Maures:** eux aussi descendants des berbères islamisés, les Zénagas, sont éleveurs nomades. Ils vivent principalement dans l'Azaouad et dans le Cercle de Bourem.

3^o) — **Les Peulhs:** répandus dans tout le Sahel, ils sont généralement sémi-nomades. A une certaine époque de l'année, ils transhument à travers les différentes régions et même en Mauritanie (Peulhs Toronké).

Les Sédentaires: dans le Sahel Soudanais ils comprennent surtout les Sarakolé, les Kassonké; dans le delta Central et dans la boucle du Niger on trouve les Songhoï, qui furent les bâtisseurs d'empires prospères jusqu'au XVIIème siècle.

Tandis que les nomades suivent leurs troupeaux au gré de longues transhumances coutumières, les sédentaires s'adonnent à l'agriculture; les Sarakolé ont une vocation de commerçants, et un goût du voyage qui les amène vers les contrées les plus lointaines. On les trouve dans la plupart des autres pays africains et ce sont eux que l'on découvre dans plusieurs pays d'Europe.

Le tableau ci-dessous donne une idée de l'importance des différentes populations.

V. ADMINISTRATION DES POPULATIONS NOMADES

La République du Mali est divisée en régions, cercles, arrondissements, communes, villages, tribus et fractions nomades.

Parmi ces collectivités deux sont essentiellement nomades :

— la tribu et la fraction.

1^o) — La fraction correspond au sous-clan. Elle est administrée par un Conseil de fraction élu, présidé par un chef de fraction. Cet organisme a des prérogatives diverses en matière d'administration locale.

2^o) — La tribu: plusieurs fractions constituent une tribu, placée sous l'autorité d'un chef de tribu. La tribu correspond au clan.

3^o) — L'arrondissement: c'est la collectivité territoriale immédiatement supérieure à la tribu. Sous l'autorité d'un chef d'arrondissement, elle administre les populations nomades ou sédentaires sur son ressort territorial.

4^o) — Plusieurs arrondissements forment le cercle administré par un Commandant de Cercle.

5^o) — L'ensemble de ces cercles constitue une région économique. Au Mali il y a six régions économiques et 42 Cercles.

VI. PROGRAMMES NATIONAUX POUR LE DEVELOPPEMENT DU SAHEL

A. Généralités

Le problème du développement du Sahel malien retient toute l'attention de notre Gouvernement. Tout plan de développement de cette zone doit tenir compte des conditions écologiques et humaines.

Le premier préalable dans ce domaine est de maintenir et de renforcer l'unité et l'intégrité de nos jeunes Etats; surtout quand il s'agit de populations qui ont mené pendant des siècles une vie plus ou moins marginale par rapport au reste de la Société. L'objectif final est l'intégration des nomades à tous les aspects de la vie du pays.

Le deuxième préalable est bien la sédentarisation, même relative. Mais là les méthodes d'approche peuvent être différentes. Pour certains, il s'agit de sédentariser d'abord les nomades eux-mêmes, dans le cadre d'un programme socio-culturel; pour d'autres c'est l'élevage qu'il faut fixer en premier lieu en améliorant les conditions du milieu.

Il est vrai que c'est la première voie que l'on a suivie jusqu'à présent par la mise en œuvre d'un programme social important: ouverture d'écoles nomades, de dispensaires, forage de puits suivant les routes de transhumance etc...

Les résultats sont ce qu'ils sont: les enfants des nomades désertent souvent l'école; des maîtres en se réveillant le matin ne retrouvent ni tente, ni élèves, ni cheptel; les structures claniques dans le cadre du patriarcat n'évoluent guère.

La seconde voie qui consiste à s'intéresser d'abord au bétail doit de plus en plus retenir l'attention des pays confrontés aux problèmes de développement des zones sahéliennes.

En effet dans ces zones, l'homme vit pour son troupeau, il le suit. Sédentariser l'éleveur, implique d'abord de fixer le troupeau. **Autrement dit la sédentarisation des nomades passe par la sédentarisation de leurs troupeaux.**

C'est à partir de cette analyse que mon pays a élaboré les lignes directrices d'un plan de développement du Sahel Malien où l'activité principale est l'élevage.

B. La Fixation des Troupeaux

L'élevage nomade est un élevage de nature, en équilibre avec le milieu environnant. Son évolution est directement liée à la modification de ce milieu, surtout en ce qui concerne l'eau et les pâturages.

1^o)—**L'Abreuvement des Animaux:** Le problème de l'eau revêt une importance capitale dans le Sahel; il y est la mesure de toute chose. Les troupeaux placés dans la nécessité de ne pas boire ou de parcourir de grandes distances pour aller jusqu'aux points d'eau se trouvent en face d'un dilemme : réunis périodiquement en grand nombre autour des puits, ils meurent de faim; ramenés sur les pâturages exploitables de plus en plus lointains : ils sont condamnés mourir de soif.

Depuis plusieurs années, le Mali a entrepris une politique d'hydraulique pastorale tendant à multiplier les disponibilités en eau par tous les moyens : forages de puits avec ou sans éoliennes, surcreusement de mares, barrages de retenue etc. Ces travaux d'investissement qui représentent déjà plusieurs milliards seront pour suivis au cours de nos futurs plans de développement, après bien sûr les résultats d'études hydrogéologiques en cours dans les zones intéressées—

2^o)—**L'Alimentation:** L'alimentation des animaux en zone Sahélienne est exclusivement assurée par les pâturages naturels où prédominent les graminées fourragères qui comprennent deux groupes principaux; les graminées aquatiques des pâturages exondés et celles des terrains cultivés, des jachères et des terrains sablonneux. La richesse de ces pâturages, leurs variations suivant les saisons ont une influence directe sur l'état du troupeau. En hivernage, l'herbe pousse, verte abondante et le troupeau s'en hepait. En saison sèche, elle devient rare, ligneuse et les animaux tombent dans un état de misère physiologique.

1. Facteurs Négatifs: Dans le cadre de l'amélioration des pâturages sahéliens, le Mali mène une action vigoureuse contre les facteurs de désertification dûs à l'homme:

- a) — destruction des arbres forestiers, soit par besoin de combustible (domestiques, pour le fumage du poisson), soit pour les chèvres.
- b) — surpâturage menant au développement des espèces indésirables ou nuisibles et favorisant l'extension des espèces annuelles.
- c) — piétinement et tassement des sols aggravant les phénomènes d'érosion.
- d) — feux de brousse destructeurs des graminées tendres et nutritives.

2. Actions d'amélioration: deux étapes sont à prévoir:

a) — **Modifications des conditions microclimatiques.**

Une solution est à trouver en matière de ravitaillement en combustible: le Mali se propose d'amener certaines collectivités (surtout les pêcheurs, les semi-sédentaires) à planter, le long du fleuve Niger et dans les zones de sédentarisation et de concentration périodiques (campements, villages), des espèces ligneuses xérophytes à reproduction végétative facile. Une journée de l'arbre est consacrée annuellement, en hivernage, à ce travail de reforestation dans tout le pays. Le coup de hache du chevrier est sévèrement réprimé; les feux de brousse sont strictement interdits en zone Sahélienne.

b) — **Amélioration et régénération des pâturages.**

Les modalités d'amélioration des pâturages sont maintenant bien connues. On peut envisager:

— soit une simple mise en défens de plus ou moins courte durée dans le cadre d'une rotation des pâturages. Il s'agit dans ce cas de zones peu dégradées.

— soit la création nouvelle de pâturages nécessitant des sémis et une mise en défens absolue. Il s'agira alors de zones dégradées ayant atteint le seuil de désertification.

C. Organisation de l'élevage en milieu Sahélien

Jusqu'à une époque récente, les différentes interventions tendant à améliorer l'élevage Sahélien, dans le domaine de l'abreuvement (forages de points d'eau) et dans le domaine de l'alimentation (accès à des nouveaux pâturages) ont eu pour but de déconcentrer les troupeaux, mais toujours dans le cadre d'un **élevage extensif nomade**.

Cet élevage restera dans cet état tant que certaines traditions de l'éleveur faites d'habitudes ancestrales ne seront pas vaincues. Il est vrai par ailleurs que les pays à élevage intensif s'adaptent difficilement à la conception de l'élevage extensif rationnel et industriel. Pour ces pays, la richesse agricole se résume tout naturellement en hectares de blé ou de vigne et les vrais pâturages sont ceux d'une Normandie aux herbes drues avec des bœufs gras. Le Sahel et la brousse les déconcertent; le nomadisme des tribus pastorales semble un pittoresque anachronisme que doivent chanter les poètes:

“ Leur errance a duré des siècles et des lustres
Encore, en bien des points vaguent-ils exilés
Transhumance, pacage sont occasion frustres
Pour entreprendre la piste, amateurs exilés.”

La prose romantique elle-même décrit le Sahel avec une note nostalgique: “ C'est également dans cette zone Sahélienne que les bergers y perpétuent la tradition millénaire des pâtres Chaldéens dont ils ont l'intelligence vive, l'esprit observateur, la philosophie sereine venue de la contemplation des larges espaces et des nuits calmes et étoilées, trouées par le seul beuglement des zébus et le canement de l'hyène.”

Maintenant nous pensons qu'il est temps que les pays qui se préoccupent du développement des zones sahéliennes surtout dans le domaine pastoral essaient de comprendre comment des élevages ambulants comme les nôtres ont pu être modernisés dans les vastes paddocks de l'Australie, de l'Argentine ou de l'Uruguay.

Dans ces groupes d'élevage, l'unité de superficie est le millier d'hectares: aux USA le King-Ranch du Texas a 500.000 ha; en Rhodésie du Nord la ferme “ d'Inyanga ” dispose de 44.000 ha etc....

Il convient donc de sortir des sentiers battus depuis plusieurs décades et dont les résultats, en ce qui concerne la modernisation de l'élevage sahélien sont bien minces.

En s'inspirant des expériences réussies ailleurs, on peut envisager les étapes suivantes pour l'organisation d'un élevage rationnel en milieu sahélien.

1^o) — choix de l'unité d'élevage

2^o) — étude et utilisation des superficies de pâturages

3^o) — exploitation.

1^o) — **Définition de l'unité d'élevage:** Nous entendons par unité d'élevage, la forme de propriété des exploitations d'élevage. Il y a trois possibilités:

a) — **Les exploitations individuelles ou familiales:** Etant donné le coût des investissements au départ, il est difficile à un individu ou à une famille ou tribu de conduire une telle organisation.

b) — **Les exploitations coopératives:** Il s'agit de grouper dans la zone d'élevage des éleveurs de plusieurs tribus en vue d'exploiter en commun: eau, pâturages et autres facilités dans le cadre d'une coopérative d'élevage.

c) — **Les exploitations pilotes:** seraient des exploitations autonomes assurées au départ de la couverture financière de l'Etat seul ou en association avec des organismes privés.

Le choix incombe à chaque pays. Néanmoins il semble, que compte tenu des réalités socio-économiques africaines les deux dernières possibilités offrent plus de chance de réussite.

2^o) — **Etude et utilisation des pâturages:**

Les conditions d'une bonne utilisation sont:

- la délimitation et la connaissance préalable du pâturage
- l'eau
- la clôture

a) — **La connaissance du pâturage:** Implique, en se référant aux méthodes des grands pays d'élevage:

— l'inventaire des espèces constituant le pâturage (espèces et leur cycle biologique, valeur bromatologique, appetabilité, carte des pâturages, etc....)

— l'étude de la nature et de la topographie du sol (dunes, cuvettes, pentes, etc....)

— la détermination de la capacité de charge

— l'établissement d'un programme d'exploitation en fonction des taux d'utilisation des différentes parties du pâturage par les animaux.

b) — **Le problème de l'eau:** En zone irriguée, les canaux adducteurs peuvent être utilisés (cas du Ranch de Niono au Mali). Dans le cas contraire toute possibilité d'abreuvement doit être exploitée: petit barrage de retenue, surcreusement de mares, réserves d'eau de pluie à l'aide d'impluvium comme en Australie, puits munis de moyens d'exhaure adéquats (éolienne ou pompes).

c) — **La clôture:** On peut dire que c'est de l'usage de la clôture que datent en Argentine et en Uruguay les progrès inouïs accomplis par l'élevage. En effet la clôture donne la possibilité de **séparer les animaux** en plusieurs lots et de préparer la sélection des sujets en vue de la reproduction, de l'élevage et de l'engraissement au lieu d'un seul troupeau laissé à lui-même comme on le pratique actuellement; l'usage de la clôture simplifie la manipulation des animaux et surtout permet une **rotation des parcelles** — Sans doute les frais de clôture sont extrêmement élevés, surtout pour nos pays. Mais il n'en demeure pas moins que le principe de cette clôture est essentiel et il convient de rechercher la solution efficace et économique à ce problème. Il semble que le choix doit être fait entre la clôture électrique et la clôture vivante. Au Mali nous avons entouré, une bonne partie du Ranch de Niono de plantes épineuses (sisal) — Malheureusement, comme il fallait s'y attendre, elles ont été progressivement détruites par les porcs-épics friands de leurs racines.

3°) — **L'exploitation proprement dite**: implique:

a) — **Les Investissements**: Ils sont énormes et ont trait:

- à l'achat du cheptel vif (pour les fermes pilotes)
- aux constructions (logements, étables, magasins)
- au matériel divers (matériel d'élevage, moyens de locomotion, matériel technique, etc....)

b) — **La conduite du troupeau**: doit se faire suivant des normes rationnelles — On veillera surtout:

- aux problèmes de pathologie (mortalité des jeunes)
- au contrôle des naissances
- à la rotation des pâturages, etc....

Notons en passant que la conscience professionnelle et la technicité du personnel d'encadrement sont indispensables. Aussi doit-on envisager de former de tels cadres dans des pays rompus aux techniques d'élevage extensif.

D. Fixation des nomades et création de centres socio-économiques

Parallèlement à la fixation du bétail, l'organisation coopérative favorisera la sédentarisation. On incitera les éleveurs à construire des villages moins mobiles tout en développant les activités socio-économiques.

- création d'écoles, de dispensaires
- Agriculture dans les zones propices
- action forestière (conservation du sol et reboisement)
- mise en place de coopératives dans différents domaines
- intégration de la petite collectivité naissante dans l'économie générale de marché.

Telles sont très brièvement les lignes de force d'un plan prospectif de développement de nos zones Sahéliennes. C'est une tâche de très longue haleine qu'il faut cependant entreprendre et poursuivre patiemment car dans ce domaine, il n'y a pas de miracle. Déjà au Mali nous envisageons une expérience dans le Sud de la boucle du Niger: le Gourma — (voir Fig. 2).

VII. PROGRAMMES ACTUELS ET ASPECTS DU DEVELOPPEMENT FUTUR

A. Introduction

Au Sud de la boucle du Niger, entre Tombouctou et Gao se situe une des plus vastes régions d'élevage du Mali appelée "Gourma de Rharous" (en Tamachèque: Sud du Rharous). Elle s'inscrit dans un trapèze dont trois cotés sont formés par le Niger. Sa grande base est une ligne Ouest-Est reliant Bambara-Maoundé à Ansongo. Le Gourma couvre environ une superficie de 60.000 km.². Recevant suivant la latitude, 200 à 400 m/m d'eau en moyenne par an, il offre en toutes saisons des pâturages souvent magnifiques mais inexploités ou inutilisés faute d'eau pour les animaux et les hommes. Aussi ne trouve-t-on à l'intérieur du Gourma aucun campement permanent. C'est par excellence une zone nomade où Maures et Touareg sont en perpétuelle errance.

De Juillet à fin Septembre, les nombreuses petites mares d'hivernage réparties à l'intérieur de la zone permettent l'abreuvement des troupeaux en transhumance.

Dès le mois d'Octobre les mares d'hivernage s'assèchant, c'est près de 500.000 bovins et 2.000.000 d'ovins et caprins qui se trouvent alors "parqués" dans une étroite bande de terrain profonde de 20 à 30 km. longeant la rive droite du fleuve et de laquelle ils ne pourront s'évader qu'à l'hivernage suivant.

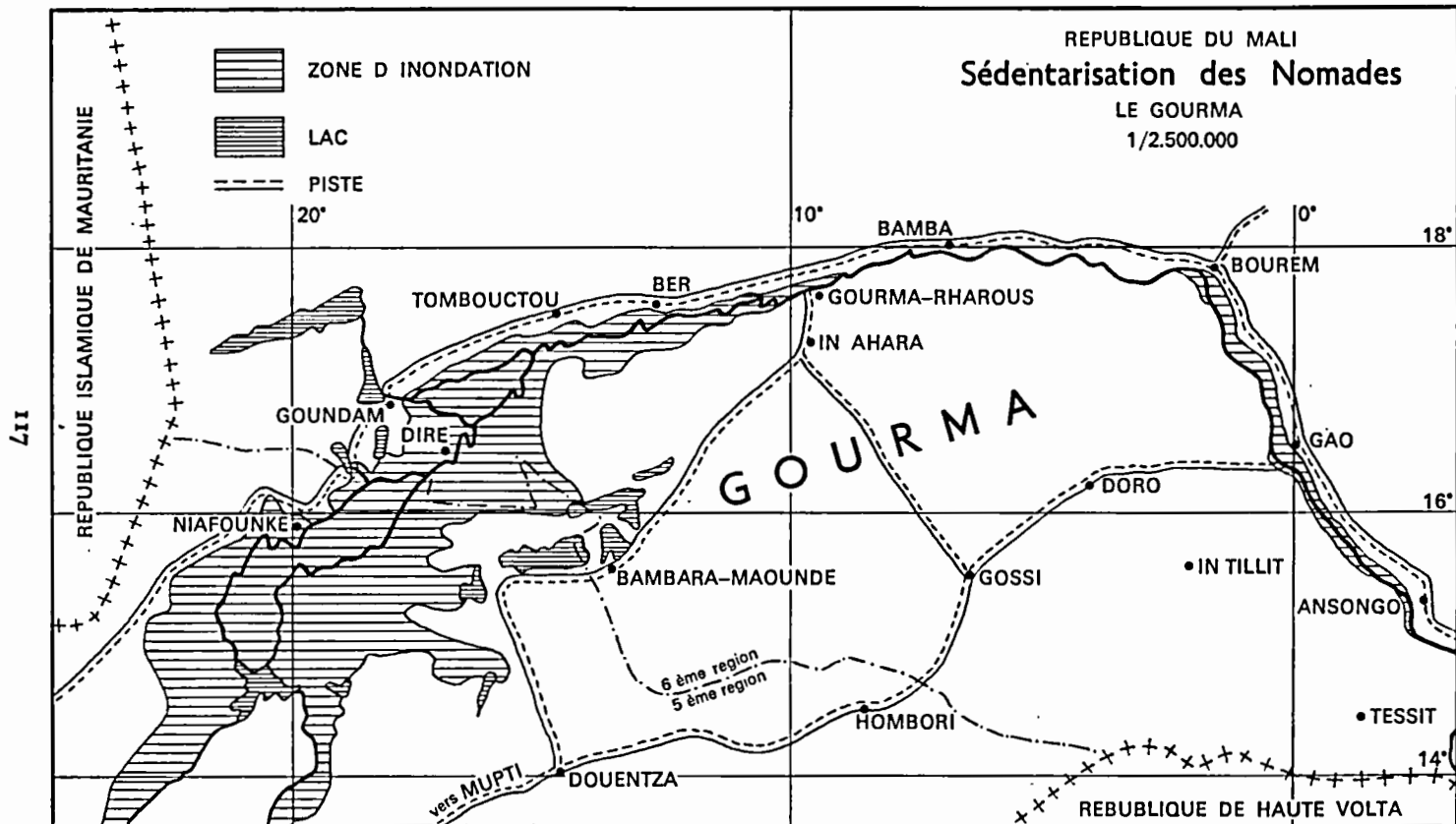


Fig. 2.

Il est clair que telles concentrations sur des parcours aussi réduits avec des animaux sous-alimentés sont sources de foyers de maladies endémiques et surtout parasitaires et aussi de surpâturage avec toutes ses conséquences.

Aussi depuis longtemps, les Services de l'Élevage du Mali se sont efforcés, par des programmes d'hydraulique de **fixer** le plus possible d'animaux en saison sèche sur ce plateau central pourvu de pâturages excellents pratiquement inutilisés. Les tentatives antérieures ont consisté à forer des puits, à aménager des mares, à construire des barrages de retenue d'eau sans pourtant envisager la mise en valeur de cette zone sous l'angle socio-économique.

B. Le projet actuel du Gourma

Le projet actuel que le Mali se propose de soumettre à des organismes internationaux vise à la sédentarisation des populations nomades de la région par la modernisation de l'élevage et des structures agraires.

Il s'agit donc, dans le cadre d'une opération intégrée de résoudre les principaux problèmes qui ont été évoqués au chapitre précédent, par la mise en place d'unités d'élevage pilotes.

La mise en oeuvre d'un tel projet implique deux phases. La première est une phase d'études générales et d'experimentation: études socio-économiques, cartographie, inventaire des pâturages, étude statique et dynamique du troupeau, études hydrogéologiques, enquêtes agricoles, etc.... Elle permettra d'implanter les futurs centres pilotes.

La deuxième phase sera celle des réalisations, donc la plus difficile qui requiert un personnel technique suffisant compétent et une organisation de travail efficace.

Si ce projet réussit, son extension sera envisagée sans difficultés.

Le problème du développement de nos zones sahéliennes est donc un problème complexe aux multiples variables — L'élimination totale du nomadisme exigera encore de longues années de persévérance et de patience.

Mais en s'attaquant à ce problème, le Gouvernement malien a conscience de s'engager dans une action difficile et coûteuse mais qui apparaît comme un impératif absolu pour la réalisation et le renforcement d'un développement harmonieux. La sollicitude des organismes internationaux comme le B.I.T. va lui permettre de réaliser les études exhaustives indispensables et la mise en oeuvre de programmes concrets que seul il ne pourrait entreprendre. Une fois la route tracée par quelques expériences-tests, le Mali espère inclure les nomades dans l'économie nationale afin que les pasteurs deviennent des consommateurs et des producteurs véritables. C'est là un pari qu'il veut gagner à tout prix.

RESUME

Après avoir défini les limites géographiques du Sahel malien ou Rivage du Sahara qui couvre 460.000 km.² soit 39% de la superficie totale du Mali, les auteurs étudient les problèmes que pose la nomadisme au Mali. Ils en étudient successivement les caractéristiques écologiques, les données démographiques, les institutions et structures sociales, les activités économiques traditionnelles. Dans une dernière partie, après avoir abordé les problèmes administratifs, ils insistent sur les programmes nationaux pour le développement du Sahel par la création de centres socio-économiques et la fixation des nomades après une fixation préalable des troupeaux (multiplication des points d'eau et utilisation des clôtures).

En conclusion ils étudient les problèmes particuliers posés par le développement d'un élevage rationnel dans le Gourma.

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Summary

After defining the geographical limits of the Mali Sahel or Sahara borders, which represents some 177,000 sq. miles, i.e. 39% of the total area of Mali, the authors studied the problems raised by nomadism in Mali. They looked in turn into ecological characteristics, demographical data, institutions and social structures, traditional economic activities. Finally, after sketching administrative problems, they dwell on national programmes for the development of the Sahel's through the creation of social economic centres and the settlement of nomads, after fixing first their herds (increasing the number of water holes and recourse to enclosures).

In conclusion, they study particular problems raised by the development of a rational breeding campaign in the Gourma.

REFLECTIONS ON SHEEP DISEASES IN KENYA

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INTRODUCTION

Experience in the government diagnostic laboratory, surveys of sheep diseases and research into sheep pneumonia, revealed interesting features of sheep diseases. Some of the diseases encountered were: bluetongue, Nairobi sheep disease, Rift Valley fever, enterotoxaemia, foot conditions, internal parasites, and several forms of pneumonia. What of their relative importance? Certainly if we were to go by the pathogens involved, then bluetongue, Nairobi sheep disease and Rift Valley fever should be of major importance. A survey of sheep diseases (Table I) carried out revealed that foot diseases, pneumonia, internal parasites and enterotoxaemia had the highest incidence. One may ask why this should be so when these diseases are less virulent. The reason could be that the major sheep scourges are seasonal and can be controlled by regular vaccination. Enterotoxaemia could be controlled by inoculation and improved animal husbandry practices. Only the three groups with highest incidence will be given further consideration.

MATERIALS AND METHODS

This study was based on three major sources of information and materials, namely:

(a) Pathological specimens and sheep that were brought for diagnostic purposes to the Government Veterinary Laboratory, Kabete in 1963 coupled with occasional laboratory and field investigations.

(b) Survey of sheep diseases in Kenya, carried out over a two-year period (1966-67). For this, a detailed questionnaire was sent to 41 sheep farmers, ranging from those with 150 to those with over 15,000, the total being about 276,000 animals. This was followed up by personal investigational visits to selected farms.

(c) Research into sheep pneumonia, in the course of which some other disease conditions were also encountered, especially internal parasites. All the pathological specimens were prepared in accordance with the manual of histologic and special staining technique (A.F.I.P.).

RESULTS

Results of the survey tabulated in Tables I and II are based on 26 returns, of which two no longer had their flocks. Total sheep covered were 125,101.

Internal parasites:

Worm parasites which have proved most costly to the Kenya sheep-men are liver and stomach flukes, and round-worms. Their life-cycles, which can be obtained from standard textbooks of veterinary parasitology (Lapage, 1968, Soulsby,

1968), are of importance both to the veterinarian and the flockmaster because from them one can learn the various stages at which the worms are most plentiful, most dangerous and most vulnerable. More than one species or even genera may be involved in a case of sheep parasitism—because one paves the way for the others.

Table I.—Sheep disease incidence based on 24 returns

<i>Sheep disease*</i>	<i>No. farms reported</i>
Bluetongue	10
Nairobi sheep disease	3
Pustular dermatitis (Orf)	2
Rift Valley fever	2
Heartwater	2
Foot conditions : Foot-rot	9
Foot-abscess	8
Foot-scald	4
Pneumonia	17
Enterotoxaemia	13
Internal parasites (<i>Helminthiasis</i>)	11
Sheep scab	6
Sheath-rot in wethers	6
<i>Caseous lymphadenitis</i> (cheesy glands)	5
Nasal fly (<i>Oestrus ovis</i>) infection	5
Necrobacillosis (<i>F. necrophorus</i>) infection	3
Intussusception	3
Gangrenous (ewe) mastitis	2
Contagious ophthalmia	2
Cancer of the eye	2
Blow fly (strike)	2
Non-specific lamb losses (between birth and weaning)	2
Foot and mouth disease	
Tetanus	}
Anaplasmosis	
Bloat	
Plant poisoning	
Multiple abscesses in lambs	

* Sheep diseases not listed were not reported.

Table II.—Sheep population on farms with foot diseases, pneumonia and internal parasites

<i>Sheep Disease</i>	<i>Sheep on farms where reported</i>
Foot conditions: Foot-rot	26,400
Foot-abscess	41,688
Foot-scald	19,200
Pneumonia	86,427
Internal parasites (<i>Helminthiasis</i>)	53,861

(a) Fascioliasis and Paramphistomiasis:

These two conditions often occur together. Furthermore their aetiological agents—*F. gigantica/hepatica* and *P. microbothrium/daubneyi* have very similar life-cycles with respect to free living stages. The former is characterised by cholangiohepatitis with generalised oedema in chronic cases and often sudden deaths in acute cases. Indeed acute massive infection may cause rupture of the liver capsule and haemorrhage into the peritoneal cavity.

Paramphistomiasis is the most important disease that would occur in conjunction with fascioliasis. The disease is brought about by the immature paramphistomes which irritate the intestinal mucosa with resultant catarrhal and haemorrhagic enteritis. If the immature stomach flukes are numerous very severe haemorrhagic

gastroenteritis results. The intestinal mucosa is found studded with numerous slightly reddish conical immature flukes. Histologically, young paramphistomes are seen attached to the intestinal mucosa with their acetabulum. The mucosal plug in the acetabulum becomes strangulated and necrotic and severing takes place. In chronic cases there is thickening of the intestinal mucosa with impaired digestion and absorption. The animal becomes unthrifty. The adult flukes in the rumen and reticulum are harmless.

(b) Round worms:

A number of species of these parasites were encountered but only those of importance to East Africa will be mentioned. *Haemonchus contortus*—wireworm, is the most important of them all. It causes many losses, not only in deaths but in the production of wool and meat. It is responsible for primary parasitism. It is capable of 'literally bleeding' to death the strongest sheep, lambs being most susceptible. Acute cases die suddenly due to rapid blood loss, while chronic cases in addition to anaemia may have generalised oedema before death. Scouring is not a feature. Heavy infestations are uncommon with respect to the small brown stomach worm—*Ostertagia circumcincta*, characterised by anaemia and diarrhoea. The black scour worm or bankrupt worm—*Trichostongylus* spp. causes more marked diarrhoea with little or no anaemia. *Oesophagostomum columbianum*—the nodular worm, causes marked persistent diarrhoea in lambs resulting in exhaustion and death unless the animals are removed from infested pasture. Older sheep tend to be more severely affected. In acute cases diarrhoea is a common feature. Emaciation is evident in chronic cases due to marked thickening and rigidity of the intestinal wall leading to impaired secretion, digestion and absorption with death owing to "starvation".

Other round worms of less significance are hookworm (*Bunostomum trigonocephalum*), large-mouthed bowel worm (*Chabertia ovina*), thin-necked intestinal worm (*Nematodirus* spp.), and, the lungworm: large lungworm (*Dictyocaulus filaria*) and small lungworm (*Muellerius capillaris*).

Foot conditions:

Where pneumonia in sheep is not a problem and where to a large extent internal parasitism can be controlled, foot diseases are the problems a number of sheepmen have to contend with. According to Carroll (1961) these can largely be placed into three aspects: *foot abscess*, *contagious foot-rot* and *foot scald*. Foot abscess is probably more common and can seriously affect flocks of all breeds, but generally older sheep. Lambs are seldom affected. Merinos tend to be more susceptible. Very wet conditions are generally predisposing. It is more acute and much more painful than contagious foot-rot. Often the cause is *Fusiformis necrophorus*, a common inhabitant of the soil. Roberts (1967) has demonstrated pathogenic synergy between this organism and *Corynebacterium pyogenes*, concerning causation and maintenance of foot-abscess. It rarely affects more than 10% of the flock and usually only one claw of one foot is affected. It is a sporadic condition, difficult to eliminate and characterised by presence of pus.

The actual cause of contagious foot-rot is *Fusiformis nodosus*, though *Spirochaeta penortha*, *Fusiformis necrophorus* and other organisms may be present. All breeds and ages are affected with high morbidity. Pus is rarely present. Both claws and generally more than one foot is affected. It is characterised by inflammation of the hoof and lameness and spreads rapidly under wet conditions.

Foot scald is a condition of unknown aetiology in which the skin between the claws is red and swollen and the foot is hot. The affected sheep suffer acute lameness generally present on all feet. Morbidity is very high. Pus is not a feature of it. Though non-contagious it could predispose to contagious foot-rot.

PNEUMONIA

Introduction:

Pneumonia has been a problem since the early days of sheepfarming in the country. Ovine pneumonia definitely covers a number of different pathological and aetiological aspects. Wandera (1967a, b) classified the various forms into four broad groups. This was based on their pathology and where possible on their aetiology. These are:

(a) "**Cuffing Pneumonia**"—Though a virus is incriminated its aetiology is unknown. It is characterised histologically by considerable hyperplasia of the lymphoid elements around the bronchi, bronchioles and their associated blood vessels.

(b) **Parasitic Pneumonia**—There are two main nematodes involved, Jubb & Kennedy (1963). The large lung-worm, *Dictyocaulus filaria*, whose adults parasitise the bronchi/bronchioles show signs of coughing. It is often quite harsh in the lighter infestations and softer in those with a greater number of worms. The diaphragmatic lobes are mostly affected—the consolidations being reddish in colour. It is characterised by interstitial pneumonia. Often bronchopneumonia occurs in the terminal stages possibly due to secondary bacterial infection. The second lung-worm—*Muellerius capillaris*, is very common and widely spread but rarely causes a clinical disease. Lesions appear around the worms as greyish firm nodules of varying sizes, commonly seen in the diaphragmatic lobes. Microscopically, a granulomatous reaction is present. Disintegrating parasites may cause cuboidal metaplasia of the extremely attenuated squamous epithelium of the alveoli, so-called "epithelialization". This adenomatoid lesion is accompanied by little proliferation, and hence can be differentiated from sheep pulmonary adenomatosis.

(c) **Bacterial Pneumonia**—In adult sheep, primary bacterial pneumonia is uncommon. Very often it is secondary to parasitic, "cuffing" or chronic progressive lung disease. Bacterial organisms often isolated in this condition are *Corynebacterium pyogenes*, *Corynebacterium ovis*, and *Pasteurella haemolytica*. In lambs the disease is more severe and usually associated with *Pasteurella haemolytica*. This is the true enzootic pneumonia of lambs and characterised by fibrinous pneumonia. The incidence is low in adults. *Corynebacterium pyogenes* which can affect all ages causes purulent bronchopneumonia.

(d) **Chronic Progressive Lung Disease** (Jaagsiekte and Maedi). Both *jaagsiekte* and *maedi* occur in certain flocks in Kenya. The two diseases have been encountered in one flock and even in one sheep. *Maedi* which is caused by an ether-sensitive virus (Sigurdardottir *et al.* 1964; Thormar 1966) is characterised by a progressive interstitial pneumonia. *Jaagsiekte* which may also be caused by a virus (Enchev 1966; Shirlaw 1959) though pleuropneumonia-like organisms have been regularly isolated, is essentially a special lung tumour. Its designation as sheep pulmonary adenomatosis amply describes its appearance. Metastases to regional lymph nodes have been observed.

CONCLUSION

Research work done on virus diseases of sheep, has made them less of a threat as regular inoculation can control them. The same applies to enterotoxaemia if proper animal husbandry methods would regularly accompany inoculation. Conditions militating against maximum economic production with respect to sheep industry are internal parasites, foot diseases and pneumonia. In an investigation of an outbreak with deaths at the rate of four a day in sheep on the Kinangop (now Nyandarua District) Roach and Lopez (1966) found both *Fasciola* spp. and *Paramphistoma* spp. involved. Fascioliasis can actually cause liver rupture. Chema (1966—personal communication) witnessed such a case in an adult goat that had a sudden death. Paramphistomiasis alone or in conjunction with fascioliasis is an important disease (Boray 1959; Simson 1926; Butler & Yeoman 1962; Horak 1966). In theory one would think that it should be easy to control internal parasites by use of anthelmintics. Thiabendazole and phenothiazine (superfine) are reputed to be effective against most of the important nematodes, while carbon tetrachloride and hexachlorethane are recommended for flukes. However, not all sheep farmers who use these drugs control the problem. This could be due to the economics involved or improper use of the drugs. May be the proper husbandry is not practised regularly.

Contagious foot-rot is present in Kenya and widespread in most districts, so is foot abscess. The position of foot-scald is unclear, though thought to be a precursor of foot-rot. Proper animal husbandry including effective fencing and adequate paring, is an important element in the control of foot conditions. In addition, the right use of formalin foot bath can adequately control foot-rot and even eradicate it in a flock. Treatment of foot abscess is not very effective. Use of sulphamezathine or penicillin as an injection may be successful in very early cases. Foot-scald may be quickly cured by hardening the feet with formalin solution.

The confusion still existing with respect to identification of the various types of ovine pneumonia, calls for concerted efforts in the study of this disease group. An attempt at classification of the various forms have been made by Wandera (1967a, b), of the chronic types the author suggests the use of Jaagsiekte or sheep pulmonary adenomatosis for the type characterised by adenomatous lesions, and "Maedi" or progressive interstitial pneumonia, for the one with interstitial pneumonia.

These two disease entities are widely distributed (Gislason, 1966). Enzootic or fibrinous pneumonia should refer to the lamb pneumonia associated with *Pasteurella haemolytica*. Parasitic pneumonia is self-explanatory. "Cuffing" pneumonia requires further elucidation. With the exception of Jaagsiekte where a formalized tissue vaccine is currently in use, a lot more needs to be done in the way of prophylaxis with respect to pneumonia.

The purpose of this paper has been to familiarise the veterinarian, and try to make him more aware of the ever-present disease problem in sheep. Infectious diseases as a group appear to be an important limiting factor to the rapid expansion of sheep industry in Kenya, especially in newer areas. This realization, of necessity demands on the part of the research scientist the developing of suitable methods of diagnosis, prevention and control of these diseases confronting the veterinarian and his sheep farmers.

SUMMARY

While it is true that sheep in Kenya can be, and sometimes are, affected with most of the ovine diseases which exist in the world, the relative importance of the

individual diseases vary. Though bluetongue, Nairobi sheep disease and Rift Valley fever are very virulent, they can be effectively controlled by prophylaxis and hence are of less importance. The very high incidence of foot diseases, internal parasites, pneumonias and enterotoxaemia, has caused heavy losses to sheep farmers in the country. Proper animal husbandry practices and vaccination may largely control enterotoxaemia but rarely so with the remaining three groups. Foot diseases, especially footrot and foot-abscess, helminths particularly *Haemonchus contortus*, *Trichostrongylus* spp., *Oesophagostomum columbianum* and flukes, and pneumonia of all types can be regarded as limiting factors with regard to sheep industry.

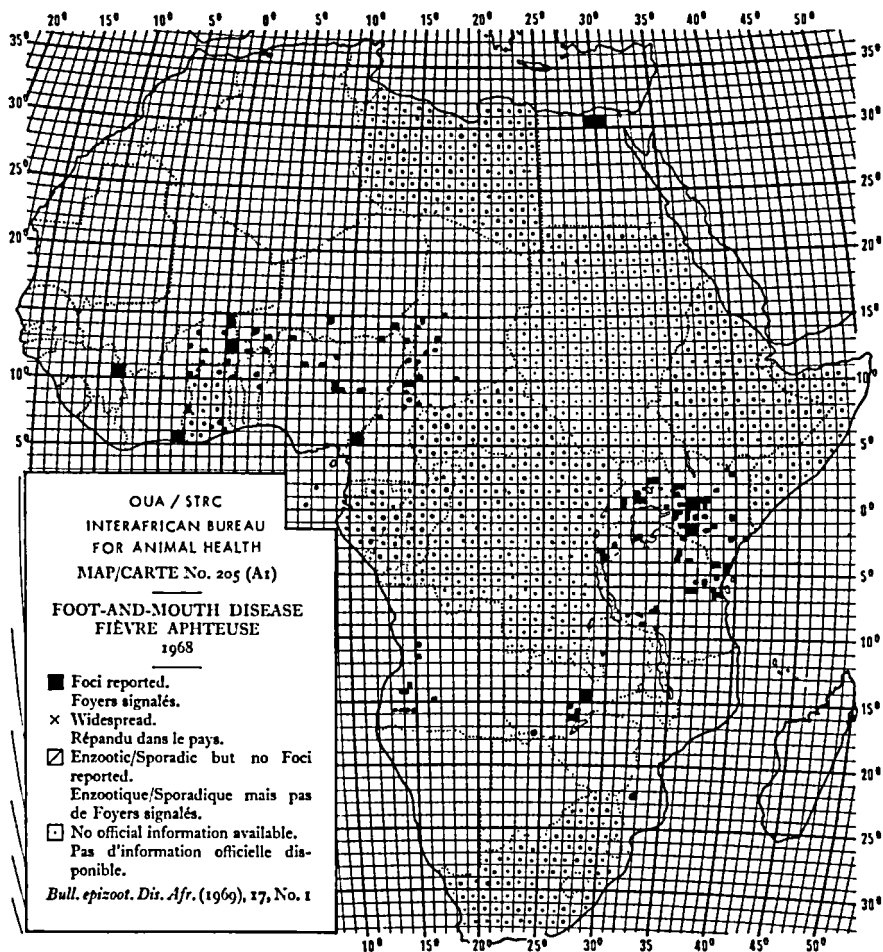
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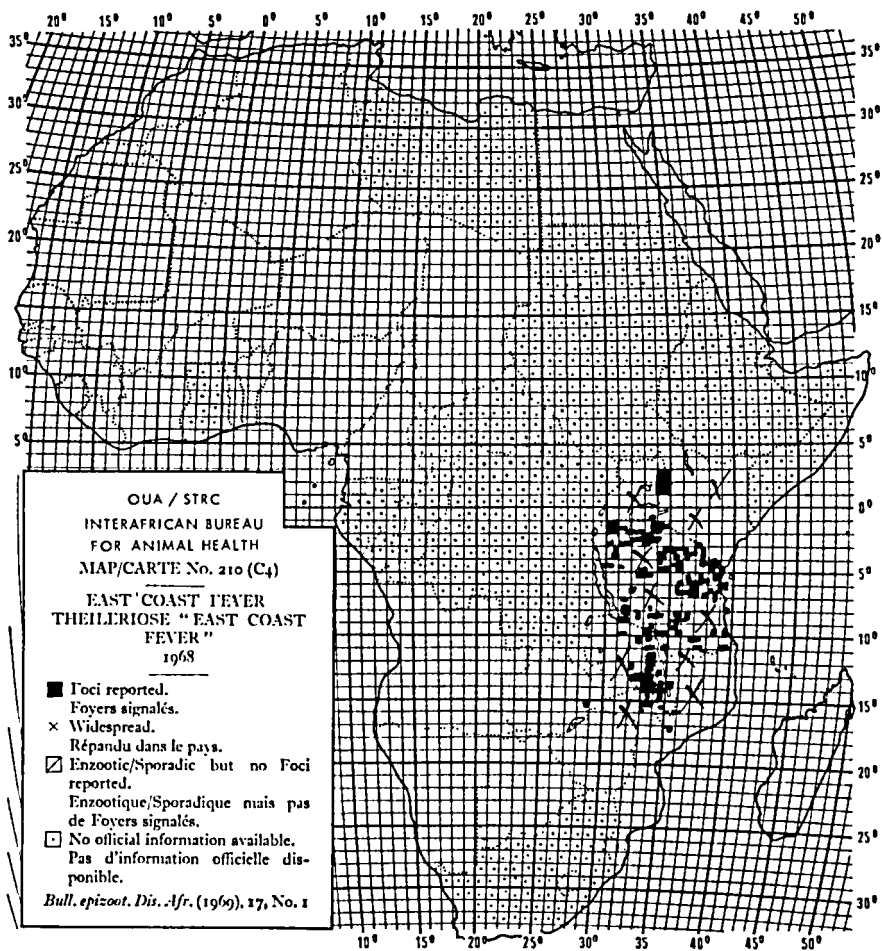
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Résumé

Bien qu'il soit vrai de dire que les ovins du Kenya peuvent être, et sont souvent, affectés par presque toutes les maladies des ovins qui existent dans le monde entier, l'importance relative des diverses maladies varie. Bien que la fièvre catarrhale, la maladie des ovins de Nairobi et l'hépatite enzootique soient très virulentes, elle peuvent être facilement contrôlées par la prophylaxie. Elles ont donc moins d'importance. Le très grand nombre de maladies qui infectent les pattes, de parasites internes, de pneumonies et d'enterotoxémies, a infligé de lourdes pertes aux éleveurs d'ovins du pays. De bonnes méthodes d'élevage et la vaccination pourront largement aider à lutter contre l'entérotoxémie mais les résultats seront rarement aussi bons dans le cas des trois autres groupes. Les maladies de la patte, spécialement le piétin et les abcès des pattes, les vers, particulièrement *Hemonchus contortus*, *Trichostrongylus* spp, *Oesophagostomum columbianum* et les douves, ainsi que tous les types de pneumonies, peuvent être considérés comme des facteurs qui restreignent l'élevage des ovins.

GEOGRAPHICAL DISTRIBUTION OF ANIMAL DISEASES
 DISTRIBUTION GEOGRAPHIQUE DES MALADIES ANIMALES





ABSTRACTS

Vol. 17, No. 1—Nos. 1-32

SUBJECT INDEX

VIRAL DISEASES

1. Rinderpest protection in cattle by measles virus. Application in calves with passive immunity from maternal antibodies.
2. Conservation of freeze-dried rinderpest virus.
3. Antigenic relationship among the various types of foot-and-mouth disease virus.
4. Studies on the presence of specific neutralizing antibodies in the blood of people having been in contact with the foot-and-mouth disease virus.
5. Immunization of cattle against rabies with the kelev strain vaccine.
6. African swine fever. Use of immuno-fluorescence for the study of virus on tissue cultures.
7. The antibody response in pigs inoculated with attenuated African swine fever virus.
8. African swine fever in wild boars. Note II: Possibility of experimental infection through ingestion and contact.
9. A survey of cattle from Kenya and Uganda for antibodies to bovine virus diarrhoea virus.

BACTERIAL DISEASES

10. Contagious bovine pleuropneumonia.
11. Contagious bovine pleuropneumonia: Serologic response of cattle after single and double vaccination with T1 culture vaccine.
12. Infection of cattle with *Mycoplasma mycoides* by nasal instillation.
13. The isolation of T-strains of mycoplasma from pneumonic calf lungs.
14. The effect on performance and bacterial flora of lactic acid, propionic acid, calcium propionate and calcium acrylate in the drinking water of weaned pigs.

PARASITIC DISEASES

15. The diagnosis of trypanosomiasis of livestock: A review of current techniques.
16. Isolation of trypanosomes of the section stercoraria from cattle in Nigeria and the United Kingdom.
17. The importance of ecological studies in the control of tsetse flies.
18. Combined infections of calves with the nematode parasites *Trichostrongylus axei* and *Ostertagia ostertagi*.
19. Investigations on the behaviour of several blood constants in bovine fasciolosis.
20. Stomach worm disease of cattle (ostertagiasis). Analytical references on the disease, its treatment and its prophylaxis.
21. Studies on the resistance of pigs to the lungworm *Metastrongylus* spp. Infections in minimal disease pigs from eight weeks of age.
22. The effect of repeated anthelmintic treatment on body weight gains of calves.

ANIMAL HUSBANDRY

23. The effect of synchronization of oestrus on the fertility of ewes inseminated artificially.
24. Stimulation of sexual activity in ewes with a view to obtaining three lambings in two years.
25. Investigations on fertility, insemination rate and length of service-period in cows inseminated at various post-partum times.
26. Effect of undernutrition in late pregnancy on the nitrogen and energy metabolism of ewes.
27. The behaviour of cattle in transit by rail.
28. Housing of ruminants. 1. Its advantages and its health problem.
29. Deficient diet as a factor in the incidence of cannibalism in layers.

THERAPEUTICS

30. The therapeutic control of calf paratyphoid (*S. dublin* infection).
31. The treatment of coccidiosis in domestic ruminants with "Amprolium".
32. Effectiveness of dichlorvos-impregnated collars in controlling fleas on dogs.

ANALYSES

Vol. 17, No. 1—Nos. 1-32

TABLE DES MATIERES

MALADIES VIRALES

1. Protection antipestique conférée aux bovins par le virus de la rougeole. Application aux veaux passivement immuns par anticorps maternels.
2. Conservation du virus de la peste bovine à l'état lyophilisé.
3. Rapports antigéniques entre les divers types de virus de fièvre aphteuse.
4. Recherches sur la présence d'anticorps neutralisants spécifiques dans le sang d'hommes ayant été en contact avec le virus aphteux.
5. Immunisation du bétail contre la rage au moyen du vaccin à souche Kelev.
6. Peste porcine africaine. Application de l'immuno-fluorescence à l'étude du virus sur les cultures de tissus.
7. La réponse des anticorps chez les porcs inoculés au moyen du virus atténué de la fièvre porcine africaine.
8. Fièvre porcine africaine chez les porcs sauvages. Note II: possibilité d'une infection expérimentale par ingestion et contact.
9. Etude du bétail du Kenya et de l'Ouganda, au point de vue des anticorps du virus de la diarrhée bovine.

MALADIES BACTERIENNES

10. Péripleurite contagieuse des bovins.
11. Péripleurite contagieuse bovine: réponse sérologique des bovins à la vaccination à simple et double dose par le vaccin T1 de culture.
12. Infection du bétail par instillation nasale de *Mycoplasma mycoides*.
13. Isolement de souche T de mycoplasma de poumons de veaux atteints de pneumonie.
14. Les effets sur le rendement et la flore bactérienne de l'acide lactique, de l'acide propionique, du propionate de calcium et de l'acrylate de calcium dans l'eau potable des porcs sevrés.

MALADIES PARASITAIRES

15. Diagnostic de la trypanosomiase chez le bétail: revue des méthodes actuelles.
16. Isolement des trypanosomes du type stercoral du bétail du Nigéria et du Royaume-Uni.
17. L'importance des études écologiques pour le contrôle des mouches tsé-tsé.
18. Infections combinées par les nématodes *Trichostrongylus axei* et *Ostertagia ostertagi* chez des veaux.
19. Recherches sur le comportement de certaines constantes sanguines dans la fasciolose bovine.
20. L'ostertagiose bovine. Revue bibliographique raisonnée sur la maladie, son traitement et sa prophylaxie.
21. Etude de la résistance des porcins aux Spp. metastrongylus de broncho-pneumonie vermineuse du porc. Infections chez les porcs à maladie minimale à partir de huit semaines.
22. Les effets d'un traitement anti-helminthique répété sur les augmentations de poids vif des veaux.

ANIMAL HUSBANDRY/ZOOTECHE

23. Effect de la synchronisation de l'œstrus sur la fécondité des brebis inseminées artificiellement.
24. Stimulation de l'activité sexuelle des brebis afin d'en obtenir trois agnelages en deux ans.
25. Recherches sur la fécondité, l'indice d'insemination et la durée du service-période des vaches inseminées à différentes termes post-partum.
26. Effet de la malnutrition aux dernières étapes du gravidisme sur le métabolisme de l'énergie et de l'azote des brebis.
27. Le comportement du bétail dans les transports par chemin de fer.
28. Le logement des ruminants. 1. Ses avantages et les problèmes de santé.
29. Les carences alimentaires et leurs effets sur le cannibalisme des poudeuses.

THERAPEUTIQUE

30. Le contrôle thérapeutique de la paratyphoïde des veaux (infection *S. dublin*).
31. Le traitement de la coccidiose des ruminants domestiques par L' amprolium (Chlorhydrate de chlorure de 1 (4-amino-2n-propyl-5-pyrimidinyméthyl) 2-picolinium).
32. Efficacité des colliers imprégnés de dichlorvos pour tenir sous contrôle les puces chez les chiens.

- IBAH/69 PROVOST, A., MAURICE, Y., BORREDON, C. **Protection antipestique conférée aux bovins par le virus de la rougeole. Application aux veaux passivement immuns par anticorps maternels.** (Rinderpest protection in cattle by measles virus. Application in calves with passive immunity from maternal antibodies.)
Rev. Elev. Méd. vét. Pays trop. (1968), 21, 145.

Résumé des auteurs: Utilisant la souche MB 113 Y du virus de la rougeole adaptée à la culture en cellules rénales bovines, les auteurs montrent que l'inoculation intramusculaire de ce virus au zébu réceptif à la peste bovine n'est suivie d'aucune réaction clinique bien qu'existe une virémie. Les bovins inoculés sont résistants pendant au moins 11 mois à la contamination bovine. Cette immunité est d'origine humorale (présence d'authentiques anticorps antipestiques) et peut-être cellulaire. Les bovins inoculés n'élaborent pas, au de très faibles titres seulement, d'anticorps antimorbilleux. Les veaux immuns de peste bovine par anticorps colostraux sont justiciables de l'inoculation avec la souche MB 113 Y qui leur confère une protection antipestique à un âge auquel le vaccin antipestique de cultures cellulaires serait inefficace. Devant le comportement biologique et immunologique particulier de cette souche morbilleuse, les auteurs expriment l'opinion qu'elle a une position intermédiaire entre les virus pestiques et morbilleux auxquels elle aurait emprunté divers constituants antigéniques.

Authors' summary: Using strain MB 113 Y of measles virus adapted to culture on bovine kidney cells, the authors show that the intramuscular injection of this virus in zebu cattle rinderpest susceptible, is followed by no clinical reaction, although there is a viraemia. Inoculated animals are resistant to rinderpest infection for at least 11 months. The origin of the immunity is humoral (presence of genuine rinderpest antibodies), and possibly cellular. Inoculated cattle either produce no measles antibodies, or produce them only at very low titres. Calves with colostrum immunity to rinderpest can be inoculated with strain MB 113 Y which confers protection against rinderpest at an age where tissue-culture rinderpest vaccine would be ineffective. In view of the particular biological and immunological characteristics of this strain of measles virus, the authors express the opinion that it occupies an intermediate position between rinderpest and measles viruses, from which it derives various antigenic constituents.

- IBAH/69 RAMYAR, H. **Conservation du virus de la peste bovine à l'état lyophilisé.** (Conservation of freeze-dried rinderpest virus.)
Bull. Off. int. Epiz. (1968), 69, 521.

Résumé de l'auteur: Le virus virulent de la Peste bovine, lyophilisé et stocké à -30° C, conserve toute son activité pendant 151 mois.

Ce procédé, qui assure au virus toute son intégrité, évite l'entretien de la souche par des passages *in vivo*. A leur caractère onéreux s'ajoute celui, beaucoup plus dangereux, d'entretenir dans un pays exempt de Peste bovine, un foyer permanent à partir duquel la maladie peut se disséminer.

Author's summary: Virulent rinderpest virus, lyophilised and stored at -30° C. maintains all its virulence for 151 months.

This procedure, which assures all the integrity of the virus, makes unnecessary the maintenance of the strain by passages *in vivo*. In addition to their onerous character, there is the much greater danger of maintaining in a country free from rinderpest, a permanent centre from which the disease could be spread.

- IBAH/69 GAGLIARDI, G., ZOLETTO, R. **Antigenic relationship among the various types of foot-and-mouth disease virus.** (Rapports antigéniques entre les divers types de virus de fièvre aphteuse.)
Vet. Ital. (1967), XVIII, 696.

Authors' summary: The writers vaccinated a number of calves with a single type of an inactivated FMD vaccine and later submitted part of them to a second vaccination with a different type.

The resulting humoral immunity was examined through the serum-neutralization test.

The results can be summarised as follows: (1) among the animals revaccinated with the same type only those which show very high homologous titres possess heterologous antibodies, although at a very low concentration; (2) following the re-vaccination with the type different from the one used in the 1st vaccination, a significant increase of titres could be obtained against the 1st type. The immune response to the type used for re-vaccination was somewhat higher than that obtained with the same type in animals which previously never had undergone a vaccination.

Résumé des auteurs: Les auteurs ont vacciné un certain nombre de veaux au moyen d'un type unique de vaccin PFWD inactivé et ils ont ensuite soumis une partie des veaux à un deuxième vaccin d'un type différent.

L'immunité humorale qui en résulte a été examinée par l'épreuve de neutralisation du sérum.

Les résultats peuvent être résumés comme suit:

1. Parmi les animaux revaccinés au moyen du même type, seuls ceux qui ont des titres homologues très élevés possèdent des anticorps hétérologues, mais à une concentration très basse. 2. A la suite de la revaccination au moyen d'un type différent du premier, le pourcentage peut être nettement plus élevé que dans le cas du premier type. L'immunisation au type utilisé par la revaccination était un peu plus élevée que celle obtenue avec le même type dans des animaux qui précédemment n'avaient jamais été vaccinés.

IBAH/69 IFTIMOVICI, R., DOHOTARU, V., BERCAN, A., APOSTOL, M.

4. **Studies on the presence of specific neutralizing antibodies in the blood of people having been in contact with the foot-and-mouth disease virus.** (Recherches sur la présence d'anticorps neutralisants spécifiques dans le sang d'hommes ayant été en contact avec le virus aphteux.)

Lucrările Inst. Cerc. Vet. Si. Biop. Pasteur (1966), 5, 53.

Authors' summary: Certain aspects of the inapparent FMD virus infection in man were investigated by means of the detection of specific neutralizing and precipitating antibodies in people working in the preparation of FMD vaccine.

Serum neutralization in cell cultures and in unweaned mice, as well as immunodiffusion in agar gel using samples taken from 10 men working for over a year in a highly infected environment (in the vaccine production from natural virus), showed that only three of them possessed specific neutralizing antibodies at a significant titre.

Blood samples taken from these people before coming in contact with the virus showed (nonspecific) neutralizing titres lower than $10^{1.8}$ ml.

The percentage of immunologically significant responses is relatively low (about 33%), in agreement with previous personal findings. It appears that a long contact period is necessary to bring about the immunobiological response as shown by the occurrence of specific neutralizing antibodies.

By serum neutralization in primary pig kidney cell cultures no specific antibodies could be detected in the serum of three children in which "aphthosis" had been diagnosed.

Agar gel immunodiffusion tests did not prove to be a practical means for detecting neutralizing antibodies in human blood.

Résumé des auteurs: Dans le but d'étudier certains aspects de l'infection non apparente chez l'homme, avec le virus de la fièvre aphteuse, les auteurs ont entrepris, en 1965-1966, une série de recherches pour déceler les anticorps spécifiques neutralisants et précipitants dans le sang des hommes qui ont travaillé à la préparation du vaccin antiaphteux.

Les recherches faites avec les méthodes de séroneutralisation sur cultures cellulaires, séroneutralisation sur souris de lait et par immunodiffusion en gel d'agar, en utilisant des échantillons prélevés sur 10 hommes qui ont travaillé pendant plus d'une année dans un milieu fortement infecté (à la production de vaccin avec virus nature), ont démontré que seulement chez trois de ces hommes on a pu dépister des anticorps spécifiques neutralisants à un titre supérieur à $10^{1.8}$ ml.

Les échantillons de sang récoltés sur ces hommes avant de venir en contact avec le virus n'ont montré que des titres neutralisants non spécifiques et inférieurs à $10^{1.8}$.

Par le test de la séroneutralisation sur cultures cellulaires primaires de reins de porc on n'a pas du dépister d'anticorps spécifiques dans le sérum de huit enfants avec le diagnostic "aphthose".

Donc, le pourcentage des hommes qui donnent des réponses immunologiques significatives est relativement faible (environ 33%) ce qui concorde avec nos recherches antérieures. Il semble que pour obtenir, chez l'homme, une réponse immunobiologique traduite par

l'apparition d'anticorps neutralisants spécifiques décelables, il est nécessaire que le contact avec le virus soit de longue durée.

Le test d'immunodiffusion en gel d'agar n'est pas pratique pour permettre de déceler les anticorps neutralisants dans le sang humain.

IBAH/69 KALMAR, E., TADMOR, A. **Immunization of cattle against rabies with the Kelev strain vaccine.** (Immunisation du bétail contre la rage au moyen du vaccin à souche Kelev.)

Res. vet. Sci. (1968), 9, 424.

Authors' summary: Sixteen cattle were vaccinated with Kelev strain rabies vaccine and challenged with street virus one year after the third vaccination. Fourteen animals (87.5%) were protected from the challenge, which killed all of the eight non-vaccinated controls. Serum neutralization (SN) tests on blood specimens, collected at different times from the vaccinated animals were carried out in mice. A general correlation was found between immunity and SN antibody titres.

Résumé des auteurs: Seize têtes de bétail ont été vaccinées au moyen du vaccin anti-rabique de la souche Kelev et subirent ensuite l'épreuve du virus courant, un an après la troisième vaccination. Quatorze bêtes (87,5%) étaient à l'abri de l'épreuve, qui tua les huit bêtes témoins non-vaccinées. Les épreuves de neutralisation de sérum SN sur des échantillons de sang recueillis à différentes époques à partir des bêtes vaccinées ont été effectuées sur des souris. Une corrélation générale a été constatée entre l'immunité et le pourcentage d'anticorps SN.

IBAH/69 CARNERO, R., LUCAS, A., RUIZ, F., LARENAUDIE, B. **Peste porcine africaine. Application de l'immuno-fluorescence à l'étude du virus sur les cultures de tissus.** (African swine fever. Use of immuno-fluorescence for the study of virus on tissue cultures.)

Rec. Méd. Vét. (1968), CXLIV, 937.

Résumé des auteurs: La technique d'immuno-fluorescence dite "directe" a été employée pour l'identification du virus de la P.P.A., en cultures de leucocytes de sang périphérique et de cellules épithéliales de reins de porc.

L'utilisation des méthodes décrites permettrait un diagnostic rapide et précis.

La spécificité de la réaction est démontrée ainsi que le rôle joué par la fraction sérique, précipitée par le sulfate de soude, du sérum d'un survivant.

Authors' summary: The direct immunofluorescence technique was used for identification of African swine fever virus on leucocytes cultures of peripheral blood and swine kidney cell cultures.

The methods used could allow a rapid and reliable diagnosis.

The specificity of the test is proved and also the specificity of the sodium precipitate fraction from the serum of a survivor pig.

IBAH/69 STONE, S. S., DELAY, P. D., SHARMAN, E. C. **The antibody response in pigs inoculated with attenuated African swine fever virus.** (La réponse des anticorps chez les porcs inoculés au moyen du virus atténué de la fièvre porcine africaine.)

Can. J. Comp. Med. (1968), 32, 455.

Authors' summary: Pigs were inoculated with a modified isolate of African swine fever virus (ASFV). Complement-fixing (CF) and agar gel diffusion precipitin (AGDP) antibodies could be detected in the serums of most pigs from 14-days post-inoculation (DPI) until their immunity was challenged with virulent ASFV at 117 DPI.

Reductive cleavage with 2-mercaptoethanol showed that serums collected at 14 to 35 DPI contained 19S antibody, but that the 7S antibody was dominant at 35 and 117 DPI. This distribution of antibody was confirmed by sucrose-gradient centrifugation. Nearly all of the early serums also contained 7S antibodies which fixed complement and reacted in the AGDP test. Pigs whose serums contained both CF and AGDP antibodies at time of challenge failed to develop acute disease while pigs without CF antibodies were usually not protected.

Pigs surviving challenge with virulent virus showed no increase in antibody titres, or reversion to 19S antibody.

Résumé des auteurs: Des porcs ont été inoculés au moyen d'un isolat modifié de virus de la fièvre porcine africaine. Lors des épreuves de fixation du complément et de la précipitine

- IBAH/69 SHIFRINE, M., MOULTON, J. E. Infection of cattle with
12. *Mycoplasma mycoides* by nasal instillation. (Infection du bétail par
instillation nasale de *Micoplasma mycoides*.)
J. Comp. Path. (1968), 78, 383.

Authors' summary: Two groups of cattle were given repeated injections of *M. mycoides* intranasally and later were given challenge inoculation subcutaneously. Neither group showed a Willems reaction upon challenge inoculation and only the group which received the larger number of injections had lung lesions typical of contagious bovine pleuropneumonia. A hypothesis is offered for the formation of lung lesions.

Résumé des auteurs: Deux groupes de bétail ont reçu des injections répétées de *M. mycoides* intranasalement et ensuite des inoculations de mise à l'épreuve subcutanées. Aucun des groupes ne révélait de réactions de Willems lors de l'inoculation d'épreuve et seul le groupe qui a reçu le plus grand nombre d'injections avait des lésions pulmonaires caractéristiques de la pleuropneumonie bovine contagieuse. Une hypothèse est formulée quant à la formation des lésions pulmonaires.

- IBAH/69 GOURLAY, R. N. The isolation of T-strains of mycoplasma from
13. pneumonic calf lungs. (Isolement de souche T de mycoplasma de
poumons de veaux atteints de pneumonie.)
Res. vet. Sci. (1968), 9, 376.

Author's summary: T-strains of mycoplasma were isolated from 9 out of 16 pneumonic calf lungs. Their role in the pathogenesis of pneumonia has not yet been investigated.

Résumé de l'auteur: Des souches T de mycoplasma ont été isolées de 9 sur 16 poumons de veau pneumoniques. Leur rôle dans la pathogénèse de la pneumonie n'a pas encore été étudié.

- IBAH/69 COLE, D. J. A., BEAL, R. M., LUSCOMBE, J. R. The effect on
14. performance and bacterial flora of lactic acid, propionic acid,
calcium propionate and calcium acrylate in the drinking water
of weaned pigs. (Les effets sur le rendement et la flore bactérienne de
l'acide lactique, de l'acide propionique, du propionate de calcium et de
l'acrylate de calcium dans l'eau potable des porcs sevrés.)
Vet. Rec. (1968), 83, 459.

Author's summary: All the substances used were effective in controlling haemolytic *Escherichia coli* and reducing counts of non-haemolytic *E. coli* in the duodenum and jejunum. The effects of treatments were only apparent during the treatment period and disappeared after treatments had ceased. The treatments were administered in the drinking water which was given on top of the food. Consequently the efficiency of the treatments, both bacteriologically and in terms of growth and performance, was dependant on their acceptability. Lactic acid appeared to be most acceptable and was the only treatment to give consistently faster growth and more efficient live-weight gains than controls.

Résumé des auteurs: Toutes les substances utilisées étaient efficaces pour contrôler l'*Escherichia coli* hémolytique et réduire la numération de *E. coli* non-hémolytique dans le duodénum et le jejunum. Les effets des traitements n'étaient visibles que pendant la période de traitement et disparaissaient dès la fin du traitement. Les traitements étaient administrés dans l'eau potable qui était donnée aux bêtes en plus des aliments. En conséquence, l'efficacité des traitements tant du point de vue bactériologique qu'en ce qui concerne la croissance et le rendement, dépendait de leur acceptabilité. L'acide lactique semblait être le plus acceptable et c'était le seul traitement qui assurait une croissance toujours plus rapide et un gain de poids viv plus net que chez les bêtes témoins.

- IBAH/69 KILLICK-KENDRICK, R. The diagnosis of trypanosomiasis of
15. livestock: A review of current techniques. (Diagnostic de la
trypanosomiase chez le bétail: revue des méthodes actuelles.)
Vet. Bull. (1968), 38, 191.

Author's summary: In common with many other diseases caused by parasitic protozoa, the main difficulty of diagnosing trypanosomal infections of livestock is the frequent scarcity of parasites in the vertebrate host. The severity of an infection is not necessarily related to the number of parasites seen, and it may be difficult or impossible to find trypanosomes in the blood of an infected animal even when it is about to die.

Unfortunately, with few exceptions, current serological methods are of little value, and a certain diagnosis almost always depends upon finding the parasites. In this paper a review of the methods of diagnosis is given, and the optimum diagnostic techniques for each of 12 species of trypanosomes of livestock are shown in a table.

Résumé de l'auteur: Comme bien d'autres maladies provoquées par des protozoaires parasitiques, la grande difficulté quand il s'agit de diagnostiquer les infections tripanosomiques chez le bétail, c'est la rareté assez fréquente de parasites chez l'hôte vertébré. La gravité des infections n'est pas nécessairement fonction du nombre de parasites que l'on peut voir, et il est souvent difficile ou impossible de trouver des trypanosomes dans le sang d'une bête infectée, même lorsqu'elle est sur le point de mourir.

Malheureusement, à quelques exceptions près, les méthodes sérologiques actuelles ne sont pas très utiles, et un diagnostic sûr dépend presque toujours de la découverte de parasites. Dans cette communication, l'on fait une revue des méthodes de diagnostic et les techniques de diagnostic optimal pour chacune des 12 espèces de trypanosome du bétail sont indiquées dans un tableau.

IBAH/69 WELLS, E. A., LUMSDEN, W. H. R., McNEILLAGE, G. J. C.
16. **Isolation of trypanosomes of the section stercoraria from cattle in Nigeria and the United Kingdom.** (Isolement des trypanosomes du type stercoral du bétail du Nigéria et du Royaume-Uni.)
Br. vet. J. (1968), 124, 382.

Authors' summary: The development is described of a simple culture technique for the examination of bovine blood for stercorarian trypanosomes. From the occurrence of epimastigote forms in culture the infection of the animals with *Trypanosoma theileri* is inferred.

In Ibadan, Nigeria, 36 adult cattle of mixed Fulani Zebu and Ndama breeds were satisfactorily examined and 32 (89%) were infected. In Scotland 200 cattle of varying ages were examined in seven different localities and 34 (17%) gave positive cultures. A sample from England gave eleven infected animals out of 20 adults (55%).

The results indicated that *Trypanosoma theileri* is available in all areas for further study.

Résumé des auteurs: L'exposé décrit de développement d'une technique simple de culture pour l'examen du sang des bovins et ayant pour but de rechercher la présence de trypanosomes stercoraux. De l'apparition de formes épimastigotiques dans la culture, on déduit que les bovins sont infestés par le *Trypanosoma theileri*.

A Ibadan, Nigéria, 36 têtes de bétail adultes de race mixte, Zébu Fulani et Ndama, ont été examinées avec succès et 32 d'entre elles (89%) étaient infestées. En Ecosse, 200 têtes de bétail d'âge variable ont été examinées dans sept localités différentes et 34 d'entre elles (17%) ont donné des cultures positives. En Angleterre, une étude partielle a permis d'identifier onze animaux infestés sur vingt adultes examinés (55%).

Les résultats ont prouvé que le *Trypanosoma theileri* se trouve dans toutes les régions et requiert une étude plus approfondie.

IBAH/69 GLOVER, P. E. **The importance of ecological studies in the control of tsetse flies.** (L'importance des études écologiques pour le contrôle des mouches tsé-tsé.)
Bull. Wld Hlth Org. (1967), 37, 581.

Author's summary: The author reviews recent ecological research on tsetse flies in East Africa and Northern Nigeria, particularly in connection with the flies' sensory reactions, and stresses the importance of an accurate knowledge of their daytime and night-time resting-sites and of identifying the sources of their blood meals in order to elucidate the reservoirs of trypanosomiasis. The epidemiology of the disease is considered in the light of studies of trypanosome infections in host and fly. The control of tsetse flies must be based on the practical application of ecological knowledge by methods involving either a direct attack upon the fly (such as trapping or the use of insecticides) or an indirect attack (such as bush clearing or game destruction to eliminate the fly's habitat or food supply); these methods are dealt with in some detail. The author concludes with a discussion of modern trends in research, and a number of lines of research are suggested.

Résumé de l'auteur: L'auteur examine les recherches écologiques récentes sur les mouches tsé-tsé en Afrique Orientale et dans le Nord du Nigéria, particulièrement à l'égard des réactions sensorielles des mouches. Il insiste sur l'importance d'une connaissance précise de leurs gîtes diurnes et nocturnes, ainsi que de l'identification des sources de repas de sang, afin d'éclaircir les réservoirs de trypanosomiase. L'épidémiologie de la maladie est examinée à la lumière des études des infections trypanosomiales chez l'hôte et la mouche. Le contrôle des mouches tsé-tsé doit se baser sur l'application pratique des connaissances écologiques par des

méthodes impliquant soit une attaque directe contre les mouches (au moyen de pièges ou de l'usage d'insecticides) soit une attaque indirecte (telle que le débroussaillage ou la destruction du gibier, pour éliminer les habitats des mouches ou leur source d'alimentation); ces méthodes sont examinées en détail. L'auteur conclut par une discussion des tendances modernes de la recherche, et il indique un certain nombre de méthodes de recherche.

IBAH/69 ROSS, J. G., PURCELL, A., TODD, J. R., DOW, C. Combined
18. infections of calves with the nematode parasites *Trichostrongylus axei* and *Ostertagia ostertagi*. (Infections combinées par les nématodes *Trichostrongylus axei* et *Ostertagia ostertagi* chez des veaux.)

Br. vet. J. (1968), 124, 299.

Authors' summary: Parasite-free calves were infected at 6-8 weeks of age with either 150,000 *T. axei* or 150,000 *O. ostertagi* third stage larvae, or varying time combinations of 100,000 *T. axei* and 50,000 *O. ostertagi* third-stage larvae. All of the calves developed a severe diarrhoea between the second and third week of infection and either died or were slaughtered *in extremis* by the eighth week. The clinical pathology, gross and histopathology of the infections are described. Differences in serum pepsinogen levels were observed following varying infection patterns and it was possible on gross pathology to distinguish distinctive lesions resulting from differences in percentage of infection of the two parasites.

Résumé des auteurs: Des veaux exempts de parasites ont été infestés, entre 6 et 8 semaines, de larves au troisième stade dans les proportions suivantes: soit 150.000 larves de *T. axei*, soit 150.000 larves de *O. ostertagi*, soit des combinaisons de 100.000 larves au troisième stade de *T. axei* et de 50.000 de *O. ostertagi*, effectuées à des périodes diverses. Dans tous les cas, une violente diarrhée s'est déclarée au cours de la deuxième ou de la troisième semaine de l'infection; puis les veaux sont morts ou ont été abattus *in extremis* à la huitième semaine. L'exposé décrit la pathologie clinique et l'histopathologie de ces infections. On a observé les différences entre les niveaux pepsinogènes du sérum, à la suite de diverses formes de développement des infections, et il a été possible de distinguer des lésions particulières résultant de la différence dans les pourcentages d'infection des deux parasites, grâce à l'étude de la pathologie.

IBAH/69 MAY, I., NEGRU, D. Recherches sur le comportement de
19. certaines constantes sanguines dans la fasciolose bovine. (Investigations on the behaviour of several blood constants in bovine fasciolosis.)

Arch. Vet. Romania (1967), III, 307.

Résumé des auteurs: En étudiant le comportement de certaines constantes sanguines dans la fasciolose des bovidés on a constaté l'installation d'une anémie par hypoglobulie ainsi que la diminution du nombre des leucocytes neutrophiles et des lymphocytes.

On a rencontré de façon constante l'éosinophilie dont l'installation a toujours précédé l'élimination des œufs du parasite par les matières fécales.

Authors' summary: The behaviour of certain cytological and biochemical blood constants in bovine fasciolosis was investigated. In chronic fasciolosis anemia and hypoglobulia occurred, as well as a decrease of the number of leucocytes neutrophilic granulocytes and lymphocytes. Among several biochemical blood constants only the sodium chloride and the serum chlorides displayed a significant decrease, and this happened only in the chronic disease too.

Eosinophilia was constantly met and its installation always preceded elimination of the parasite's eggs through the faeces. No relationship could be ascertained between eosinophilia and the intensity of the *Fasciola hepatica* invasion.

It is suggested the cytological and biochemical changes observed in this infestation could represent the expression in the blood picture, of a cortico-suprarenal insufficiency.

IBAH/69 RAYNAUD, J. P. L'ostertagiose bovine. Revue bibliographique
20. raisonnée sur la maladie, son traitement et sa prophylaxie. Stomach worm disease of cattle (ostertagiasis). Analytical references on the disease, its treatment and its prophylaxie.

Résumé de l'auteur: L'ostertagiose bovine est une affection généralement méconnue en France. Le types cliniques en sont détaillés et analysés, comparés au complexe fasciolose-ostertagiose.

Des considérations sur l'écologie, la séméiologie, l'étiologie et la pathogénie sont données.

Le diagnostic clinique et biologique fait appel à la coproscopie dont les résultats sont irréguliers et au dosage du pepsinogène plasmatique qui est de grande valeur.

Le diagnostic nécropsique est aisé.

Le traitement du type clinique I est réalisé par de nombreux anthelminthiques; par contre, supprimer le pré-type II ou traiter le type II sont beaucoup plus difficiles.

Les cas particuliers du thiabendazole, du pyrantel et du tétramisole sont examinés.

Le programme de prophylaxie avec ces produits comprend:

- un traitement éventuel en mai;
- un traitement systématique en juillet;
- un traitement éventuel en septembre.

Les rotations sur pâturage neuf se font soit en juillet, soit en septembre.

Author's summary: Bovine ostertagiosis is a disease generally ignored in France. Clinical types are detailed, and analysed, compared to the complex fasciolosis-ostertagiosis.

Considerations on ecology, semeiology, etiology and pathogeny are given.

Clinical and biological diagnosis calls upon coproscopy of which results are irregular and upon dosage of plasmatic pepsinogen which is of great value.

Necropsic diagnosis is easy.

Treatment of clinical type I is realized by numerous anthelmintics; on the other hand, the neutralisation of the pre type II or the treatment of type II are much more difficult.

The particular cases of Thiabendazole and Pyrantel* are examined. The prophylaxis program with these drugs includes:

- an eventual treatment in May;
- a systematic treatment in July;
- an eventual treatment in September.

Rotations on new pasture are made either in July or in September.

* And tetramisole.

IBAH/69 JAGGERS, S. E., HERBERT, I. V. **Studies on the resistance of pigs to the lungworm *Metastrongylus* spp. Infections in minimal disease pigs from eight weeks of age.** (Etude de la résistance des porcs aux *Spp. metastrongylus* de broncho-pneumonie vermineuse du porc. Infections chez les porcs à maladie minimale à partir de huit semaines.)

J. Comp. Path. (1968), 78, 161.

Authors' summary: Investigations of pig lungworm disease have been carried out using experimental infections and re-infections in specific pathogen-free pigs. The characteristic symptoms associated with lungworm infection were observed, namely, egg counts were detectable in the faeces by 28 days after initial infection and two animals were rendered immune to re-infection after receiving four separate infections totalling 20,000 larvae. In these latter cases there were no peaks of egg production following the second and third re-infection.

There was evidence that in longstanding infections the female lungworm was eliminated before the male and that existing parasites were eliminated on re-infection.

The circulating eosinophilia that occurred after infection with the lungworm and heightened rapidly on second infection was not stimulated further by a third infection within the period of peak eosinophilia.

Significant increases in percentage serum gamma globulin occurred following re-infection together with a fall in percentage serum albumin. Antibody production to the infection was demonstrated by an intradermal skin test.

It is considered that the differentiation of haematological and serological changes due to lungworm infections was considerably assisted by the use of parasite-free minimal disease pigs.

Résumé des auteurs: Des études sur la métastrongylose bronchique du porc ont été effectuées en utilisant des infections et réinfections expérimentales sur des porcs exempts de certains pathogènes particuliers. Les symptômes caractéristiques de l'infection de la broncho-pneumonie vermineuse ont été observés, à savoir des numérations d'œufs étaient dépiatables dans les matières fécales 28 jours après l'infection initiale et deux bêtes ont été immunisées contre la réinfection après avoir reçu quatre infections séparées totalisant 20,000 larves. Dans ces derniers cas, il n'y avait pas de crêtes de production d'œufs à la suite de la deuxième et de la troisième réinfections.

Il semble que dans les infections de longue durée, le métastrongylus soit éliminé avant le mal et les parasites existants sont éliminés lors de la réinfection.

L'éosinophilie circulante qui se produisait après l'infection par le métastrongylus et qui s'accroissait rapidement lors de la deuxième réinfection n'était plus stimulée par une troisième infection pendant la période de crête d'éosinophilie.

Les augmentations significatives du pourcentage de globuline gamma du sérum se produisaient à la suite de la réinfection, ainsi qu'une baisse de l'albumine du sérum en pourcentage. La production d'anticorps contre l'infection était démontrée par une épreuve cutanée intradermique.

L'on pense que la différenciation des changements hématologiques et sérologiques provoqués par des infections métrastroglyosiques soit considérablement favorisée par l'emploi de porcs exempts de parasites et aussi sains que possible.

**IBAH/69 KEITH, R. K. The effect of repeated anthelmintic treatment on
22. body weight gains of calves. (Les effets d'un traitement anti-helminthique répété sur les augmentations de poids vif des veaux.)**
Aust. Vet. J. (1968), 44, 326.

Author's summary: Studies are reported on the effect of frequent anthelmintic treatment on the body weight gains of grazing calves.

In one experiment, eight calves treated nine times with trichlorphon at intervals of four weeks gained an average of 73 lb. more than seven untreated calves grazing the same worm-infected pasture.

In a second and similar experiment eight calves treated eight times gained an average of 74 lb. more than the survivors of seven untreated calves, two of which died of helminthosis.

The helminths mainly responsible for the deaths and reduced weight gains of the untreated calves were *Cooperia* spp. (*C. punctata* and *C. pectinata*), and *Oesophagostomum radiatum*.

Résumé de l'auteur: Des études sont décrites quant aux effets d'un traitement antihelminthique fréquent sur l'accroissement du poids vif des veaux au pâturage.

Au cours d'une épreuve, huit veaux traités neuf fois au moyen de trichlorphon à des intervalles de quatre semaines ont pris en moyenne trente trois kilos de plus que sept veaux non traités qui pâturaient les mêmes prés infestés de vers.

Au cours d'une deuxième épreuve analogue, huit veaux traités huit fois ont pris en moyenne trente trois kilos et demi de plus que les survivants de sept veaux non traités, dont deux sont morts d'helminthose.

Les helminthes qui ont provoqué le plus de morts et de réduction de l'accroissement de poids chez les veaux non traités étaient *Cooperia* spp. (*C. punctata* et *C. pectinata*), et *Oesophagostomum radiatum*.

**IBAH/69 WIGGAN, LLOYD, S., CLARK, J. B. K. The effect of synchroni-
23. zation of oestrus on the fertility of ewes inseminated artificially.**
(Effect de la synchronisation de l'œstrus sur la fécondité des brebis
inseminées artificiellement.)
Br. Vet. J. (1968), 124, 460.

Authors' summary: Seventy-seven ewes were assigned on the basis of day of oestrous cycle to one or other of two main treatment groups (1 and 2). Group 1 ewes were treated with a progestogen and group 2 ewes remained untreated.

Each of the two main groups was further sub-divided randomly into three sub-groups (1a, b and c; 2a, b and c). Each sub-group was inseminated with diluted ram semen that had been stored for 0, 24 and 48 hours respectively. Total fertility attributed to A.I. over two oestrous cycles, based on fertile eggs and embryos recovered *post mortem* and lambs born, was 100, 62 and 77% respectively for the synchronized ewes, and 92, 82 and 62% for the non-synchronized control ewes. These differences are not significant although, on the basis of first oestrous periods only, the synchronized ewes showed a significantly lower conception rate than did the control ewes.

There was a significant difference between the quality of the semen used at the first oestrous periods and that used at the second oestrous periods but differing frequencies of insemination (governed by duration of oestrous periods) had no effect on the resultant conception rates.

Résumé des auteurs: Soixante-dix-sept brebis ont été partagées en deux groupes de traitement (1 et 2) en considération du jour de leur cycle œstral. Le groupe No. 1 a été traité par administration d'un progestagène tandis que les brebis du groupe No. 2 n'ont pas été traitées.

Chacun de ces deux groupes a ensuite été divisé au hasard en trois sous-groupes (1a, b et c; 2a, b et c). Les brebis de chaque sous-groupe ont été inseminées avec du sperme de bélier qui avait été mis en réserve respectivement 0, 24 et 48 heures. En se fondant sur les nombres d'œufs fécondés, des embryons récupérés après autopsies et des agneaux portés à terme, on a pu évaluer la fécondité totale imputable à l'insemination artificielle pendant deux cycles œstraux à, respectivement, 100, 62 et 77% pour les brebis synchronisées et à 92, 82 et 62%

pour les brebis de contrôle non synchronisées. Ces différences ne sont pas significatives mais, sur la base des premières périodes œstrales seulement, les brebis synchronisées ont donné preuve d'un taux de conception nettement inférieur à celui des brebis de contrôle.

Il y avait une différence significative entre la qualité du sperme utilisé pendant les premières périodes œstrales et celui utilisé pendant les secondes périodes, mais les différentes séquences d'insémination (déterminées par la durée des périodes œstrales) n'ont eu aucun effet sur les taux de conception en résultant.

IBAH/69 LUNCA, N., TUDORASCU, R. **Stimulation de l'activité sexuelle
24. des brebis afin d'en obtenir trois agnelages en deux ans.** (Stimulation of sexual activity in ewes with a view to obtaining three lambings in two years.)

Arch. Vet. Romania (1967), III, 299.

Résumé des auteurs: Deux séries d'expériences ont été dédiées à des essais de stimuler la fonction sexuelle des brebis dans la période printanière au but d'obtenir trois mises bas en deux années.

Le traitement par la progesterone seule ou associée à la gonadotrophine a déterminé l'apparition des chaleurs chez les brebis dans une proportion importante, tandis que leur fécondité a été en moyenne de 64,6%.

Authors' summary: Sexual activity in ewes was stimulated by progesterone, serum gonadotropin, and by an association of both in two experimental series.

Heat occurred in 93.8% of the ewes after progesterone treatment in spring, and in 89.6% of the ewes after gonadotropin treatment, their prolificity rates being of 130 and 102%, respectively. Sex ratio in the lambs was 57.9% males, 42.1% females, while the average weight at birth was of 3.80 and 3.60 kg. in males and females, respectively.

After lambing in autumn hormonal stimulation brought about heat in a proportion of 92.6% of the ewes, with a fertility rate of 86.8%. It is concluded that hormonal stimulation of the ovarian function enables the obtaining of three lambings in two years.

IBAH/69 TUDORASCU, R. **Investigations on fertility, insemination rate
25. and length of service-period in cows inseminated at various post-partum times.** (Recherches sur la fécondité, l'indice d'insémination et la durée du service-période des vaches inséminées à différents termes post-partum.)

Rev. de zoo si med. vet. (1968), 7, 34.

Author's summary: Fertility subsequent to first insemination and mean service-period time for cows inseminated for the first time at various post-partum periods registered an ascending curve both from the 1st to the 4th months, as well as from the sub-groups of animals with high milk yields to those with low milk outputs.

Fertility subsequent to the 2nd and 3rd insemination was independent of the first post-partum time.

In estimating insemination efficiency at various post-partum times, service-period should be taken into account, together with fertility ratio subsequent to first insemination and the insemination rate.

Résumé de l'auteur: L'auteur montre la fécondité après la première insémination et la durée moyenne du service-période, chez les vaches inséminées pour la première fois à différents termes après le vêlage, enregistrent une courbe ascendante du premier au quatrième mois et des sous-groupes d'animaux à grande production laitière aux animaux de faible production.

La fécondité après la seconde et la troisième insémination n'est pas en fonction du temps de la première insémination post-partum.

Dans l'appréciation de l'efficacité de l'insémination des vaches pratiquée à différents termes post-partum, il faut tenir compte, non seulement du pourcentage de fécondité après la première insémination et de l'indice d'insémination, mais aussi de la durée du service-période.

IBAH/69 GRAHAM, N. McC. **Effects of undernutrition in late pregnancy
26. on the nitrogen and energy metabolism of ewes.** (Effet de la malnutrition aux dernières étapes du gravidisme sur le métabolisme de l'énergie et de l'azote des brebis.)

Aust. J. agric. Res. (1968), 19, 555.

Author's summary: The nitrogen metabolism of five non-pregnant ewes and 16 pregnant.

ewes was studied. The aim was to examine the effects of pregnancy on the response to severe undernutrition. Some measurements of energy metabolism and blood composition were also made.

Pregnant ewes excreted less urea nitrogen in the urine than did non-pregnant ewes when they were all well fed. When food intake was reduced by 75%, excretion by the non-pregnant ewes declined, whereas excretion by the pregnant ewes declined less or increased. After five days on the lower ration, pregnant ewes excreted up to 9 g. more urea nitrogen daily than did non-pregnant ewes. Urea clearance was constant throughout and was 30-40% of creatinine clearance.

Undernutrition caused hypoglycaemia and hyperketonaemia in the pregnant ewes only but there were no clinical signs of pregnancy toxæmia.

The heat production of pregnant ewes declined when their ration was reduced. The estimated heat increment of pregnancy was greater with the reduced ration than with the large ration and it is suggested that this change represented the energy cost of gluconeogenesis from protein. The gross energy content of protein apparently oxidized was estimated to be about 20% of the energy requirement of the foetus.

The effects of pregnancy on nitrogen and energy metabolism and on response to undernutrition were approximately proportional to the birth weight of the lamb, and were smaller seven weeks before lambing than two weeks before lambing.

Résumé de l'auteur: Le métabolisme azoté de cinq brebis non gravides et de 16 brebis gravides a été étudié. Le but était d'examiner les effets du gravidisme sur la réaction à une grave sous-alimentation. L'on a également effectué quelques mesures du métabolisme énergétique et de la composition du sang.

Les brebis gravides excrétaient moins d'azote uréique dans l'urine que les brebis non gravides lorsque toutes étaient bien alimentées. Lorsque l'ingestion alimentaire était réduite de 75%, l'excrétion des brebis non gravides diminuait, tandis que l'excrétion des brebis gravides diminuait moins ou augmentait. Au bout de cinq jours à ration réduite, les brebis gravides excrétaient jusqu'à neuf grammes de plus d'azote uréique par jour que les brebis non gravides. L'élimination de l'urée était constante pendant toute l'épreuve et elle représentait 30 à 40% de l'élimination de créatinine.

La sous alimentation provoquait de l'hypoglycémie et de l'hyperkétonémie seulement chez la brebis gravide, mais sans aucun signe clinique de toxicité de gravidisme.

La production thermique des brebis gravides baissait lorsque leur ration était réduite. L'indice d'augmentation de dégagement thermique dû au gravidisme était plus grand lors de la réduction de ration qu'avec la ration forte et l'on suggère que ce changement représentait le coût énergétique de la gluconéogénèse de la protéine.

La valeur énergétique brute de la protéine apparemment oxydisée était évaluée à environ 20% des besoins d'énergie du fœtus.

Les effets du gravidisme sur le métabolisme azoté et énergétique et sur la réaction à la sous-alimentation étaient approximativement proportionnels au poids à la naissance de l'agneau et ils étaient plus faibles sept semaines avant l'agnelage que deux semaines avant l'agnelage.

IBAH/69 SUTTON, G. D., FOURIE, P. D., RETIEF, J. S. The behaviour of
27. **cattle in transit by rail.** (Le comportement du bétail dans les transports par chemin de fer.)

J. S. Afr. vet. med. Ass. (1967), 38, 153.

Authors' summary: Observations during the transport of two truck-loads of experimental slaughter cattle have revealed a distinct pattern of behaviour in transit and whilst the train was stationary. Their reactions to short periods of rest in pens, with food and water available, was also recorded. These are considered of significance in reviewing existing regulations under which animals are transported over long distance by rail.

Résumé des auteurs: Des observations faites pendant le transport de deux chargements de bétail expérimental destiné à l'abattoir ont révélé un comportement distinct en transit et pendant les stationnements du train. Les réactions du bétail à de brèves périodes de repos dans des enclos, où ils avaient accès à de l'alimentation et de l'eau ont également été notées. Elles sont considérées comme significatives pour la révision des règlements existants qui régissent le transport de bétail sur de longues distances par chemin de fer.

IBAH/69 PARKER, W. H. Housing of Ruminants. 1. Its advantages and its
28. **health problem.** (Le logement des ruminants. 1. Ses avantages et les problèmes de santé.)

Vet. Rec. (1968), 83, 208.

Author's summary: Despite the risk of enteric and respiratory diseases intensive housing

increases production, gives higher live-weight gains, and offers better opportunities for close observation of stock. The epidemiology and control of enteric diseases are relatively well understood. Respiratory diseases are much more complex as well as being much more common. The symptoms and epidemiology are discussed, prior to consideration in a second paper of housing requirements.

Résumé de l'auteur: Malgré le risque de maladies entériques et respiratoires, une stabulation intensive augmente la production, fournit une augmentation de poids vif plus forte et de meilleures possibilités de surveiller le bétail. L'épidémiologie et le contrôle des maladies entériques sont relativement bien compris. Les maladies respiratoires sont bien plus complexes et beaucoup plus fréquentes. Les symptômes et l'épidémiologie sont examinés, en vue d'une seconde communication sur les conditions de stabulation.

IBAH/69 NESIC, P., BUKOJEVIC, J., BAJRIC, A. **Deficient diet as a factor**
29. **in the incidence of cannibalism in layers.** (Les carences alimentaires et leurs effets sur le cannibalisme des poudeuses.)
Veterinaria Sarajevo (1968), 1717, 185.

Authors' summary: The object of this trial was to answer the question whether deficient diet as a single factor can cause cannibalism in layers and whether this phenomenon can be warded off by feeding hens a nutritious mixture of full value. By using deficient feeds composed of corn meal and barley and by eliminating the effects of adverse environmental factors, we provoked cannibalism in experimental layers. When this deficient diet was replaced with the nutritious mixture of full biological value cannibalism was arrested and its spread prevented. This led us to the conclusion that deficient diet can be the only factor in the etiology of cannibalism in hens and that it can be successfully eradicated by correct diet. Besides, we noticed that overcrowding also played a certain role in the manifestation of cannibalism, the rate of its spreading and the extent of losses caused by it.

Résumé des auteurs: Le but de cette épreuve était de répondre à la question de savoir si un régime alimentaire déficient peut à lui seul provoquer le cannibalisme chez les poudeuses et si ce phénomène peut être évité en fournissant aux poules un mélange nutritif de valeur suffisante. En utilisant une alimentation à carence composée de farine de blé et d'orge et en éliminant les effets des facteurs nocifs du milieu, nous avons provoqué le cannibalisme chez les poules expérimentales. Lorsque ce régime insuffisant fut remplacé par l'alimentation nutritive de pleine valeur biologique, le cannibalisme cessa et sa diffusion fut empêchée. Cela nous amena à la conclusion qu'un régime insuffisant peut être le seul facteur de l'étiologie du cannibalisme chez les poules et que l'on peut l'éliminer avec succès en fournissant une alimentation correcte. En outre, nous avons remarqué que le surpeuplement jouait aussi un certain rôle dans les cas de cannibalisme, dans le rythme de sa diffusion et l'importance des pertes qu'il provoque.

IBAH/69 VAN DER WALT, K., JENKINS, W. L., BOTES, H. J. W. **The**
30. **therapeutic control of calf paratyphoid (*S. dublin* infection).**
(Le contrôle thérapeutique de la paratyphoïde des veaux (infection *S. dublin*.)
J. S. Afr. vet. med. Ass. (1967), 38, 425.

Authors' summary: Four drugs, chloramphenicol, furazolidone, Sulpha 18605-Ba (Sulphamethyphenasole-Ciba), and neomycin were tested for efficacy against *S. dublin* infection in calves. The trial involved 54 calves.

Fully susceptible animals were artificially infected intraduodenally with a known pathogenic strain of *S. dublin* and treatment was carried out for four days with each drug after the calves were severely ill. Survivors were slaughtered four weeks after infection.

An efficacy index (EI), based on the percentage of carriers, was established. Chloramphenicol had an EI 77.7, furazolidone 50, Sulpha 18605-Ba 33.3, and neomycin 16 compared to 10 in the untreated control group.

Résumé des auteurs: Quatre produits pharmaceutiques, chloramphenicol, furazolidone, Sulpha 18605-Ba (Sulphamethyphenasole-Ciba), et néomycine ont été mis à l'épreuve du point de vue de l'efficacité contre l'infection *S. dublin* chez les veaux. L'épreuve portait sur 54 veaux.

Les animaux pleinement réceptifs furent infectés artificiellement par la voie intraduodénale au moyen d'une souche pathogénique connue de *S. dublin* et le traitement fut donné pendant quatre jours au moyen de chaque produit, les veaux étant déjà gravement malades. Les survivants furent abattus quatre semaines après l'infection.

Un indice d'efficacité (EI), basé sur le pourcentage des vecteurs fut établi. Le chloramphénicol avait un EI de 77,7, furazolidone 50, Sulpha 18605-Ba 33,3, et néomycine 16 en comparaison avec 10 dans le groupe témoin non traité.

IBAH/69 GRETILLAT, S., VASSILIADES, G. Le traitement de la
31. coccidiose des ruminants domestiques par L' "amprolium"
Chlorhydrate du chlorure de 1 (4-amino-2n-propyl-5-pyrimidinylméthyl) 2-picolinium. (The treatment of Coccidiosis in Domestic Ruminants with "Amprolium").

Rev. Elev. Méd. vét. Pays trop. (1968), 21, 191.

Résumé des auteurs: L' "Amprolium" (Chlorhydrate du chlorure de 1 (4-amino-2n-propyl-5 pyrimidinylméthyl) 2-picolinium) déjà utilisé dans la prophylaxie et le traitement des coccidioses aviaires a été essayé avec succès dans la thérapeutique de la coccidiose des ruminants domestiques au Sénégal.

Pour éviter les risques de surinfestation ou de réinfestation en cours d'expérimentation, ont été désinfectés et stérilisés périodiquement les stalles, instruments, outils en contact avec les animaux, ainsi que les vêtements et chaussures du personnel.

Le produit anticoccidien utilisé pour ces essais est une poudre soluble dans l'eau, renfermant 20 p 100 d'Amprolium, et administrée per os le matin à jeun.

Les contrôles du taux d'infestation (nombre d'oocystes par gramme de fèces) sont faits avant, puis 6, 12, 20 et 30 jours après début de la cure. L'amélioration de l'état général (disparition ou régression partielle des troubles morbides, gain de poids) sont comparés avec le comportement et l'état de témoins non traités à l' "Amprolium".

12 chèvres, 18 moutons et 12 veaux atteints de coccidiose intestinale aiguë sont répartis en lots de 2 à 3 animaux sur lesquels sont testées les doses suivantes:

50, 100, 200 et 400 mg./kilo, en une dose unique.

200 mg./kilo/jour, pendant deux jours consécutifs.

25, 50, 100 et 200 mg./kilo/jour, pendant 4 jours consécutifs.

50 mg./kilo/jour, pendant 6 jours consécutifs.

50 mg./kilo/jour, pendant 8 jour consécutifs.

Les résultats les plus intéressants (taux d'infestation diminué de 90 à 95 p. 100 amélioration de l'état général, gain de poids, dans les trois semaines qui suivent le début de la cure) sont obtenus avec la dose de 50 mg./kilo/jour pendant 4 jours consécutifs: une dose unique, même élevée (200 et 400 mg./kilo) étant insuffisante pour aboutir à une guérison clinique.

En conclusion, l' "Amprolium" utilisé per os sous forme de poudre soluble dans l'eau et renfermant 20 p. 100 de produit actif permet de traiter efficacement les caprins, ovins et jeunes bovins atteints de coccidiose aiguë ou subaiguë.

La dose minimum active est de 50 mg./kilo/jour pendant 4 ou mieux 6 jours consécutifs.

Comme pour la plupart des antiparasitaires internes, des doses moyennes renouvelées plusieurs jours de suite sont plus actives qu'une dose élevée unique.

Authors' summary: "Amprolium" (Chlorhydrate of 1 (4-amino-2n-propyl-6 pyrimidinyl-methyl) 2-picolinium chloride) already used for treatment and prophylaxis of avian coccidiosis has been tried with success in the therapy of ruminant coccidiosis in Senegal.

To avoid the risk of superinfestation and reinfestation during the experiment, the stalls, instruments, materials in contact with the animals as well as the clothes and shoes of the staff, were disinfected and sterilized regularly.

The coccidiocidal product used in these trials was a water-soluble powder containing 20 per cent Amprolium, administered by mouth, in the morning, before feeding.

The level of infestation was measured by the number of oocysts per gram of faeces, before and at 6, 12, 20 and 30 days after the beginning of treatment. The improvement in general condition (disappearance or regression of symptoms, gain in weight) are compared with the condition of controls not treated with "Amprolium".

12 goats, 18 sheep and 12 calves with acute intestinal coccidiosis were divided into groups of 2 or 3 animals on which the following doses were tested:

50, 100, 200 and 400 mg./kg in one dose.

200 mg./kg. per day on two consecutive days.

25, 50, 100 and 200 mg./kg. per day on 4 consecutive days.

50 mg./kg. per day on 6 consecutive days.

50 mg./kg. per day on 8 consecutive days.

The most interesting results (infestation rate reduced by 90-95 per cent, improvement in general condition, gain in weight during the three weeks following the onset of treatment) were obtained with the dose of 50 mg./kg. per day for 4 consecutive days: a single dose, even at 200 and 400 mg./kg., was insufficient to bring about a clinical cure.

In conclusion "Amprolium" given by mouth in the form of a water-soluble powder containing 20 per cent of active ingredient, is efficient in the treatment of acute or subacute coccidiosis in goats, sheep and calves.

The minimum effective dose is 50 mg./kg. per day for 4 or, better, 6 consecutive days.

As with most treatments for internal parasites, a medium dose repeated on several successive days is more effective than a single high dose.

IBAH/69 KIBBLE, R. M. Effectiveness of dichlorvos-impregnated collars in controlling fleas on dogs. (Efficacité des colliers imprégnés de dichlorvos pour tenir sous contrôle les puces chez les chiens.)

32.

Aust. Vet. J. (1968), 44, 456.

Author's summary: A trial was conducted with 24 dogs kennelled under controlled conditions to investigate the efficiency of dichlorvos-impregnated dog collars for control of flea infestation.

The results indicate that good flea control by the use of impregnated dog collars under trial can be expected for nine weeks—the treated dogs having a mean of less than 5% of the fleas counted on the control dogs. Flea control was still being exerted after 13 weeks, when the treated dogs had a mean of less than 15% of the fleas counted on the control dogs. On removal of the collars a highly significant increase occurred ($p < 0.001$) in the fleas counted on the treated dogs.

All treated dogs remained healthy, and the impregnated collars were not associated with significant changes in body weight of treated dogs.

The death of one puppy, not in the original trial, wearing an incorrectly placed dog collar is noted. The precise cause of death was not determined.

Résumé de l'auteur: Une épreuve fut effectuée sur 24 chiens au chenil dans des conditions contrôlées pour examiner l'efficacité de colliers de chiens imprégnés de dichlorvos pour lutter contre les puces.

Les résultats montrent qu'il est possible de s'attendre pendant neuf semaines à un bon contrôle des puces au moyen de colliers imprégnés. Les chiens traités ont en moyenne moins de 5% du nombre des puces comptées sur les chiens témoins. Le contrôle des puces continuait à se faire sentir au bout de 13 semaines: les chiens traités avaient en moyenne moins de 15% du nombre de puces comptées sur les chiens témoins. Lorsque les colliers étaient enlevés, une augmentation très significative se produisait ($P < 0,001$) dans le nombre de puces comptées sur les chiens traités.

Tous les chiens traités demeuraient sains et le port de colliers imprégnés ne coïncidait avec aucun changement significatif du poids vif des chiens traités.

La mort d'un chiot qui ne figurait pas dans la première épreuve et qui portait un collier de chien mal placé, est également notée. La cause précise de la mort n'a pas été déterminée.

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